CHAPTER 7

DESIGN CRITERIA AND PRELIMINARY DESIGN

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7.1 Geometric Design Criteria

(1) Geometric Design Requirements and Criteria

As mentioned in Chapter 6, The following bridge widths were adopted:

Single lane: 5.5 m for Bridge No.1 Kurizampa
Bridge No.3 Bjee
Bridge No.4 Wachy Zam
Bridge No.5 Mangdichu

Double lane: 7.5 m for Bridge No.2 Chamkar Zam

Criteria for the geometric design are summarized in Table 7.1.

Table 7.1 Geometric Design Criteria

Item	Unit	Figure	Remarks
Shoulder width	m	0.90	Paved with AC for case of R=6.0m curve
Hard strip width	m	0.15	Paved with AC
Cross fall for carriageway	%	2.0	
Cross fall for shoulder	%	4.0	
Maximum vertical grade	%	6.0	
Minimum horizontal curve radius	m	6.0	

(2) Cross Section of Approach Road

1) Slope protection of cliff

The following curve radii were decided.

Bridge No. 1 Kurizampa, Right Bank : R = 8.0 m
Bridge No. 2 Bjee, Right Bank : R = 6.0 m
Bridge No. 4 Wachy Zam, Left Bank : R = 6.0 m
Bridge No. 5 Mangdichu, Right Bank : R = 7.0 m

For the above four (4) bridges sites, slope protection was designed as shown in Figure 7.1.

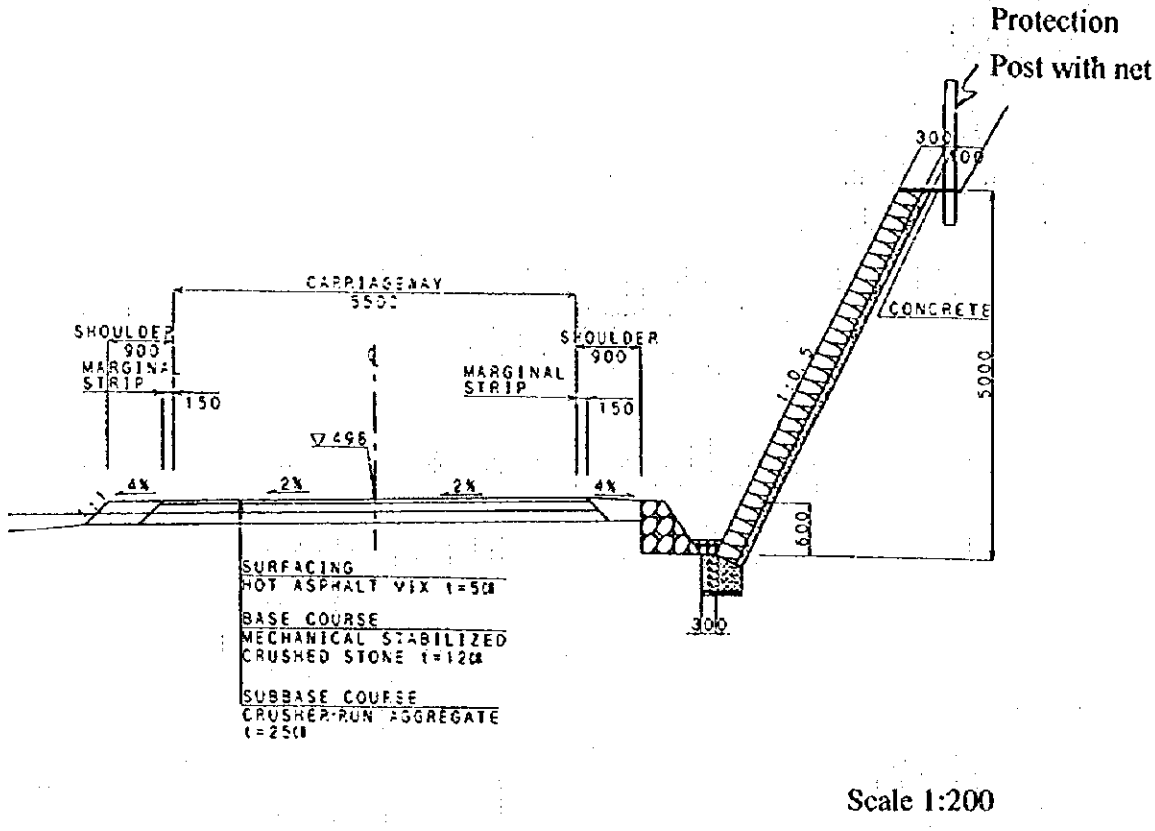


Figure 7.1 Typical Cross Section of Cutting Area

2) Cross Section of Approach Road

Typical cross section of approach road on the embankment is shown in Figure 7.2.

3) Pavement

Pavement was designed as shown in above Figure 7.2, based on CBR value of 3 to 5 percent, in accordance with RCM.

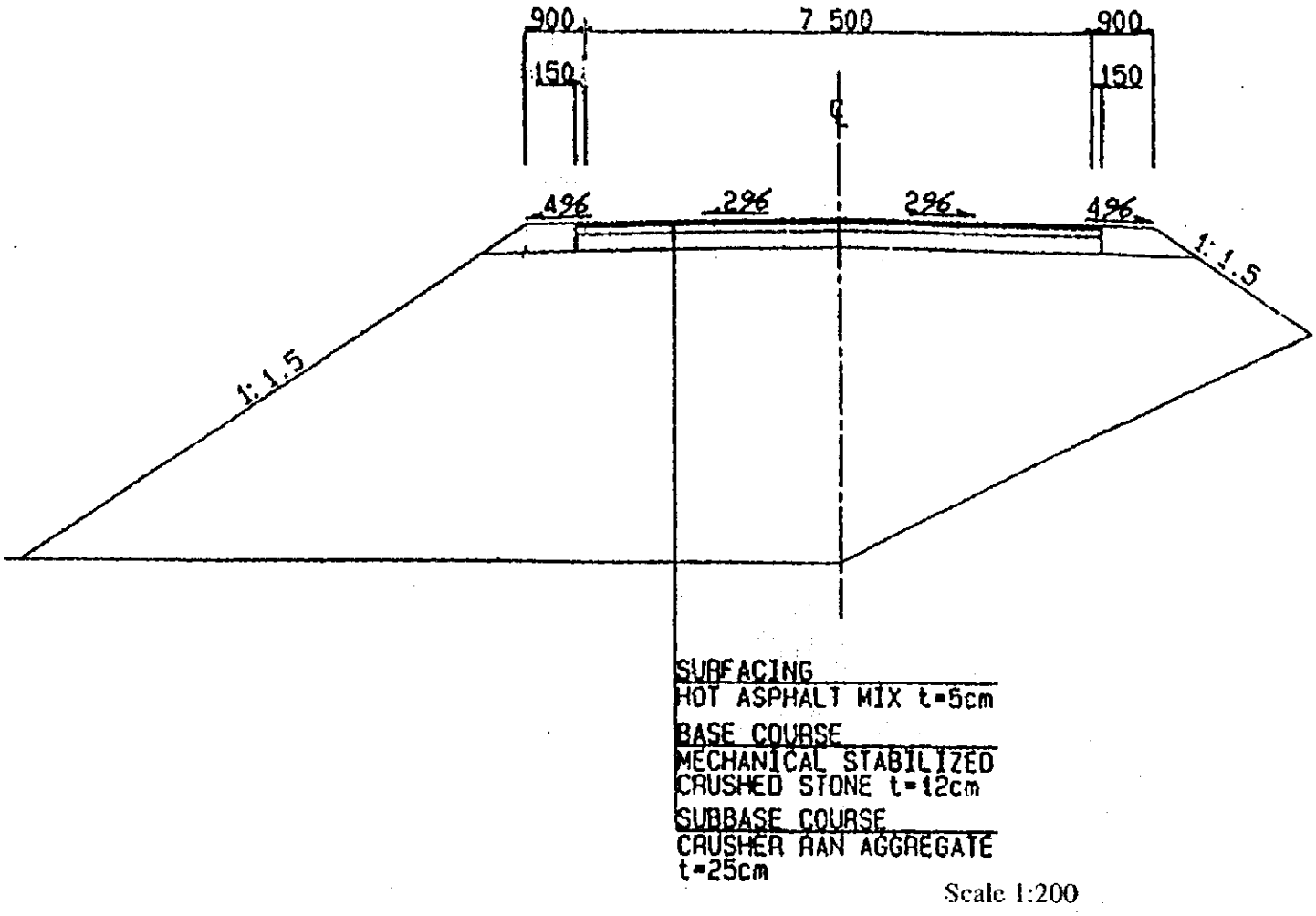


Figure 7.2 Typical Cross Section of Approach Road on the Embankment

7.2 Bridge and Approach Road Design Criteria

For the design criteria other than items specified in this chapter, the design requirements and criteria described in Section 6.1 were adopted for the preliminary design.

(1) Bridge Design Criteria

1) Bridge Superstructure

The following types of superstructure were adopted in the preliminary design:

Bridge No.	Br. Name	Br. Type
No.1	Kurizampa	Truss
No.2	Chamkar Zam	Truss
No.3	Bjee	Truss
No.4	Wachy Zam	Truss
No.5	Mangdichu	Lohse

2) Bridge Substructure and Foundation

Considering the topographic and geological conditions and limited space for the construction and existing traffic at bridge sites, it was decided to use the following substructure types were in the design:

Br. No.	Br. Name	Bank	Substructure Type
No. 1	Kurizampa	Left Bank: Right Bank	Inverted T Abutments with Deep wells
No. 2	Chamkar Zam	 Right Bank	Left Bank: Inverted T Abutments
No. 3	Bjee Right Bank	Left Bank:	Inverted T Abutments with Deep wells
No. 4	Wachy Zam	Left Bank: Right Bank	Inverted T Abutment with Deep wells Inverted T Abutment
No. 5	Mangdichu,	Left Bank: Right Bank	Inverted T Abutments with Deep wells

3) Pavement

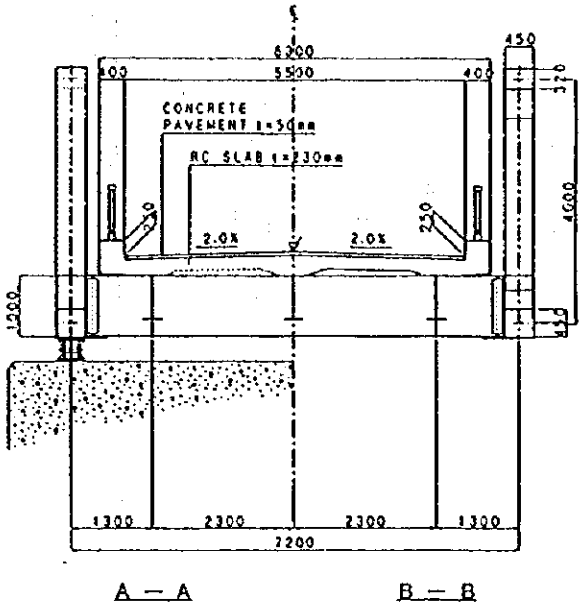
5 cm concrete pavement with steel mesh on reinforced concrete bridge deck was adopted in the design.

(2) Cross Section of Bridges

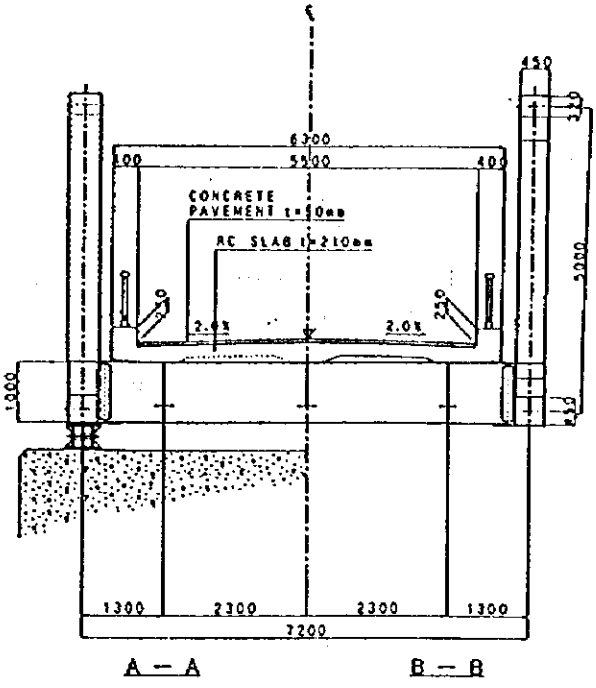
Bridge cross section for each case is shown in Figure 7.3.

(3) List of Proposed Bridges

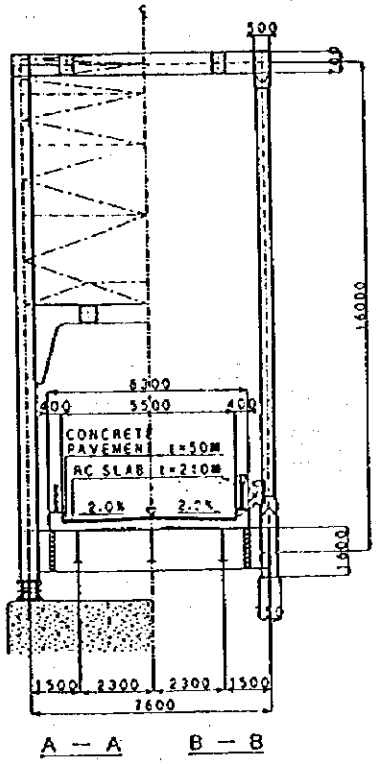
Priority projects (bridges) finally selected are listed in Table 7.2.



Truss, Bridge Length 43 m



Truss, Bridge Length 50 m and 54 m



Lohse, Bridge Length 100 m

Figure 7.3 Bridge Cross Sections

Table 7.2 List of Proposed Bridges

Br. No.	Bridge Name	Bridge Type	Alignment Alternative	Coordinate Left, N,E Right, N,E	Formation Level of Exist. Br. (m)	Formation Level of Prop'd. Br. (m)	Bridge Width (m)	Bridge Length (m)	Abutment Height (m)		Curve Radius (m)	
									Left	Right	Left	Right
1	Kurizampa	Truss	A-2 (On existing alignment)	9982N,50060E 10017N,50021E	498.1	498.1	5.5	54.0	8.3*	8.3*	15.0	8.0
2	Chamkar Zam	Truss	-	19986N,49989E 19991N,49947E	499.5	499.5	7.5	43.0	6.0	10.5	20.0	125.0
3	Bjee	Truss	- (A-1)	9900N,20048E 9917N,20001E	493.4	493.4	5.5	50.0	8.8*	10.8*	10.0	6.0
4	Wachy Zam	Truss	A-2	9963N,19983E 9993E,19987E	499.5	499.5	5.5	43.0	7.8*	12.8	6.0	30.0
5	Mangdichu	Lohse	A-3	20003N,10108E 19934N,10035E	496 - 500	495.7	5.5	100.0	12.5*	12.5*	40.0	7.0

Notes A-1~ A-3: Figures 6.13 to 6.17

Note: * On deep wells

7.3 Topographical Survey and Geological Investigation

Topographical survey and geological investigation were conducted in order to facilitate necessary information for the preliminary design. The results were used in the design. The results of geological investigation are presented in Appendix-F.

7.4 Bridge and Approach Road Design

Preliminary bridge design was carried out, based on the geometric and bridge criteria decided, and structural dimensions were designed. Approach roads, slope protection and pavement were designed simultaneously.

Contents of Drawings

Drawing No.	Name of Drawings	Scale
1	Bridge No.1 Kurizampa Bridge	1:500
2	Bridge No.2 Chamkar Zam Bridge	1:500
3	Bridge No.3 Bjee Bridge	1:500
4	Bridge No.4 Wachy Zam Bridge	1:500
5	Bridge No.5 Mangdichu Bridge	1:600
6	Approach Road of Bridge No.2 Chamkar Zam Bridge	1:1000
7	Approach Road of Bridge No.4 Wachy Zam Bridge	1:1000
8	Approach Road of Bridge No.5 Mangdichu Bridge	1:1000
9	Detour for Bridge No.5 Mangdichu Bridge	1:1000
10	Detour for Bridge No.5 Mangdichu Bridge	1:1000

7.5 Quantifies for Cost Estimate

Based on the preliminary design, quantities for cost estimate were obtained.

Table 7.3 List of Quantities

Item	Unit	Br. No.1	Br. No.2	Br. No.3	Br. No.4	Br. No.5	Total
[Superstructure]							
Steel							
Structural	ton	108.8	101.2	98.6	93.5	299.9	702.0
Ancillary	ton	4.3	4.1	4.0	3.9	12.6	28.9
Deck Slab							
Concrete	cm	90.5	86.1	83.8	72.9	172.3	505.6
Re-Bar	ton	20.0	20.9	18.5	15.9	37.2	112.5
Conc. Pavement	sm	297.0	322.5	275.0	236.5	550.0	1681.0
[Substructure]							
Deep Wells	lm	16.0	0	22.0	7.0	30.0	75.0
Concrete	cm	78.6	0	108.0	34.4	147.2	368.2
Re-bar	ton	6.7	0	9.2	2.9	12.5	31.3
Excavation	cm	152	0	177	59	123	511
Abutment							
Concrete	cm	217.8	460.8	217.8	538.8	243.2	1,678.4
Re-bar	ton	21.8	46.1	21.8	53.9	24.3	167.9
Excavation	cm	687	1,796	841	1,529	878	5,731
[Approach Road]							
Embankment	cm	0	3,348	99	1,883	3,269	8,599
Excavation	cm	352	508	420	2,035	2,607	5,922
Stone Masonry	sm	63.8	0	142.8	425.6	820.7	1,452.9
AC Pavement	sm	406	1,636	406	630	1,404	4,482
[Detour Work]							
Structural Steel	ton	49.4	0	0	0	0	49.4
Emankment	cm	0	544	245	0	0	789
Excavation	cm	0	51	0	0	3,814	3,865
AC Pavement	sm	0	455	137	0	587	1,399

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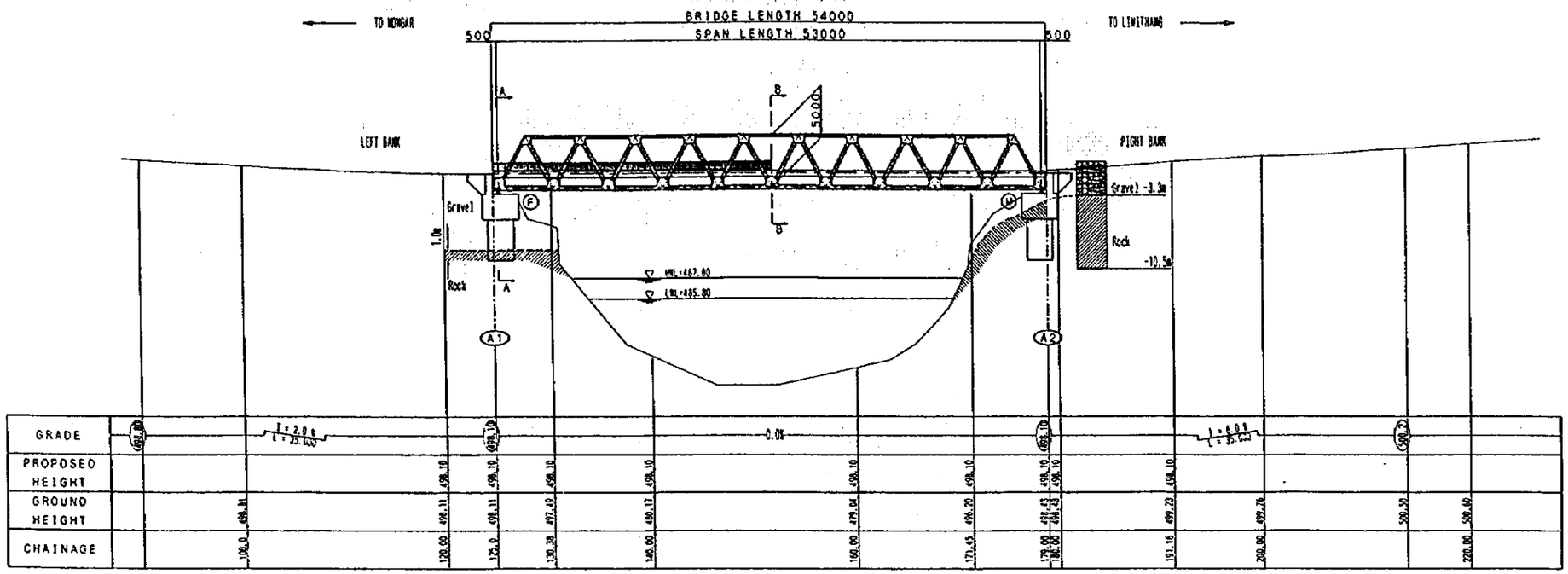
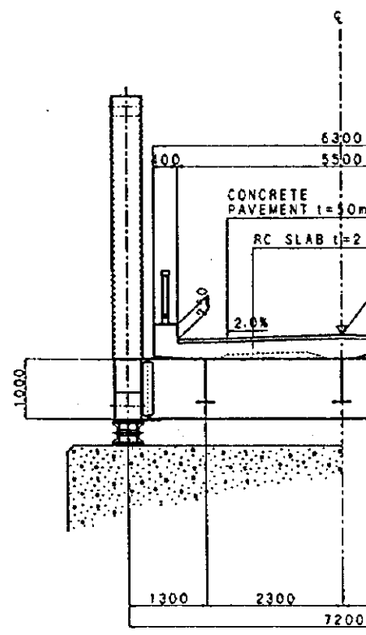


CROSS SECTI



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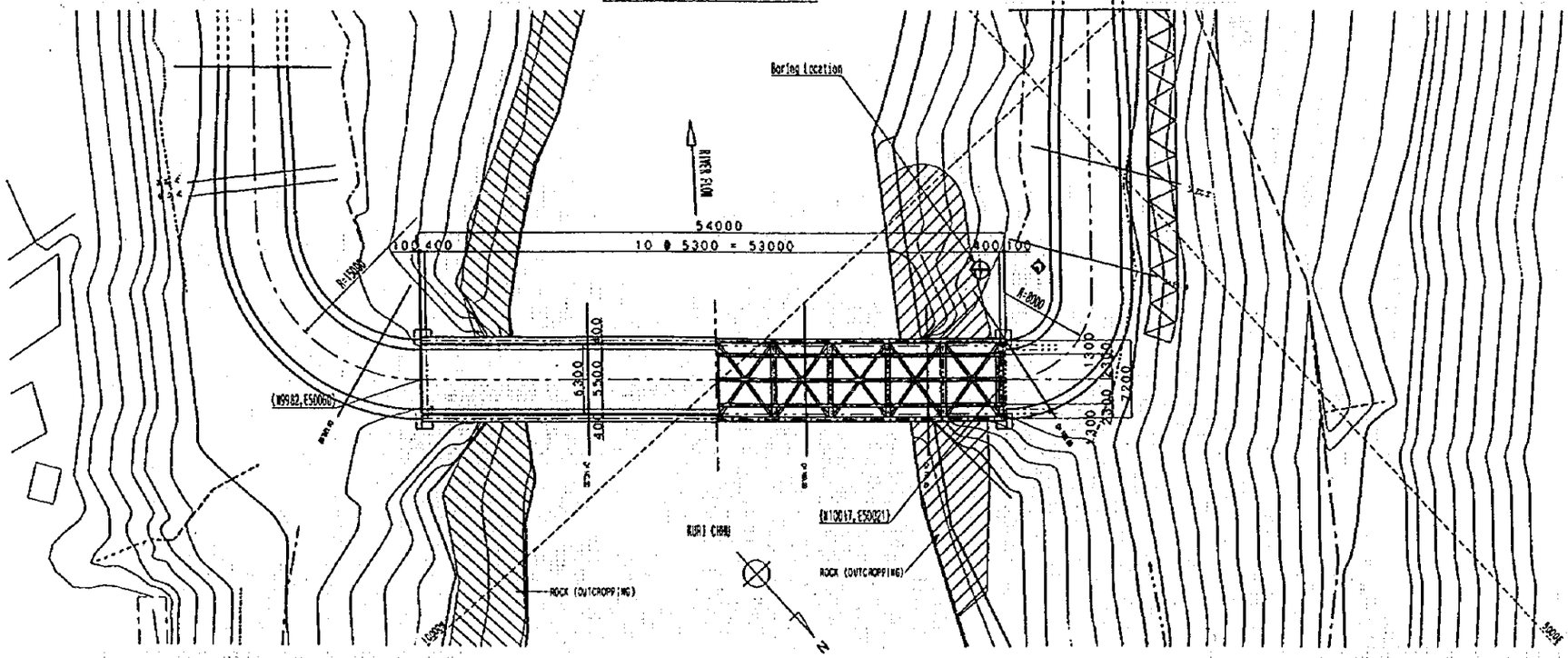

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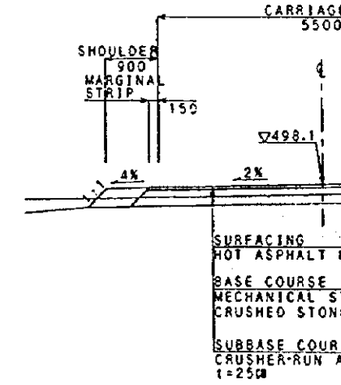

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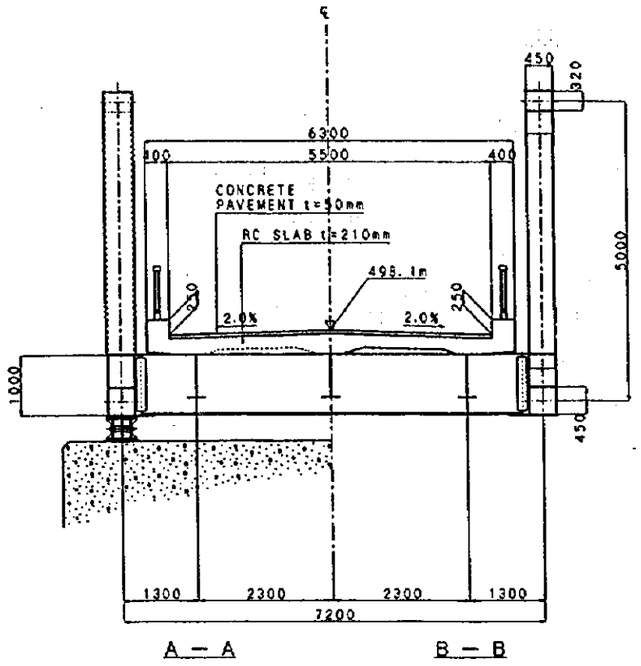

A — A　　B — B

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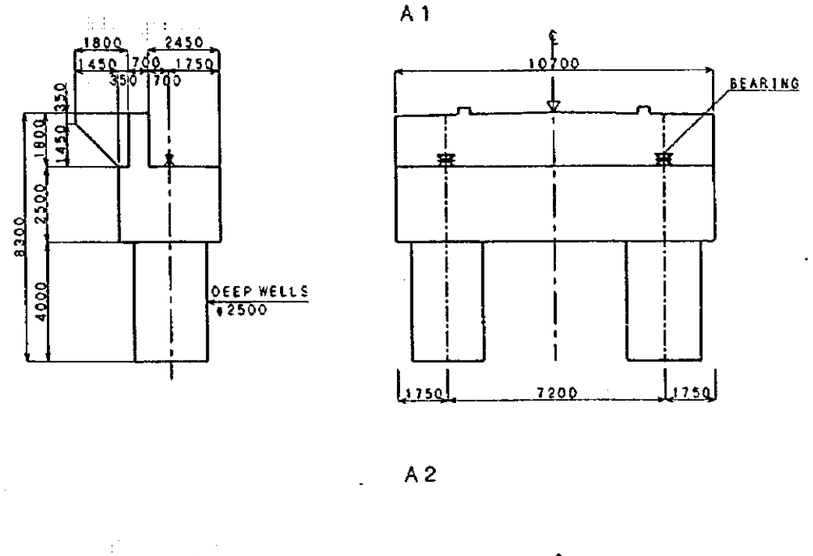

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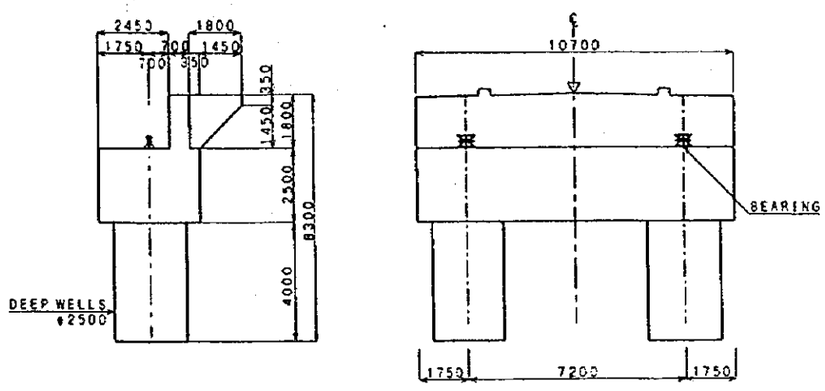

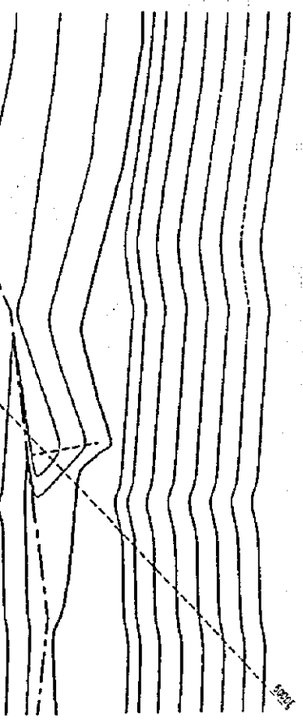

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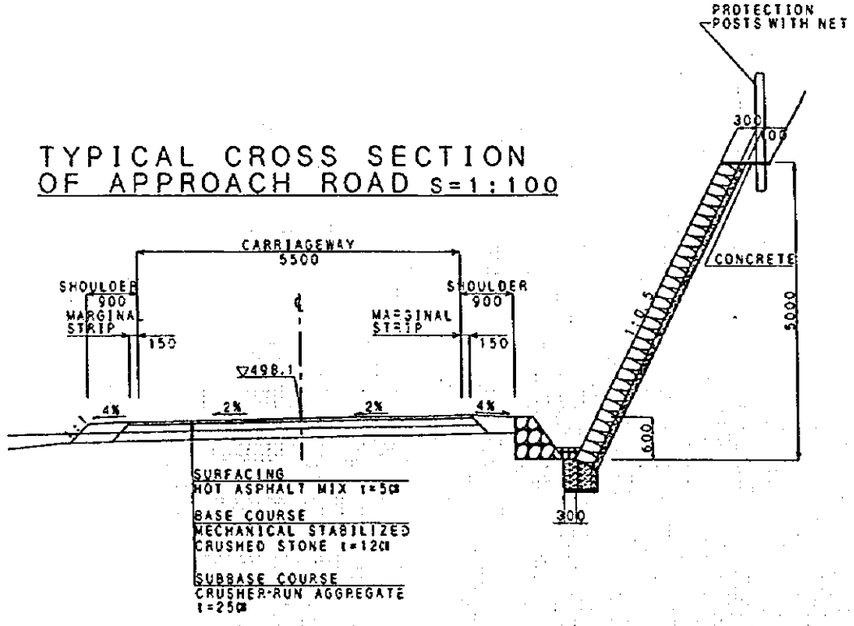

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BRIDGE NO.1 KURIZAMPA BRIDGE GENERAL VIEW & DIMENSIONS	DRAWING NO. 1	

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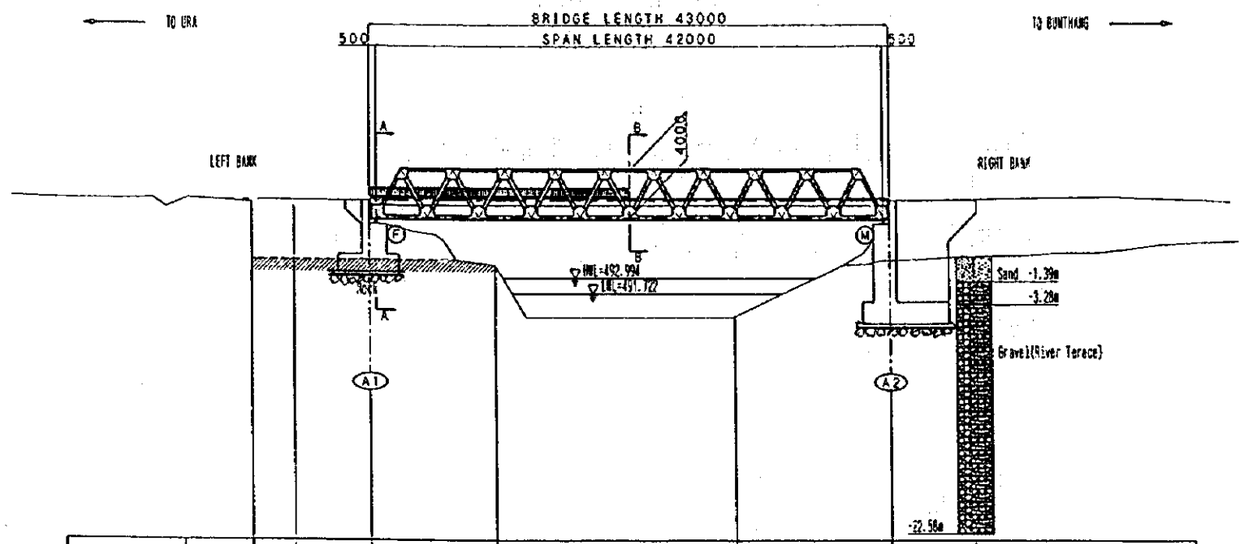

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GROUND HEIGHT	499.32	499.06	494.11	489.82	494.79	
CHAINAGE	60.00	63.38	80.00	100.00	120.00	

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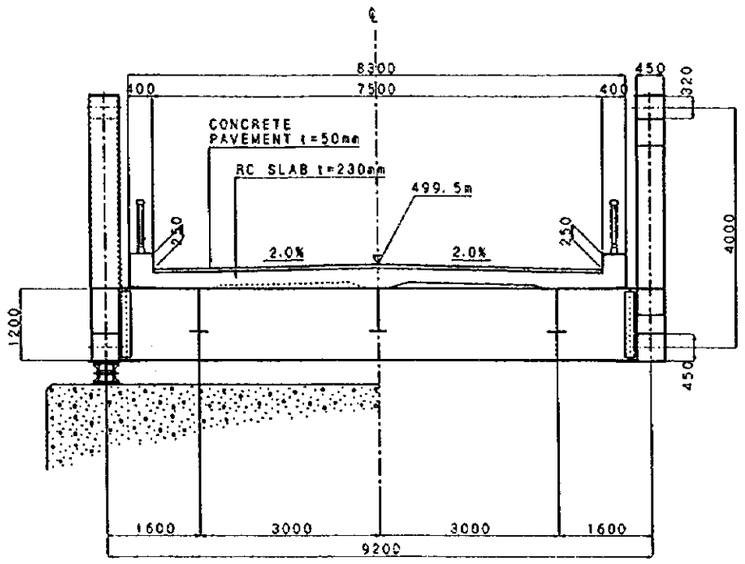

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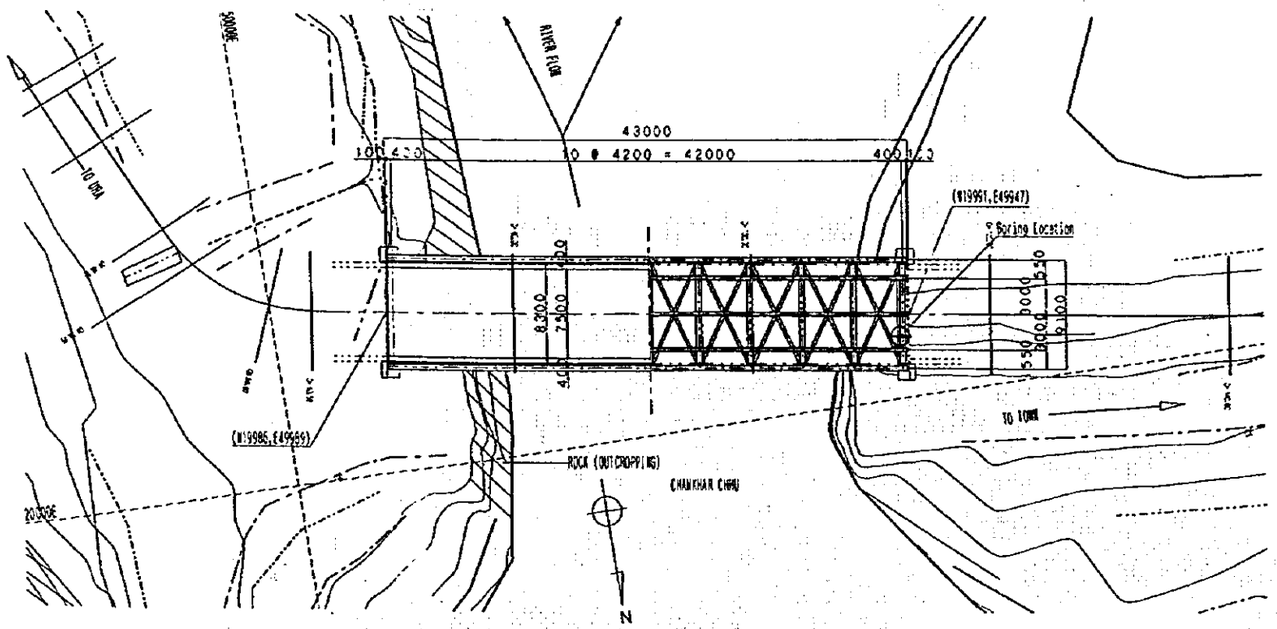

TO GUNTHANG

RIGHT BANK

Sand -1.3m

-3.2m

Gravel(River Terace)

-22.56m

	499.50
	494.70
120.000	

(N19951,E49547)

Boring Location

5.50
3.000
9.100
5.50

TO TCHK

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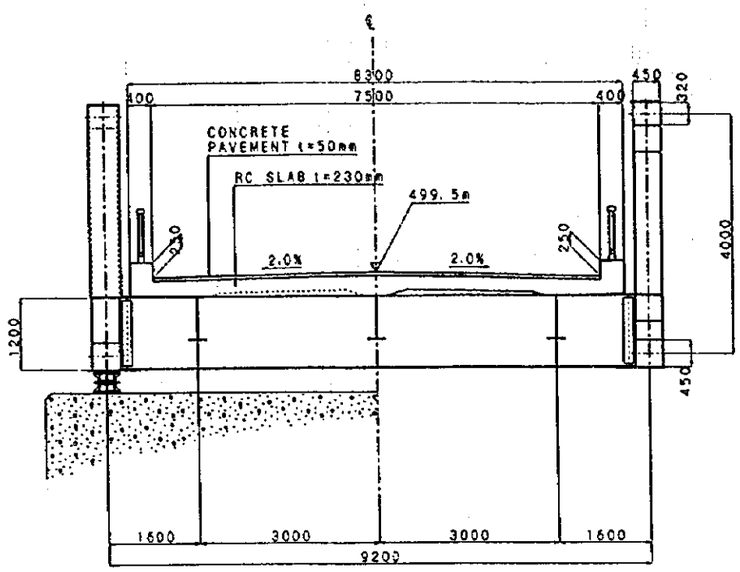

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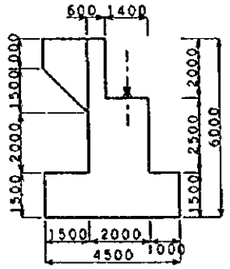

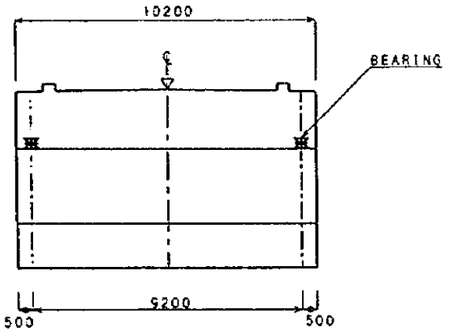

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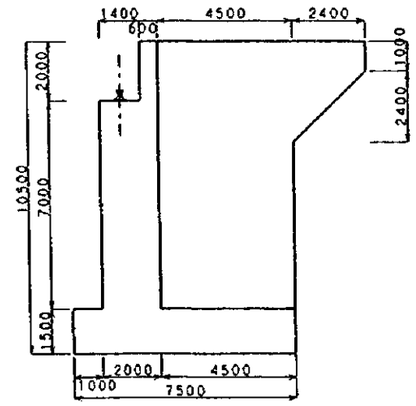

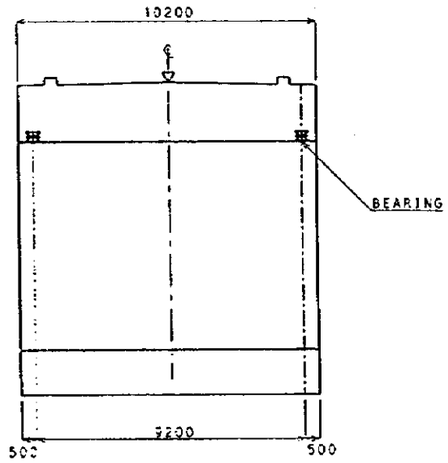

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BRIDGE NO.2 CHAMKAR ZAM BRIDGE GENERAL VIEW & DIMENSIONS	DRAWING NO. 2	

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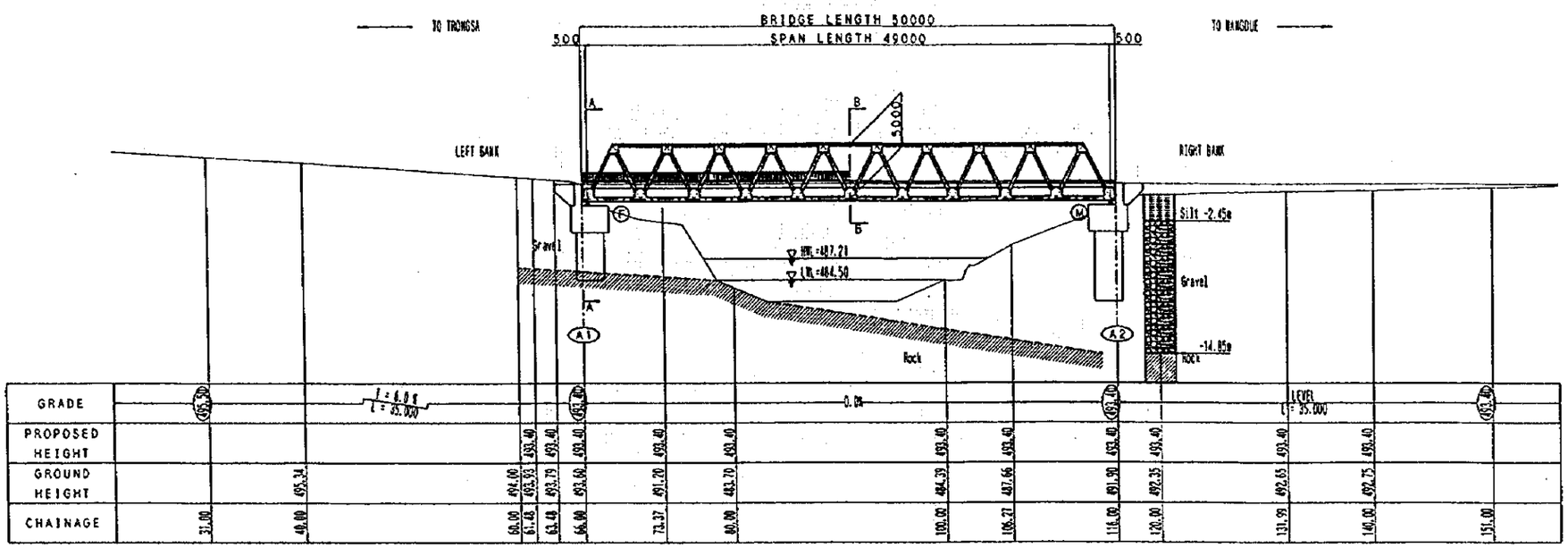

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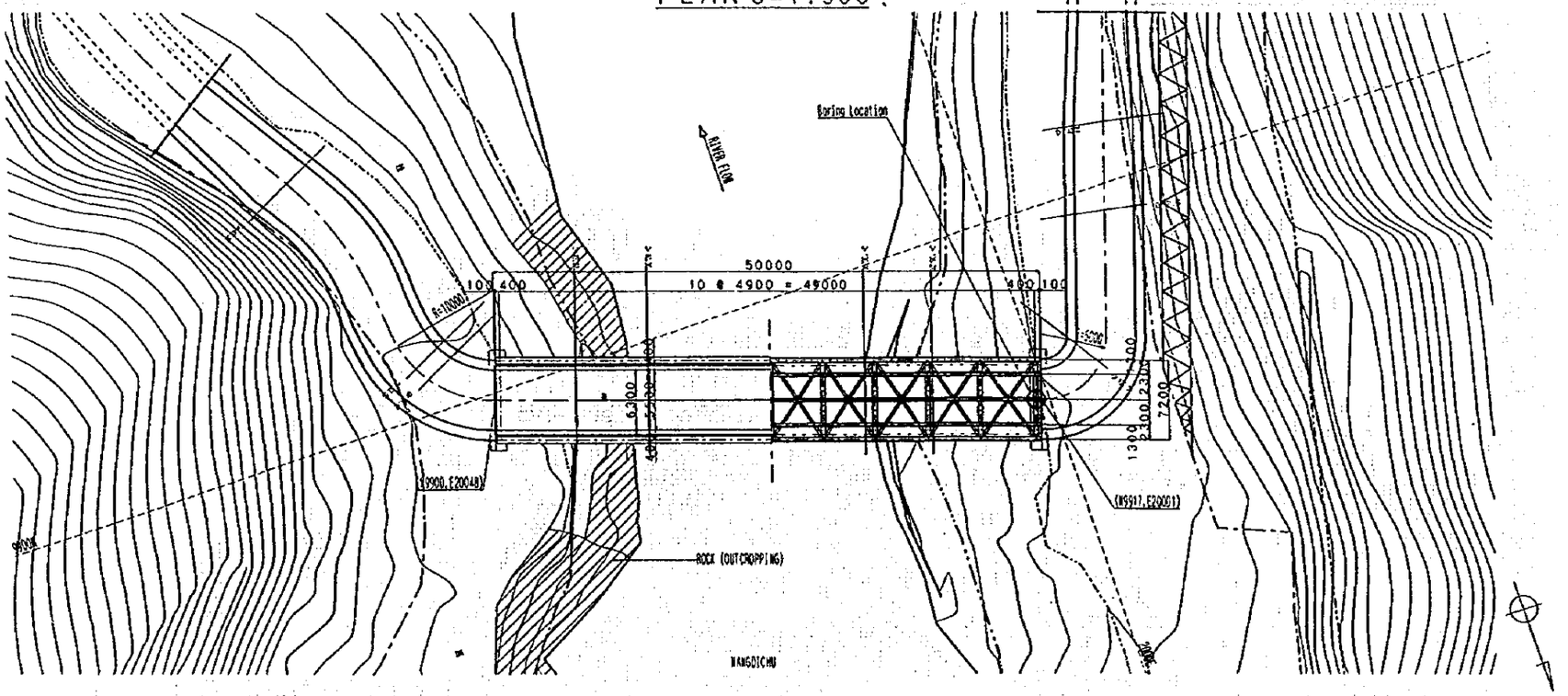

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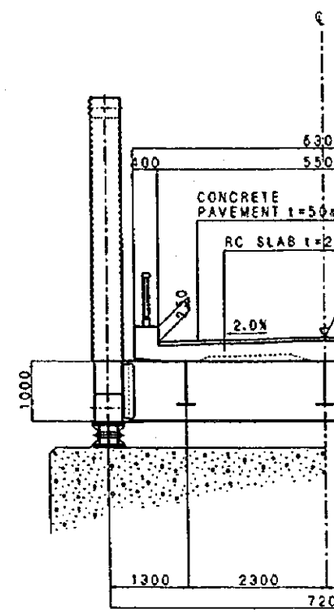
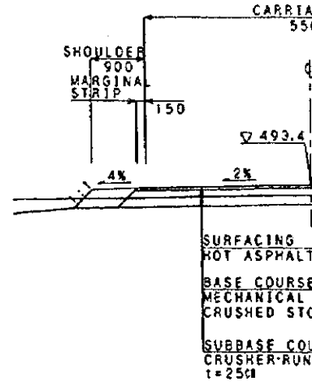


A — A

TYPICAL CRO
OF APPROACH



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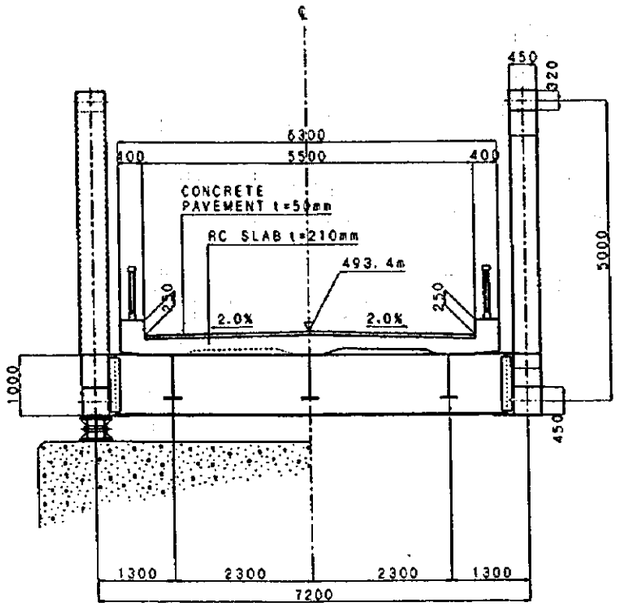
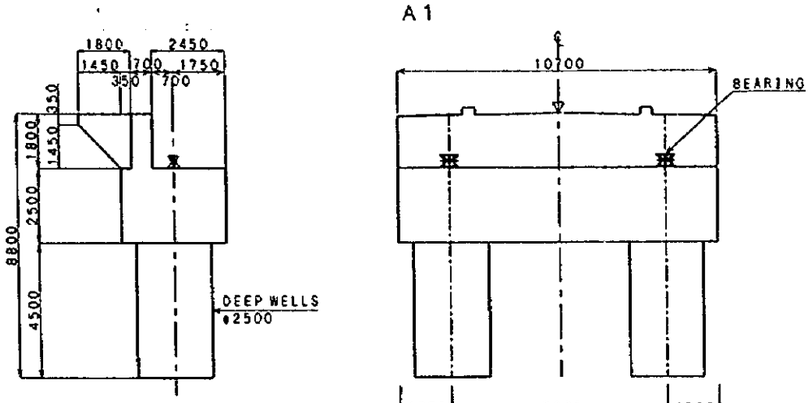


A — A　　B — B

ABUTMENT S=1:200

A1



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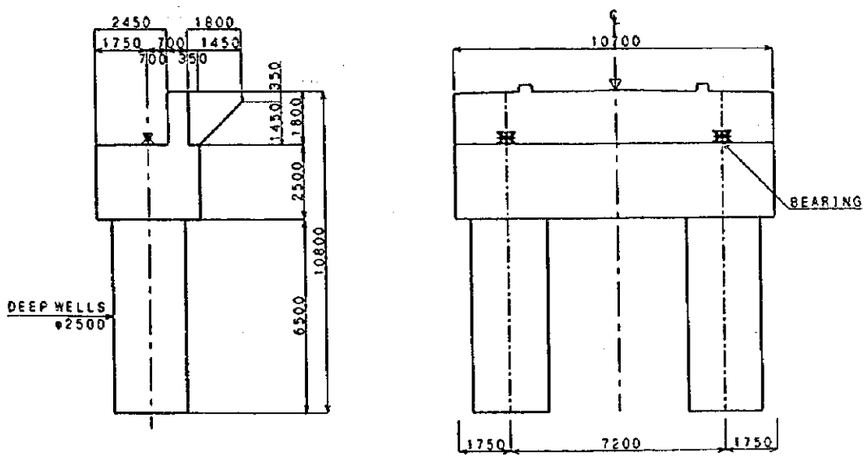
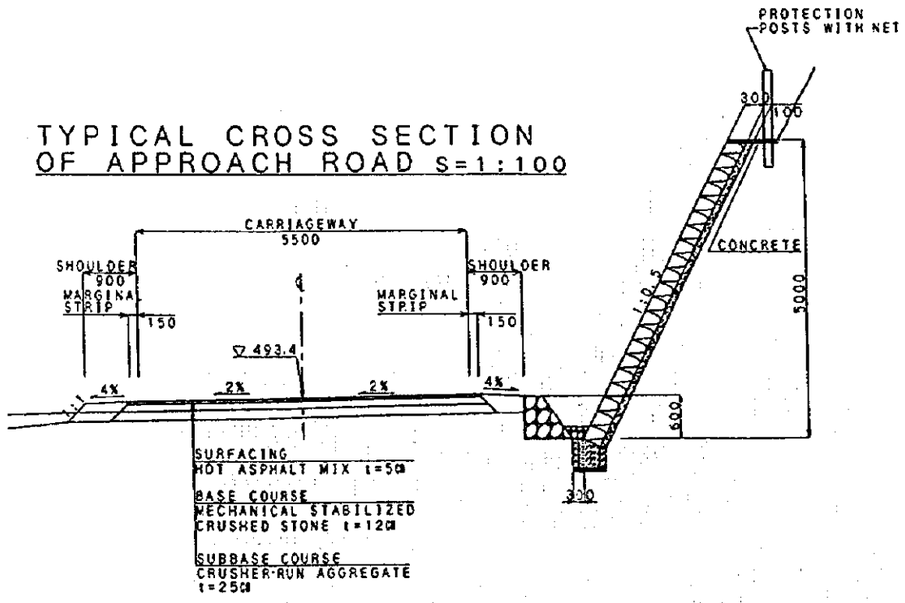
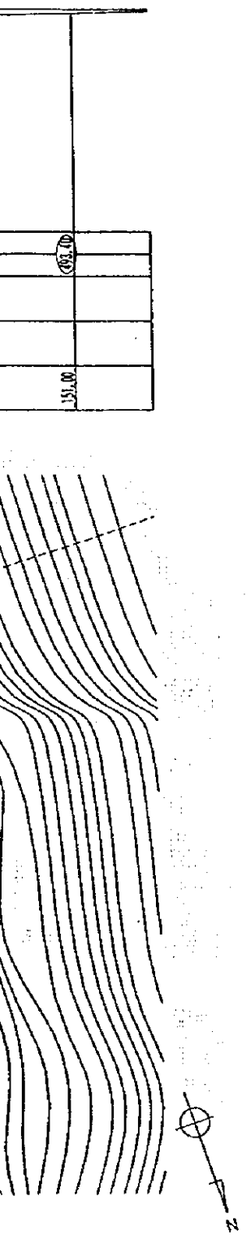


TYPICAL CROSS SECTION OF APPROACH ROAD S=1:100





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BRIDGE NO.3 BJEE BRIDGE GENERAL VIEW & DIMENSIONS	DRAWING NO. 3	

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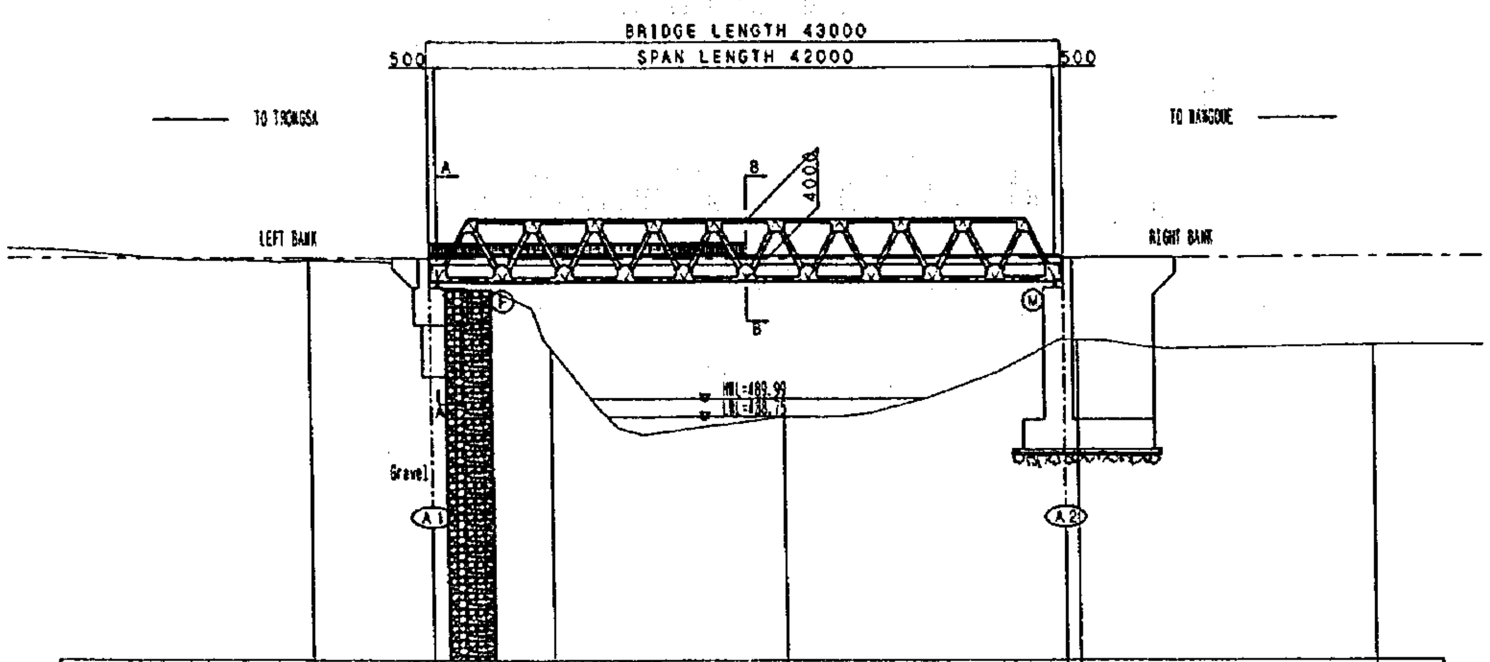
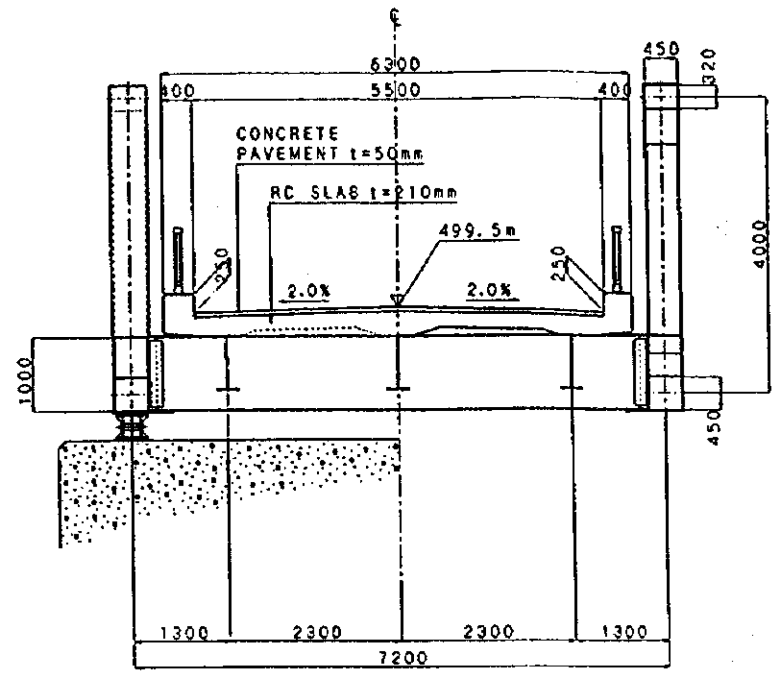


GRADE			0.0%			
PROPOSED HEIGHT	499.5	499.5	499.5	499.5	499.5	499.5
GROUND HEIGHT	499.36	497.34	493.44	488.69	493.93	493.56
CHAINAGE	47.86	60.00	63.93	80.00	100.00	120.00

CROSS SECTION S=1:100



A – A B – B

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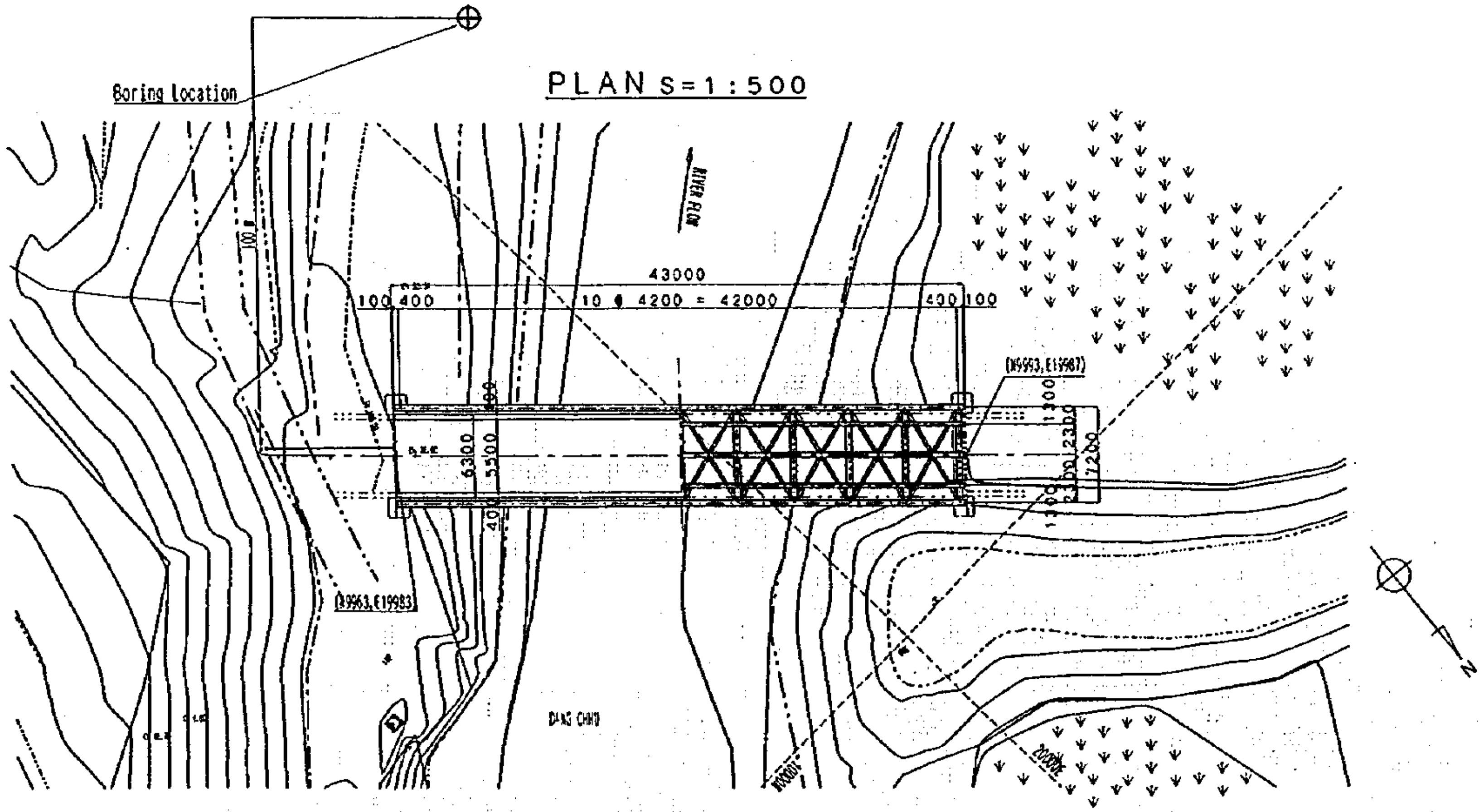

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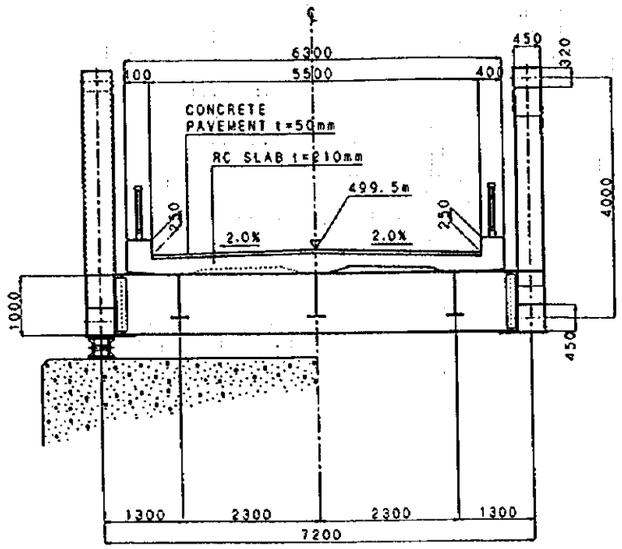

A — A

B — B

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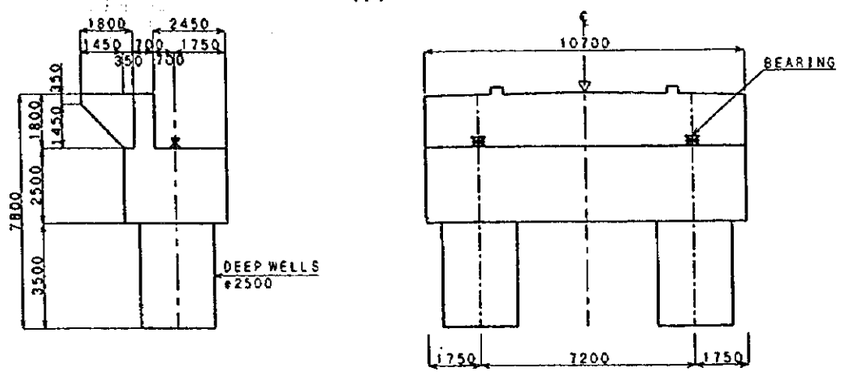

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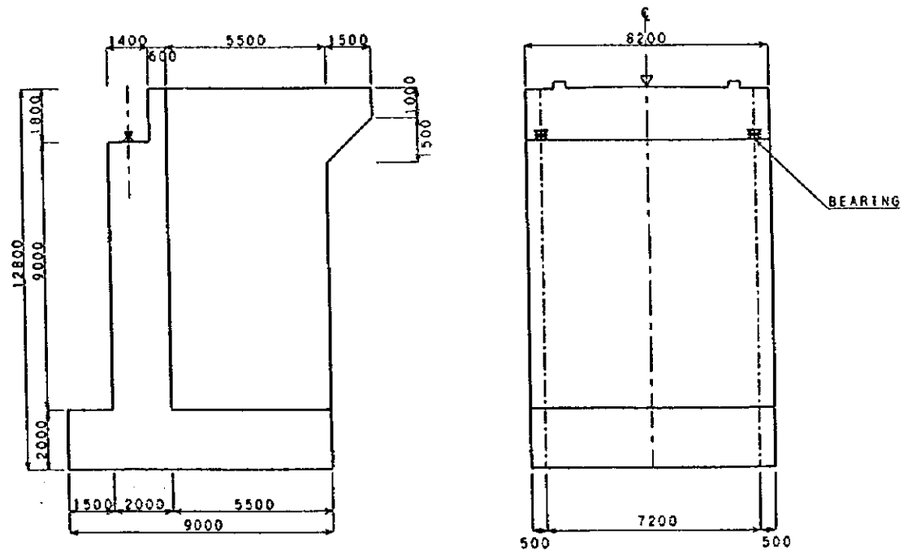
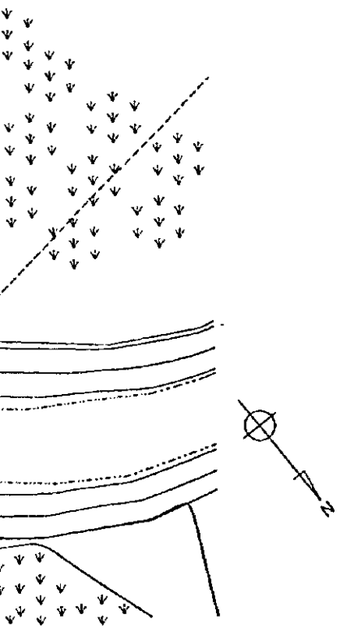
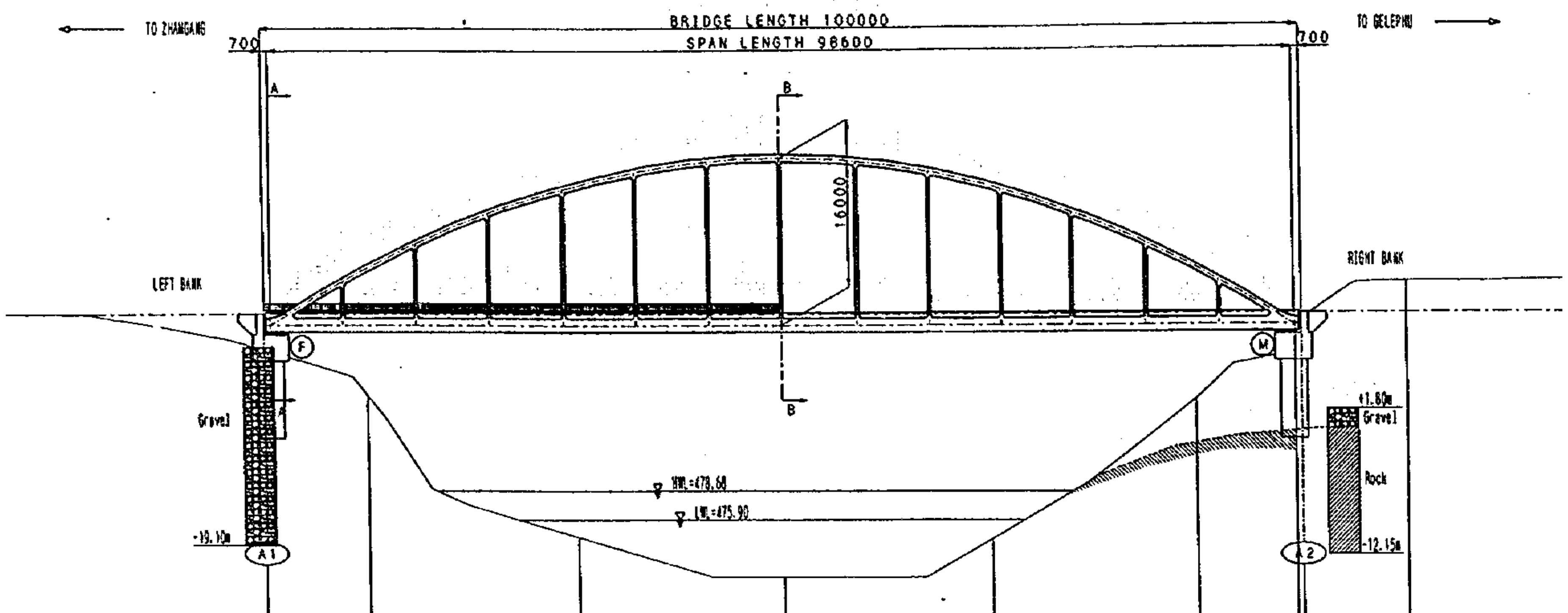




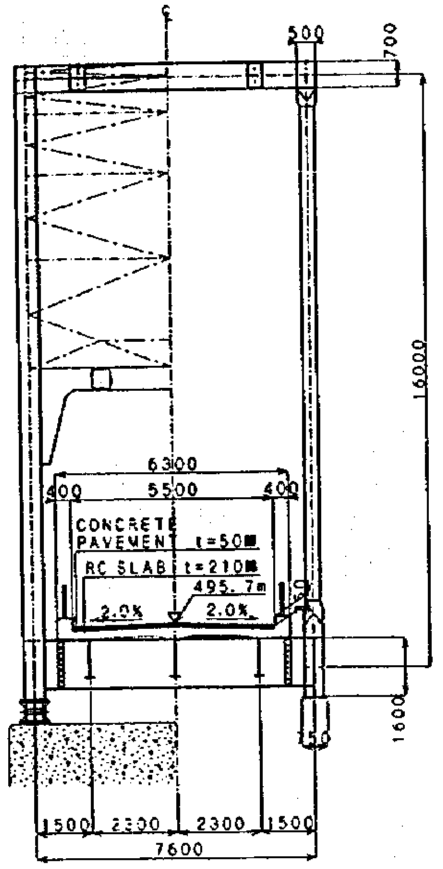
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) THE STUDY ON NATIONAL HIGHWAY BRIDGE CONSTRUCTION IN THE KINGDOM OF BHUTAN		
CONSULTANT: PACIFIC CONSULTANTS INTERNATIONAL / HOKKAIDO ENGINEERING CONSULTANTS Co.,Ltd.		
BRIDGE NO.4 WACH BRIDGE NO.4 BRIDGE GENERAL VIEW & DIMENSIONS	DRAWING NO. 4	

PROFILE S=1:600



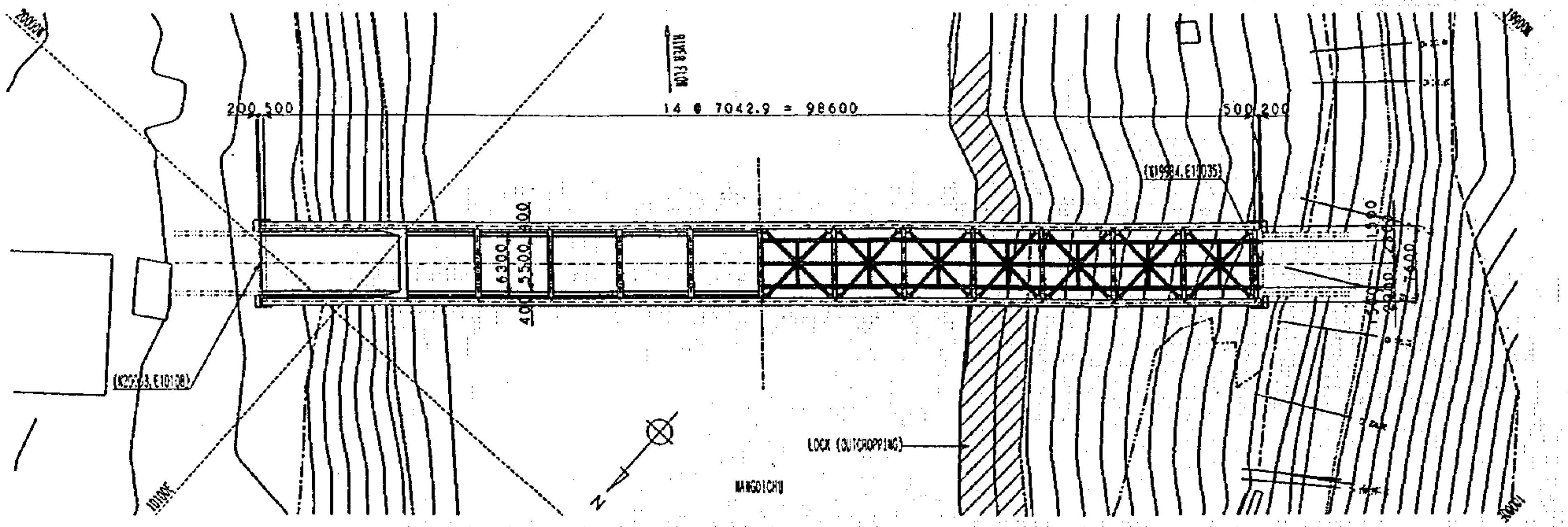
GRADE	0.0%						
PROPOSED HEIGHT	495.70	495.70	495.70	495.70	495.70	495.70	495.70
GROUND HEIGHT	487.88	474.26	470.40	474.09	487.53	494.80	498.72
CHAINAGE	120.00	140.00	160.00	180.00	200.00	209.45	220.00

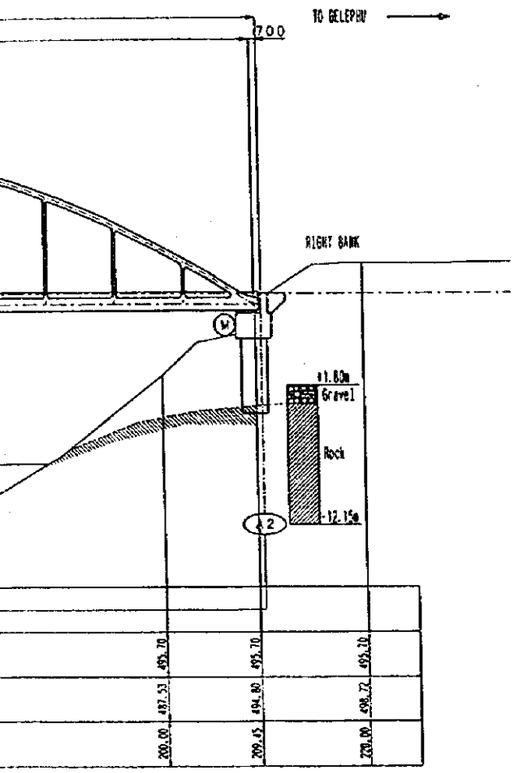
CROSS SECTION S=1:200



A – A　　B – B

PLAN S=1:600





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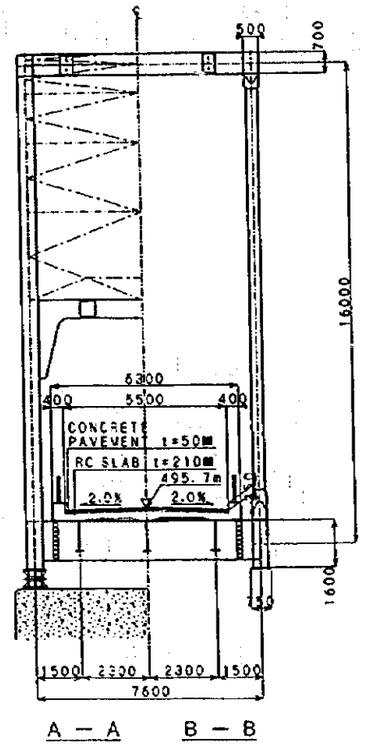
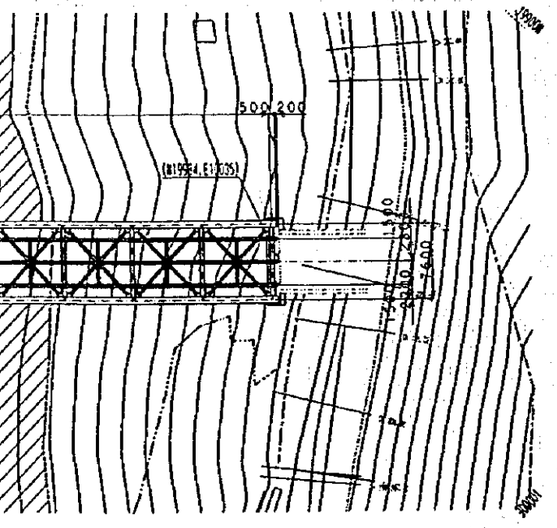
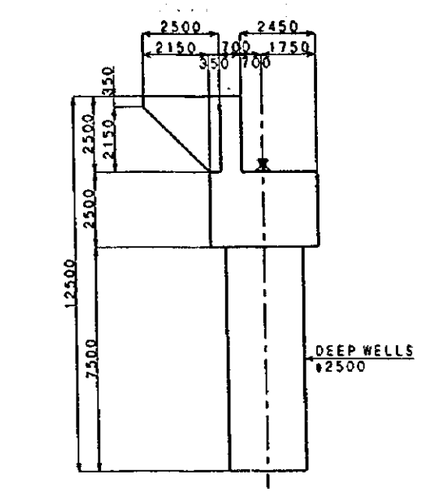
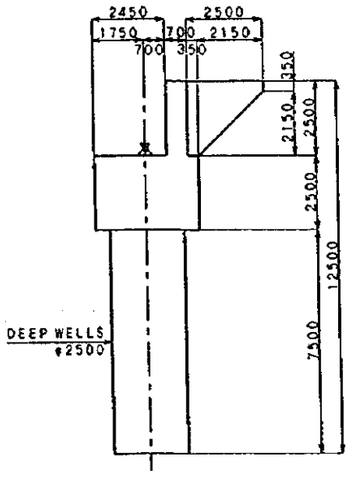


A — A B — B

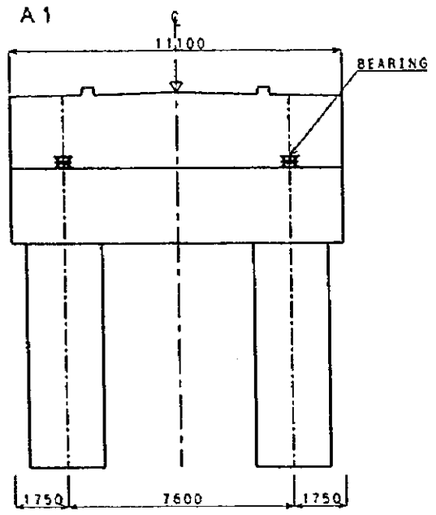


ABUTMENT S=1:200





A1



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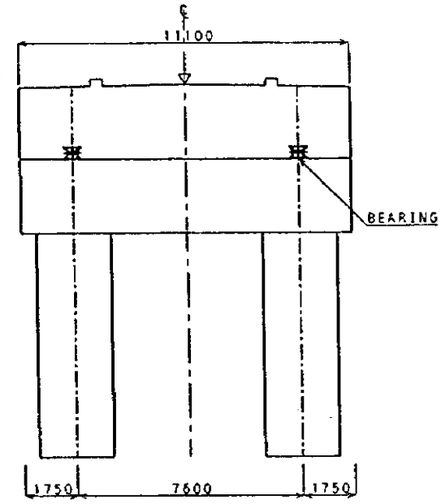
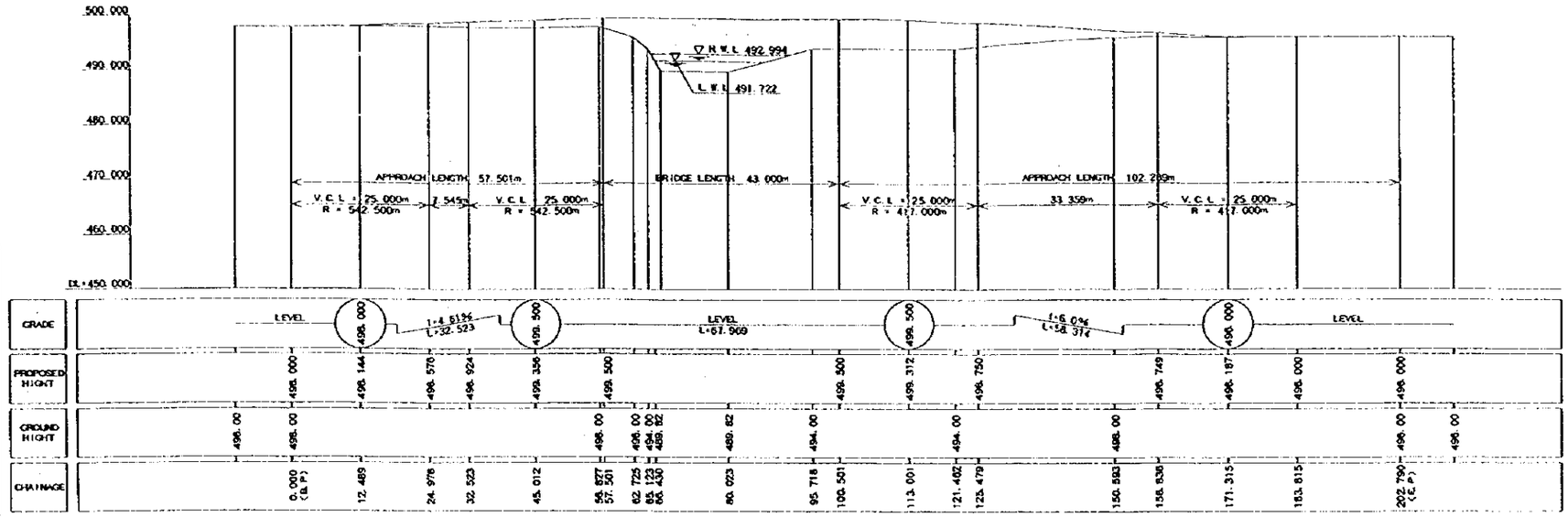


JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) THE STUDY ON NATIONAL HIGHWAY BRIDGE CONSTRUCTION IN THE KINGDOM OF BHUTAN		
CONSULTANT: PACIFIC CONSULTANTS INTERNATIONAL / HOKKAIDO ENGINEERING CONSULTANTS Co.,Ltd.		
BRIDGE NO.5 MANGDICHU BRIDGE GENERAL VIEW & DIMENSIONS	DRAWING NO. 5	

PROPOSED ROAD OF BRIDGE NO. 2 CHAMKAR ZAM BRIDGE

PROFILE

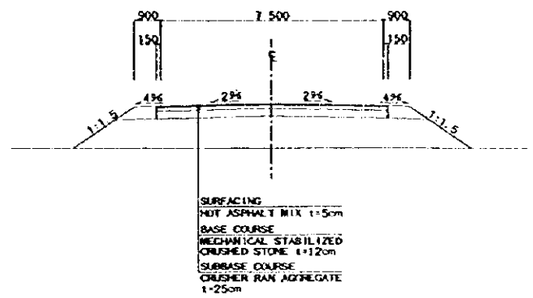
S=1:1000



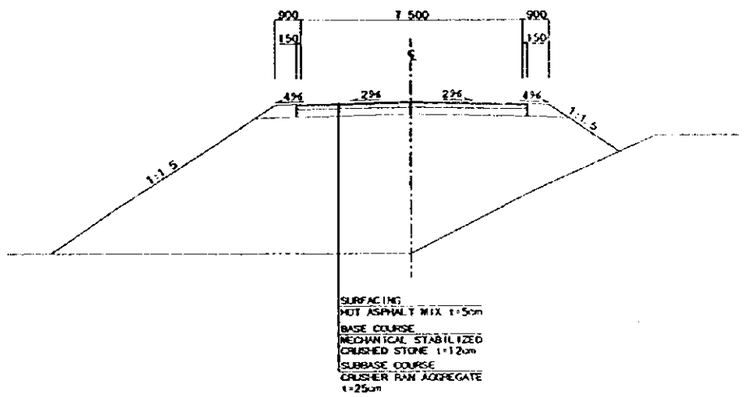
TYPICAL ROAD CROSS SECTION

S=1:200

A - A

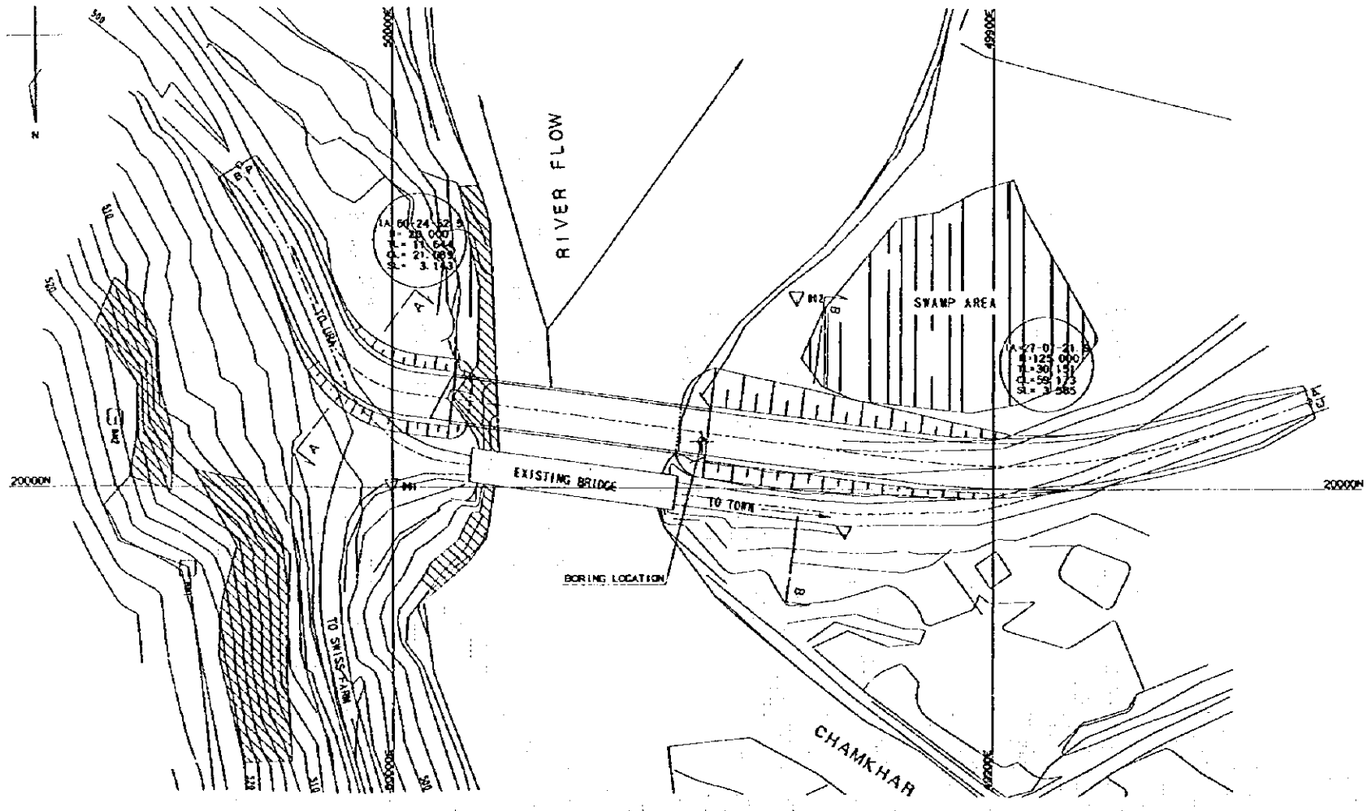


B - B



PLAN

S=1:1000



JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) THE STUDY ON NATIONAL HIGHWAY BRIDGE CONSTRUCTION IN THE KINGDOM OF BHUTAN		
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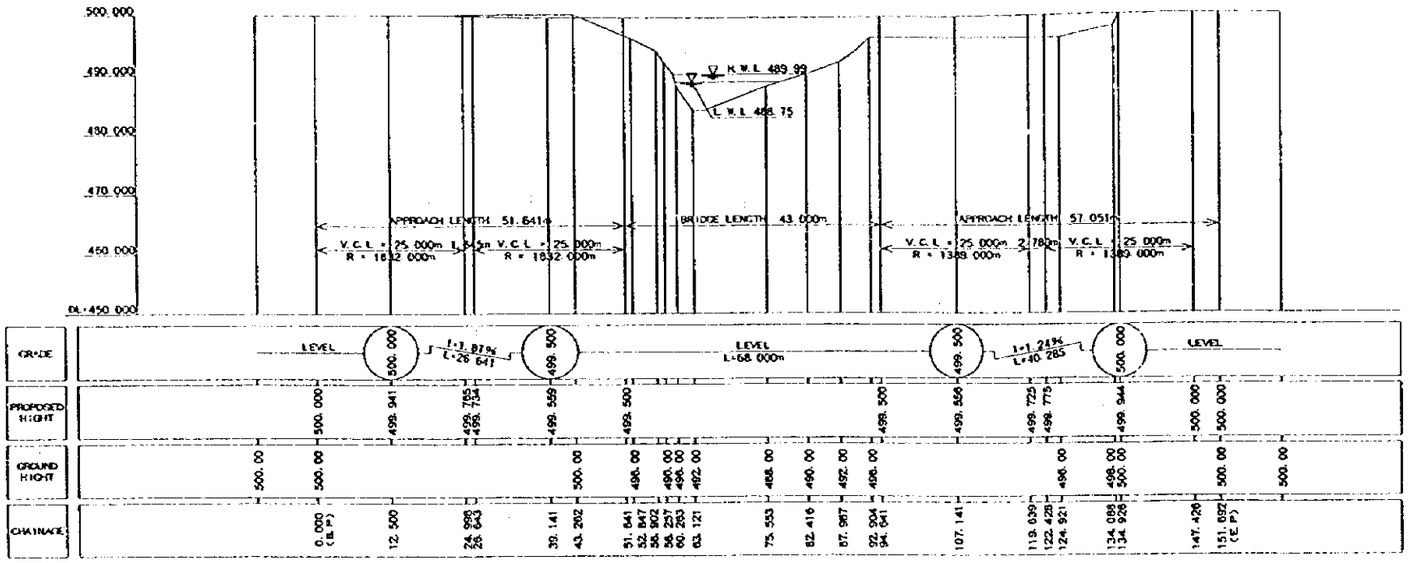
APPROACH ROAD OF BR. NO. 2 CHAMKAR ZAM BRIDGE GENERAL VIEW & DIMENSIONS	DRAWING NO. 6	

PROPOSED ROAD OF BRIDGE NO. 4 WACHY ZAM BRIDGE

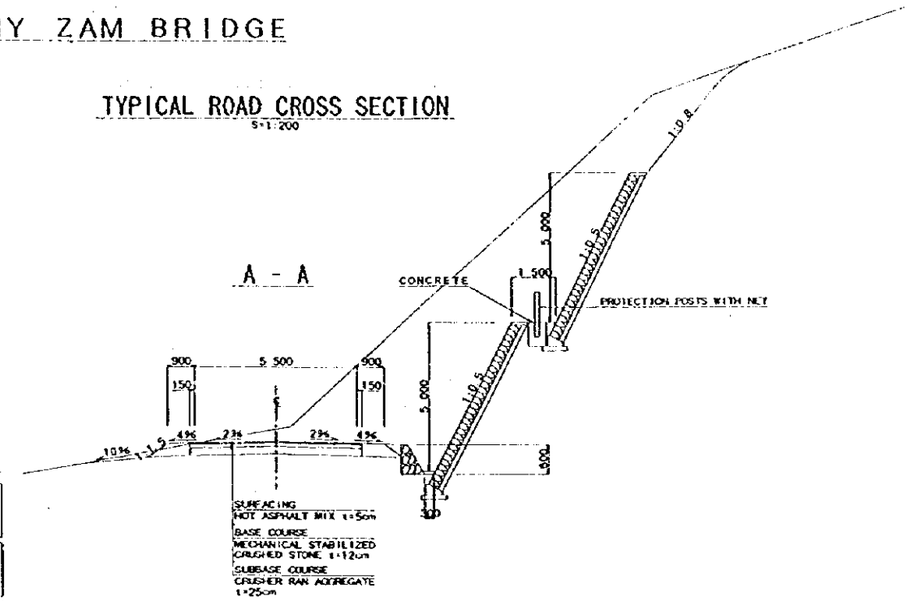
PROFILE

S=1:1000

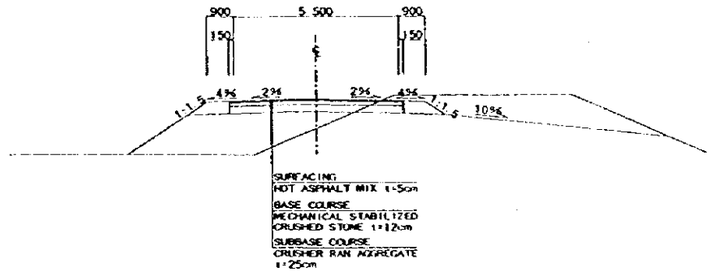


TYPICAL ROAD CROSS SECTION

S=1:200

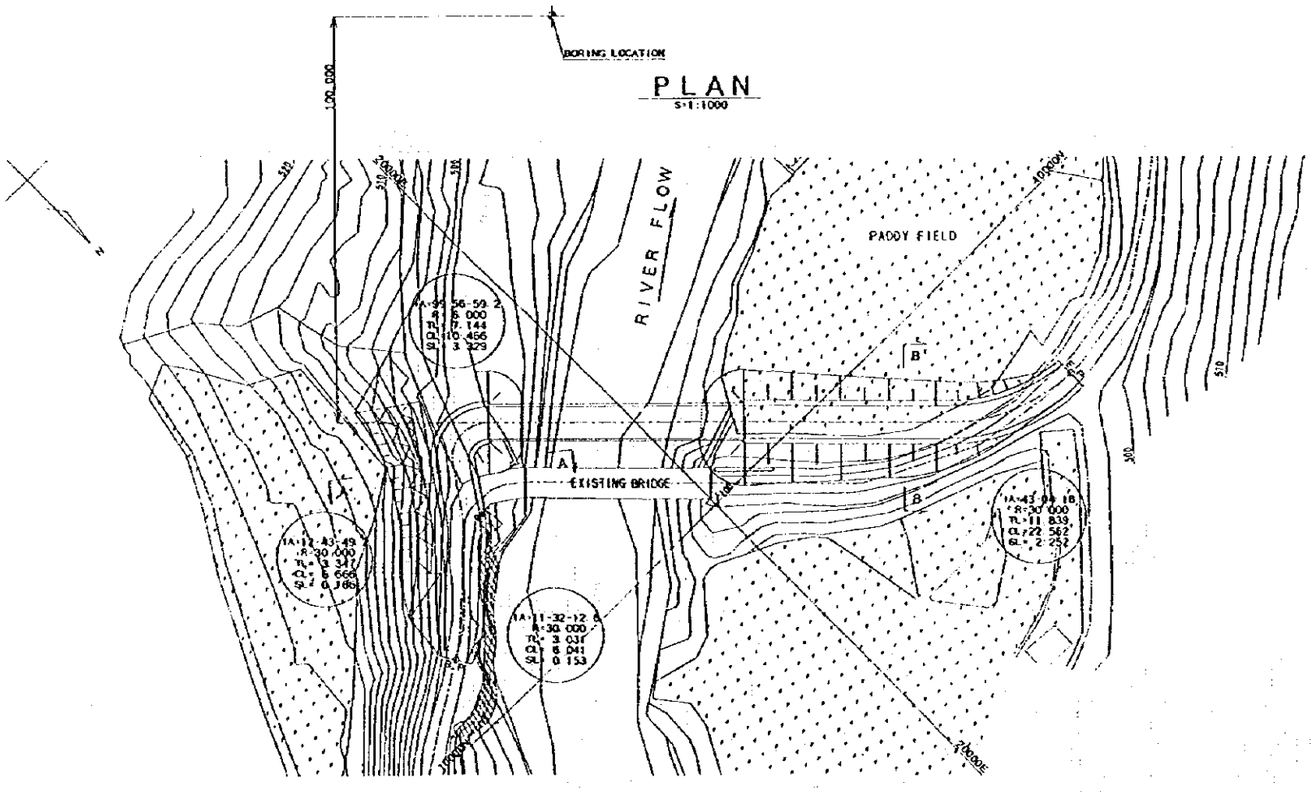


B - B



PLAN

S=1:1000

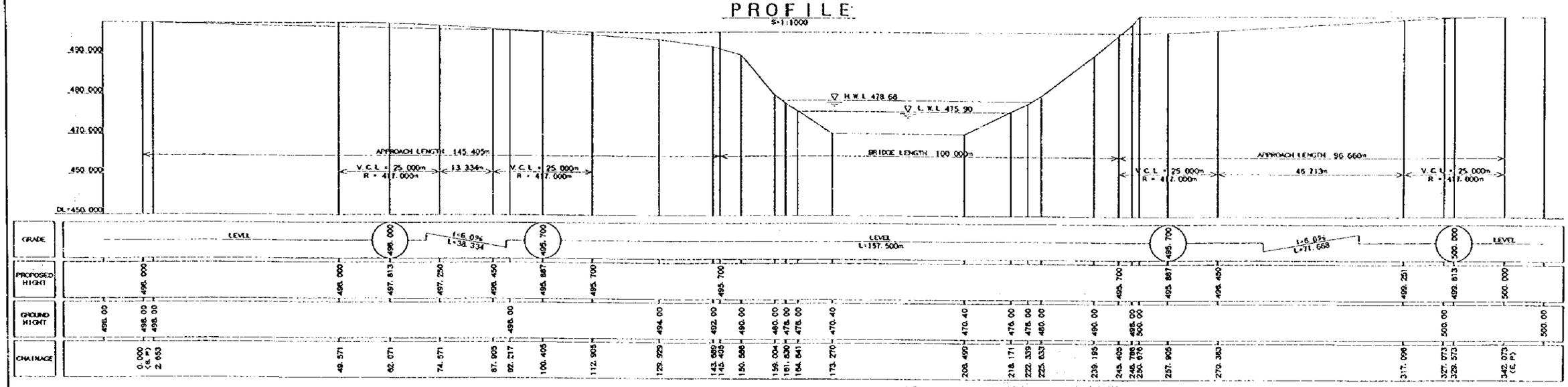


JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) THE STUDY ON NATIONAL HIGHWAY BRIDGE CONSTRUCTION IN THE KINGDOM OF BHUTAN		
CONSULTANT: PACIFIC CONSULTANTS INTERNATIONAL / HOKKAIDO ENGINEERING CONSULTANTS Co.,Ltd.		
APPROACH ROAD OF BR.NO.4 WACHY ZAM BRIDGE GENERAL VIEW & DIMENSIONS	DRAWING NO. 7	

PROPOSED ROAD OF BRIDGE NO. 5 MANGDICHU BRIDGE

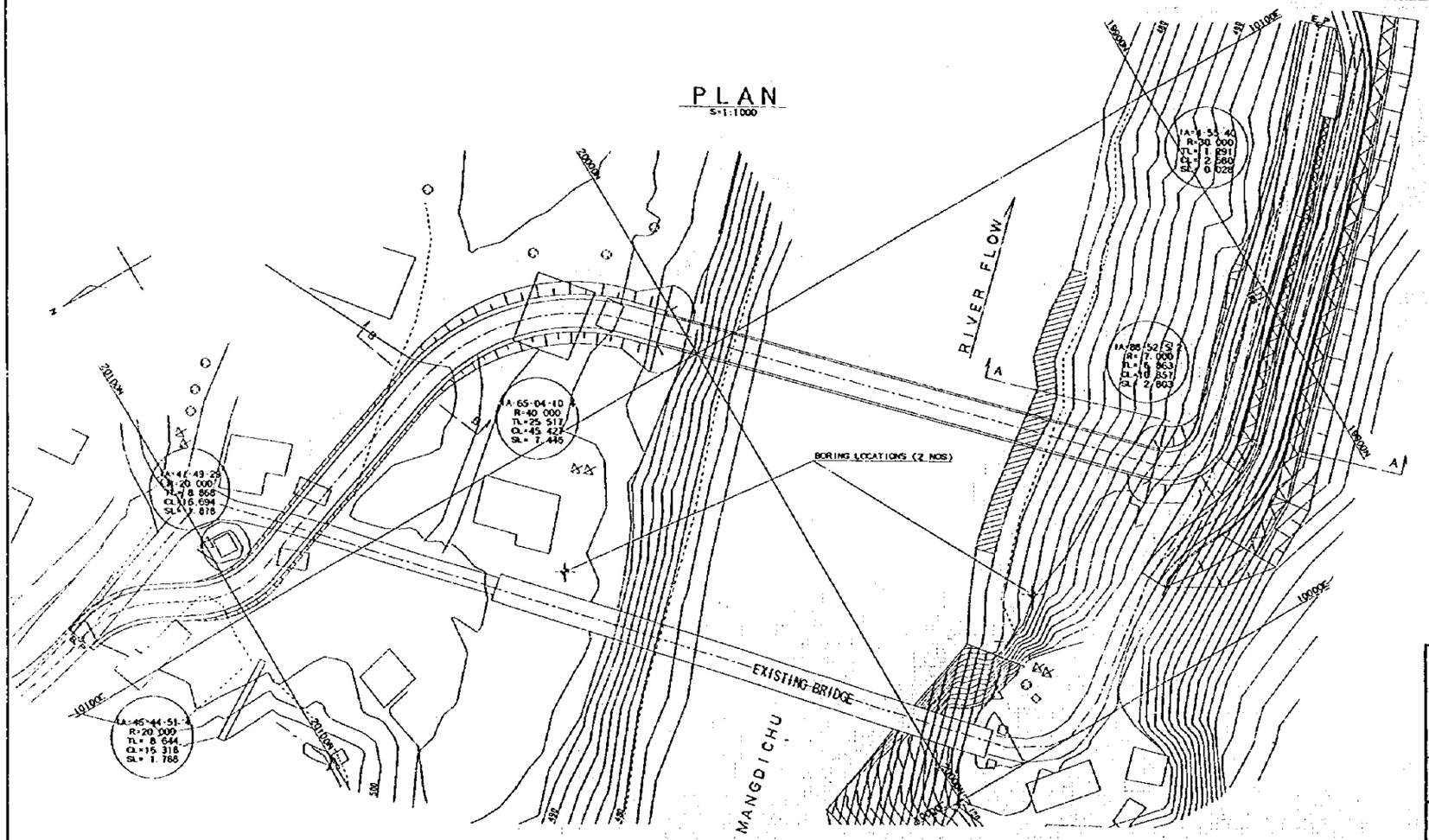
PROFILE

S=1:1000



PLAN

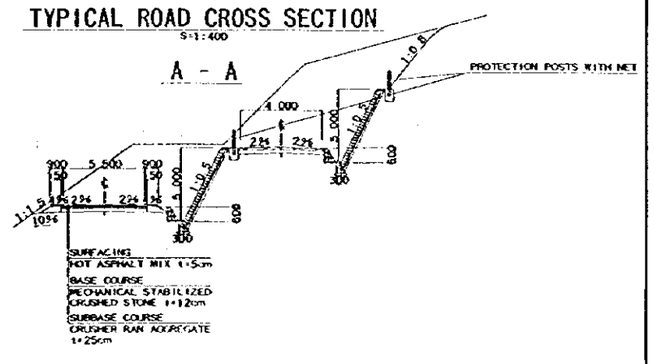
S=1:1000



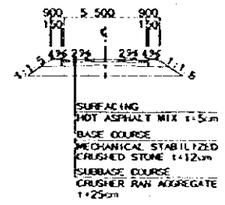
TYPICAL ROAD CROSS SECTION

S=1:400

A - A



B - B

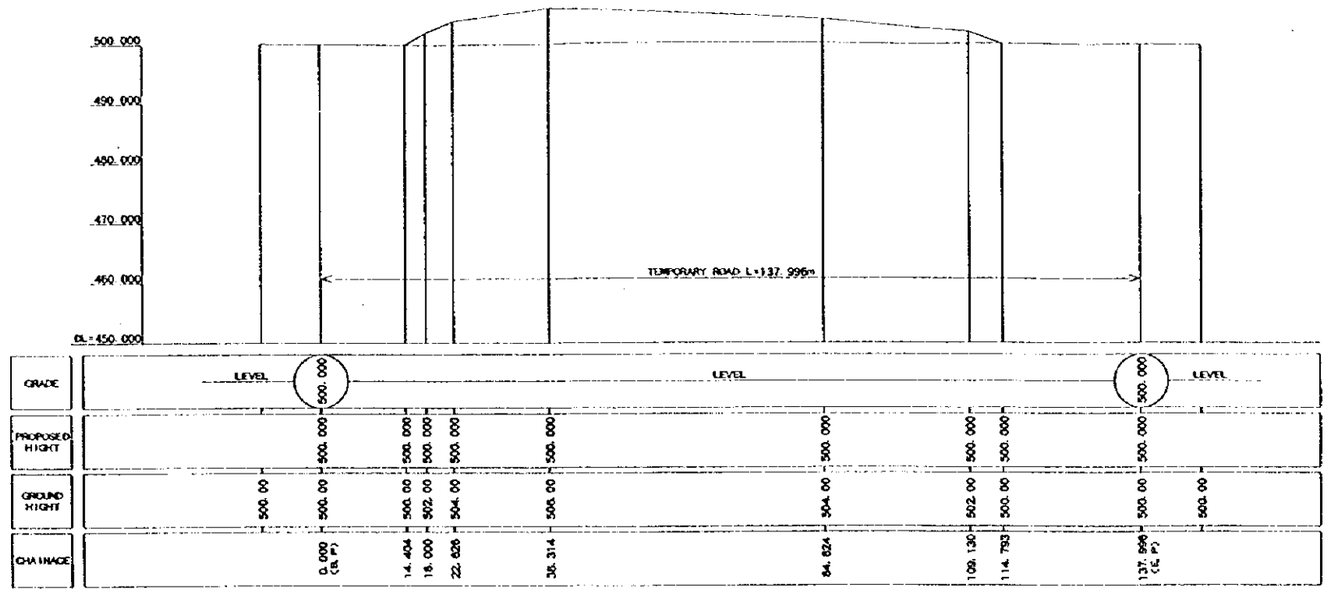


JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) THE STUDY ON NATIONAL HIGHWAY BRIDGE CONSTRUCTION IN THE KINGDOM OF BHUTAN		
CONSULTANT: PACIFIC CONSULTANTS INTERNATIONAL / HOKKAIDO ENGINEERING CONSULTANTS Co.,Ltd.		
APPROACH ROAD OF BR.NO.5 WACMANGDICHU BRIDGE GENERAL VIEW & DIMENSIONS	DRAWING NO. 8	

TEMPORARY ROAD OF BRIDGE NO. 5 MANGDICHU BRIDGE (1/2)

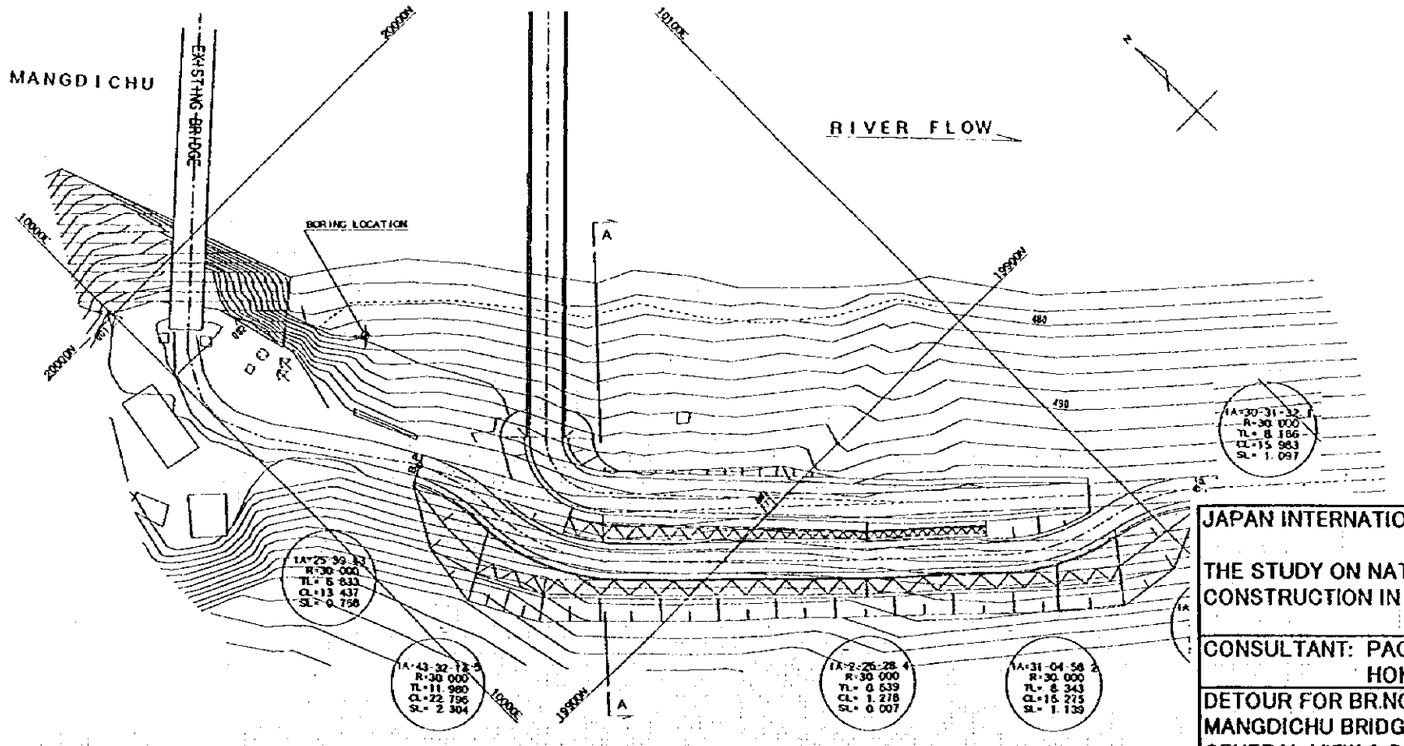
PROFILE

S=1:1000



PLAN

S=1:1000

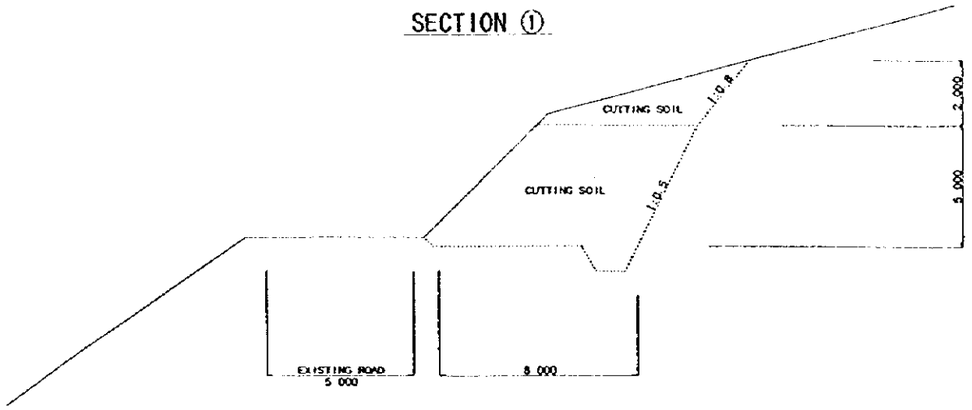


JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) THE STUDY ON NATIONAL HIGHWAY BRIDGE CONSTRUCTION IN THE KINGDOM OF BHUTAN		
CONSULTANT: PACIFIC CONSULTANTS INTERNATIONAL / HOKKAIDO ENGINEERING CONSULTANTS Co.,Ltd.		
DETOUR FOR BR.NO.5 MANGDICHU BRIDGE GENERAL VIEW & DIMENSIONS	DRAWING NO. 9	

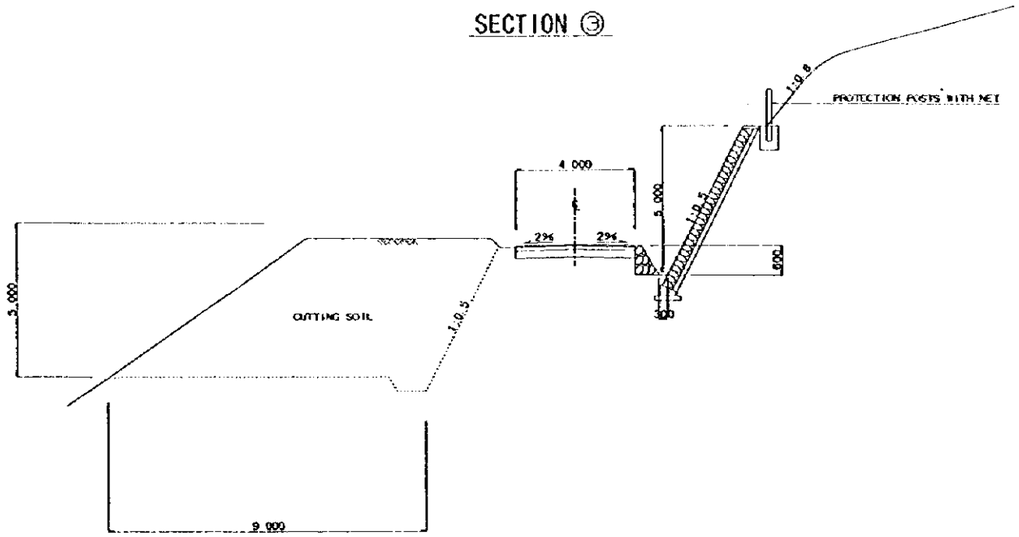
TEMPORARY ROAD OF BRIDGE NO. 5 MANGDICHU BRIDGE (2/2)

WORKING DIAGRAM S=1:200
(TYPICAL ROAD CROSS SECTION A-A)

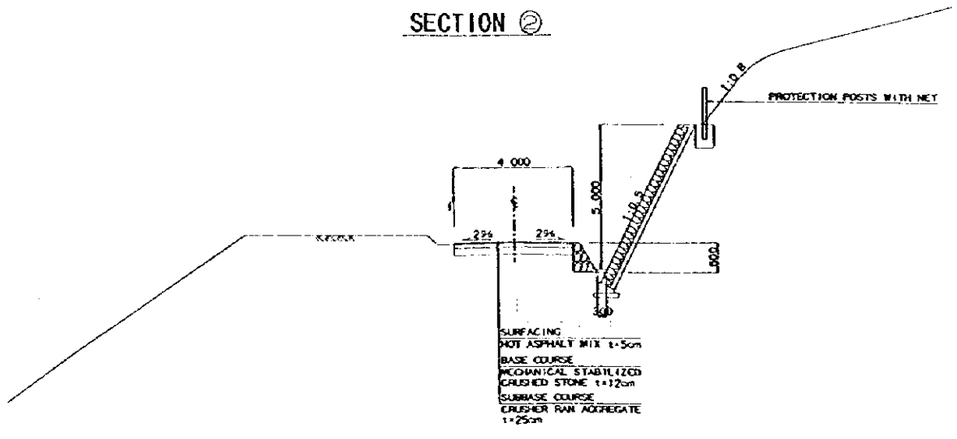
SECTION ①



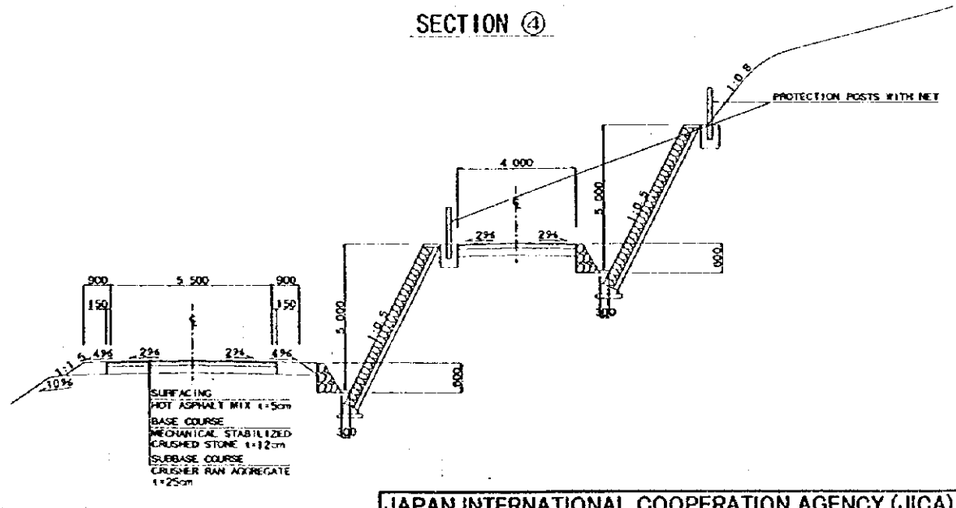
SECTION ③



SECTION ②



SECTION ④



※ EXECUTION OF WORK ORDER SECTION ①→②→③→④

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) THE STUDY ON NATIONAL HIGHWAY BRIDGE CONSTRUCTION IN THE KINGDOM OF BHUTAN		
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DETOUR FOR BR.NO.5 MANGDICHU BRIDGE GENERAL VIEW & DIMENSIONS	DRAWING NO. 10	

CHAPTER 8
CONSTRUCTION PLANS AND COST

CHAPTER 8 CONSTRUCTION PLANS AND COST

8.1 Construction Plans

8.1.1 Construction Methods

The bridge construction ,in the order of implementation, is classified into the following works;

- Mobilization
- Detour Works (Detour Bridge / Road)
- Substructure Works
- Superstructure Works
- Approach road Works
- Revetment Works
- Demobilization

(1) Mobilization

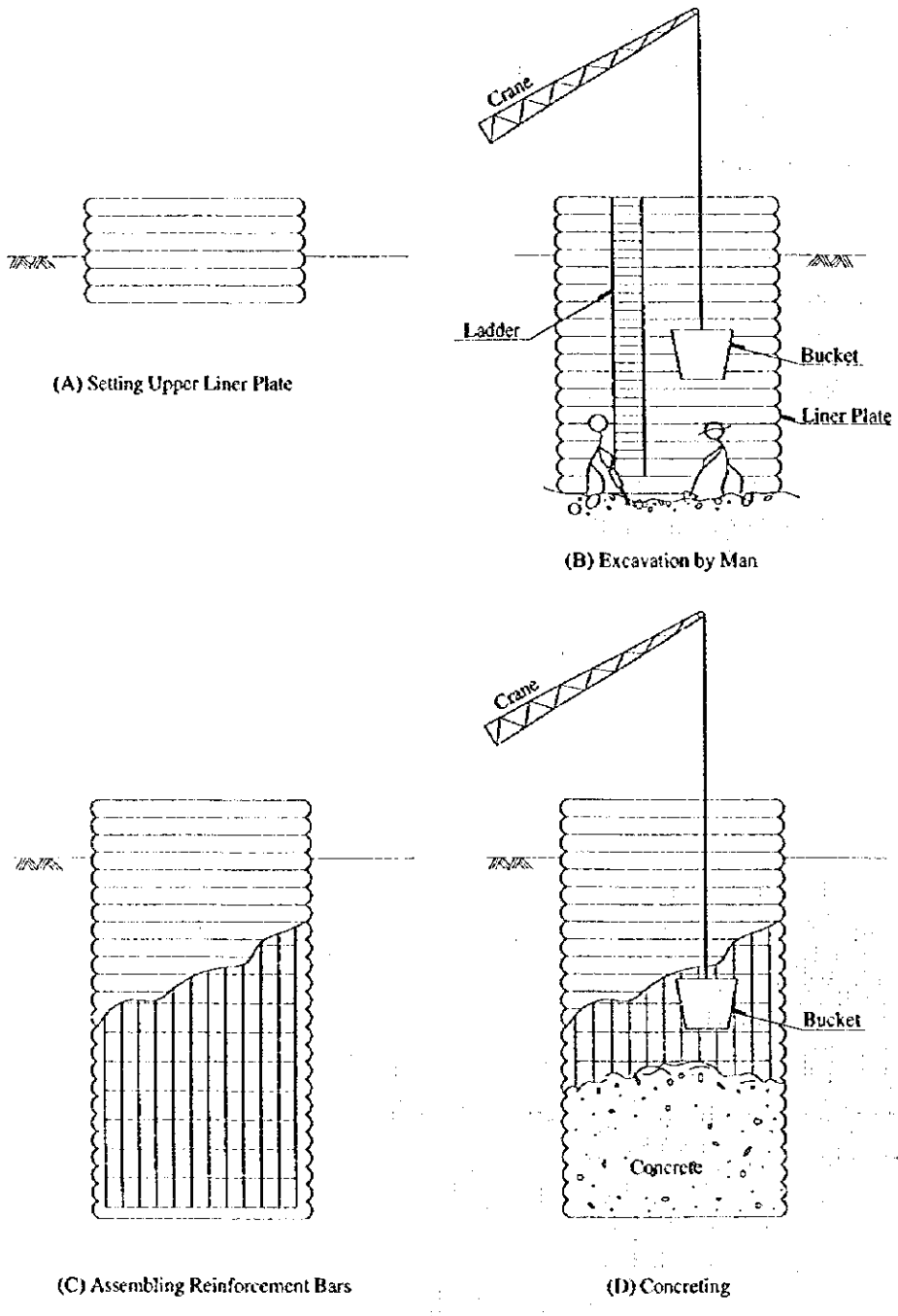
The mobilization work consists of two divisions. One is for the project as a whole, and the another for every individual bridge. The major part is composed of a Thimphu-set-up head-quarter office, execution of related procedures, procurement of construction materials / equipment and the employment of local staff.
Where as, for the minor mobilization, a construction yard is set-up, after the execution of land acquisition and compensation caused due to realignment.

(2) Detour Works

The existing bridges except Bridge No.1 would continue to be in use for the present traffic and the new bridge construction. As the new bridge is planned to be erected at the original location of the existing one, the superstructure of the existing bridge will be shifted down stream above temporary abutments.
As the new approach road on the right bank of Bridge No.5 is planned at the same location as the existing one, the detour road to the existing bridge will be constructed at the mountain side.

(3) Substructure Works

The reversed T abutment with spread foundation or deep well has been selected during the preliminary design. Deep well method is constructed by using the imported liner plates. (Refer to Fig. 8.1)



(A) Setting Upper Liner Plate

(B) Excavation by Man

(C) Assembling Reinforcement Bars

(D) Concreting

Fig 8.1 Deep Well Method

(4) Superstructure Works

The types selected for superstructures are truss and Lohse bridge. For the truss and Lohse bridge, cable erection method is recommended. (Refer to Fig. 8.1)

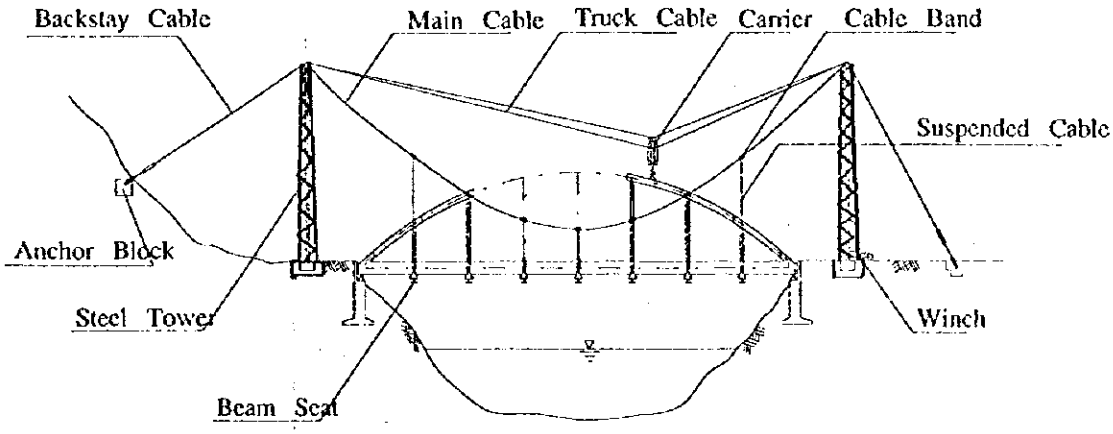


Fig.8.2 Cable Erection Method

(5) Approach Road Works

The approach road works, in according to implementation order, consist of clearing and grubbing, cutting (rock), filling / subgrade, pavement (subbase course, base course, asphalt mixed-in-place wearing course), and lawn / stone masonry slope protection. Further, drainage facilities including cross pipes are necessary at certain sites.
The borrowpit for filling and disposal area are located within five kilometers of the bridge site.

(6) Revetment Works

To protect abutments from the scour of river bed or river bank , wire mats are placed in the front of these structures.

(7) Demobilization

After the completion of all bridges, site clearance is performed. This includes disposing of site facilities, used construction equipment and the materials.

8.1.2 Procurement Plan

(1) Materials

The procurement methods of major construction materials are shown in Table 8.1 in accordance with the result of field survey.

Table 8.1 Procurement of Materials

Item		Procurement			Remarks
	Standard	Bhutan	India	Others	
Cement	Portland	○			
Stone	Boulder	○			
River Gravel	20mm to 10mm	○			
Sand		○			Production by stone crusher at each site
Crushed Rock	20mm/40mm	○			
Deformed Bar	415Mpa		○		
Structural Steel	Truss member			○	For bridge works
Structural Steel	Angle,Channel etc.		○		For temporary works
Bridge Bearing				○	
Liner Plate	D2.5m, t=3.2mm			○	
Gabion Net	100*100*8-Gauge		○		
Timber		○			
Plywood	T=12mm		○		
Asphalt Cement	60/70		○		
Petrol/Diesel			○		

(2) Construction Equipment

The procurement methods of major construction materials are shown in Table 8.2 in accordance with the result of field survey.

Table 8.2 Procurement of Construction Equipment

Item		Procurement			Remarks
	Specification	Bhutan	India	Others	
Bulldozer	15ton/Cat D6D	○	○		If insufficient in Bhutan
Excavator	0.6m3			○	
Wheel Loader	1.4m3			○	
Road Roller	10-20ton	○			
Dump Truck	8ton	○	○		If insufficient in Bhutan
Wheel Crane	Hoist 16ton			○	
Stone Crusher	10ton/hr		○	○	If insufficient in India
Concrete Mixer	0.5m3		○	○	-do-
Erection Apparatus				○	For Bridge Works

8.2 Construction Schedule

8.2.1 Basic Conditions

This project consists of the construction of five medium-to-long sized bridges located in the mountain area. In the case that this project be carried out under the international tender, the implementation concept can be summarized as follows.

- The project will be carried out under the direct supervision of a foreign contractors.
- The local A class contractor with is expected to be employed as sub-contractor.
- Considering the lack of civil engineers, foramens and skilled labours with sufficient experience in bridge construction, these individuals will be procured from a third country.
- The training supervisors for the structural steel works and foundation works (Deep well method) which require a high degree of accuracy will be procured from the overseas.
- In order to complete the project within the limited period, these bridges are divided into several groups, and are to be constructed simultaneously.
- In order to decrease construction costs, construction equipment will be shifted from site to site.

The following restrictions for the construction schedule are derived from the site investigation.

- During rainy seasons, mainly superstructure works would be implemented.
- Considering the transportation conditions, especially the load capacity of existing bridges, light construction equipment and smaller transportation vehicles are adopted. For example, Crane : Suspension capacity 16 tons, Transportation vehicle : ten-wheelers, Adequate length of structural steel : 6m.

8.2.2 Construction Schedule

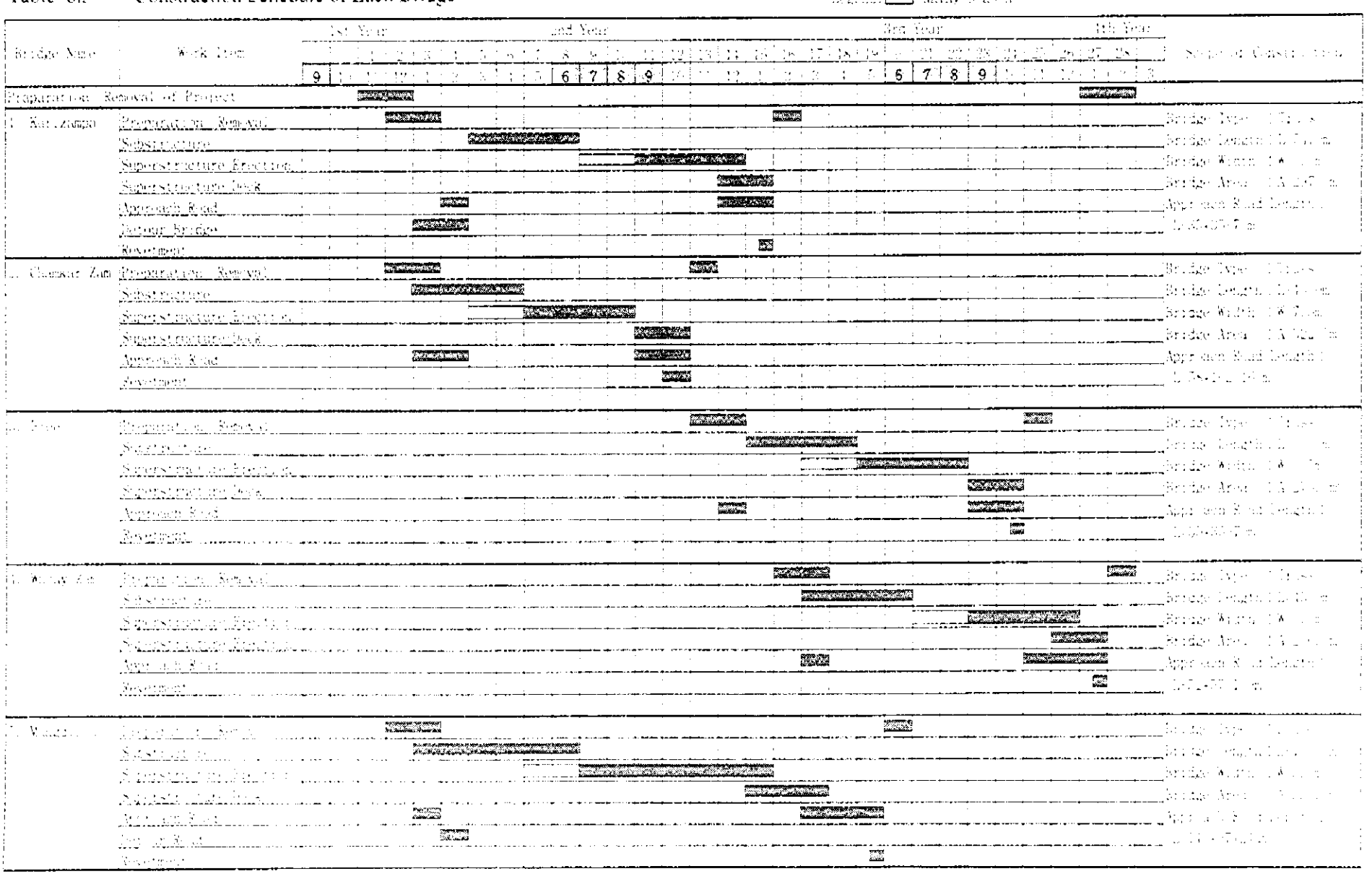
The construction schedule for the project is shown in Table 8.3. The effective period for the entire construction work including preparation / removal works is estimated 28 months.

Table 8.3 Construction Schedule of Each Bridge

Legend: Rainy season

Bridge Name	Work Item	1st Year				2nd Year												3rd Year												4th Year			Scope of Construction
		9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
Praparation/Removal of Project																																	
1. Kurizampa	Preparation/Removal																																Bridge Type : Truss Bridge Length : L=54.0m Bridge Width : W=5.5m Bridge Area : A=297.0m² Approach Road Length : L=35+35=70m
	Substructure																																
	Superstructure(Erection)																																
	Superstructure(Deck)																																
	Approach Road																																
	Detour Bridge																																
	Revetment																																
2. Chamkar Zam	Preparation/Removal																																Bridge Type : Truss Bridge Length : L=43.0m Bridge Width : W=7.5m Bridge Area : A=322.5m² Approach Road Length : L=58+102=160m
	Substructure																																
	Superstructure(Erection)																																
	Superstructure(Deck)																																
	Approach Road																																
	Revetment																																
3. Bjee	Preparation/Removal																																Bridge Type : Truss Bridge Length : L=50.0m Bridge Width : W=5.5m Bridge Area : A=275.0m² Approach Road Length : L=35+35=70m
	Substructure																																
	Superstructure(Erection)																																
	Superstructure(Deck)																																
	Approach Road																																
	Revetment																																
4. Wachy Zam	Preparation/Removal																																Bridge Type : Truss Bridge Length : L=43.0m Bridge Width : W=5.5m Bridge Area : A=236.5m² Approach Road Length : L=52+57=109m
	Substructure																																
	Superstructure(Erection)																																
	Superstructure(Erection)																																
	Approach Road																																
	Revetment																																
5. Mangdichu	Preparation/Removal																																Bridge Type : Lohse Bridge Length : L=100.0m Bridge Width : W=5.5m Bridge Area : A=550.0m² Approach Road Length : L=145+97=242m
	Substructure																																
	Superstructure(Erection)																																
	Superstructure(Deck)																																
	Approach Road																																
	Detour Road																																
	Revetment																																

Table 8.3 Construction Schedule of Each Bridge



8.3 Preliminary Cost Estimate

8.3.1 Basic Conditions

The Project costs consist of construction costs, physical contingency costs, engineering costs, land acquisition and compensation costs for house relocation. The basic conditions for the calculation of these costs are as follows:

1) All construction works and engineering services will be performed by foreign contractors and consultants respectively.
2) The project costs are estimated according to the financial values of 1998.
3) The main unit costs such as Labour costs, major material costs, and depreciation for equipment have bean used the results of the cost surveys described in Appendix J.
4) The Bhutan sales taxes and business income taxes are levied on the project.
5) The engineering costs consist of consultant cost for preparation of the detailed design and construction supervision costs.
6) The physical contingency cost for the construction and engineering is assumed to be about 10 % of the construction amount and 5% of the engineering amount respectively.
7) Land acquisition including the house compensation cost is calculated from the road area / house numbers. The land acquisition cost is excluded of all taxes.

8.3.2 Project Cost Estimation

The project cost of each bridge is given in Table 8.4.

Table 8.4 Preliminary Estimation of Project Cost (Financial Cost Unit : Million Nu.)

Bridge No.	1	2	3	4	5	Total
Bridge Name	Kurizampa	Chamkar Zam	Bjee	Wachy Zam	Mangdichu	---
Bridge Length (m)	54	43	50	43	100	290
Bridge Width (m)	5.5	7.5	5.5	5.5	5.5	---
Bridge Type	Truss	Truss	Truss	Truss	Lohse	---
Detour Works	15.3	1.2	0.6	0.4	5.8	23.3
Substructure Works	9.7	11.5	12.1	14.0	14.8	62.1
Superstructure Works	65.4	57.4	60.5	53.6	153.7	390.6
Approach Road Works	2.6	8.5	3.9	8.1	18.6	41.7
Revetment Works	0.4	0.5	0.4	0.4	0.4	2.1
Construction Amount (A)	93.4	79.1	77.5	76.5	193.3	519.8
Contractors Taxes (B) [(A)*3%]	2.8	2.4	2.3	2.3	5.8	15.6
Physical Contingencies (C) [(A)*10%]	9.3	7.9	7.8	7.7	19.3	52.0
Detailed Design and Construction Supervision (D)	12.7	12.7	12.7	12.7	17.9	68.7
Consultants Taxes (E) [(F)*3%]	0.4	0.4	0.4	0.4	0.5	2.1
Physical Contingencies (F) [(C)*5%]	0.6	0.6	0.6	0.6	0.9	3.3
Land Acquisition (G)	0.1	0.1	0.1	0.1	0.8	1.2
Project Cost ; Total (H) (A)+(B)+(C)+(D)+(E)+(F)+(G)	119.3	103.2	101.4	100.3	238.5	662.7
Project Cost ; Foreign Cost	96.5	78.8	84.2	76.5	198.0	534.0
Project Cost ; Local Cost	22.8	24.4	17.2	23.8	40.5	128.7

Notes:
1. Exchange Rate : 1 US$ = 38.6 Nu
2.Land acquisition for construction yard at Bridge No.2 is includes the rental charge of paddy field (18,000Nu).

CHAPTER 9
ENVIRONMENTAL IMPACT STUDY

CHAPTER 9 ENVIRONMENTAL IMPACT STUDY

9.1 Existing Environmental Conditions

9.1.1 General

(1) Bhutan's National Heritage

Located in the Eastern Himalayas, Bhutan is one of the ecological wonders of the world. The country straddles two bio-geographical reams: the Palearctic ream of the temperate Euro-Asia and the Indo-Malayan ream of the Indian subcontinent. The result is a country rich in biodiversity, with its natural forest cover largely intact. The biomes in Bhutan stretch from sub-tropical in the south (100m ASL) through temperate in the central interior, to an Alpine zone in the north (7550m ASL). Wild animals such as the tiger, elephant, one-horned rhinoceros, asiatic water buffalo, pygmy hog and the rare golden langur exist in the lush tropical forest of the south. The snow leopard, blue sheep and takin are found in the cool forests and alpine meadows of the North. Over 165 species of animals (mammals), and more than 770 species of birds have been identified.

Bhutan's known biodiversity includes more than 7,000 vascular plants. The status of many of these species is unknown as there have been few quantitative studies of Bhutan's flora and fauna.

Considering the above, the Royal Government of Bhutan (RGOB) has decided that conservation of the biodiversity of Bhutan is of national importance.

(2) Conservation Ethic

Conservation is a central tenet of Buddhism. Buddhism believes in preserving nature and giving back to the earth what one has taken, and also in the sanctity of life. The importance of protecting nature in all its manifestations has permeated Bhutanese consciousness and has become integral to the Bhutanese way of life. Therefore, preservation of the environment, as well as of sacred and cultural heritage sites are an important and integral part of the Bhutanese value system.

(3) Fauna

A number of rare animals can still be found since Bhutan's flora have remained undisturbed. The exact number of species is unknown, but over 165 have been reported. Rare animals including the golden langur, takin and blue sheep are found

distributed quite widely. Tigers, leopards, snow leopards, red panda, gaur, serow, Himalayan black bears, brown bears, wild pigs, musk deer and other types of deer are commonly found in many parts of Bhutan. The Phobjikha valley in Wangdue Dzongkhag and Bomdiling in Yangtse are two of the three wintering grounds for the rare Black-necked cranes. About 26% of the country has been declared as nature parks and reserves, which form havens for a number of world's rare and endangered species.

According to the "Forest and Nature Conservation Act of Bhutan, 1995", the List of Totally Protected Wild Life have been formulated as follows:

No	Common Name	Scientific Name
1	Asian Elephant	*Elephas maximus*
2	Clouded Leopard	*Neofelis nebulosa*
3	Golden Langur	*Presbytis geei*
4	Musk Deer	*Moschus chrysogaster*
5	Pangolin	*Manis*
6	Pigmy Hog	*Sus sylvanicus*
7	Snow leopard	*Panthera uncia*
8	Takin	*Budorcas taxicolor*
9	Tiger	*Panthera tigris*
10	Wild Buffalo	*Bubalus bubalis*
11	Black-Necked Crane	*Grus nigricollis*
12	Monal Pheasant	*Lophophorus impejenus*
13	Peacock Pheasant	*Polyplectron bicalcaratum*
14	Raven	*Corvus corax*
15	Rufous-Necked Hornbill	*Aceros nepalensis*
16	Golden Mahseer	*Tor tor*
17	Spotted Deer	*Axis axis*
18	Gaur	*Bos gaurus*
19	Leopard	*Panthera pardus*
20	Leopard Cat	*Felis bengalensis*
21	Himalayan Black Bear	*Selenarctos thibetanus*
22	Red Panda	*Ailurus fulgens*
23	Serow	*Capricornis sumatraensis*

The detail of above species is attached in Appendix-G.

(4) Flora

The flora of Bhutan is exceptionally diverse as a result of a great range of altitudinal zones and varied climatic conditions, and 72% of the country is covered by forests of fir, mixed coniferous, temperate and broadleaf species. In addition, there are many species which are unique to Bhutan. Moreover, much of Bhutan's flora has remained undisturbed thus Bhutan probably has the richest flora in the Himalayan region. Within

Bhutan's borders, one can find over 50 species of rhododendron, and over 300 species of medicinal plants, mostly alpine, used in traditional herbal medicine. The floral wealth of Bhutan is highly appreciated by both Bhutanese and the outside world. The government is determined to conserve this wealth and has a national policy to maintain at least 60% of land under forest cover for all times to come.

According to the "Forest and Nature Conservation Act of Bhutan, 1995", the List of Totally Protected Plants have been formulated as follows:

No	Local Name	Common Name	Botanical Name
1	Agar/agaru	Eaglewood/ Indian aloewood	*Aquilaria malaccensis*
2	Yartsa-guenboop	Chinese caterpillar	*Cordyceps sinensis*
3	Pang-gen metog		*Gentiana crassuloides*
4		Snowdown lily	*Lloydia yunnanensis*
5	Tsher-ngeon	Blue poppy	*Meconopsis grandis*
6	Kirang-shing	Yew	*Taxus baccata*
7	Bhreeng-gee ra-dza	Ginseng	*Panax pseudo-ginseng*

The detail of above species is attached in Appendix-G.

(5) Protected Areas

The Nature Conservation Section (NCS) conducts biodiversity surveys in protected areas. To date, surveys have been completed for two national parks, the Royal Manas and the Jigme Dorji National Park, and work has currently started in the third park, the Black Mountain National Park. Critical surveys of the Phibsoo, the Kholong Chu and the Thumshingla National Park have also been initiated. National parks, wildlife sanctuaries and nature reserves are shown in Figure 9.1. The details of the Black Mountain and Manas National Park are given below, as they are near the proposed bridge sites:

1) Black Mountains National Park

The Black Mountains of central Bhutan have a unique landscape covered by sub-tropical, sub-alpine, and alpine forests, as exemplified by broad-leafed forests of oaks, birch, maple in the lowlands and coniferous species such as hemlock, spruce, pine; sub-alpine plants and alpine shrubs.

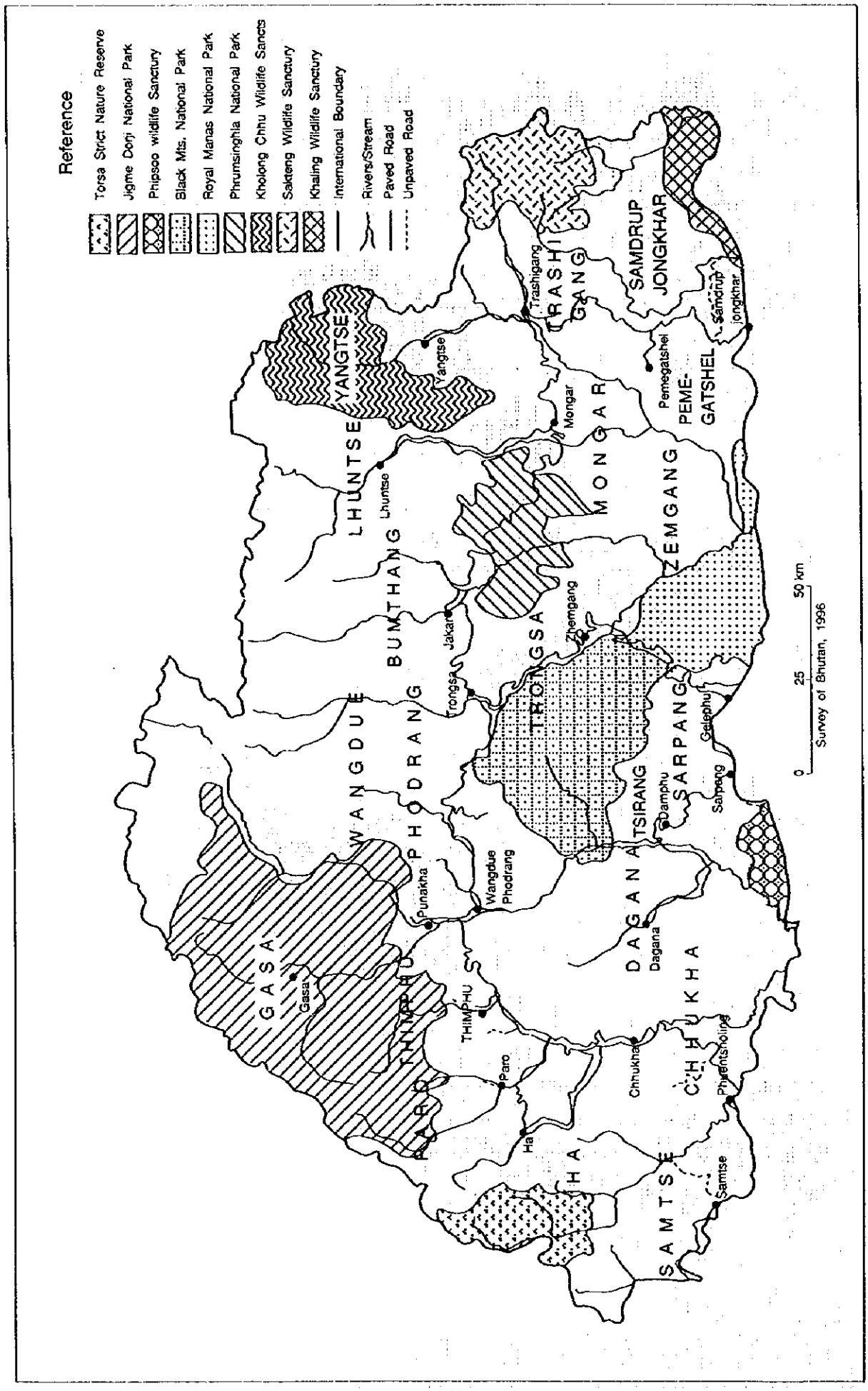


Figure 9.1 Protected Areas

Animals found in the Black Mountains include the Himalayan black bear, the panther, goral, panda, serow, sambar, wild boar, tiger and golden langur. Guar and elephants can be spotted in the southern regions of the Black Mountains. The area is well known for its bird species. Currently no areas in the mountain ecological zones have been set aside as protected areas. Throughout the Himalayas, most of the mid-hill regions have been cleared for agriculture.

The Park will be connected to Royal Manas National Park in the south to facilitate wildlife movement. Socioeconomic assessment of communities living adjacent to the two protected areas were conducted and their participation in reserve management will be encouraged through buffer area management. Biological inventories were conducted in the park area to assess the flora and fauna and habitat conditions of the entire reserve.

2) Royal Manas National Park

The Royal Manas National Park is the oldest established protected area in Bhutan, having been declared a Wildlife Sanctuary in 1966, and upgraded to a national park in 1988. Encompassing an area of 463 km^2, Manas is located at the foothills of the Himalayas in south of Bhutan. It lies on the Indo-Bhutan border and forms a contiguous ecosystem with the Manas Tiger Reserve on the Indian side of the border.

Manas has a variety of habitats, ranging from open savannah woodlands, dry deciduous tropical forest, to moist deciduous tropical forest, and contains more significant species than any other area in the country, including populations of wild buffalo, tigers, leopards, guar, sloth bears, several species of deer, seasonal populations of elephants, and the endemic golden langur. This diversity is well worth preserving for the future, some species being on the brink of extinction (rhino, hispid hare, pygmy hog etc.).

(6) Global Warming

Global climate change due to emissions of greenhouse gases, particularly carbon dioxide from the burning of coal, oil and gas to produce energy and power automobiles, is expected on a scale that will surpass any change experienced in human history. The 1995 report of International Panel on Climate Change (the world's top 2,500 climatologists) suggests the planet will warm by up to 3.5 °C over the coming century. Current global warming has past the tolerance levels of many species and ecosystems, especially in high-altitude areas. Experts predict the surface warming over the southern Asian region will increase by 1 to 2 °C by the year 2030. Precipitation may increase over south Asia by 5-10 percent in summer, and decrease during winter.

In the Himalayas, these changes have been manifested by disastrous glacial lake outbursts. Melting ice has become a worldwide occurrence, not just in the Himalayas. From Bhutan to Switzerland, receding glaciers are bringing in their wake avalanches, soil erosion and dramatic changes in river flow. In Bhutan, glacial melting can result in large floods at a heavy human cost. Already, global warming has been blamed for the 1994 glacial breach of Lugge Tsho in Lunana (about 60 km straight line north of Punakha), which resulted in a flash flood in Punakha.

Specialists are worried about the growth of Rakshathreng Tsho, in Lunana, form a mere pond in the 1950s to a lake 2 km long and 1 km wide, far bigger than Lugge Tsho. Glaciers in the Bhutan Himalayas are more dangerous than the Nepal Himalayas due to the strong effect of the monsoons and high precipitation.

(7) Environmental Degradation

The decline in per capita availability of agricultural land and shortage of grain, due to high rate of population growth, exacerbated by lack of alternative job opportunities other than agriculture in rural areas, will lead to over-exploitation of resources, including cultivation of marginal land and steep hilly terrain to meet the increasing demand of the growing population. This will not only damage the natural resource base of land, water and air, but also threaten the sensitive balance of fragile mountain ecosystem.

Some of these likely adverse impacts are already on the horizon. For example, in some valleys, the forestline is receding to make way for cash crop plantations such as orange, apple and cardamom. The pressure on the forest will further increase with over grazing and accelerated use of forest products for fuel wood, fodder and construction due to persistent high rate of population growth. The depletion of the natural resource base and the adverse impact on forest, which threatens the existence of all life, are matter of serious concern for the sustainable development of Bhutan.

(8) Environmental Quality Criteria

In regard to environmental quality, the bridge projects are expected to affect only water and air quality during the construction phase. However, there are no air or water quality standards for construction in Bhutan. Generally speaking, construction projects discharge water pollutants in the form of total dissolved solids (TDS) and total suspended solids (TSS), and air pollutants as carbon monoxide (CO), nitrogen oxides (NOx), and total suspended particulates (TSP). Recommended water and air quality standards for Bhutan are as follows.

1) Recommended Ambient Environmental Quality Standards

a. Ambient Water Quality Standards

Parameter	Standards
Drinking water supply	TDS ≤ 500 mg/L
Raw water supply	TDS ≤ 500 mg/L
Freshwater, lake and stream	TSS ≤ 110% of normal levels (to protect aquatic life)
Water for agricultural use	TDS ≤ 2,100 mg/L, TSS ≤ 200 mg/L

b. Ambient Air Quality Standards

Parameter	Time-weighted Average	Averaging Time(or Time Interval)
Carbon Monoxide	100 mg/ m^3	15 min.
	60 mg/ m^3	30 min.
	30 mg/ m^3	1 hr.
	10 mg/ m^3	8 hrs.
Nitrogen Oxides	100 mcg/ m^3	1 hr.
	150 mcg/ m^3	24 hrs.
Total Suspended Particulates (TSP)	40-60 mcg/ m^3	Annual avg.
	150-230 mcg/ m^3	24 hrs.

2) Recommended Pollution Discharge and Emission Standards

a. Industrial Wastewater Discharge

Industrial wastewater discharge TSS ≤ 60 mg/L

b. Air Emissions

Nitrogen Oxides (Nox)	470 mcg/m^3
Carbon Monoxide (CO)	5,000 mcg/m^3

(9) The Environmental Impact Assessment (EIA) Guideline

NEC, in collaboration with Asian Development Bank (ADB) prepared draft EIA guidelines in 1993 for the following priority sectors: hydropower, transmission lines, forestry, highway and roads, mining and industry.

Highway and roads include expressways, primary roads, and rural roads. Rural roads generally connect villages and smaller population centers such as regional market towns, and are comprised of feeder roads. Supporting infrastructure such as drainage systems and bridges, culverts, etc., are included.

According to the above guidelines, environmental problems for new major highway and road projects are as follows:

a. Encroachment on precious ecology
b. Encroachment on religious/historical/cultural monuments/areas
c. Impairment of fisheries/aquatic ecology and other beneficial water uses
d. Erosion and siltation
e. Environmental aesthetics
f. Noise and vibrations
g. Air pollution hazards
h. Highway pollution
i. Highway spills
j. Construction phase problems:
   Erosion and silt runoff, Health and safety of construction workers, adequate monitoring system
k. Post-construction monitoring and maintenance:
   monitoring for the actual environmental impacts, long-term maintenance of the project
l. Critical review criteria:
   - Will the project cause unwarranted losses in precious and or irreplaceable natural resources?
   - Will the project make unwarranted accelerated use of scarce resources in favor of short-term over long-term economic needs?
   - Will the project result in unwarranted hazards to endangered species?
   - Will the project tend to intensify undesirable migration from rural to urban areas to an unwarranted degree?
   - Will the project adversely depreciate the national energy and foreign exchange situation to unwarranted degree?
   - Will there be intensification of national socio-economic imbalances due to increases in the affluent to poor income gap?

(10) Environmental Assessment Process

One of the major objectives of the EIA process is to coordinate the information requirements for permit approvals. No final permits or licenses are granted until approval-in-principle has been given, though where the proponent is applying to lease government land a conditional site approval may be considered after approval of EIA terms-of-reference, in order to protect the proponent's interests during feasibility studies.

For public sector projects, where government is both proponent and regulator, the process will be somewhat different. Environmental and social assessment will take place through interagency participation and review during planning and design. Environmental management and monitoring requirements will be formulated as codes-of-practice or operating procedures as part of the contracts issued to private firms engaged in project construction, operation and maintenance. Adequate budgets for compliance monitoring and supervision by responsible government agency should be identified as part of overall project costs.

9.1.2 Existing Environmental Conditions at Each Bridge

(1) Br. No.1 Kurizampa Bridge (800 m ASL)

1) Fauna

Fish traps were set from 4:30 PM to 6:40 AM on the 9th and 10th of February. No fish were caught. Nets were cast at 13 places along the river from 6:50 AM to 7:15 AM on the 10th of February. One "asala" of 50 cm in length was caught. Fish of various sizes were also observed in the river. According to the locals, fish such as "asala", "katole" and "masheer" are commonly found in the river. The river color is light brown in summer and clear in winter.

The "asala" (*Schizothoraichthys* sp.) is called the "snowtrout" in English. The geographical distribution of "asala" ranges from the Kashmir Valley in India, Nepal, to Afghanistan, Pakistan, and beyond. This species is known to breed from November to January in Bhutan.

The "katole" (*Neolissochlus hexgonolepis*) is called "katli" in English, and "boka, bokar, boolooah or katoli" in Assam. The geographical distribution of "katole" ranges from the Indian Eastern Himalaya to Assam, Bangladesh, Nepal, and elsewhere. This species is known to breed from November to January in Bhutan.

The "masheer" (*Tor* sp.) is called "pithia" in Assam. The geographical distribution of "masheer" is found in Pakistan, India, Himalaya, Nepal, and elsewhere. This species is known to breed from November to January in Bhutan.

2) Flora

According to the field survey, the following species were confirmed.

Name	Botanical Name
Siris (Nep)	*Albizia gamblei*
Phaledo (Nep)	*Erythrina suberosa*
= Chhatsashing (Dz)	
Kharshing (Sha)	*Calamus erectus*
Titepalti (Nep)	*Artemesia Vulgaris*
Guyalo (Dz)	*Callicarpa arborea*
Chilauney (Nep)	*Schima wallichii*
Bestanangshing (Sha)	*Quercus lanata*
Sito (Nep)	*Neyraudia arundinacea*
Malinggo	*Yushania maling* or *Yushania microphylla*
Hone (Sha)	*Dryptes indica*
Banana (En)	*Musa fera*
Hemp (En)	*Canavis sativa*
= Ganza (Nep)	
Walnut (En)	*Juglans regia*
Pine (En)	*Pinus roxbusgii*
Grass (En)	-
Silver grass (En)	-
Bamboo grass (En)	-
Lemon grass (En)	*Gymbopogon flexuosus*

(Note) En : English
Dz : Dzongkha (Western Bhutan Language)
Sha : Sharchopkha (Eastern Bhutan Language)
Nep : Nepali (Lhotsham Bhutan Language)

(2) Br. No.2 Chamkhar Zam Bridge (2400 m ASL)

1) Fauna

A fish trap was set from 10:20 AM to 1:20 PM on the 26th of February. No fish were caught. However, a fish of about 30 cm in length was found in the river. According to the locals, "trout" are common and "asala" are sometimes found in the river. These species are found upstream and downstream of the bridge over the Chamkarchu River. The river colour is clear in all seasons.

The alwan snowtrout (*Schizothorax richardsonii*) is called "alwan" or "jis" in Kashmir and "trout" in Uttar Pradesh. Trout are distributed in India along the Himalayas, from Jammu and Kashmir to Assam, Sikkim, Nepal, and Afghanistan. The species is known to breed from November to January in Bhutan.

2) Flora

According to the field survey, the following species were confirmed.

Name	Botanical Name
Titepalti (Nep)	*Artemesia Vulgaris*
Willow tree	*Salix Wallichiana*
Bayor (Nep)	*Zizyphus oenoplia*
Tshoshing (Sha) = Mauwa (Nep)	*Englhardia spicata*
Gayo (Nep)	*Bridelia retusa*
Kans (Nep)	*Saccharum spontaneum*
Betsanangshing (Sha)	*Quercus lanata*
Thistle (En)	-
Pine (En)	*Pinus wallichiana*
Moss (En)	-
Peach (En) = Lengsey shing (sha) = Aru (Nep)	*Prunus persica*
Cosmos (En) = Khee-metog (sha)	*Cosmos bipinnatus*
Hemp (En) = Ganza (Nep)	*Cannabis sativa*

(Note) En : English
Dz : Dzongkha (Western Bhutan Language)
Sha : Sharchopkha (Eastern Bhutan Language)
Nep : Nepali (Lhotsham Bhutan Language)

3) Others

A "chorten" is located about 55m from the bridge. However this will not be disturbed by the new alignment. The chorten, or receptacle of offerings, is a Buddhist monument whose origin lies in the *stupa* of ancient India. It is a votive monument to the memory of the Buddha and his meritorious deeds. The symbolic significance of the chorten requires that the building consist of five parts, corresponding to the five elements of the cosmos, i.e. earth, water, fire, air and sky.

(3) Br. No.3 Bjee Bridge (1800 m ASL)

1) Fauna

A fish trap was set from 4:30 PM on the12th to 8:00 AM on the 13th of February and a net was cast at 12 places along the river from 4:00 PM to 4:45 PM on the 12th of February. No fish were caught. According to the locals, "asala", "katole" and "trout" and deer, bear and wild boar are also found. The fish species are found upstream and downstream of the bridge over Mangdichu River. The river color is clear in all seasons.

2) Flora

According to the field survey, the following species were confirmed.

Name	Botanical Name
Siris (Nep)	*Albizia gamblei*
Lalchandan (Nep)	*Daphnephyllum himalayenso*
Jurooshing (Dz) = Awa shing (Sha) = Lalchandan (Nep)	*Daphniphyllum chartaceum*
Totne (Nep)	*Polygonum molle*
Titepalti (Nep)	*Artemesia vulgaris*
Churp Shing (Dz)	-
Guyalo (Dz)	*Callicarpa arborea*
Katus (Nep)	*Castanopsis indica*
Bestanangshing (Sha)	*Quercus lanata*
Pine (En)	*Pinus wallichiana*
Hemp (En) = Ganza (Nep)	*Canavis sativa*
Ningro (Nep)	-
Houtuonga (tosturudone)	-
Cosmos (En)	*Cosmos bupinnata*
Lichen (En)	-
Oak (En)	*Quercus* sp.
Moss (En)	-

(Note) En : English
Dz : Dzongkha (Western Bhutan Language)
Sha : Sharchopkha (Eastern Bhutan Language)
Nep : Nepali (Lhotsham Bhutan Language)

(4) Br. No.4 Wachy Zam Bridge (1500 m ASL)

1) Fauna

A fish trap was set from 10:30 AM to 0:30 PM on the 23th of February, but no fish were caught. However, a small fish of about 3 cm in length was found. Locals find "katole" and "trout" in the river, and other animals such as leopard, deer, bear and wild boar in the vicinity. The fish species are found upstream and downstream of the bridge over the Dangchu River. River color is gray in summer and clear in winter. In summer, cicadas, butterflies and beetles are to be found in the vicinity of the bridge.

2) Flora

According to the field survey, the following species were confirmed.

Name	Botanical Name
Nigaro (Nep) = Tashaa (Dz)	*Arundinaria intemedia*
Mingdomashing (Dz)	*Saurauia napaulensis*
Thinge (Dz)	*Zathoxylum* spp.
Phaledo (Nep)	*Erythrina suberosa*
Chhatsashing (Dz)	*Erethena indica*
Kharshing (Sha)	*Calamis erectus*
Titepalti (Nep)	*Artemesia vulgaris*
Willow tree	*Salix wallichiana*
Phamshing(Sha)	*Sterculia villosa*
Yoka Shingh (Sha)	*Aesandra butyracea*
Whi Shingh (Dz)	-
Chilauney (Nep)	*Schima wallichii*
Malinggo	*Arundrnaria* species
Orange (En)	*Citrus reticulata*
Bamboo (En)	-
Sumac tree (En)	-
Pine (En)	*Pinus wallachiana*

(Note) En : English
Dz : Dzongkha (Western Bhutan Language)
Sha : Sharchopkha (Eastern Bhutan Language)
Nep : Nepali (Lhotsham Bhutan Language)

3) Others

Private paddy fields may be affected by the new alignment.

(5) Br. No.5 Mangdichu Bridge (600 m ASL)

1) Fauna

One "asala" of 52 cm in length was caught by casting net with the help of locals. On 11th of February, a young "asala" 8 cm in length was caught in the fish trap set in the river from 3:00 PM to 4:30 PM. Fish traps were set from 5:00 PM on the 11th to 6:30 AM on the 12th of February, but not a single fish. According to the locals, "masheer" and "katole" are found in summer in the river, whereas "asala" can be found in winter. These fish species are found upstream and downstream of the bridge over Mangdichu River. River color is light brown in summer, and clear in winter. A dragonfly larva was confirmed in the river on the 15th of September, 1997.

2) Flora

According to the field survey, the following species were confirmed.

Name	Botanical Name
Siris (Nep)	*Albizia gamblei*
Titepalti (Nep)	*Artemesia Vulgaris*
Churp Sing (Dz)	*Tamarindus indicus*
Guyalo (Dz)	*Callicarpa arborea*
Katus (Nep)	*Castanopsis indica*
Lampatey (Nep)	*Duabanga grondiflora*
Chilauney (Nep)	*Schima wallichii*
Grass (En)	-
Mango tree (En)	*Mangifera india*
Pine (En)	*Pinus* sp.
Saur	*Betula alnoides*
Moss (En)	-

(Note) En : English
Dz : Dzongkha (Western Bhutan Language)
Sha : Sharchopkha (Eastern Bhutan Language)
Nep : Nepali (Lhotsham Bhutan Language)

3) Others

A "chorten" is located about 50 m from the existing bridge. However this will not be influenced by the new alignment. A PWD office measuring 14 m x 12 m is included inside the new alignment.

9.2 Environmental Impact Study

9.2.1 Initial Environmental Evaluation (IEE)

IEE has the two following objectives : 1) to evaluate whether EIA is necessary for the project and, if so, to define its contents; 2) to examine, from an environmental viewpoint, the measures for alleviating the effects of the project which requires environmental consideration but not a full-scale environmental impact assessment.

IEE for each of 22 bridges was carried out based on the Environmental Guidelines of Royal Government of Bhutan and that of JICA. Information on twenty six (26) environmental items were collected and checked by screening and scoping during the site survey as shown in Table 9.1. The results of IEE are shown in Appendix-H.

Screening was conducted to evaluate whether or not it will be necessary to include an environmental consideration in the project development. Scoping was to identify the important environmental impacts among those which can be caused by the implementation of a development plan or development project, and to define the study items of EIA based on the findings.

The result of IEE for all bridges is shown in Table 9.2. The result of IEE for 12 bridges which were selected to be replacement urgently is shown in Table 9.3.

9.2.2 Environmental Impact Assessment

EIA of each bridge was carried out based upon the results of the IEE, the final bridge construction plan, and existing environmental conditions at each site. These assessments are described below. The terms of reference for the EIA were agreed upon by the PWD and the NEC. The terms of reference are shown in Appendix-I.

Table 9.1 Description of Environmental Items

No.	Environmental Item	Description
	Social Environment	
1	Resettlement	Resettlement due to land occupancy (transfer of rights of residence / land ownership)
2	Economic Activities	Loss of bases of economic activities, such as land, and change of economic structure
3	Traffic and Public Facilities	Impacts on schools, hospitals and present traffic conditions, such as the increase of traffic congestion and accidents
4	Split of Communities	Community split due to interruption of area traffic
5	Cultural Property	Damage to or loss of the value of churches, temples, shrines, archaeological remains or other cultural assets
6	Water Rights and Common Rights	Obstruction of fishing rights, water rights, common rights
7	Public Health Condition	Deterioration of public health and sanitary conditions due to generation of garbage and the increase of vermin
8	Waste	Generation of construction and demolition waste, debris and logs
9	Hazards (Risk)	Increase in risk of landslides, cave-ins and accidents
	Natural Environment	
10	Topography and Geology	Changes of valuable topography and geology due to excavation or filling work
11	Soil Erosion	Topsoil erosion by rainfall after reclamation and vegetation removal
12	Groundwater	Change of distribution of groundwater by large-scale excavation
13	Hydrological Situation	Changes of river discharge and riverbed condition due to landfill and drainage inflow
14	Coastal Zone	Coastal erosion and sedimentation due to landfill or change in marine condition
15	Fauna and Flora	Obstruction of breeding and extinction of species due to change of habitat condition
16	Meteorology	Changes of temperature, precipitation, wind, etc. due to large -scale land reclamation and building construction
17	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures
	Pollution	
18	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles and factories
19	Water Pollution	Pollution by inflow of silt, sand and effluent into rivers and groundwater
20	Soil Contamination	Contamination of soil by dust and chemicals, such as herbicides
21	Noise and Vibration	Noise and vibration generated by vehicles
22	Land Subsidence	Deformation of land and land subsidence due to the lowering of groundwater table
23	Offensive Odour	Generation of exhaust gas and offensive order by facility construction and operation
	Others	
24	Highway Runoff Pollution	Surface runoff from highways may contain sufficient petroleum drippage and spilled materials to pose a hazard to aquatic ecology and road-side communities.
25	Highway Spills	A serious potential hazard associated with highways and roads is accidental spillage of hazardous materials.
26	Monitoring and Maintenance	Does the project plan make provision for any needed continuing post-construction monitoring for assessing the actual environmental impacts ? Have adequate provisions been made for the long-term maintenance of the project ?

Note: "Social Environment, Natural Environment and Pollution (No.1 to No.23)" were made with reference to the "Environmental guidelines for infrastructure projects, Sector III Road, JICA". "Others (No.24 to No.26)" was made with reference to the "Draft Environmental Assessment Sectoral Guidelines - Bhutan, NEC, 1997"

Table 9.2 Result of Screening and Scoping for All Bridges

No.	Bridge No. / Environmental Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Resettlement	-	-	-	-	Y2	-	-	-	Y2	-	-	-	-	-	-	-	-	-	-	-	Y2	Y2
2	Economic Activities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Traffic and Public Facilities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Split of Communities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Cultural Property	-	U	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Water Rights and Common Rights	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Public Health Condition	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
8	Waste	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
9	Hazards (Risk)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Topography and Geology	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Soil Erosion	-	-	-	-	U	-	-	U	-	-	-	-	-	-	-	U	-	-	-	-	U	-
12	Groundwater	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	Hydrological Situation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Coastal Zone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Fauna and Flora	U	U	U	U	U	U	U	U	U	U	U	U	U	U	-	U	U	U	U	U	U	U
16	Meteorology	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	Landscape	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	Air Pollution	U	U	U	U	U	-	-	-	U	-	-	U	U	-	-	-	-	-	-	-	U	U
19	Water Pollution	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
20	Soil Contamination	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	Noise and Vibration	U	U	U	U	U	-	-	-	U	-	-	U	U	-	-	-	-	-	-	-	U	U
22	Land Subsidence	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	Offensive Odour	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Highway Runoff Pollution	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	Highway Spills	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	Monitoring and Maintenance	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U

Note :

Y: Environmental impact is expected. (Y1: Serious impact is expected. Y2: Minor impact is expected.)

-: No environmental impact is expected. EIA is not necessary.

U: Extent of impact is unknown (Examination is needed. Impacts may become clear as study progresses.).

Table 9.3 Result of Screening and Scoping for 12 Bridges

No.	Environmental Item \ Bridge No.	1	2	3	4	5	6	8	16	17	21	22
1	Resettlement	-	-	-	-	Y2	-	-	-	-	Y2	Y2
2	Cultural Property	-	U	-	-	-	-	-	-	-	-	-
3	Public Health Condition	U	U	U	U	U	U	U	U	U	U	U
4	Waste	U	U	U	U	U	U	U	U	U	U	U
5	Soil Erosion	-	-	-	-	U	-	U	U	-	U	-
6	Fauna and Flora	U	U	U	U	U	U	U	U	U	U	U
7	Air Pollution	U	U	U	U	U	-	-	-	-	U	U
8	Water Pollution	U	U	U	U	U	U	U	U	U	U	U
9	Noise and Vibration	U	U	U	U	U	-	-	-	-	U	U
10	Monitoring and Maintenance	U	U	U	U	U	U	U	U	U	U	U

Note :

Y : Environmental impact is expected. (Y1: Serious impact is expected. Y2: Minor impact is expected.)

- : No environmental impact is expected. EIA is not necessary.

U : Extent of impact is unknown (Examination is needed. Impacts may become clear as study progresses.).

(1) Br. No.1 Kurizampa Bridge

1) Fauna

No "Totally Protected Wild Life" as listed in the "Forest and Nature Conservation Act of Bhutan, 1995" could be found in the vicinity of the proposed bridges, whereas fish including "asala", "katole" and "masheer" were found in the river to be spanned by the proposed bride. The breeding season for these fish species runs from November to January, in Bhutan. In general, it is necessary to avoid construction causing river discharge to become very muddy during the breeding season. However no construction from which very muddy water will be discharged is planned in the construction of Kurizampa Bridge. No construction will be carried out during the rainy season in which muddying river water can occur.

The impact to other aquatic life is not severe, as riverbed construction works are not planned. Air pollution and noise stress during construction will be not so severe to fauna, due to their mobility.

2) Flora

No "Totally Protected Plants" listed in the "Forest and Nature Conservation Act of Bhutan, 1995" could be found in the vicinity of the proposed bridges. Only some common species were found in the area expected to be disturbed during the course of the projects. Since rock for the project will be quarried from existing quarries or rocky areas, no listed plants are expected to be disturbed. The impact on flora will not be severe.

3) Waterway Constrictions

Waterways will not be constricted, as new abutments will not be built within the river.

4) Soil Erosion

The slope disturbed by the new alignment will be protected by a masonry retaining wall and gabion wire cylinder. Soil erosion will not be incurred.

5) Issues in Construction Phase

a) Public Health Conditions

First aid kits for emergency injury or illness will be prepared to ensure worker health during construction. A communication system between the construction yard and the PWD office will be established in case of accidents. Public health conditions will be paid due attention.

b) Waste

Waste generated in construction will include concrete, rock, soil, broken asphalt and garbage from workers. Concreat, rock and asphalt volume will be in all about 500 m^3, excavated soil volume about 300 m^3. These wastes will be kept in designated areas under supervision. Worker garbage will be buried in a pit. Waste will not be allowed to become an environmental problem.

c) Air Pollution

Anticipated sources of significant exhaust gas during construction are the electric generator (50 kW), and the rock breakers. However, those machines will be few and will not be working continuously. Air pollution will not be incurred.

d) Water Pollution

No construction in the river itself is planned for this bridge. Construction will not be carried out during the rainy season. Any discharge from the construction yards will be clarified in precipitation ponds. Drainage from the worker camp will be collected in seepage basins. With the above precautions, there will be negligible water pollution.

e) Noise and Vibration

Dynamite will not be used in construction. Giant rock breakers will be used for hard rock destruction, however, when the rock is too hard, smooth blasting will be used; therefore severe noise will not be incurred. Anticipated sources of significant noise during construction are the giant rock breaker ($0.6m^3$), and the vibration roller (10t), electric generator (50 kW), and jaw-crusher (10t/H). The sound levels of the giant rock breaker ($0.6m^3$), the vibration roller (10t), electric generator (50 kW) and jaw-crusher (10t/H) are 126 dB(A), 117 dB(A), 109 dB(A) and 98 dB(A), respectively.

The noise level at the house nearest to the construction machines (this distance estimated to be 40 m) is expected to be 85 dB(A), 76 dB(A), 68 dB(A) and 56 dB(A) from each of the above machines. At 85 dB(A), a phone cannot be heard, and at 76 dB(A) it is difficult to hear the phone. However, this noise will not be continuous nor occur during the night; accordingly, construction noise will not be a severe problem.

Severe vibration will not occur, because vibration at frequencies with impacts on human activities (3 Hz to 10 Hz) cannot spread in hard rock such as found in the construction areas.

(2) Br. No.2 Chamkar Zam Bridge

1) Fauna

Fish including "asala" and "trout" were found in the river to be spanned by the proposed bride. Similar to Kurizampa Bridge, the impact to aquatic life will not be severe.

2) Flora

By the same reasoning as described for Kurizampa Bridge, the impact on flora will not be severe.

3) Cultural Properties

A "chorten" is located about 55 m from the existing Chamkhar Zam Bridge. However this will not be influenced by the new alignment of the road.

4) Waterway constrictions

Waterway constrictions will not be incurred, as new abutments will not be built within the river.

5) Issues in Construction Phase

a) Public Health Conditions

By the same reasoning as described for Kurizampa Bridge, public health conditions will be paid due attention.

b) Waste

Waste generated in construction will include rock, broken asphalt and garbage from workers. Rock and asphalt volume will be in all about 100 m^3. By the same reasoning as described for Kurizampa Bridge, waste will not be allowed to become an environmental problem.

c) Air Pollution

By the same reasoning as described for Kurizampa Bridge, air pollution will not be incurred.

d) Water Pollution

By the same reasoning as described for Kurizampa Bridge, there will be negligible water pollution.

e) Noise and Vibration

Dynamite will not be used in construction. Anticipated sources of significant noise during construction are the same machines as described for Kurizampa Bridge. The noise level at the house nearest to the construction machines (this distance estimated to be 100 m) is expected to be 75 dB(A), 66 dB(A), 58 dB(A) and 57 dB(A) from each machine. At 75 dB(A) it is difficult to hear the phone, and at 66 dB(A) it is slightly difficult to hear the phone. However, the noise and vibration in construction will not be a severe problem, by the same reasoning for Kurizampa Bridge.

(3) Br. No.3 Bjee Bridge

1) Fauna

Fish including "asala", "katole" and "trout" were found in the river to be spanned by the proposed bride. Similar to Kurizampa Bridge, the impact on aquatic life will not be severe.

2) Flora

By the same reasoning as described for Kurizampa Bridge, the impact on flora will not be severe.

3) Soil Erosion

The slope disturbed by the new alignment will be protected by masonry retaining wall and gabion wire cylinder. Soil erosion will not be incurred.

4) Waterway constrictions

Waterway constrictions will not be incurred, as new abutments are not planned within the river.

5) Issues in Construction Phase

a) Public Health Conditions

By the same reasoning as described for Kurizampa Bridge, public health conditions will be paid due attention.

b) Waste

Waste generated in construction will include rock, soil, broken asphalt and garbage from workers. Rock and asphalt volume will be in all about 300 m^3, and excavated soil volume about 200 m^3. By the same reasoning as described for Kurizampa Bridge, waste will not be allowed to become an environmental problem.

c) Air Pollution

By the same reasoning as described for Kurizampa Bridge, air pollution will not be incurred.

d) Water Pollution

By the same reasoning as described for Kurizampa Bridge, there will be negligible water pollution.

e) Noise and Vibration

Dynamite will not be used in construction. Anticipated sources of significant noise during construction are the same machines as described for Kurizampa Bridge. The noise level at the house nearest to the construction machines (this distance estimated to be 30 m) is expected to be 88 dB(A), 78 dB(A), 70 dB(A) and 59 dB(A) from each machine. At 88 dB(A), a phone cannot be heard, and at 78 dB(A) it is difficult to hear the phone. However, the noise and vibration in construction will not be a severe problem, by the same reasoning for Kurizampa Bridge.

(4) Br. No.4 Wachy Zam Bridge

1) Fauna

Fish including "katole" and "trout" were found in the river to be spanned by the proposed bride. Similar to Kurizampa Bridge, the impact to aquatic life will not be so severe.

2) Flora

By the same reasoning as described for Kurizampa Bridge, the impact on flora will not be so severe.

3) Land Tenure

The expropriation of private paddy fields will be caused by the new alignment of the road. The size of this area is to be about 400 m^2. Compensation for this area will be carried out by the Royal Government of Bhutan, with gifts of plots of land of equal size, and money.

4) Soil Erosion

The slope disturbed by the new alignment will be protected by a masonry retaining wall and gabion wire cylinder. Soil erosion will not be incurred.

5) Waterway constrictions

Waterway constrictions will not be incurred, because a new abutment is not planed within the river.

6) Issues in Construction Phase

a) Public Health Conditions

By the same reasoning as described for Kurizampa Bridge, public health conditions will be paid due attention.

b) Waste

Waste generated in construction will include rock, soil, broken asphalt and garbage from workers. Rock and asphalt volume will be in all about 400 m^3, and excavated soil volume about 4,000 m^3. By the same reasoning as described for Kurizampa Bridge, waste will not be allowed to become an environmental problem.

c) Air Pollution

By the same reasoning as described for Kurizampa Bridge, air pollution will not be incurred.

d) Water Pollution

By the same reasoning as described for Kurizampa Bridge, there will be negligible water pollution.

e) Noise and Vibration

Dynamite will not be used in construction. Anticipated sources of significant noise during construction are the same machines as described for Kurizampa Bridge. The highest noise level at the house nearest to the construction machines (this distance estimated to be 40 m for the vibration roller and 60 m for the giant rock breaker) is expected to be 81 dB(A), 76 dB(A), 64 dB(A) and 52 dB(A) from each machine. At 81 dB(A), a phone cannot be heard, and at 76 dB(A) it is difficult to hear the phone. However, the noise and vibration in construction will not be a severe problem, by the same reasoning for Kurizampa Bridge.

(5) Br. No.5 Mangdichu Bridge

1) Fauna

Fish including "asala", "katole" and "trout" were found in the river to be spanned by the proposed bride. Similar to Kurizampa Bridge, the impact to aquatic life will not be severe.

2) Flora

By the same reasoning as described for Kurizampa Bridge, the impact on flora will not be severe.

3) Resettlement

A few PWD offices will be removed to other locations, but it will not to be a social environmental issue, as these houses are both managed by the Royal Government of Bhutan.

4) Cultural Properties

A "chorten" is located about 50 m from the existing Mangdichu Bridge. However this will not be influenced by the new alignment of the road.

5) Soil Erosion

The slope disturbed by the new alignment will be protected by a masonry retaining wall and gabion wire cylinder. Soil erosion will not be incurred.

6) Waterway constrictions

Waterway constrictions will not be incurred, as new abutments are not planned within the river.

7) Issues in Construction Phase

a) Public Health Conditions

By the same reasoning as described for Kurizampa Bridge, public health conditions will be paid due attention.

b) Waste

Waste generated in construction will include rock, soil, broken asphalt and garbage from workers. Rock and asphalt volume will be in all about 8,000 m^3, and excavated soil volume about 9,000 m^3. By the same reasoning as described for Kurizampa Bridge, waste will not be allowed to become an environmental problem.

c) Air Pollution

By the same reasoning as described for Kurizampa Bridge, air pollution will not be incurred.

d) Water Pollution

By the same reasoning as described for Kurizampa Bridge, there will be negligible water pollution.

e) Noise and Vibration

Dynamite will not be used in construction. Anticipated sources of significant noise during construction are the same machines as described for Kurizampa Bridge. The highest noise level at the house nearest to the construction machines (this distance

estimated to be 10 m for the vibration roller and 60 m for the giant rock breaker) is expected to be 89 dB(A) and 81 dB(A) from each machine. At 89 or 81 dB(A), a phone cannot be heard. However, the noise in construction will not be a severe problem, by the same reasoning for Kurizampa Bridge. Vibration may be generated by vibration roller, however this vibration will not continue for more than several hours per day. Vibration in construction will not be a environmental problem, because the affected areas belong to PWD.