No. 2

JAPAN INTERNATIONAL COOPERATION AGENCY
MINISTRY OF WORKS AND TRANSPORT
KINGDOM OF NEPAL

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR CONSTRUCTION OF SINDHULI ROAD (SECTION I : BARDIBAS - SINDHULI BAZAR) IN KINGDOM OF NEPAL

DECEMBER, 1994

NIPPON KOEI CO., LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY
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BASIC DESIGN STUDY REPORT
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PREFACE

In response to the request of His Majesty's Government of Nepal, the Government of Japan has decided to conduct a basic design study on the Project for Construction of Sindhuli Road (Section I: Bardibas-Sindhuli Bazar) and entrusted the study to the Japan International Cooperation Agency (JICA). JICA conducted the study in Japan to review the results of the Aftercare Study, and the result of this study was compiled in the draft report.

JICA sent a mission to Nepal headed by Mr. Shin INOUE, Assistant Director, Grand Aid Division, Economic Cooperation Bureau of Ministry of Foreign Affairs and constituted by member of Nippon Koei Co., Ltd., from October 22 to November 5, 1994, in order to discuss the draft report, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Kingdom of Nepal for their close cooperation extended to the team.

December, 1994

Kimio Fujita
President
Japan International Cooperation Agency

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

December 1994

Letter of Transmittal

We are pleased to submit to you the Basic Design Study Report on the Project for Construction of Sindhuli Road (Section I: Bardibas-Sindhuli Bazar) in Nepal.

This Study was conducted by Nippon Koei Co., Ltd. under a contract to JICA during the period 15 August 1994 to 9 January 1995. In conducting the study, we have examined the feasibility and rationale of the Project with due consideration to the present situation of Nepal and have formulated the most appropriate basic design for the Project under the Japan's grant aid scheme.

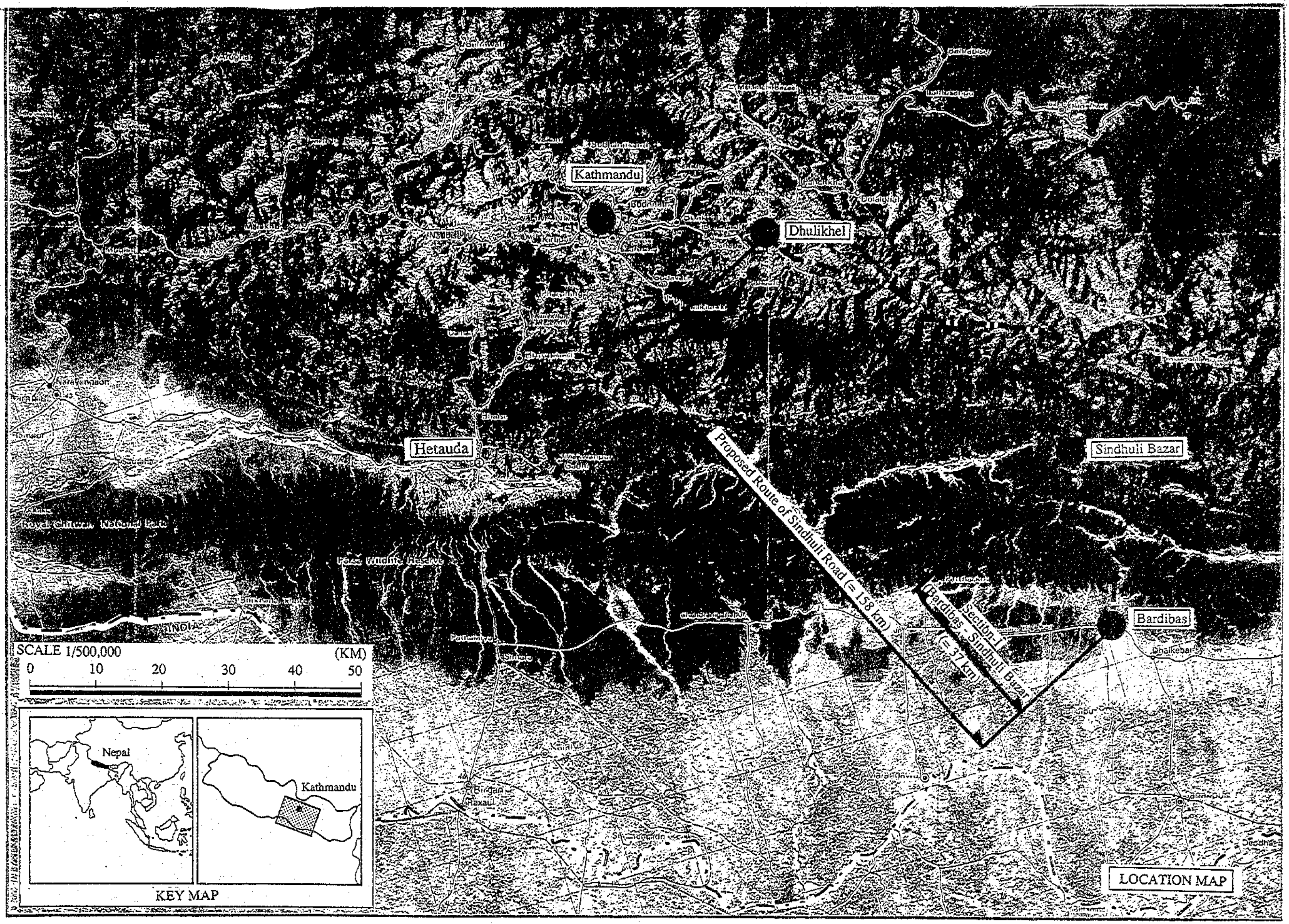
We wish to take this opportunity to express our sincere gratitude to the concerned officials of JICA and the Ministry of Foreign Affairs. We would also like to express our gratitude to the officials concerned of the Department of Roads in Nepal, the JICA office in Nepal, the Embassy of Japan in Nepal and the Water Induced Disaster Prevention Technical Centre for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to further promotion of the Project.

Very truly yours,

M. Koshiba

Masaru Koshiba
Project Manager
Basic Design Study Team on the Project for
Construction of Sindhuli Road (Section I :
Bardibas-Sindhuli Bazar)
Nippon Koei Co., Ltd.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Dhulikhel
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Sindhuli Bazar
Bardibas
Proposed Route of Sindhuli Road (= 158 km)
Section-I
(Bardibas - Sindhuli Bazar)
(= 37 km)
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Kathmandu
KEY MAP
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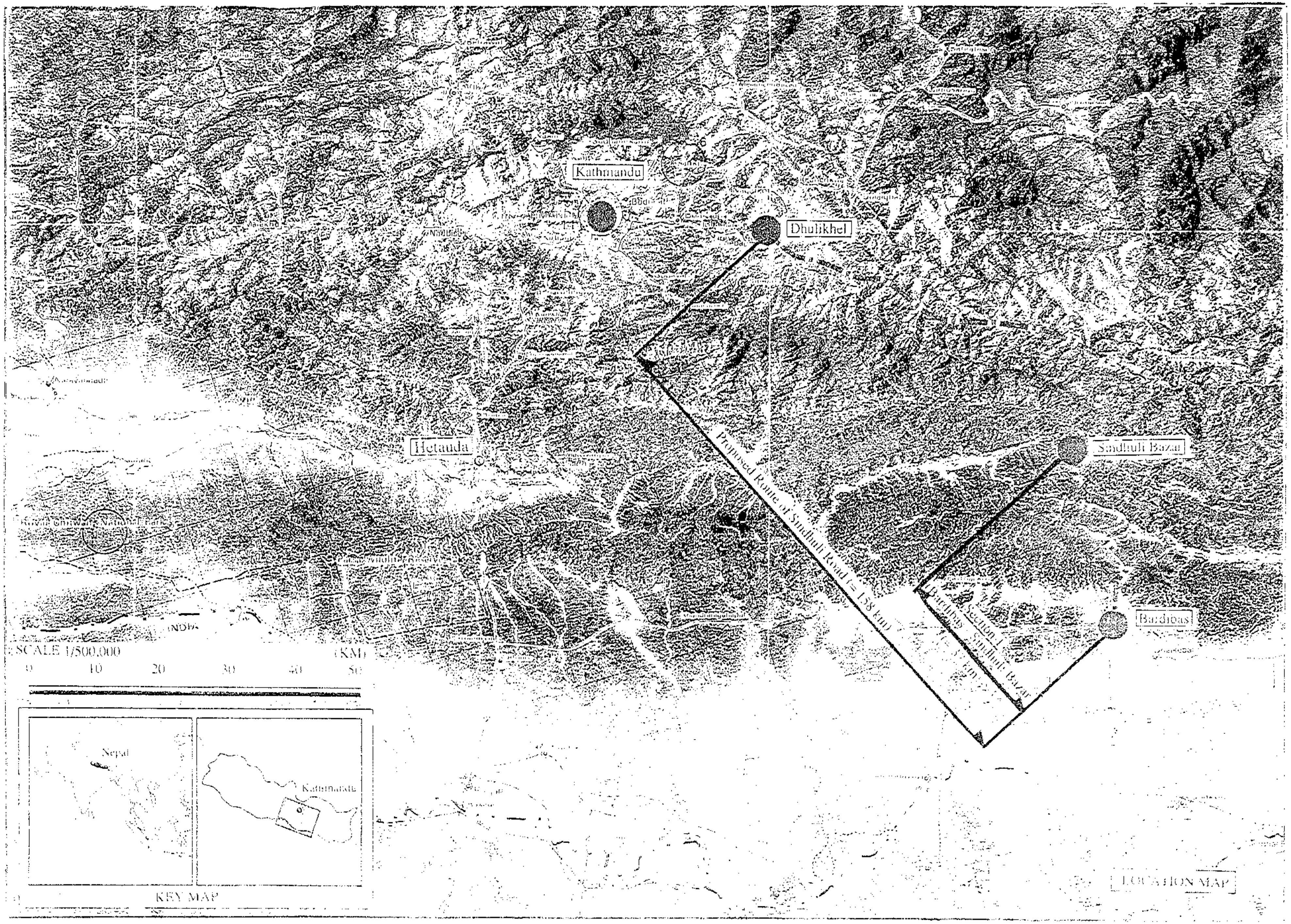
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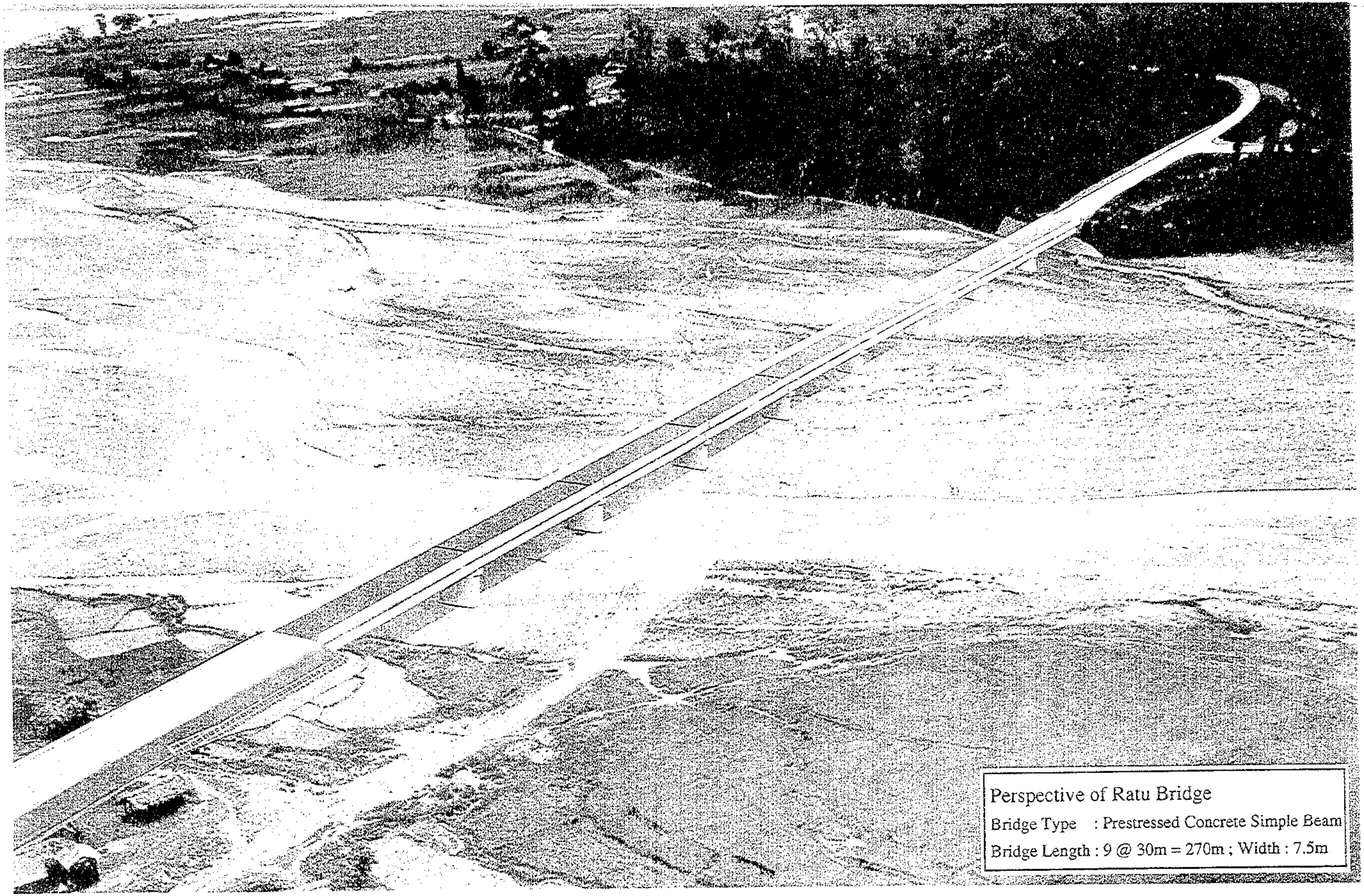

Perspective of Ratu Bridge

Bridge Type : Prestressed Concrete Simple Beam

Bridge Length : 9 @ 30m = 270m ; Width : 7.5m

SUMMARY

The Kingdom of Nepal, a landlocked country, covers an area of about 140 square kilometers and has a population of around 20 million. Nepal is pre-dominantly an agricultural country with about ninety percent of the economically active population working in agrarian-based and allied fields. The main agricultural belt of Nepal is the Terai Plain which is situated along its southern border with India.

Kathmandu, the capital of Nepal as well as being a center of economic and administrative activities, is located in the Kathmandu Valley near the approximate center of Nepal. The Kathmandu Valley has a population of about 1.1 million that is equivalent to approximately 6% of the country's population.

Presently, there are the two main highway connecting Kathmandu with the Terai Plain; namely, the Tribhuban Highway and the Prithiri Highway. However, the Tribhuban Highway is not used as a main trunk line because of its narrow road width and winding alignment. Although the Prithiri Highway is a main transport route, it is a roundabout way for people to travel and is at risk due to landslides and hillside erosion in the rainy season.

Taking into account the condition of the present road network linking Kathmandu and the Terai Plain, His Majesty's Government of Nepal (HMG) recognized the necessity to upgrade it and thus formulated the Sindhuli Road Construction Project (the Project). The Project has been planned to connect Bardibas on the East-West Highway with Dhulikhel on the Kodari Road and, when completed, will provide not only economic growth for the area, it will also allow an alternative route from the viewpoint of national security.

The Project road is broadly divided into two sections: Section I between Bardibas and Sindhuli Bazar with a total length of 37 km, and Section II between Sindhuli Bazar and Dhulikhel having an approximate length of 121 km.

The existing 2-lane road of Section I has been constructed by the HMG Department of Roads (DOR) using equipment provided in 1982 by the Japanese Grant Aid Program; however, the service level of the road is extremely low because of a lack of bridges and paved surface. In Section II, only foot trails and mule tracks exist except in a 20 km section near Dhulikhel where there is now a gravel road.

In response to a request from HMG for assistance, the Government of Japan (GOJ) decided to conduct a Feasibility Study (F/S) for the Project in 1986. The F/S was carried out by the

Japan International Cooperation Agency (JICA) during the period from November 1986 to March 1988 and the Final Report for it was submitted to HMG in June 1988. The Report concluded that the Project is both economically and technically feasible.

Since the construction cost determined in the F/S was of a considerable amount, the efforts taken by HMG to look for possible funding sources were not successful. However, as need for the project continued to increase, HMG gave high priority to it which was stressed in the "Eighth Plan" (1992-1997) prepared by the National Planning Commission of Nepal in July 1992.

Recognizing the importance and necessity for the Project, in May 1992 HMG requested GOJ to provide technical assistance for reviewing the F/S and grant aid for construction of the Sindhuli Road.

In response to a request from HMG, the GOJ decided to have JICA conduct an Aftercare (A/C) Study for the Project. The objective of this study was to establish practical and realistic development schemes, and to formulate an implementation program for the optimum development scheme based on a review of the previous F/S report.

According to the results of the A/C Study, the GOJ decided to have JICA conduct a Basic Design Study for the Project (Section I: Bardibas - Sindhuli Bazar), taking into consideration the long construction period. The JICA basic design team formulated a development scheme for the Project (Section I and II) on the condition that the Project is to be implemented under the Japanese Grant Aid Program.

Based on the development scheme, the basic design for the Project (Section I) was carried out and the draft report was prepared.

JICA dispatched a mission to explain the draft report to HMG during the period from 22 October 1994 to 5 November 1994. A basic agreement was then signed and exchanged after the contents of the draft report were verified and agreed upon by both parties.

According to the examination of the necessity/effectiveness of the basic design study, the request from HMG for the Project (Section I) was modified as follows:

- Nine bridges including approach roads at Bhogate, Karkare, Gangate, Ratu, Sindhuse, Kamara, Phittang, Buka and Gadeuli are to constructed in Section I instead of the originally proposed 15 bridges.

- The remaining six bridges and 11 box culverts planned in the F/S should be changed to 17 causeways at Section I.

- Strengthening of the DOR maintenance capabilities for Section I should be included as a part of the Project.

The scope of work for the Project recommended by the basic design study is summarized as follows:

- **Scope of Work by GOJ:**

  - Construction of nine bridges with approach roads:

Bridge Name	Bhogate Bridge		
Main Bridge	Bridge Length : 60 m		Effective Width : 7.5 m
	Superstructure	2 Spans of PC Simple Post-tensioned Girders	
	Substructure	Inverted T-type Abutment × 1, Gravity-type Abutment × 1, Circular Column type Pier × 1	
Foundation	Spread Type		
Approach Roads	Bardibas Side : 185 m		Sindhuli Bazar Side : 340 m

Bridge Name	Karkare Bridge		
Main Bridge	Bridge Length : 50 m		Effective Width : 7.5 m
	Superstructure	2 Spans of PC Simple Post-tensioned Girders	
	Substructure	Gravity-type Abutment × 2, Circular Column type Pier × 1	
Foundation	Spread Type		
Approach Roads*	Bardibas Side : –		Right Bank : –

* The approach roads for the Karkare Bridge will also be used as the north approach road for the Gangate Bridge and the south approach road for the Bhogate Bridge.

Bridge Name	Gangate Bridge		
Main Bridge	Bridge Length : 30 m		Effective Width : 7.5 m
	Superstructure	1 Spans of PC Simple Post-tensioned Girders	
	Substructure	Inverted T-type Abutment × 2	
Foundation	Spread Type		
Approach Roads	Bardibas Side : 35 m		Sindhuli Bazar Side : 150 m

Bridge Name	Ratu Bridge			
Main Bridge	Bridge Length	: 270 m	Effective Width	: 7.5 m
	Superstructure	9 Spans of PC Simple Post-tensioned Girders		
	Substructure	Inverted T-type Abutment × 2, Wall type Pier × 8		
Foundation	Spread Type			
Approach Roads	Bardibas Side	260 m	Sindhuli Bazar Side	420 m

Bridge Name	Shinhuse Bridge			
Main Bridge	Bridge Length	: 60 m	Effective Width	: 7.5 m
	Superstructure	2 Spans of PC Simple Post-tensioned Girders		
	Substructure	Inverted T-type Abutment × 2, Circular Column type Pier × 1		
Foundation	Spread Type			
Approach Roads	Bardibas Side	: 250 m	Sindhuli Bazar Side	: 420 m

Bridge Name	Kamara Bridge			
Main Bridge	Bridge Length	: 120 m	Effective Width	: 7.5 m
	Superstructure	3 Spans of PC Simple Post-tensioned Girders		
	Substructure	Inverted T-type Abutment × 1, Gravity-type Abutment × 1, Circular Column type Pier × 2		
Foundation	Spread Type			
Approach Roads	Bardibas Side	: 180 m	Sindhuli Bazar Side	: 590 m

Bridge Name	Phittang Bridge			
Main Bridge	Bridge Length	: 50 m	Effective Width	: 7.5 m
	Superstructure	2 Spans of PC Simple Post-tensioned Girders		
	Substructure	Inverted T-type Abutment × 2, Circular Column type Pier × 1		
Foundation	Spread Type			
Approach Roads	Bardibas Side	185 m	Sindhuli Bazar Side	: 210 m

Bridge Name	Buka Bridge			
Main Bridge	Bridge Length	: 50 m	Effective Width	: 7.5 m
	Superstructure	2 Spans of PC Simple Post-tensioned Girders		
	Substructure	Inverted T-type Abutment × 1, Circular-type Abutment × 1, Wall type Pier × 1		
Foundation	Spread Type			
Approach Roads	Bardibas Side	: 185 m	Sindhuli Bazar Side	: 215 m

Bridge Name	Gadeuli Bridge		
Main Bridge	Bridge Length : 50 m	Effective Width : 7.5 m	
	Superstructure	2 Spans of PC Simple Post-tensioning Girder	
	Substructure	Inverted T-type Abutment × 2, Wall type Pier × 1	
Foundation	Spread Type		
Approach Roads	Bardibas Side : 240 m	Sindhuli Bazar Side : 210 m	

- Construction of 17 Causeways:

No.	Station	Type	Length (m)
1.	STA 172 + 15	Riverbed Level Causeway	60
2.	STA 184 + 50	"	30
3.	STA 194 + 25	"	40
4.	STA 200 + 90	"	40
5.	STA 211 + 93	"	30
6.	STA 217 + 60	"	30
7.	STA 223 + 15	"	30
8.	STA 226 + 80	"	40
9.	STA 229 + 50	"	60
10.	STA 234 + 15	"	60
11.	STA 238 + 95	"	40
12.	STA 246 + 10	"	80
13.	STA 250 + 65	"	80
14.	STA 258 + 150	"	30
15.	STA 260 + 80	"	30
16.	STA 265 + 35	"	80
17.	STA 272 + 30	"	50
Total Length			810

- Supply of Equipment for the Maintenance of the Section I Road:

Item of Equipment	Capacity	Bardibas
Bulldozer	14.0 t	1
Backhoe	0.6 m^3	1
Wheel Loaders	1.4 m^3	2
Crawler Loader	1.5 m^3	1
Dump Trucks	8.0 t	3
Vibratory Roller	4.0 t	1
Truck Crane	5.0 t	1
Motor Graders	2.8 m	1
Plate Compactors	80 kg	3
Diesel Generator	50/60 kVA	1
4-Wheel Jeep	2/5 Passenger 350/150 kg	1
Pickup Trucks	1 t	2
Repair Shop Equipment & Tools	-	1 lot
Spare Parts	-	1 lot

- **Scope of Work by HMG:**

  - To perform maintenance of the road, drainage ditches and bridges from Bardibas to Sindhuli Bazar using equipment provided by Japanese Grant Aid.

  - To improve selected segments of the road.

  - To staff and operate the maintenance repair shop.

On the condition that Japan's Grant Aid will be used for the Project, the detailed design of this Project will be commenced after the Exchange of Notes between the GOJ and the HMG. It will then take about six months for the preparation of the bid documents and the tendering. After evaluation of the bids, the construction contract will be concluded and the construction work will be commenced. The total construction period is estimated to be approximately 19 months.

Based on the basic design study, this Project has been justified as follows:

Sindhuli District, having a population of about 130,000, has only one road connecting it to the East-West Highway. The road has been constructed by DOR using equipment provided in 1982 by the Japanese Grant Aid Program; however, its service level is extremely low because of a lack of bridges and paved surface.

The lack of bridges and the problem of natural disasters such as landslides cause road blockages which isolate the District during the rainy season, thus placing serious hardships on the villagers.

The Project (Section I) consists of the construction of nine bridges with approach roads and 17 causeways in order to make the existing road/traffic conditions safe, especially during the rainy season. This will ensure an adequate transportation line for hauling subsistence commodities and agricultural produce between the East - West Highway and Sindhuli Bazar

Such improvements will not only provide safety for the villagers in Sindhuli District and Ramechhap District, they will also allow the linkage of farms around the Districts and market centres thereby intensifying regional economic gains.

DOR can carry out the maintenance of the Project after its completion because of its strengthened maintenance capability that is included as a part of the Project and due to a lesser requirement for maintaining concrete bridges as compared to steel bridges.

The objectives of the Sindhuli Road Project are consistent with the objectives of the road transport development called for in the Eighth Plan. Also the effects of the Project (Section I) mentioned above fully agree with the policies of the Eighth Plan such as consolidation of regional integration.

The main environmental impact will be that of land acquisition and demolition of some (not many) houses.

The construction period of about 19 months is considered to be reasonable.

Based on the above findings, it is concluded that the Project (Section I) should be implemented under the Japanese Grant Aid Program with the starting date to be at the earliest possible time.

In order to ensure the smooth progress of the Project (Section I) it is recommended DOR undertake the following:

- To establish an efficient organization for implementing the Project.
- To obtain the required land and pay an adequate amount of compensation to the residents and land owners that will be affected by the Project.
- To limit the use of borrow areas (for fill, sand and boulders) in the vicinity of the bridges so that scoring of the riverbed will be avoided.
- To carry out the maintenance and improvement operations planned for Section I.
- To carry out the site inspection immediately after rain and remove any deposits at the causeways.

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Abbreviations

HMG	His Majesty's Government
DOR	Department of Roads
GOJ	Government of Japan
F/S	Feasibility Study
JICA	Japan International Cooperation Agency
A/C	Aftercare Study
DPTC	Disaster Prevention Training Center
DBSD	Double Bituminous Surface Dressing
MRCU	Maintenance and Rehabilitation Coordination Unit
RMSMS	Road Maintenance Strategy and Management System
NRS	National Road Standards
JRA	Japan Road Association
SHB	Specifications for Highway Bridges
PC	Prestressed Concrete
SPT	Standard Penetration Tests
P/Q	Prequalification
A/P	Authorization to Pay
E/N	Exchange of Notes

CHAPTER 1 BACKGROUND OF THE PROJECT

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1.1 General

Kathmandu, the capital of the Kingdom of Nepal as well as being a center of economic and administrative activities, is located in the Kathmandu Valley near the approximate center of Nepal. The Kathmandu Valley has a population of about 1.1 million that is equivalent to approximately 6% of the country's total population.

Nepal is pre-dominantly an agrarian-based country with about ninety percent of the economically-active population working in the agriculture and allied industries. The main agricultural belt of Nepal is the Terai Plain situated along the southern border with India and having an approximate mean width of 30-40 km.

Presently, there are two main highways connecting Kathmandu with the Terai Plain; namely, the Tribhuban Highway and Prithivi Highway. The Prithivi Highway is being used as the main transport route linking Kathmandu and Terai Plain because of it having a two-lane width and a relatively acceptable alignment; however, the Tribhuban Highway (which crosses the Daman Pass at El. 2,300 m) is not used as a main trunk line because of its narrow road width and winding alignment.

Although the Prithivi Highway is a main transport route, it is a roundabout way to travel. For example, the distance from Janakpur in Eastern Terai to Kathmandu is almost 390 km by the existing highway, while the actual straight-line distance is only 130 km. A part of this highway has been recently improved, but the potential risk of interrupting the traffic flow due to landslides or bank erosion still remains.

Taking into account the condition of the present road network linking Kathmandu and the Terai Plain, His Majesty's Government of Nepal (HMG) recognized the necessity to upgrade it and thus formulated the Sindhuli Road Construction Project (the Project). The Project has been planned to connect Bardibas on the East-West Highway with Dhulikhel on the Kodari Road and, when completed, will provide not only economic growth for the area it will also allow for an alternative route from the viewpoint of security.

The Project road is broadly divided into two sections: Section I between Bardibas and Sindhuli Bazar with a total length of 37 km, and Section II between Sindhuli Bazar and Dhulikhel having an approximate length of 118 km.

The existing 2-lane road of Section I has been constructed by the HMG Department of Roads (DOR) using equipment provided in 1982 by the Japanese Grant Aid Program; however, the service level of the road is extremely low because of a lack of bridges and paved surface. In Section II, only foot trails and mule tracks exist except in the 20 km section near Dhulikhel where there is now a gravel road.

In response to a request from HMG for assistance, the Government of Japan (GOJ) decided to conduct a Feasibility Study (F/S) for the Project in 1986. The F/S was carried out by the Japan International Cooperation Agency (JICA) during the period from November 1986 to March 1988 and the Final Report for it was submitted to HMG in June 1988. The Report concluded that the Project is both economically and technically feasible.

Since the construction cost determined in the F/S was of a considerable amount, the efforts taken by HMG to look for possible funding sources were not successful. However, as need for the Project continued to increase, HMG gave high priority to it which was stressed in the "Eighth Plan" (1992-1997) prepared by the National Planning Commission of Nepal in July 1992.

1.2 Outline of the HMG Request and Main Project Components for Sections I & II

Recognizing the importance and necessity of the Project, in April 1992 HMG requested GOJ to provide assistance concerning the following:

A. Review of the Feasibility Study

A review of the F/S was made from the viewpoint of reducing the design standards (including the roadway width, pavement structure, slope protection and bridge width) for Section II of the Project.

B. Construction of Section I

Construction of 15 bridges with approach roads.

C. Procurement of Construction Equipment and Materials for Section II

Procurement of construction equipment, portable asphalt plant, rock crushing plant and maintenance equipment for use by DOR in constructing Section II. Also, the procurement of materials including cement, reinforcement steel, temporary steel bridges, corrugated pipe, wire gabions and rock nets.

D. Procurement of Consultant Services for Section I and Section II

Consultant services are to be procured for the Detailed Engineering Design and Construction Supervision Stages of Section I and Section II.

1.3 Previous Studies and Report

1.3.1 General

The following previous studies and report have been conducted for the Sindhuli Road Construction Project.

- Feasibility Study.

- Aftercare Study.

- Reconnaissance Report on Damages by Heavy Rainfall Along the Proposed Sindhuli Road (July 1993).

Outlines of the contents of above studies and report are summarized in the below sub-sections.

1.3.2 Feasibility Study

A. Basic Concepts

The F/S was carried out in 1988 according to the following concepts:

- The Project road is to be used as an alternative trunk road to connect the Kathmandu Valley and the Terai Plain.

- There is to be a reduction in the maintenance cost for the road.

B. Scope of the Project

The Project road was estimated to be 155 km long and was divided into two sections as follows:

Section I : Improvement of the existing 37 km road between Bardibas and Sindhuli Bazar to include construction of bridges.

Section II : Construction of a 118 km road between Sindhuli Bazar and Dhulikel including bridges.

In addition to the road improvement, the establishment of maintenance training for DOR was recommended for the Project.

C. Design Standards

Road Classification : Class I Trunk Road for both sections

Design Speed
- Section I : 40 km/hr to 50 km/hr
- Section II : 30 km/hr to 40 km/hr

Roadway Width
- Section I : 7.5 m (6.0 carriageway and 2 x 0.75 shoulders)
- Section II : 6.5 m (5.5 carriageway and 2 x 0.50 shoulders)

Road Surface : Asphaltic Concrete

D. Implementation Period

The Project was scheduled to be constructed over an 8-year period and implemented in two phases: Phase-1 (Section I and Section II-1 from Sindhuli Bazar to Khurkot), and Phase-2 (Section II-2 from Khurkot to

Nepalthok and Section II-3 from Nepalthok to Dhulikhel). The construction period for each phase was 5-years with a 1-year overlap between phases.

E. Engineering and Construction Cost in 1988

The estimated engineering and construction cost for the Project in 1988 is as shown below in Table 1.3.1.

Table 1.3.1 Estimated Engineering and Construction Cost in 1988

Unit: Mil.

Item	Phase 1 (Sec. I & Sec. II-1)	Phase 2 (Sec. II-1 & Sec. II-2)	Total
Construction Cost	NR 1,204	NR 1,893	NR 3,097
Physical Contingency	NR 181	NR 284	NR 465
Engineering Services	NR 120	NR 189	NR 309
Sub-total	NR 1,505	NR 2,366	NR 3,871
(Yen Equivalent):	(¥9,316)	(¥14,645)	(¥23,961)

US$1.0 = ¥130.0 = NRs. 21.0 (as of January 1988)

F. Project Feasibility

It was concluded that the Project was technically and economically feasible for constructing a 2-lane paved road having a total length of 155 km, with the highest internal rate of return (IRR) being 9.88%.

1.3.3 Aftercare Study

A. General

As mentioned earlier, in response to a request from the HMG, the GOJ decided to have JICA conduct an A/C Study for the Project. The objective of this Study was to establish practical and realistic development schemes, and to formulate an implementation program for the optimum development scheme based on a review of the previous F/S report carried out by JICA in 1988.

For this purpose, the A/C Study included a comparative analysis of two basic alternatives (single lane and double lane) in conjunction with several other alternatives in terms of pavement and bridges in order to select the optimum development scheme. The A/C Study covered the following sections.

Section I	:	Review of the F/S and the preliminary design of the road, bridges and causeways between Bardibas and Sindhuli Bazar.
Section II	:	Review of the F/S with the conclusion (among other things) that a large part of the road needs to be realigned as well as to perform the preliminary design of the road, bridges and causeways between Sindhuli Bazar and Dhulikhel.

The conclusions and recommendations presented in the A/C Study were formulated only after a thorough evaluation of all pertinent data and activities such as traffic forecast, field reconnaissance, environmental impact assessment, formulation of the development scheme alternatives, preliminary design, construction planning, maintenance formation, cost estimate and establishment of a tentative implementation program. The A/C Study also included an assessment of the need to initiate the Project within the earliest possible time.

B. Formulation of Development Scheme and Alternatives for the Project

In formulating the development scheme, the following basic concepts for the design were applied:

- Application of a minimal development scheme by applying stage-wise construction methods as well as reduction of the carriageway width and to use causeways in place of some bridges. The causeways (which require adequate maintenance in the rainy season) are to be used as a river-crossing structure on the condition that the strengthening of DOR's maintenance capabilities are included in the scope of the Project.

- Consideration for further improvement by widening of the trunk road during the 2nd stage.

- Maximum usage of local materials, and using construction methods suitable for the site conditions.

Taking into account the basic concepts to be applied, five alternatives were established in the A/C Study for the Project as listed in Table 1.3.2.

Table 1.3.2 Alternatives Presented in Aftercare Study

Alternatives		Nos. of Lanes	Type of Surface	River Crossing Structure		Slope Protection
				Bridges	Causeways /1	
ALT-1	1st Stage	1 lane	Gravel	4 m/4 m /2	Temporary	Minimum
	2nd Stage	2 lanes	Macadam	Add'l 4/4 /2	Replaced	Full Const
ALT-2	1st Stage	1 lane	Gravel	4.75/6.5 m /3	Temporary	Minimum
	2nd Stage	2 lanes	Macadam	Widened	Replaced	Full Const
ALT-3	1st Stage	1 lane	Macadam	4 m/4 m /2	Temporary	Minimum
	2nd Stage	2 lanes	Widening	Add'l 4/4 /2	Replaced	Full Const
ALT-4	1st Stage	1 lane	Macadam	4.75/6.5 m /3	Temporary	Minimum
	2nd Stage	2 lanes	Widening	Widened	Replaced	Full Const
ALT-5	Full	2 lanes	Macadam	2 Lane Br.	2 Lane Br.	Full Const

Notes: ALT-1 through ALT-4 are to be done by stage construction.
ALT-5 is a full-scale construction plan (without stages).

/1 Most of the causeways installed in the first stage are later to be replaced by 2-lane bridges in the 2nd stage.

/2 This will be a single lane bridge with a 4 m wide superstructure and a 4 m wide substructure.

/3 This will be a single lane bridge with a 4.75 m wide superstructure but having a 6.5 m substructure (to provide for future widening).

C. Evaluation of Alternatives

The results of the preliminary design, construction planning and schedule, cost estimate and Project evaluation carried out for the above alternatives are summarized in Table 1.3.3.

Table 1.3.3 Project Evaluation of A/C Study Alternatives

Alternatives		Const. Period	Est. Construction Cost		Economic IRR	Selection of Alternative
			Mil. NRs	(Mil. Yen)/1		
Alt-1	1st	5 years	3,562	(8,940)	4.19	Selected
	2nd	4 years	5,128	(12,870)	8.08	
Alt-2	1st	5 years	3,791	(9,520)	4.32	Discarded
	2nd	4 years	4,888	(12,270)	8.24	
Alt-3	1st	5 years	4,181	(10,490)	6.74	Discarded
	2nd	4 years	4,633	(11,630)	8.51	
Alt-4	1st	5 years	4,410	(11,070)	7.05	Discarded
	2nd	4 years	4,449	(11,170)	8.78	
Alt-5	Full	7 years	7,566	(18,990)	8.45	Discarded

US$1.0 = ¥115.08 = NR 49.88 (as of March 1993)

/1 Equivalent cost only (not in addition to NR).

Alternative-5, which is for full construction, is considered inferior to stage-wise construction. Among the other stage-wise construction alternatives, Alternative-1 was selected as the most desirable development scheme (in spite of a low IRR) considering the low cost of principle and the comparative extent of indirect benefits derived from the alternatives.

D. Implementation Program for Alternative-1

The implementation program for Alternative-1 was prepared taking into consideration the following assumptions and conditions:

- The 2nd stage construction shall be completed in order to cope with the increased traffic demand.

- Preparatory works including land/house acquisition shall be done before commencing the construction work.

- The Project is to be implemented with assistance of foreign aid.

- Participation of DOR by means of Force Account during the construction, aiming at self-reliance as well as the technology transfer (i.e. DOR being given some small segments of the road to construct with training being provided by the consultant and contractor).

- Strengthening of DOR's maintenance capabilities including construction of maintenance offices/shops and supply of materials and equipment shall be included as a part of the Project.

An implementation program having a 7-year construction period was established based on the above conditions.

E. Estimated Project Cost

The total Project cost that was estimated as of March 1993 is presented below.

Table 1.3.4 Estimated Project Cost Based on the Aftercare Study

A. Funds to be Covered by Foreign Aid	Mil. NRs.	(Mil. Yen Equivalent)
A-1 Construction Cost	3,500	(8,790)
A-2 Materials/Equipment for Use by DOR Force Account Construction of Section I	48	(120)
A-3 DOR Maintenance Cost	78	(196)
A-4 Materials/Equipment for DOR Maintenance	231	(580)
A-5 Engineering Services	352	(883)
A-6 Contingency (10% of Const. Cost)	350	(880)
Total	4,559	(11,442)

B. Funds to be Covered by HMG Budget	Mil. NRs.
B-1 Construction by DOR (Force Account)	24
B-2 Land/House Acquisition	279
B-3 Environmental Clearance Arrangement	20
Total	323

Exchange rate: US$1.0 = NRs. 45.88 = ¥115 (or NRs. 1.0 = ¥2.51) as of March 1993

1.3.4 Reconnaissance Report for Sindhuli Road After Heavy Rainfall in July 1993

After submission of the Final Report for the Aftercare Study, exceptionally heavy rains hit the southern part of the Central and Eastern Regions of Nepal on 20 and 21 July 1993. The heaviest rainfalls were recorded in the Bagmati and the Rapti River catchment areas.

The heavy rains and floods caused widespread damage to roads, irrigation works, a hydroelectric station and other social infrastructure. Moreover, the Terai Plain was totally isolated for about 20 days (July 20 - August 9) from Kathmandu and the rest of the country as the two major highways (Tribhuban and Prithvi) linking the Plain with Kathmandu were severely damaged.

It was also reported that Sindhuli and Kavre Districts, where the proposed alignment of the Project road passes through steep topography and fragile geology, were affected by the rain and floods. The extent of such heavy rains can be realized by noting that the Sindhuli Gadhi rainfall station (No. 1107) in Sindhuli District recorded a maximum rainfall of 403 mm on 21 July 1993, while at Tistung the daily rainfall of 540 mm on 20 July 1993 was the highest ever recorded in Nepal.

As a result, it was recognized that there is a necessity to identify and assess the damages/disasters caused by heavy rainfall and flooding of the topography and geology along the proposed alignment before the Project can proceed into the next stage. Subsequently, a reconnaissance team consisting of two engineers from DOR, two specialists from the Disaster Prevention Training Center (DPTC) and two experts from the Consultant (Nippon Koei) was organized with the following study objectives:

- To observe the extent and type of the damages to the proposed alignment.
- To determine the damage to the geology along the existing roadway.
- To assess the amount of damages and failures.
- To check the stability of the proposed alignment after the heavy rains.
- To recommend countermeasures for the identified damaged areas and for possible damages that could occur after construction of the Project.

The Team's findings are summarized as follows:

- The heavy rainfall on 20 and 21 July 1993 hit both Section I and Section II-1 of the Project road.

- Newly identified damages were observed at 113 spots along the proposed alignment of Sindhuli Road during the last monsoon. Out of this total, there were 11 seriously damaged sections requiring additional countermeasures.

- Section I had no serious damages except for the two sections that suffered damages requiring appropriate countermeasures for the slope failure and pebble type debris flow.

- Section II-1 suffered serious damages at eight places which required countermeasures.

- Section II-2 suffered serious damages requiring countermeasure at one station.

- Damage at two places along Section II-1 were serious enough to require a realignment of the road.

- At Section II-3, no serious damages were found.

- The causeway design for Section I has to be reviewed taking into account the tendency of the riverbed to change during flooding.

After the field information was obtained, a Reconnaissance Report was prepared. A summary of the recommendations from the Reconnaissance Report is as follows:

- To implement the proposed Project at the earliest time.
- To incorporate the results of the reconnaissance into a further study.
- To strengthen DOR's maintenance capabilities for the Project road.

1.4 Basic Design Study

As a result of the A/C Study, JICA has now prepared a Basic Design aims to formulate the Project (Section I) scheme. Details pertaining to there are included in Chapter 4.

CHAPTER 2 FORMULATION OF THE PROJECT (SECTIONS I AND II) UNDER JAPANESE GRANT AID

CHAPTER 2 FORMULATION OF THE PROJECT (SECTIONS I AND II) UNDER JAPANESE GRANT AID

2.1 General

A practical and realistic development scheme and implementation program was established in the Aftercare Study; however, on the condition that the Project is implemented under a Japanese Grant Aid Program, the development scheme and implementation program is required to be further studied and examined.

As such, the development scheme and implementation program have now been refined in such a manner to be compatible with the Japanese Grant Aid Program. An outline of this is presented herein.

2.2 Objectives of the Sindhuli Road Construction Project

The objectives of the Sindhuli Road Construction Project are as follows:

- To use it as an alternative trunk road in the function of serving as a "second backbone" to enhance security, economic growth and expansion in the Kathmandu Valley.

- To reduce the travel distance as well as time for all the traffic between the Kathmandu Valley and the Eastern Terai Plain, especially the traffic transporting agricultural products.

- To upgrade and stimulate social and economic activities as well as to satisfy the basic human needs of the villagers living in the remote hill areas of the Central Development Region, particularly in the Sindhuli, Ramechhap and Kavrepalanchok Districts.

2.3 Issues of the Project under Japanese Grant Aid

2.3.1 General

A. Conditions for Japanese Grant Aid Program

Projects to be implemented under a Japan Grant Aid Program should be formulated with following conditions:

- The construction should be completed within a limited period. Usually, the maximum period is five fiscal years.

- The scope of work should be fixed.

- The expenditures for all of the fiscal years should be approximately balanced.

- The construction cost should be fixed.

- The country's own work forces should be organized to carry out the maintenance of the Project after its completion.

B. Issues Affecting the Project Implementation

Taking into account the above conditions, the Project has the following issues to be considered regarding it implementation:

- A long construction period, even by following a minimal development scheme.

- An inadequate DOR maintenance force.

- A risk for expansion of the scope of work.

- A risk for extending the construction period.

The development scheme and implementation program for the Project should therefore be formulated to provide solutions for the above issues, as discussed in the following sub-sections.

2.3.2 Long Construction Period

A seven-year implementation program was proposed in the A/C Study report, but the construction period implemented by Japanese Grant Aid should preferably be within five years. As such, it is recommendable to divide the Project to shorten the construction period by introducing the stage-wise construction method.

2.3.3 Inadequate DOR Maintenance Force

As recommend in the A/C Study report, the development scheme was formulated on condition that the road and bridges would be maintained in order to secure the construction investment and to provide road serviceability. It is therefore absolutely necessary to carry out the inspection and maintenance of each completed segment on a DOR Force Account basis.

However, there are no DOR maintenance offices at present in the Sindhuli and Kabhre Districts through which nearly 90% of the Sindhuli road passes. To make matters worse, the DOR maintenance budget is very limited and DOR has not enough equipment to perform the type of road maintenance that is required.

In view of the above situation, it is recommended that the upgrading of DOR's maintenance operations for the Sindhuli Road be included within the scope of work for the Project.

2.3.4 Risk for Expansion of the Scope of Work

The expansion of the scope of work can occur by the following causes:

(1) Disasters such as landslide, slope failure, and debris flow that occur along the completed and handing over sections.

(2) Additional work that HMG may want to have undertaken such as improvement of the existing drainage system.

(3) Change of the conditions such as due to differences between the design conditions and the site conditions such as subsurface, etc.

The additional cost that could result by expanding the scope of work due to above Causes (1) and (2) should be borne by HMG because an alteration of the scope of work is not allowed in the Japanese Grant Aid system, and thus the HMG budget should cover all of this.

It is required to identify and estimate the cost for any possible additional work due to Cause (2) before the commencement of the Project, especially on Section II, so as to fix the scope of work and budget for both Japanese Grant Aid and HMG. On that point, the strengthening of DOR's maintenance capabilities for the Project should be established simultaneously with the construction as such action will eventually assist in reducing the overall HMG expenditures.

Concerning above Cause (3), a careful engineering field investigation before commencement of the Project will help to keep changed conditions to a minimum, but in the event they do occur HMG will be required to cope with and/or to carry out any additional land acquisition that may be needed for such changes.

2.3.5 Risk for Extension of the Construction Period

The Project could be extended for several reasons but, since the Grant Aid Program does not allow this, HMG must take steps to prevent unnecessary time extensions from happening such as to ensure no delays are caused regarding land acquisition, approval of official correspondence, payments, importation of needed construction equipment/materials, etc.

2.4 Basic Concepts in Formulating a Development Scheme

2.4.1 General

According to the A/C Study report and considering that the Project implementation will be under Japanese Grant Aid, the basic concepts in the following sub-sections have been applied in formulating a realistic development scheme. Such scheme also takes into account the objectives of the Project, environmental impact and reduction of the construction cost.

2.4.2 Introduction of Staggered Construction Schedule for the Project

In view of the expected function of the Project road, (i.e. alternative trunk road having the shortest transportation route connecting Kathmandu Valley and Eastern Terai Plain), it is beneficial that the entire section of the Project route be built under a full-scale construction schedule; however, the staggered concept (i.e. segment-by-segment) has to be considered from a practical viewpoint as mentioned in Section 2.3.

2.4.3 Introduction of Stage-Wise Construction for Section II

The function of the road to serve as a National Highway and the traffic demand forecasts included with the A/C Study lead to the requirement of a double lane road in principle. Even so, a single lane road that can be widened to a double lane in the future should be applied for Section II of the Project taking into account the initial traffic volume, minimizing adverse environmental effects and construction cost as well as its early opening to the traffic.

The concept of an all-weather road is normally introduced in accordance with the requirements of a National Highway, but this concept has not been fully applied for the Project in the first part of the stage-wise construction in order to reduce the construction cost.

For example, low cost river crossing structures such as causeways have been applied in the initial part of the stage-wise construction. Later, when the road is to be widened in the second part of the stage-wise construction, the causeways are to be replaced by bridges, and at the same time full-scale slope protection can be constructed.

2.4.4 Approach to Minimize Environmental Impact

Since most of the route passes through steep slopes and on fragile geology, the construction of the road can cause a massive interference with the environment and should thus be undertaken with care.

As such, it is useful to apply a similar approach toward the Project construction as was successfully utilized in the recently completed Lamosangu - Jiri Road Project.

This concept will be reflected especially in selecting the route alignment, balancing the cut and fill volumes and in designing the slope protection work.

2.4.5 Maximum Usage of Locally Available Materials

Huge amounts of boulders, cobblestones and sand have been deposited on the riverbeds that cross the route. The concept with regard to maximum usage of these available materials without special treatment being required leads to using gabion and masonry structures instead of reinforced concrete structures that were called for in the F/S, and this consequently results in considerable cost savings.

Furthermore, planting of vegetation of the type developed from a bio-engineering viewpoint on the Dharan-Dhankuta Road Project should be applied for stabilizing slopes as much as possible.

2.4.6 Strengthening DOR Maintenance Capabilities

At present, there are no DOR maintenance offices in the Sindhuli and Kavre Palanchok Districts through which most of the proposed route passes. However, the Project will require routine inspection and maintenance work such as removal of falling debris, cleaning out side ditches, repairing potholes, etc.

It is therefore necessary to establish new maintenance offices/shops at several locations along the route. A maintenance program with the above requirements should be formulated as a part of the implementation program so that it is accomplished simultaneously with the construction of the Project.

2.4.7 Timely Transfer of Each Completed Stretch to DOR for Maintenance

Because the villagers have been waiting a long time for the road, each completed stretch should be transferred to DOR and be opened to the public at the earliest possible time. In such case though, DOR will have to maintain the stretch transferred by means of a strengthened maintenance capability.

2.4.8 DOR Force Account to Perform Maintenance

Further to what has been discussed above in Sections 2.4.6 and 2.4.7, it is recommended to have DOR utilize the Force Account System to start maintaining the stretches of the road as soon as each one is completed by the contractor.

2.5 Main Features of the Project Road

2.5.1 General

Based on the concepts in formulating the development scheme and as outlined in the A/C Study, the main features of the Project road are presented below in the following sub-sections.

2.5.1 Design Standards

The design criteria to be applied for the Project road is based on NRS 2027 except where it is not clear; then, the Japan Road Standards published by the JRA are to be applied.

As mentioned in the A/C Study, the design speed and road width are established taking into account not only the requirements stipulated in the standards, but also the terrain through which the Project road runs.

The geometric design criteria to be applied to the Project road are tabulated in Table 2.5.1.

Table 2.5.1 Geometric Design Criteria

Geometric Elements	Classification of Terrain		
	Flat/Rolling	Mountainous	Extremely Steep Section
Design Speed (km/hr)	40-50	30-40 (20) L[1]	20
Superelevation (%)	2 (4) L[2]	2 (4) L[2]	2 (4) L[2]
Max. Superelevation (%)	10	10	10
Minimum Radius (m)	70 (at 50 km/hr) 45 (at 45 km/hr)	45 (at 40 km/hr) 25 (at 30 km/hr) 10 (at 20 km/hr) L[3]	
Maximum Gradient (%)	6	9	9

Notes:

L[1] : The design speed of 20 km/hr shall be adopted as an exceptional case for: (i) the sections where hairpin bends are planed in mountainous area, and (ii) the sections where the alignment will be shifted to the mountain side to alter minor bridges to slab culverts.

L[2] : The superelevation of 4% shall be applicable to all gravel roads.

L[3] : The minimum radius of 10 m shall be only applicable to the hairpin bend sections.

2.5.2 Typical Road Cross-sections

Following the basic design concepts and according to the A/C Study, the road in Section I will have a double lane, while the road in Section II will have single lane for the initial part of the stage-wise construction. In the sections where topography is extremely steep and/or geology is very fragile, a minimal width of 4.0 m will be applied as an exceptional case. Typical cross-sections for Section I and Section II are shown below.

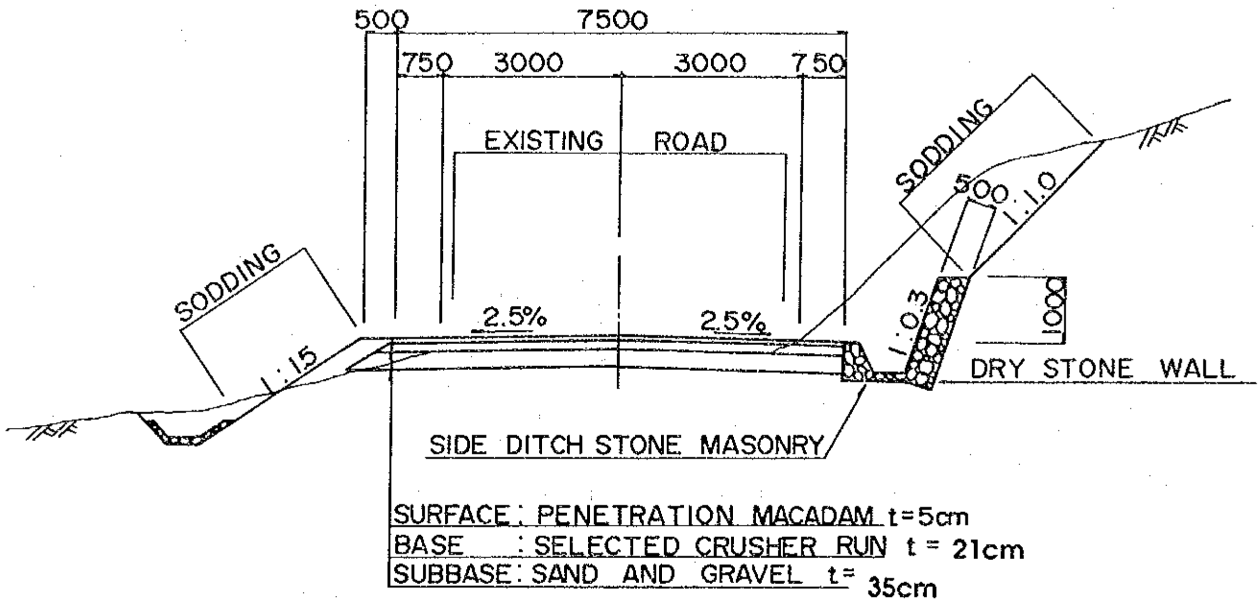


Figure 2.5.1 Typical Cross-section for Section I

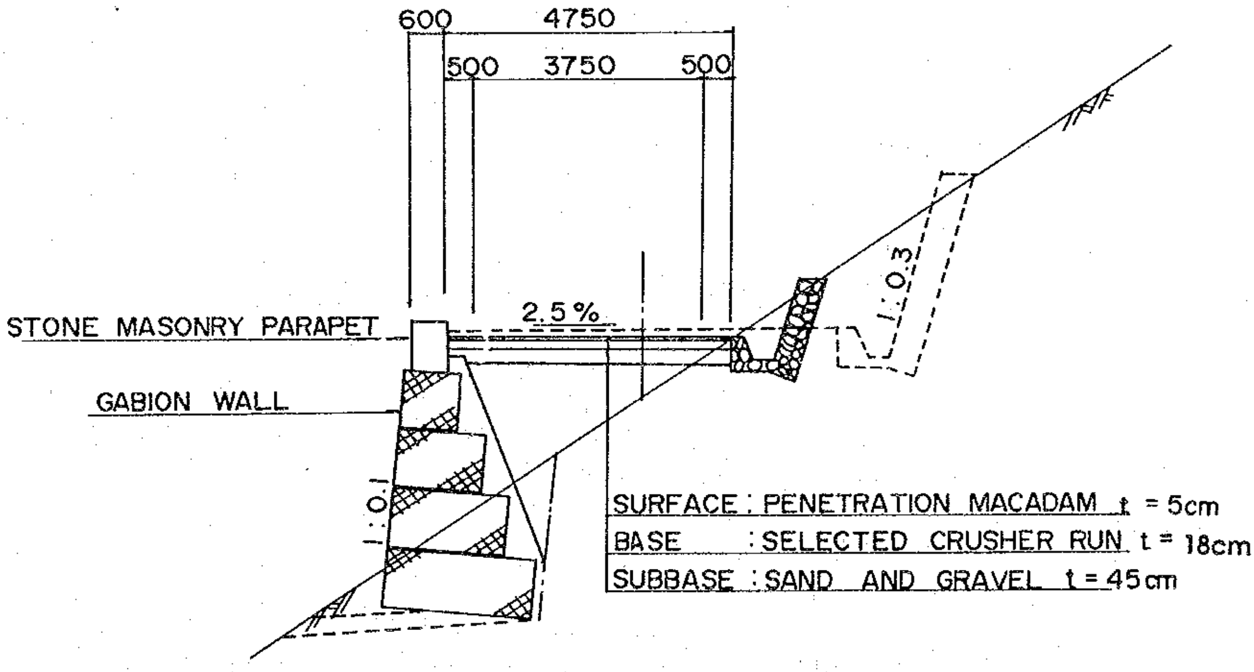


Figure 2.5.2 Typical Cross-section for Section II (Normal Case)

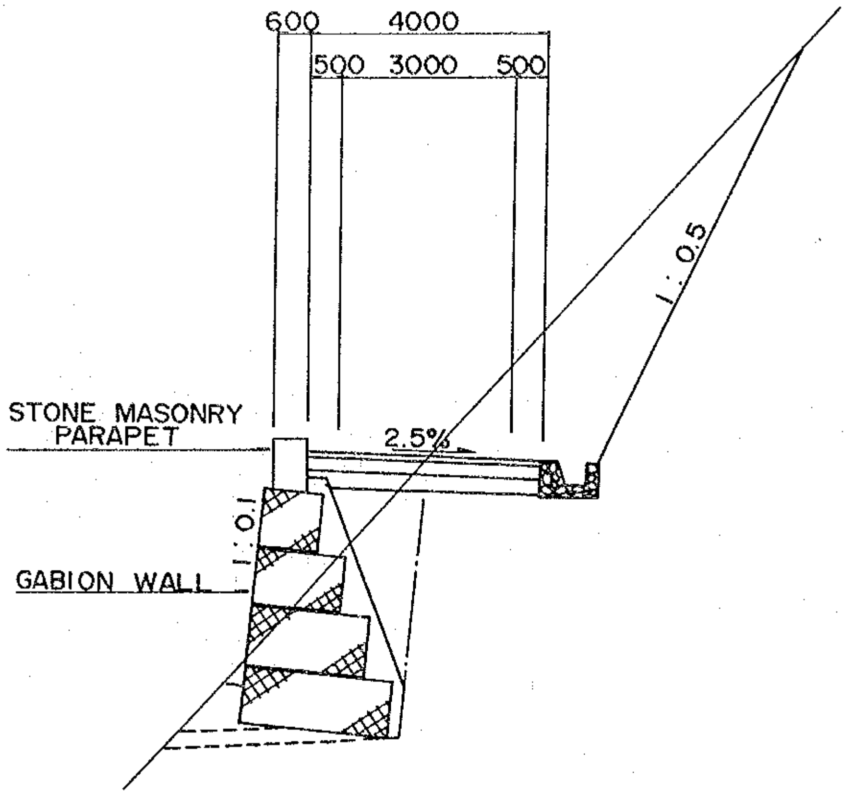


Figure 2.5.3 Typical Cross-section for Section II (Exceptional Case)

2.5.3 Road Alignment

The Project road alignment will follow the one outlined in the A/C Study except for the two sections which require realignment due to the landslides in which occurred July 1993 (as recommend in the Reconnaissance Report).

2.5.4 Retaining and Breast Walls, Slope Protection and Drainage Structures

Retaining and breast walls, slope protection and drainage structures to be constructed for the Project will be of the type presented in the A/C Study and recommendations in the Reconnaissance Report.

2.5.5 Pavement

In the A/C Study, gravel surface and penetration macadam surface were both considered, with the gravel surface being selected from an economical viewpoint.

In this regard, it is recommendable that penetration macadam pavement be selected taking into account the relatively steep grades, riding comfortability, lower maintenance cost, environmental aspects and safety.

The pavement structures to be applied for Section I and Section II are shown in Figure 2.5.4.

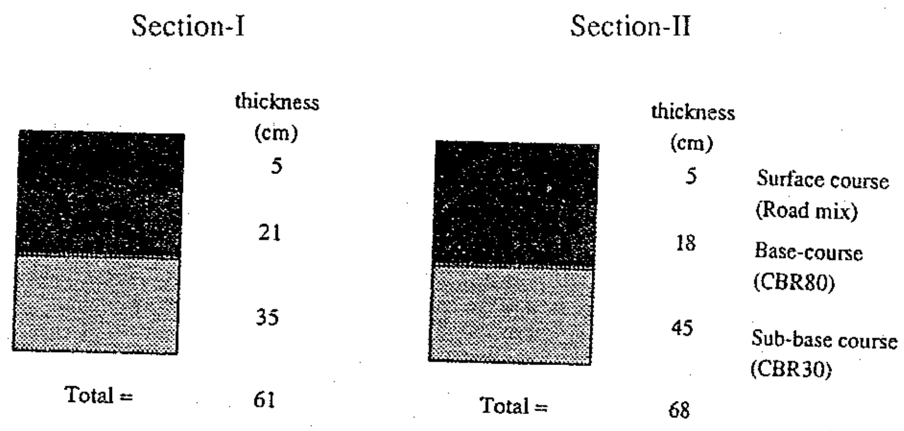


Figure 2.5.4 Pavement Structures for Sections I & II

2.5.6 Major River Crossing Structures

River crossing structures are broadly divided into causeways and bridges. The former have been applied to the rivers and creeks that experience flash floods while the latter are applied to those sites where the causeways cannot cope with the conditions such as flood duration, frequency and level. Details pertaining to the causeways and bridges are given below.

A. Causeways

According to the A/C Study, three types of causeways were considered: Riverbed Level Causeway, Vent Causeway, and Submersible Bridge type as shown in Figure 2.5.5. These will be constructed for the Project road at the sites as described in Table 2.5.2.

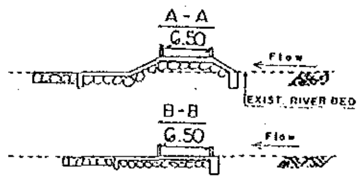
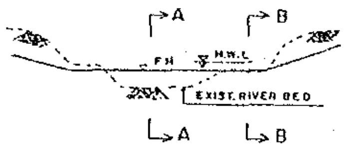
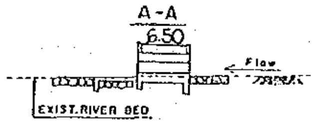
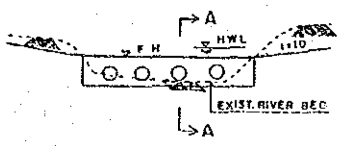
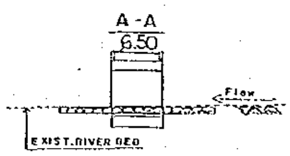
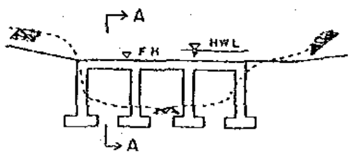
Type of Causeway	Profile	Cross Section
Riverbed Level Causeway		
Vented Causeway		
Submersible Bridge		

Figure 2.5.5 Typical Cross-sections of Causeways

Table 2.5.2 Applicable Criteria of Causeway

Parameters	Application Criteria					
Type of Causeway	Flood Run-off	Velocity of Flow	Flood Depth	Duration of Flood	Floating Debris	Profile
Bed Level Causeway	Small to medium	Fast	Shallow	Short	A little or considerable	Generally flat
Vented Causeway	Small to medium	Slow to fast	Shallow to Deep	Short	A little	Flat
Submersible Bridge	Considerable	Slow to fast	Considerably deep	Relatively short	A little or considerably	Eroded section

B. Bridges

(1) Bridges in Section I

The bridges in Section I should be double lane types having 7.5 m widths, which is the same as the road width and are thus required from a safety viewpoint. The standard cross-section of the bridges to be constructed in Section I is as shown in Figure 2.5.6.

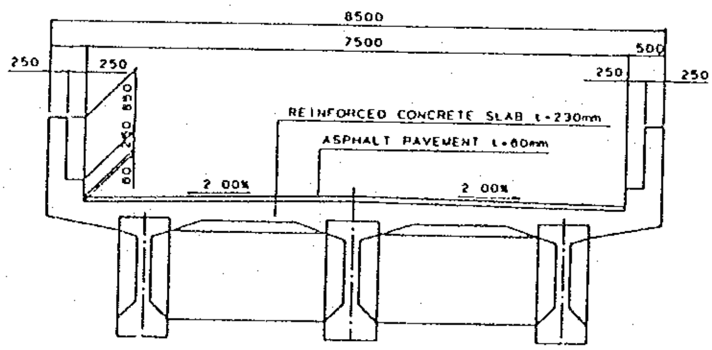


Figure 2.5.6 Standard Cross-section of Bridges for Section I

(2) Bridges in Section II

The traffic demand of the Sindhuli Road in the year 2010 is estimated to be about 6,600 PCU per day and that is out of capacity for a single lane road. Therefore, the bridge design in Section II will be carried out taking into consideration the widening to two lanes in the future.

2.6 Strengthening of DOR's Maintenance Capabilities

2.6.1 General

As stated in Sections 2.4.6 and 2.4.7 and the A/C Study, the DOR's maintenance capabilities must be strengthened. Details pertaining to this are provided in the following sub-sections.

2.6.2 Establishment of DOR Maintenance Offices and Workshops

According to the A/C Study, the DOR maintenance offices and workshops will be established at locations shown in Figure 2.6.1.

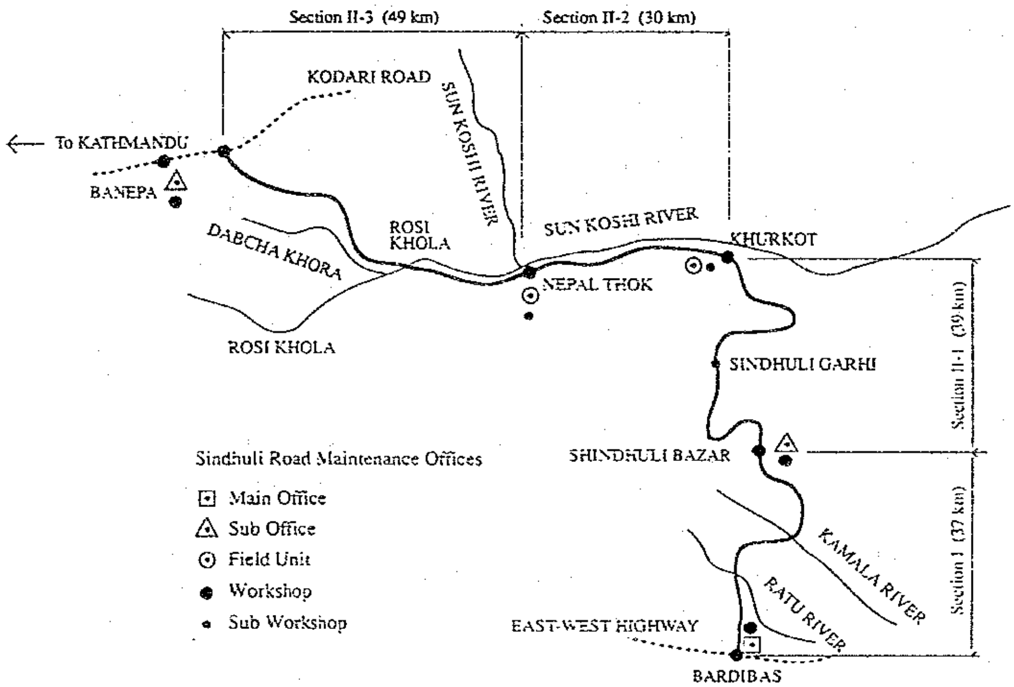


Figure 2.6.1 Locations of the DOR Maintenance Offices and Workshops

2.6.3 Scope of Maintenance Work

A. Scope of Maintenance Work

The scope of maintenance work for the Project is as shown below:

Table 2.6.1 Scope of Maintenance Work

Types of Maintenance and Work Items	Method /1
Routine Maintenance	
- Pothole Patching	MP
- Cleaning of Ditches and Culverts	MM&MP
- Removal of Deposits on Road & Causeways	MM&MP
- Regravelling of Road	MM&MP
- Minor Repairs of Stone Masonry, Gabions, etc.	MP
- Sodding and Replanting	MP
Periodic Maintenance	
- Overlay by DBST	MM&MP
- Repainting of Steel Bridges	MP
- Replacement of Expansion Joints	MP
- Replacement/Repair of Deteriorated Structures	MM&MP
Emergency Maintenance	
- Removal of Landslide Materials	MM&MP
- Slope Stabilization Work	MM&MP
- Restoration of Road Failures	MM&MP
- Repairs to Road & Causeways After Flooding	MM&MP

/1 MP: Manpower
MM: Mechanical Method

B. Estimated Quantities for Types of Maintenance Work

The quantities estimated for the various types of maintenance work are listed below.

(1) Removal of Earth and Rocks on the Road

According to a Mult-Agency Seminar Paper, it is reported that landslide deposit average 400 to 700 $cu.m^3$ per km per year on the hill roads in Nepal. The work quantities are therefore estimated as follows:

158 km times 700 cu.m/km/year = 110,600 cu.m

(2) Removal of Sediment Materials at Causeways

The required work volume for the 36 causeways is estimated at 36,000 cu.m per year, based on a sediment volume of 250 cu.m per place and it to be carried out four times per year at each of the causeways.

(3) Removal of Sediment Materials from the Drainage Ditches

It is difficult to estimate the required work volume for the drainage ditches running along the sides the road; however, the amount and type of maintenance equipment planned for the Project should be adequate to meet the needs for maintaining all 158 km of the road length.

(4) Repair and Rehabilitation of the Road

The repair work to be performed includes hauling and dumping of gravel along the road's surface and then grading and compacting it. Also, to rehabilitate the road (by DBST) and rebuild deteriorated structures.

As in the case of (3) above, it is difficult to estimate the required work volume quantitatively; however, the planned equipment should be enough to meet the needs for repairing the entire Project road.

(5) Other Types of Maintenance Work

Other types of maintenance work are transportation of rubble masonry stones to required locations to repair gabions and slope protection, patching potholes, etc.

2.6.4 Required Maintenance Equipment for DOR Offices

The equipment required for DOR to perform maintenance is classified into the following two categories.

- Maintenance equipment
- Equipment and tools for repair shops

A. Maintenance Equipment

This equipment should be selected based on consideration the following factors:

- To meet the required maintenance work.
- To repair the equipment by the DOR maintenance staff.
- To have a readily available supply of spare parts and tools.

Considering the above factors and the estimated work quantities, the equipment shown in Table 2.6.2 has been selected for the maintenance work:

Table 2.6.2 List of Maintenance Equipment and Capacities

Type of Work	Equipment	Capacity	Number
Excavation/Hauling	Bulldozers	14.0 t	2
Excavation/Loading	Backhoes	0.6 m^3	3
Excavation/Loading	Wheel Loaders	1.4 m^3	5
Excavation/Loading	Crawler Loaders	1.5 m^3	2
Hauling	Dump Trucks	8.0 t	11
Compaction	Vibratory Rollers	4.0 t	5
Production of Aggregate	Portable Rock Crushing Plants	10 t/hr	2
Production of Concrete	Concrete Mixers	0.3 m^3	5
Lifting	Truck Cranes	5 t	5
Grading	Motor Graders	2.8 m	5
Compaction	Plate Compactors	80 kg	12
Transportation	4-Wheel Jeeps	2/5 passenger	10
Power Supply	Generators	60 kVA	8

The following Table 2.6.3 shows the type of equipment to be assigned to and located at the DOR maintenance offices and repair shops.

Table 2.6.3 Equipment for DOR Maintenance Offices

Equipment and Capacity	Bardibas	Sindhuli Bazar	Benepa	Khurkot	Nepalthok	Total
Bulldozers, 14 t	1		1			2
Backhoes, 0.6 m^3	1	1	1			3
Wheel Loaders, 1.4 m^3	1	1	1	1	1	5
Crawler Loaders, 1.5 m^3	1		1			2
Dump Trucks, 8.0 t	3	3	3	1	1	11
Vibratory Rollers, 4.0 t	1	1	1	1	1	5
Portable Rock Crushing Plants, 10 t/hr		1			1	2
Concrete Mixers, 0.3 m^3	1	1	1	1	1	5
Truck Cranes, 5 t	1	1	1	1	1	5
Motor Graders, 2.8 m	1	1	1	1	1	5
Plate Compactors, 80 kg	3	2	3	2	2	12
4-Wheel Jeeps, 2/5passenger	3	2	3	1	1	10
Generators, 60 kVA	2	2	2	1	1	8

B. Equipment and Tools for DOR Repair Shops

After the equipment has been received and placed in operation, it will have to be maintained by DOR repair shops. The equipment and tools required for these repair shops are listed in Table 2.6.4.

Table 2.6.4 List of Equipment and Tools for DOR Repair Shops

Equipment/Tools	Bardibas	Sindhuli Bazar	Banepa	Khurkot	Nepalthok	Total
Gas Welding Sets	1	1	1	1	1	5
Arc Welding Sets	1	1	1	1	1	5
Gear Pullers	1	1	1	1	1	5
Drilling Machines	1	1	1	1	1	5
Electric Grinders	1	1	1	1	1	5
Portable Air Compressors	1	1	1	1	1	5
Vices	2	2	2	1	1	8
Chain Blocks	1	1	1	1	1	5
Hydraulic Jacks	1	1	1	1	1	5
Compression Gauges	1	1	1	1	1	5
Revolution Indicators	1	1	1	1	1	5
Thickness Gauges	1	1	1	1	1	5
Hydraulic Meters	1	1	1	1	1	5
Current Meters	1	1	1	1	1	5
Voltage Meters	1	1	1	1	1	5
Tool Sets for Vehicle Repair	2	2	2	1	1	8
Tools for Construction Equipment Repair	2	2	2	1	1	8
Tools Sets for Tire Repair	1	1	1	1	1	5
Battery Chargers	1	1	1	1	1	5

2.7 Executing Agency and Operational Structure

The DOR will serve as the implementing agency for the Project and as such the Sindhuli Road Construction Project will be under the Director General of DOR. The current DOR organization chart is depicted in Figure 2.7.1.

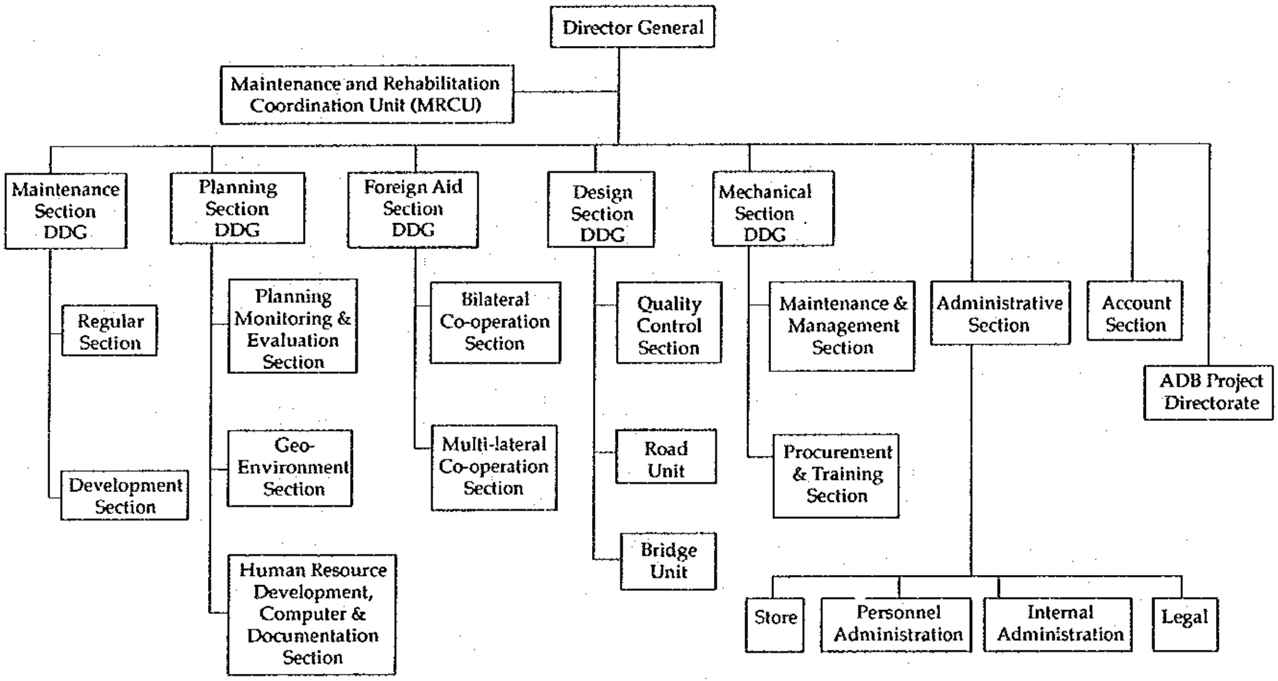


Figure 2.7.1 Organization Chart for DOR as of 1994

The Project will be implemented by means of two DOR sections: The Construction Section and the Maintenance Section, both of which will be under a common DOR Project Manager.

The DOR Construction Section will be responsible to supervise the construction of Section I and Section II while the actual construction work will be undertaken by a Japanese contractor.

The DOR Maintenance Section will carry out maintenance for each segment of the road as it is transferred from the contractor. This will be done on a DOR Force Account basis.

The organization chart for the Project implementation is shown in Figure 2.7.2.

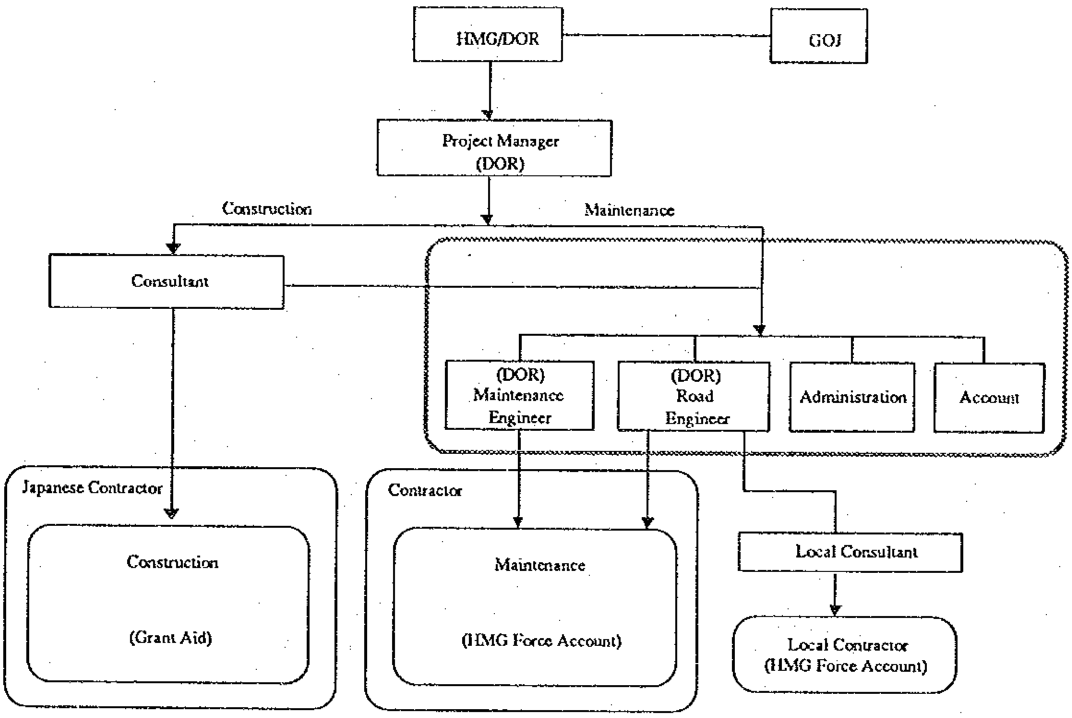


Figure 2.7.2 Organization Chart for the Project Implementation

The Interrelation of the DOR Maintenance Offices and the staffing of each office are recommended as shown in Figure 2.7.3 and Figure 2.7.4, respectively.

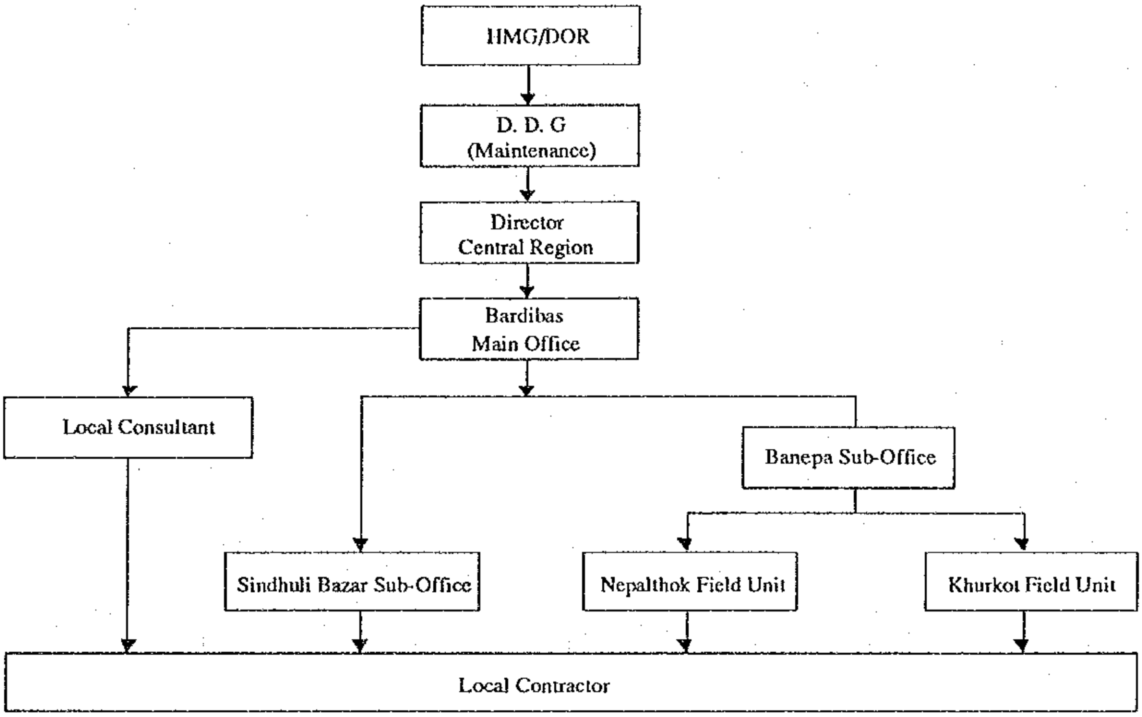


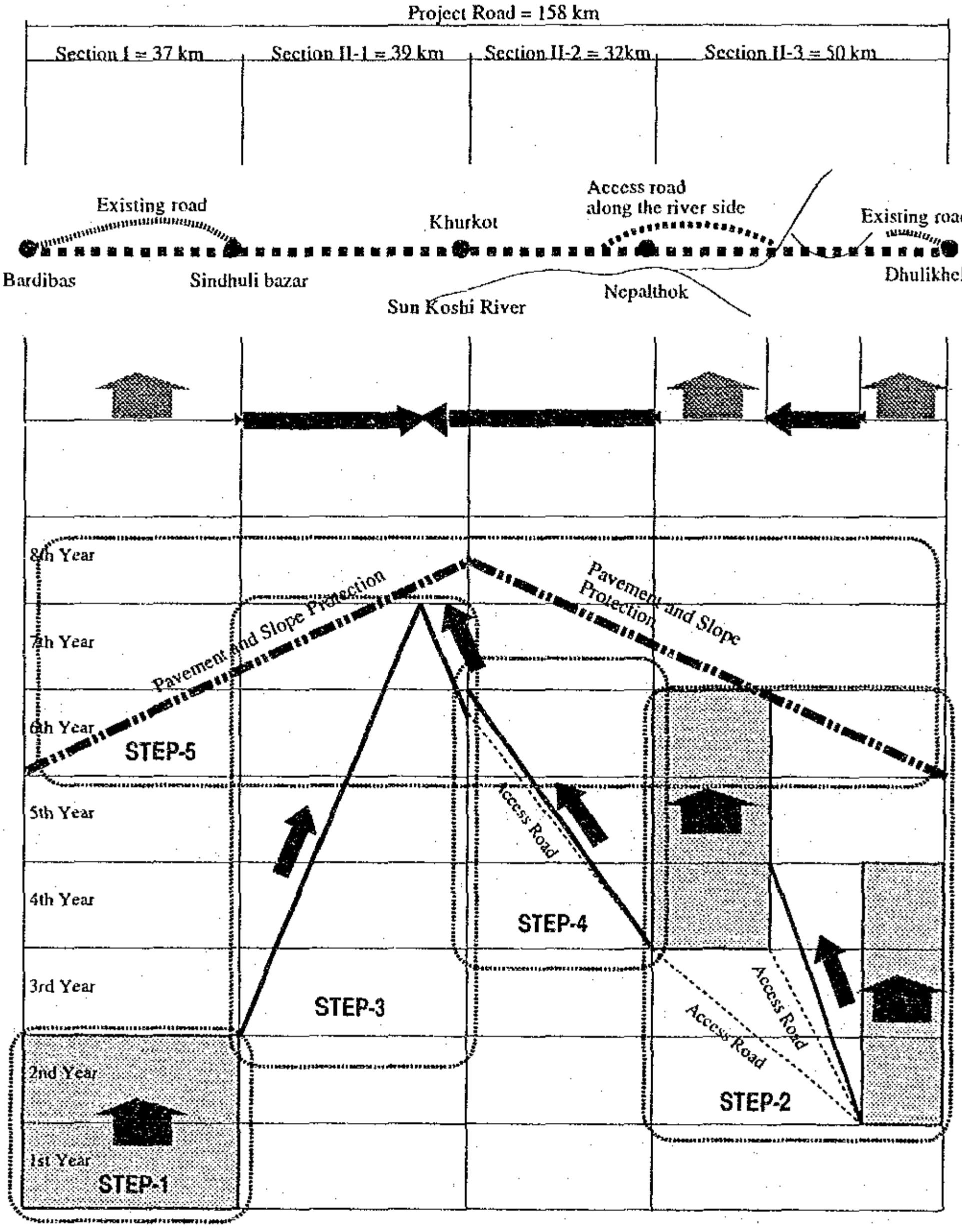
Figure 2.7.3 Recommended Interrelation of the DOR Maintenance Offices

Table 2.7.1 Recommended Staffing of the DOR Maintenance Offices

Office / Position	Main Office at Bardibas	Sub-Office at Sindhuli Bazar	Sub-Office at Banepa	Field Unit at Khurkot	Field Unit at Nepalthok	Total
Project Manager	1	-	-	-	-	1
Maintenance Engineer	1	1	1	-	-	3
Sr. Mechanical Engineer	1	-	-	-	-	1
Mechanical Engineer	1	1	1	-	-	3
Chief Inspector	2	2	2	1	1	8
Forman	3	3	3	2	2	13
Mechanical Technician	3	3	3	2	2	13
Operator/Drivers	10	10	10	4	4	38
Administration Staff	6	4	4	2	2	18
Total	28	24	24	11	11	98

2.8 Implementation Schedule

The construction of the Project can be divided into five steps as shown in Figure 2.8.1.



Conception of Implementation Schedule

Legend :

Single Approach Construction Method

Multiple Approach Construction Method

Figure 2.8.1 Planned Construction Steps of the Project

According to Figure 2.8.1, the implementation of the Project can be divided into the following five steps.

Step 1 : Construction of Bridges with Approaches and Causeways for Section I

Step 2 : Construction of Section II-3

Step 3 : Construction of Section II-1

Step 4 : Construction of Section II-2

Step 5 : Pavement and Slope Protection for Sections I and II

The strengthening of DOR's maintenance capabilities should be accomplished as listed below:

Step 1 : Start the maintenance for Section I.

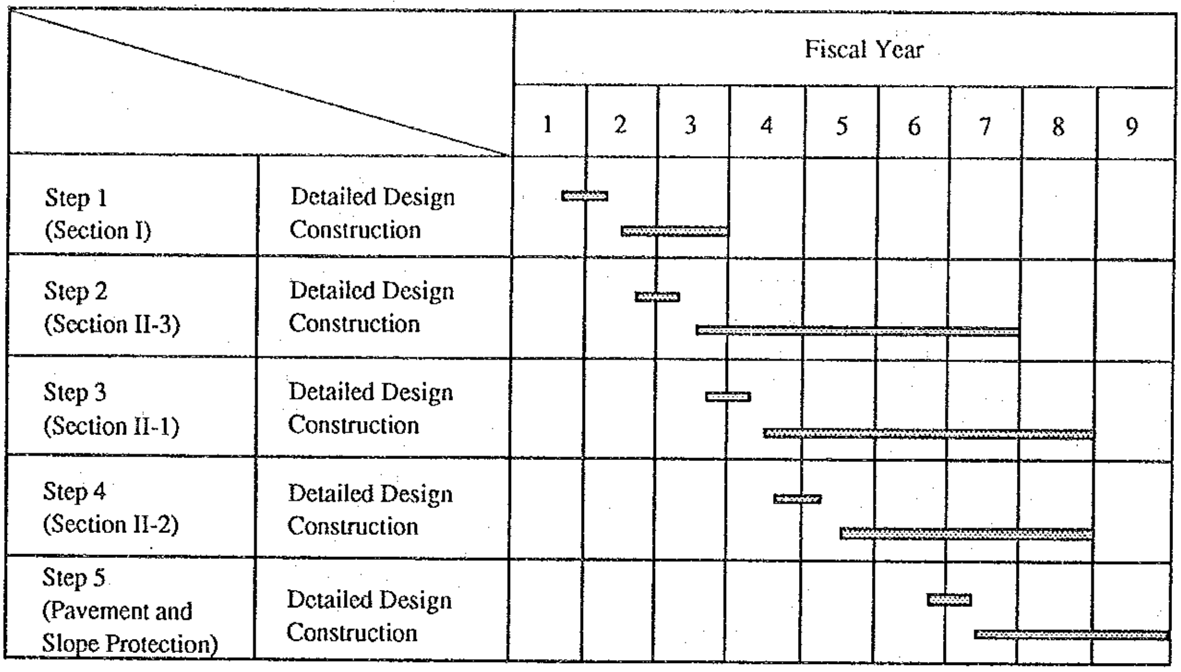
Step 2 : Establish a Maintenance Office at Banepa and start the maintenance for Section II-3.

Step 3 : Establish a Maintenance Offices at Bardibas and Sindhuli Bazar and start the Maintenance for Section II-1.

Step 4 : Establish a Maintenance Units at Nepalthok and Khurkot and start the maintenance for Section II-2.

The implementation schedule for the construction and maintenance aspects of the Project is proposed as shown in Figure 2.8.2.

Construction



Maintenance

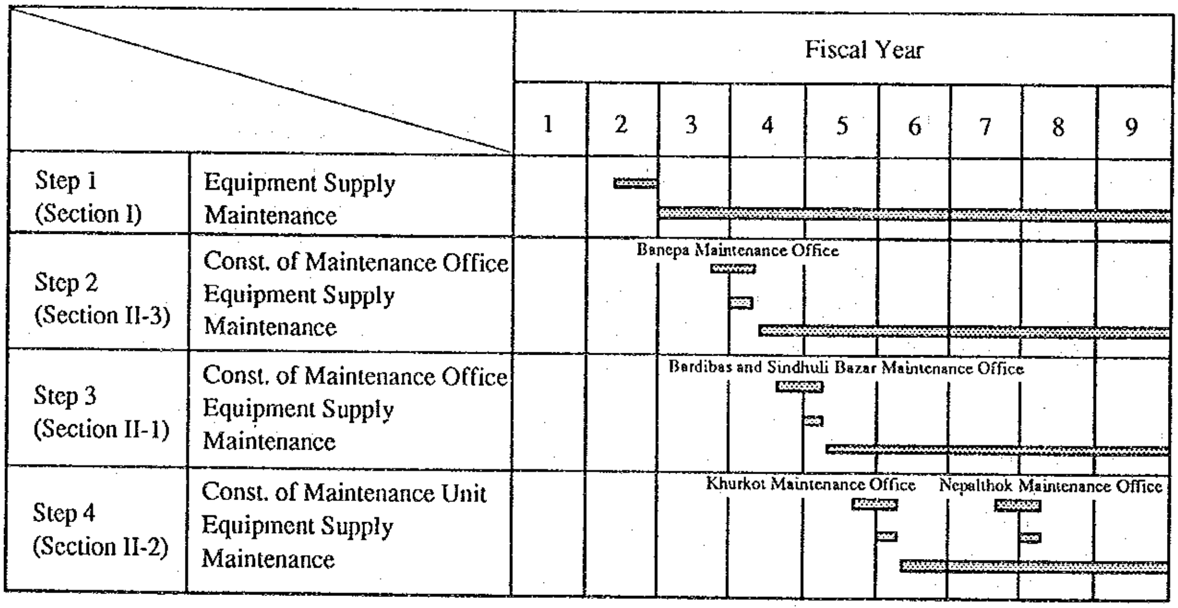


Figure 2.8.2 Proposed Implementation Schedule of the Project

2.9 Technical Cooperation

The Project road passes along slopes of the mountainous topography and on fragile geology. Under these circumstance, the road suffers various types of disasters such as surface erosion, landslides, slope failures, etc. Therefore, the maintenance of the Project road will require the application of adequate counter-measures that prevent/mitigate the disasters.

As explained earlier, the actual maintenance of the Project road will be implemented by a systematized and mechanized structure composed of DOR maintenance offices, maintenance equipment and repair shops that will be established and supplied as a part of the Project.

Since the DOR capabilities for the above work are not adequate because of limited budget and equipment, two technical cooperation programs have been established for the purpose of strengthening the DOR maintenance capability: the Maintenance and Rehabilitation Coordination Unit (MRCU) financed by ODA and Swiss Government, and the Strengthened Maintenance Division (SMD) under financing by the Swiss Government.

The MRCU works as an advisory and monitoring unit to assist DOR to establish the policy and to upgrade its management which helps the Department in implementing the transport network properly.

On the other hand, the SMD aims to introduce a planned road regular maintenance system with a view of protecting the large investments already made. In addition, it is to strengthen DOR capability of maintenance policy.

Also, in order to promote prevention/mitigation of the disasters, a Disaster Prevention Technical Centre (DPTC) has been established with the cooperation of JICA. It is therefore recommendable to request DPTC's cooperation regarding the investigation, planning, design and construction of disaster prevention/mitigation work for the road, and to attach specialists to the DOR maintenance structure that is to be established as a part of the Project. These specialists will be used to transfer the technology and assist DOR to upgrade its maintenance capabilities.

2.10 Examination of the HMG Request and Recommendation

2.10.1 Examination of the HMG Request

The objectives and effects of the Project must conform to the requirements of the Japanese Grant Aid Program. In this regard, it is noted that the high amount of the construction cost and the long construction period require introduction of stage-wise construction, reduction of the Project scheme, and strengthening of the DOR maintenance capabilities.

Therefore, if the Project is to be implemented under the Japanese Grant Aid Program, the previously mentioned request from HMG shall be modified as follows, according to its requirement and the results of the A/C Study that was carried out responding to such request:

A. Modifications of the HMG Request for Construction of Section I

The modifications of the HMG request for Construction of Section I are as follows:

- Nine bridges including its approach roads at Bhogate, Karkare, Gangate, Ratu, Sindhuse, Kamara, Phittang, Buka and Gadeuli should be constructed in Section I instead of the 15 bridges, that were originally proposed in the A/C Study.

- The remaining six bridges and 11 box culverts planned in the F/S should be changed to 17 causeways at Section I.

- Strengthening of the DOR maintenance capabilities for Section I should be included as a part of the Project.

B. Modifications of the HMG Request for the Procurement of Construction Equipment and Materials for Use by DOR at Section II

This request should be modified as follows:

- The construction of Section II should be carried out under the contract basis instead of by DOR Force Account Work.

- The stage-wise type of construction should be applied for Section II.

- Strengthening of the DOR maintenance capability for Section II should be included in the Project.

C. Procurement of Consultant Services for Section I and Section II

- The kind of required consultant services will include the detailed design and construction supervision for Section I and Section II.

2.10.2 Recommendation

According to the above, the basic design for Section I will be performed as described in the following Chapters on the condition that the construction of Section I of Sindhuli Road Project be implemented under Japanese Grant Aid.

CHAPTER 3 MAIN OBJECTIVES AND WORK COMPONENTS FOR SECTION I

CHAPTER 3 MAIN OBJECTIVES AND WORK COMPONENTS FOR SECTION I

3.1 General

In this Chapter, the main objectives and work components of Section I are outlined taking into consideration the overall implementation schedule, the existing road conditions and the requests from HMG.

3.2 Main Objectives and Work Components for Section I

3.2.1 Objectives

The main objectives for Section I are to upgrade and stimulate social and economic activities as well as to satisfy basic human needs for the villagers in Sindhuli District by improving the road service level, especially in the rainy season.

3.2.2 Work Components of Section I

Section I will require construction of bridges with approaches, causeways, pavement, drainage ditches, and slope protection; the paving and realignment of some sections of the road; and strengthening of the DOR maintenance capabilities. In doing so, the following items should be considered:

- Because Section I will serve as an access road for the construction of Section II, some of the new pavement would be destroyed by heavy construction equipment travelling over it. Therefore, it is recommendable that the pavement work for Section I be delayed and performed during the final stage of the Project (Section II).

- The construction of drainage ditches and slope protection should be carried out in parallel with the placing of the pavement during the final stage of the Project.

- Maintenance work and any required improvements should be carried out by DOR using the equipment supplied by the GOJ under the Project.

3.2.3 List and Locations of Bridges and Causeways

According to the A/C Study, the bridges and causeways to be constructed are listed in Table 3.2.1 and Table 3.2.2 respectively, with their locations being shown in Figure 3.2.1.

Table 3.2.1 List of Bridges in Section I

No.	Name of Bridge	Aftercare Study	Basic Design Study
1	Bhogate Bridge	50 m = 2 @ 25	60 m = 2 @ 30
2	Karkare Bridge	50 m = 2 @ 25	50 m = 2 @ 25
3	Gangate Bridge	25 m = 1 @ 25	30 m = 1 @ 30
4	Ratu Bridge	175 m = 7 @ 25	270 m = 9 @ 30
5	Shindhuse Bridge	Causeways (First stage of stage-wise construction)	60 m = 2 @ 30
6	Kamara Bridge	120 m = 4 @ 30	120 m = 3 @ 40
7	Phittang Bridge	50 m = 2 @ 25	50 m = 2 @ 25
8	Buka Bridge	50 m = 2 @ 25	50 m = 2 @ 25
9	Gadeuli Bridge	50 m = 2 @ 25	50 m = 2 @ 25

Table 3.2.2 List of Causeways in Section I

No.	Station	Aftercare Study		Basic Design Study	
		Type	Length	Type	Length
1	Sta. 172 + 25	Riverbed Level	60 m	Riverbed Level	60 m
2	Sta. 183 + 60	Riverbed Level	30 m	Riverbed Level	30 m
3	Sta. 194 + 00	Riverbed Level	40 m	Riverbed Level	40 m
4	Sta. 201 + 00	Riverbed Level	40 m	Riverbed Level	40 m
5	Sta. 211 + 85	Riverbed Level	30 m	Riverbed Level	30 m
6	Sta. 217 + 75	Riverbed Level	30 m	Riverbed Level	30 m
7	Sta. 223 + 20	Riverbed Level	30 m	Riverbed Level	30 m
8	Sta. 226 + 70	Riverbed Level	40 m	Riverbed Level	40 m
9	Sta. 229 + 50	Riverbed Level	60 m	Riverbed Level	60 m
10	Sta. 234 + 15	Riverbed Level	60 m	Riverbed Level	60 m
11	Sta. 238 + 95	Riverbed Level	40 m	Riverbed Level	40 m
12	Sta. 246 + 20	Riverbed Level	80 m	Riverbed Level	80 m
13	Sta. 249 + 75	Riverbed Level	80 m	Riverbed Level	80 m
14	Sta. 258 + 50	Riverbed Level	30 m	Riverbed Level	30 m
15	Sta. 260 + 85	Riverbed Level	30 m	Riverbed Level	30 m
16	Sta. 265 + 50	Riverbed Level	80 m	Riverbed Level	80 m
17	Sta. 272 + 30	Riverbed Level	50 m	Riverbed Level	50 m
-	Sta. 282 + 90	Riverbed Level	40 m	–	–

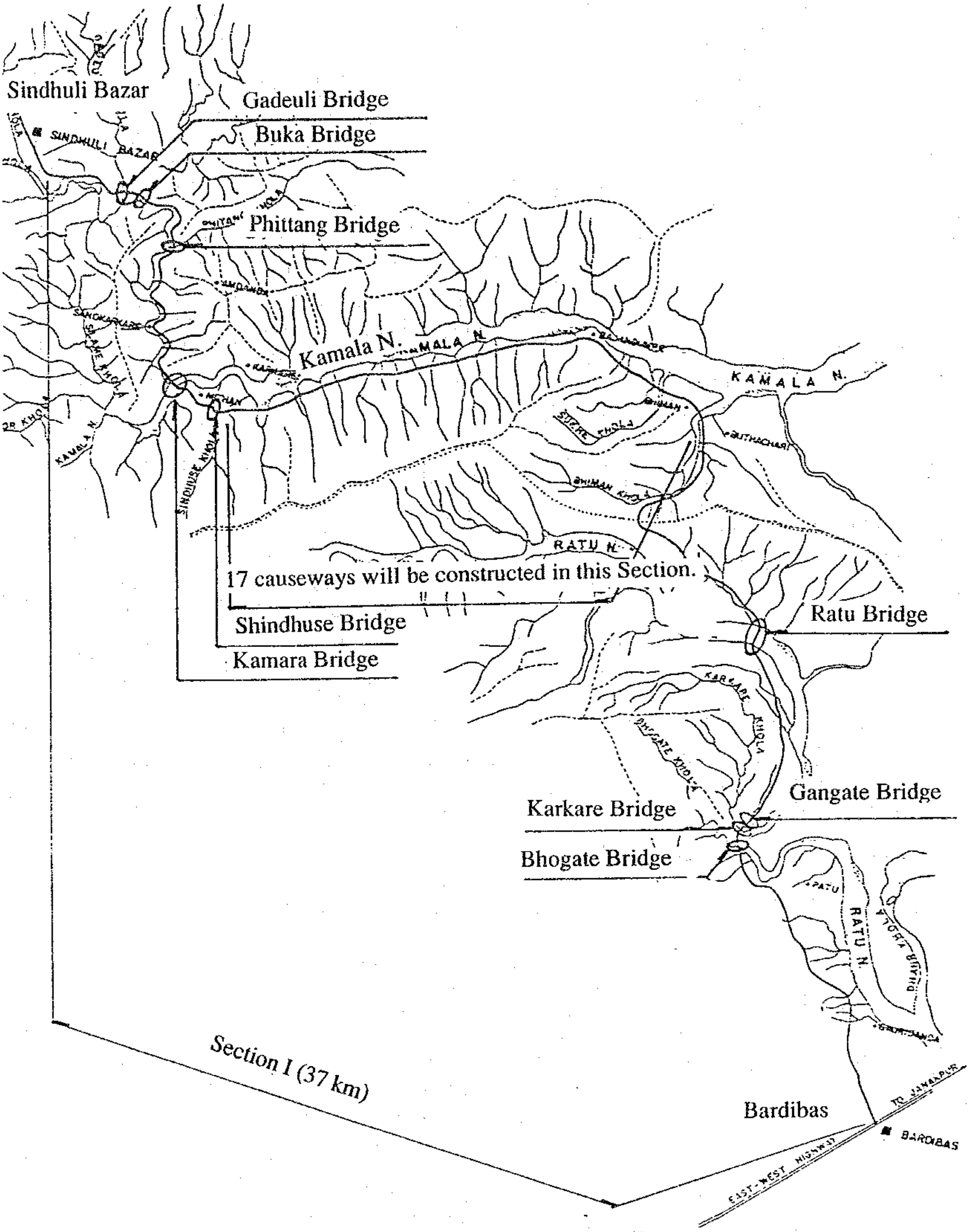


Figure 3.2.1 Locations of the Bridges and Causeways

3.3 Operational Structure

3.3.1 Organization for Section I

The organization for Section I should be established as follows:

- DOR is to be the HMG Agency responsible for the implementation of the Project.

- The operational structure that is to be established will be under the control of the Director General of DOR.

- The DOR Project Manager responsible for the construction and maintenance will be appointed by the Director General. Also, the required DOR supporting staff will be appointed.

- Under the DOR Project Manager, a Japanese consultant responsible for the construction supervision, and other DOR supporting engineers responsible for the maintenance will be used.

- The maintenance activities will be carried out using the equipment supplied by Japanese Grant Aid as well as by the HMG budget. This work is to be done by the DOR with assistance by the consultant.

The proposed organization to accomplish the above is shown in Figure 3.3.1.

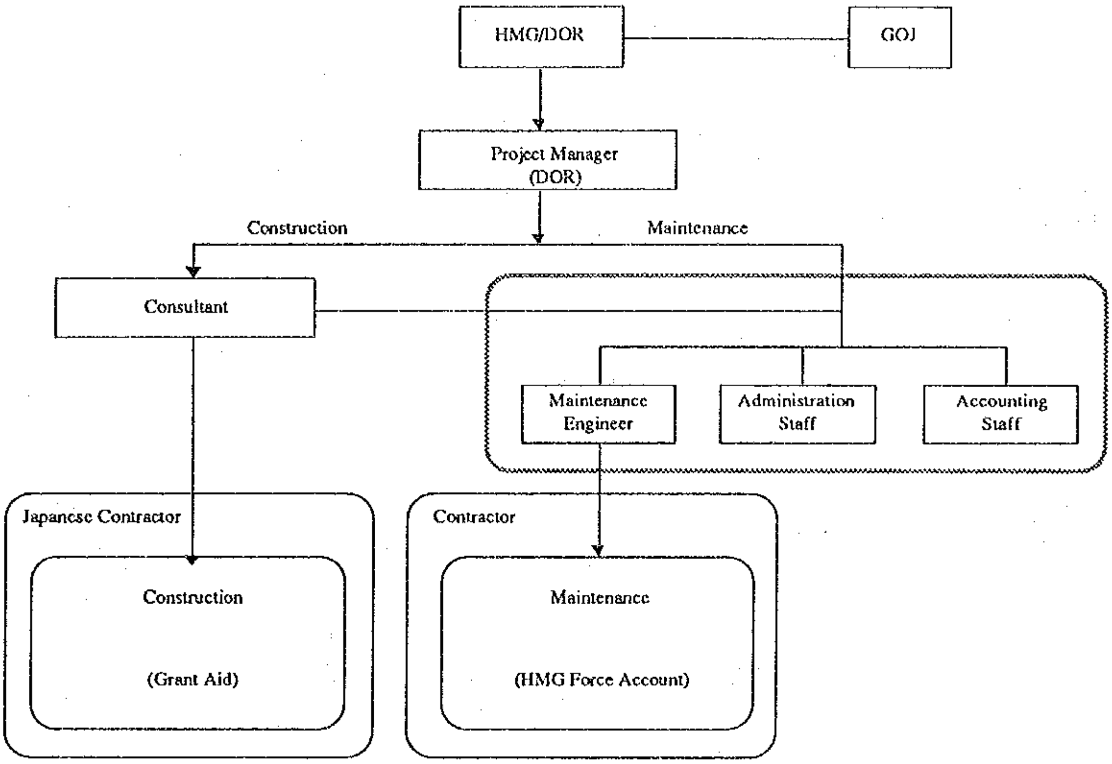


Figure 3.3.1 Organization Chart of the Project (Section I)

3.3.2 Staffing

The staffing requirements for the above organization is recommended as shown in Table 3.3.1.

Table 3.3.1 Staffing for the Project (Section I)

Position	Numbers
Project Manager	1
Maintenance Engineer	1
Senior Mechanical Engineer	1
Civil Overseer	2
Mechanical Engineer	1
Mechanical Technician	3
Operator/Drivers	10
Administration Staff	6
Total	25

CHAPTER 4 BASIC DESIGN FOR SECTION I

CHAPTER 4 BASIC DESIGN FOR SECTION I

4.1 Design Policy

The basic design for Section I has been prepared taking into consideration the following:

- Placing special consideration on the river bank and riverbed protection because of the natural river condition and heavy rain during the rainy season.

- Reducing the construction cost.

- Maximizing the usage of local materials and efficient construction methods.

4.2 Study and Examination of Design Criteria

4.2.1 Basis of the Design

The design of the approach roads and bridges was carried out using 1:2000 scale aerial photogrammetry maps and 1:200 scale topomaps prepared during the F/S, respectively. The foundation design was based on the results of Standard Penetration Tests (SPT) made during the F/S.

4.2.2 Approach Road Design Criteria

The geometric design criteria for the bridges' approach roads are based on the National Road Standards (NRS) No. 2027, except where the standards were not clear. In such cases, the Japan Road Standards (JRS) published by the Japan Road Association (JRA) were applied.

In establishing the geometric design criteria, the applicable design speed (which directly affects the construction cost) was carefully assessed taking into account not only the requirements stipulated in the above Standards but also the terrain through which the Project road runs, the estimated traffic volume and the Project viability. Using these the assessment results, the design speed was firstly determined and then the other geometric elements were decided.

The geometric design criteria that were used are tabulated in Table 4.2.1.

Table 4.2.1 Geometric Design Criteria for Approach Roads

Geometric Elements	Classification of Terrain	
	Flat/Rolling	Mountainous
Design Speed (km/hr)	40-50	30-40
Superelevation (%)	2.5 (4) L[1]	2.5 (4) L[1]
Max. Superelevation (%)	10	10
Minimum Radius (m)	70 (at 50 km/hr) 45 (at 45 km/hr)	45 (at 40 km/hr) 25 (at 30 km/hr) 10 (at 20 km/hr)
Maximum Gradient (%)	6	9
Minimum Stopping Sight Distance (m)	65 (at 50 km/hr) 45 (at 40 km/hr)	45 (at 40 km/hr) 30 (at 30 km/hr) 20 (at 20 km/hr)

Note: L[1]: A superelevation of 4% shall be used for the gravel roads.

The approach road design was carried out according to the following design manuals.

Highway Earthwork Series: published by the Japan Road Association

- Manual for Slope Protection
- Manual for Retaining Walls • Culverts • Temporary Structures
- Manual for Drainage
- Manual for Asphalt Pavement (including Penetration Macadam)

4.2.3 Bridge Design Criteria

The Design Standards to be applied for the bridge design are Specifications for Highway Bridges (SHB) I, II, III, IV & V published by the Japan Road Association. The A live load, which is equivalent to HS20-44 in ASSHTO specifing in NRS No. 2027, was applied in accordance with the SHB of Japan.

The Design Standard applied for concrete structures was the Standard Specification for Design and Construction of Concrete Structures published by the Japan Society of Civil Engineers.

A horizontal seismic coefficient of 0.15 was applied in accordance with the Indian Standard, Criteria for Earthquake Resistance Design of Structures, 1986 as follow:

Zone No. : V

Basic horizontal seismic coefficient (L_0)	:	0.08
A coefficient depending upon the soil-foundation system (β)	:	1.2
A factor depending upon the importance of the structure (I)	:	1.5
The design value of horizontal seismic coefficient ($L_h = \beta I \alpha o$)	:	0.144 (0.15)

4.2.4 Causeway Design Criteria

The causeways were designed using the Design Specification for Riverbed Protection Works stipulated in the Technical Specifications for River and Sabo Works published by the Ministry of Construction in Japan.

4.3 Bridge Design

4.3.1 Bridge Planning Criteria

Based on the data from the hydrographic survey and hydrological study conducted on the F/S, the following planning criteria for the bridges were established.

A. River Characteristics and Proposed Widths

The river characteristics at Section I are summarized below.

River Gradient (%)	Type of River Deposits	Grading (mm)	Average Velocity (m/sec)
0.5 to 2.0	Course sand & gravel	0.6 - 200	2 - 5

Some of the river widths in Section I can be reduced by constructing man-made river training banks since these rivers have a shallow flood water level and a wide flood area.

The following data was applied to estimate the desirable width between the banks, but in such case its flood velocity should be less than 3 m/sec.

Q	B
300	40 - 60
500	60 - 80
1,000	90 - 120
2,000	160 - 220
5,000	350 - 450

where, Q: Peak runoff (m^3/sec)
B: Width between the banks (m)

B. Minimum Span Length Required

The minimum span length required is determined by one of the following factors based on the hydrographic survey results:

(1) Peak Runoff Discharge

The minimum span length required due to peak runoff discharge is estimated by the following formula which is stipulated in the Standards on River Control and River Facilities published by the Japan River Association.

$$L = 20 + 0.005\ Q$$

where, L: Standard minimum span length (meter)
Q: Peak runoff discharge (m^3/sec)

In case that the peak runoff discharge is less than 500 m^3/sec and the safety is confirmed technically, the minimum span length required can be 15 meters.

The following Table 4.3.1 lists the runoff peak and required minimum span lengths for the main rivers in Section I.

Table 4.3.1 The Runoff Peak and Required Minimum Span Length

Name of River	Catchment Area (km^2)	Runoff Peak (1/100) (m^3/sec)	Runoff Peak (1/50) (m^3/sec)	Estimated Velocity (m/sec)	Height of Flood Level (m) /1	Minimum Span Length (m)
Bhogte	5.4	199	177	4.5	3.1	21
Karchare	5.2	157	140	3.4	1.8	21
Ratu /2	42.4	960	855	3.5	1.4	25
Sindhure	2.1	80	71	2.5	1.0	20
Kamala	142.8	2,857	2,546	4.1	4.9	35
Phitting	7.4	246	219	3.2	2.9	22
Buka	13.4	406	362	2.8	3.5	24
Gadeuli	31.6	779	694	5.1	3.9	24

Notes:

/1 The height of the flood level was measured from the lowest point of the riverbed.

/2 The estimated velocity and flood level were calculated under the condition of providing man-made river banks.

/3 The proposed Gangate Khola bridge was deleted out because of the narrow catchment area.

(2) Scouring Depth at the Piers

The scouring depth will severely affect the stability of any piers with spread footings depending on the pier shape in plan, pier width, depth of peak runoff, riverbed materials, etc. In this regard, roughly 1.8 to 2.1 m of local scouring depth at the river piers has been estimated by Andrew's and Laursen's experimental formula.

The minimum cover for a river pier footing should be more than 2 m.

C. Freeboard

Freeboard, the clearance between the high water level and the bottom of the girders, was determined by the estimated size of drifting logs and the high flood level. The minimum freeboard was determined to be more than 2 m.

4.3.2 Superstructure

A. Selection of Superstructure Type

Prestressed concrete (PC) beams and steel plate girders were both considered based on the range of the span length. In this case, the construction cost and maintenance cost of PC beams were determined to be lower than steel plate girders.

Three span lengths (25 m, 30 m and 40 m) of PC Simple I-Beams were used for the bridges in Section I. This is based on the minimum span length, span arrangement, topographic/geological conditions and river conditions from the viewpoint of low construction cost and ease of construction.

B. Materials and Design Conditions

Structural calculations were carried out according to the SHB III published by the JRA and applying the following design conditions:

(1) Main PC Girder Concrete (using normal Portland cement):

- Specified compressive strength	350 kg/cm^2
- Allowable bending compressive stress (by stressing)	160 kg/cm^2
- Allowable bending compressive stress (other)	125 kg/cm^2
- Allowable bending tensile stress (by stressing)	-13.5 kg/cm^2
- Allowable bending tensile stress (by dead-load)	0.0 kg/cm^2
- Allowable bending tensile stress (other)	-13.5 kg/cm^2
- Young's Modules (by design load)	2.95E + 0.5 kg/cm^2
- Young's Modules (by stressing)	2.47E + 0.5 kg/cm^2
- Creep coefficient	2.6
- Drying shrinkage	0.0002

(2) Cross Beam Concrete (high-early strength Portland cement):

- Specified compressive strength	300 kg/cm^2
- Allowable bending compressive stress	110 kg/cm^2

(3) Slab Concrete (normal Portland cement):

- Specified compressive strength	240 kg/cm^2
- Allowable bending compressive stress	65 kg/cm^2

(4) Steel Tendons for Prestressed Concrete:

- Kind of PC cable	12T 12.4
- Sectional area for PC cable	1,120 mm^2
- Diameter of sheath	65 mm
- Initial stressing	125 kg/cm^2
- Allowable tensile unit stress (by stressing)	122.5 kg/cm^2
- Allowable tensile unit stress (by design load)	105 kg/cm^2
- Young's Modules	2.00E +0.6 kg/cm^2
- Unit skid resistance coefficient per meter	0.004
- Unit skid resistance coefficient	0.3

- Slippage at anchorage 12 mm
- Relaxation ratio 5%
- Unit weight per meter 8.75 kg

(5) Reinforcement Bars (SR235, maximum dia. of 25 mm):

- Allowable tensile stress 1,400 kg/cm^2
- Allowable compressive stress 1,400 kg/cm^2

(6) Live Load:

- Live load Class A Live Load
- Loading width 6 m
- Uniform live load P_1 (bending movement) 1.0 t/m^2
- Uniform live load P_1 (shearing force) 1.2 t/m^2
- Uniform live load P_2 0.35 t/m^2

Span Length Data:

- Bridge length	25 m	30 m	40 m
- Girder length	24.9 m	29.9 m	39.9 m
- Span length	24.2 m	29.2 m	39.2 m
- Impact coefficient, i = 10/(25+L)	0.203	0.185	0.154

Typical cross-sections of superstructures based on the above design conditions are shown in Figures 4.3.1, 4.3.2 and 4.3.3.

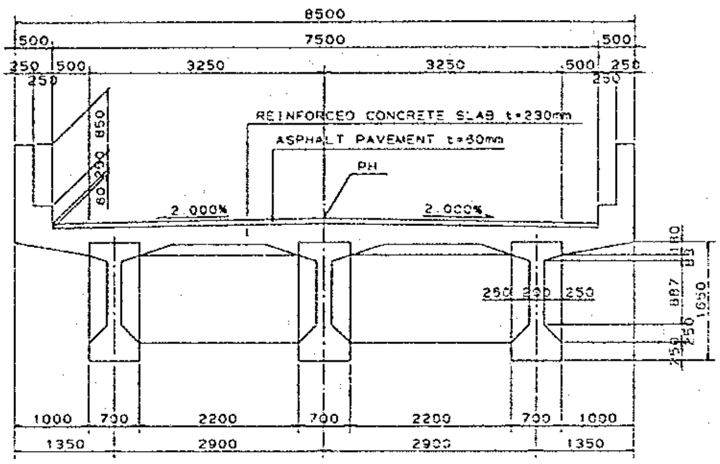


Figure 4.3.1 Typical Cross-section of Superstructure (Span length = 25 m)

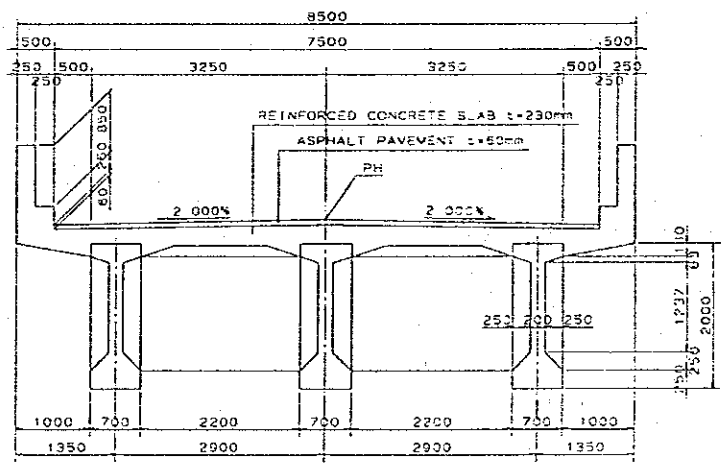


Figure 4.3.2 Typical Cross-section of Superstructure (Span length = 30 m)

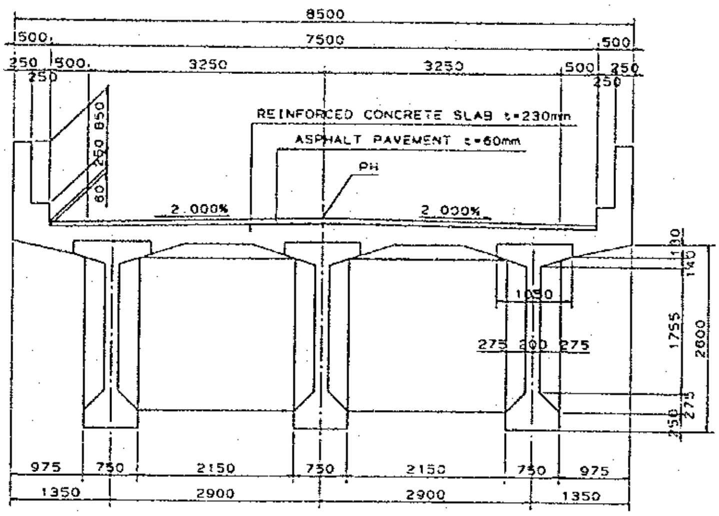


Figure 4.3.3 Typical Cross-section of Superstructure (Span length = 40 m)

4.3.3 Substructure

A. Selection of Substructure Type

According to the Standard Penetration Tests (SPT) conducted during the F/S, the N-values are more than 30 for all the bridge foundations. Therefore, a spread footing foundation was selected for each bridge in Section I.

Among the standard types of abutments, a gravity or invert-T type was designed from the viewpoint of economy and ease in construction. Abutments placed on a slope are as shown in Figure 4.3.4.

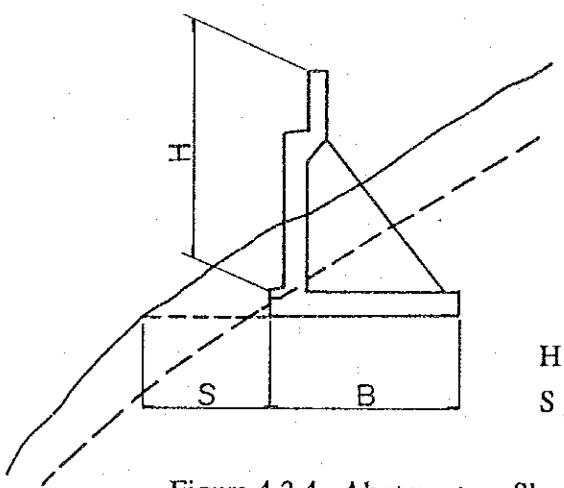


Figure 4.3.4 Abutment on Slope

All piers for the bridges at Section I are of a wall type (rectangle with semicircular noses at the up and downstream sides) or a circular column type. This was decided based on a hydraulic viewpoint.

B. Materials and Design Conditions

Structural calculations were carried out according to the SHB IV published by the JRA and applying the following design conditions:

(1) Concrete (using normal Portland cement)

- Specified compressive strength	240 kg/cm^2
- Allowable bending compressive stress	80 kg/cm^2
- Allowable compressive stress	65 kg/cm^2
- Allowable shear stress	3.9 kg/cm^2
- Allowable bond stress	16 kg/cm^2

(2) Reinforcement Bars (SR235, maximum dia. of 25 mm):

- Allowable tensile stress	1,400 kg/cm^2
- Allowable compressive stress	1,400 kg/cm^2

4.3.4 Effect of Approach Roads on the Bridges

Since the existing road alignments at the bridge sites are not always adequate, the following applications were required:

- To keep the pier heights within 15 m.
- To allow a freeboard of more than 2 m.
- To make the bridge length as short as possible.

4.3.5 Types of Bridges for Section I

The types of bridges for Section I were designed using the above concepts and conditions as shown below in Table 4.3.2.

Table 4.3.2 List of Bridges in Section I

S. No.	Bridge Name	Type	No. of Spaces & Length
1.	Bhogate Bridge	PC (Post-tensioned)	2 @ 30.0 = 60.0 m
2.	Karkare Bridge	PC (Post-tensioned)	2 @ 25.0 = 50.0 m
3.	Gangate Bridge	PC (Post-tensioned)	1 @ 30.0 = 30.0 m
4.	Ratu Bridge	PC (Post-tensioned)	9 @ 30.0 =270.0 m
5.	Shindhuse Bridge	PC (Post-tensioned)	2 @ 30.0 = 60.0 m
6.	Kamara Bridge	PC (Post-tensioned)	3 @ 40.0 =120.0 m
7.	Phittang Bridge	PC (Post-tensioned)	2 @ 25.0 = 50.0 m
8.	Buka Bridge	PC (Post-tensioned)	2 @ 25.0 = 50.0 m
9.	Gadeuli Bridge	PC (Post-tensioned)	2 @ 25.0 = 50.0 m
Total Length of Bridges			740.0 m

4.4 Approach Road Design

The approach road design has been carried out according to the design criteria as shown in Section 4.2.2. The lengths of the planned approach roads are listed in Table 4.4.1.

Table 4.4.1 Lengths of Approach Roads

Bridge Name	Length of Approach Road		
	Bardibas Side (m)	Sindhuli Bazar Side (m)	Total (m)
Bhogate Bridge	185	340	525
Karkare Bridge		/1	
Gangate Bridge	35	150	185
Ratu Bridge	260	420	680
Shindhuse Bridge	250	420	670
Kamara Bridge	180	590	770
Phittang Bridge	185	210	395
Buka Bridge	185	215	400
Gadeuli Bridge	240	210	450
Total Length of Approach Roads			4,075

Note: /1: The approach roads of Karkare Bridge will also be used as the north approach road for the Gangate Bridge and the south approach road for the Bhogate Bridge.

The approach roads are of gravel with a thickness of 30 cm. The segments having a gradient more than 5% are covered by a cold-mix asphalt surface (penetration macadam) with a thickness of 5 cm.

The standard cross-section for the Section I approach roads on slopes and flat areas are shown below in Figures 4.4.1 and 4.4.2, respectively.

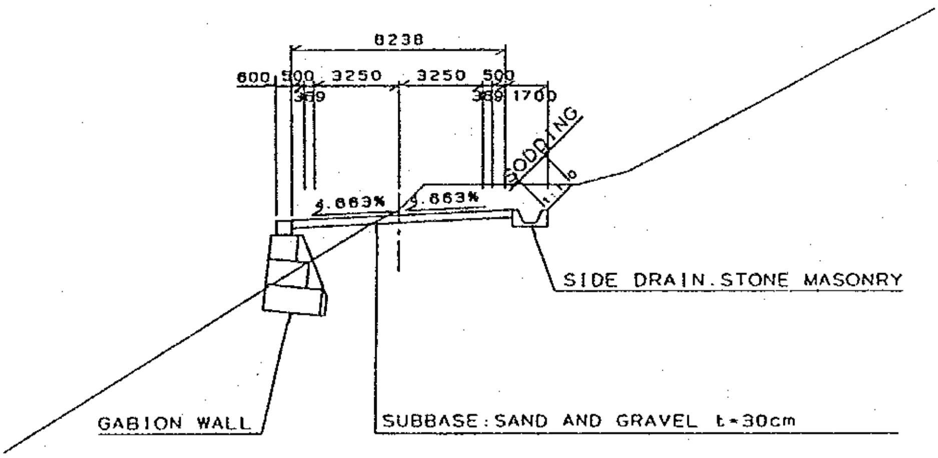


Figure 4.4.1 Cross-section of Roads on Slopes

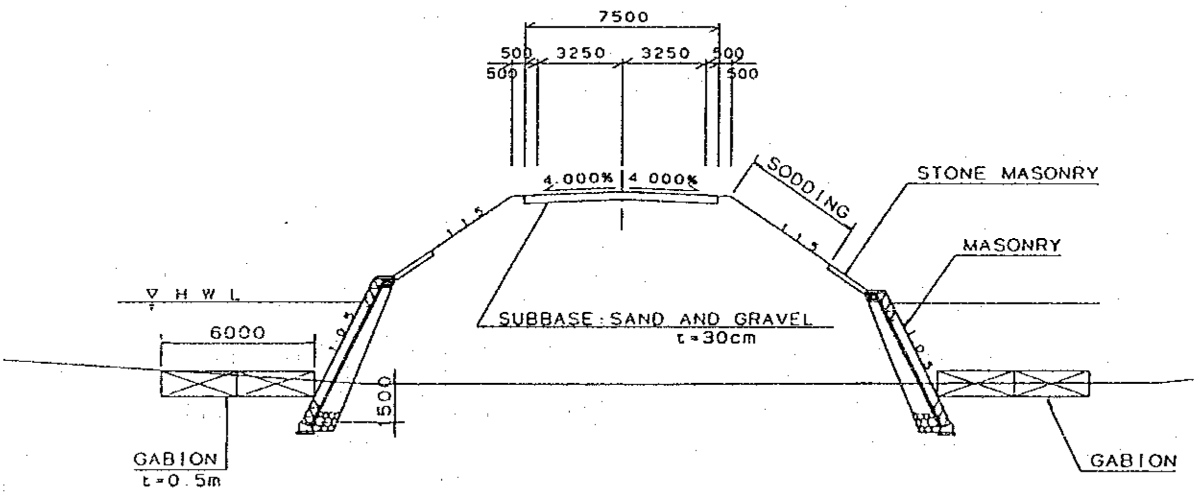


Figure 4.4.2 Standard Cross-section of Approach Roads on Flat Areas

4.5 Causeway Design

Three types of causeways were designed based on the river conditions of the A/C Study as outlined below.

Type of Causeway	Applicable Criteria
Riverbed Level Causeway	Normal flood depth is shallow, say less than 2 m. The duration for each flood is short, say less than 2 hr and the flood frequency during the rainy season is not often, say less than 10 times per the 3-month rainy season. Drifting logs and debris flow are acceptable.
Vented Causeway	The flooding condition is more or less the same as above, but it is desirable to apply this type to streams having a minimum amount of drifting logs and debris flow.
Submersible Bridge	In this case, the normal flood depth is relatively deep, say more than 2 m but less than 4 m. The duration for each flood is relatively short, say less than a 5-6 hour flood frequency during the 3-month rainy season and it occurs less than 10 times per season. It is desirable to apply this type to streams having a minimum amount of drifting logs.

It should be noted that the Riverbed Level Causeway was applied only in Section I, taking into consideration the existing river conditions.

The Riverbed Level Causeway follows the Design Specification for the riverbed protection work stipulated in the Technical Specifications for River and Sabo Work published by the Ministry of Construction in Japan.

A standard section of the Riverbed Level Causeway is shown in Figure 4.5.1.

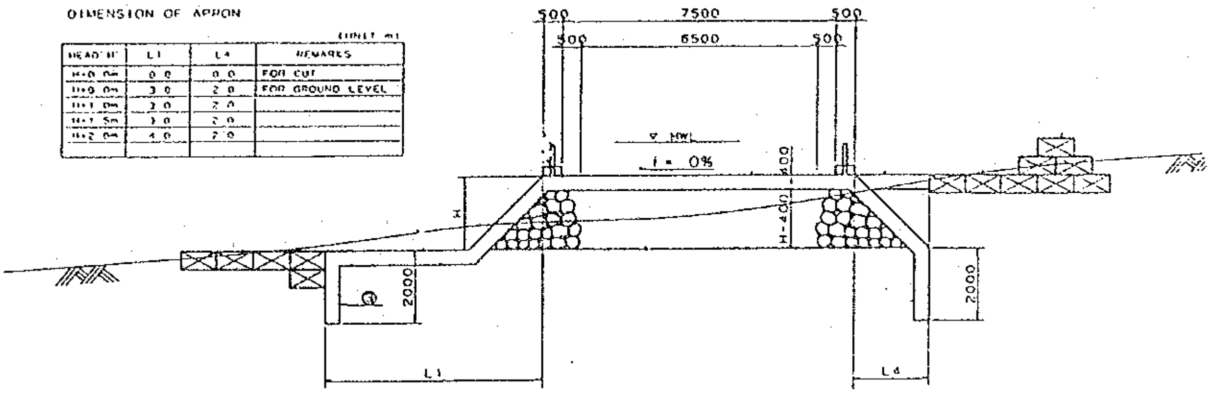


Figure 4.5.1 Standard Section of Riverbed Level Causeway

The locations and lengths of the causeways planned for Section I are listed in Table 4.5.1.

Table 4.5.1 List and Lengths of Causeways in Section I

S. No.	Station	Length (m)
1.	STA 172 + 15	60
2.	STA 184 + 50	30
3.	STA 194 + 25	40
4.	STA 200 + 90	40
5.	STA 211 + 93	30
6.	STA 217 + 60	30
7.	STA 223 + 15	30
8.	STA 226 + 80	40
9.	STA 229 + 50	60
10.	STA 234 + 15	60
11.	STA 238 + 95	40
12.	STA 246 + 10	80
13.	STA 250 + 65	80
14.	STA 258 + 150	30
15.	STA 260 + 80	30
16.	STA 265 + 35	80
17.	STA 272 + 30	50
Total Length		810

4.6 Basic Design Drawings

Drawings have been prepared for cost estimation and construction planning purposes.

Drawings such as general layout plans of the bridges, plan, profile and typical cross-section views of the approach roads and general plans of the causeways were prepared as follows.

Figure 4.6.1	General Plan of Bhogate Bridge
Figure 4.6.2	General Plan of Karkare Bridge
Figure 4.6.3	General Plan of Gangate Bridge
Figure 4.6.4	General Plan of Ratu Bridge
Figure 4.6.5	General Plan of Shindhuse Bridge
Figure 4.6.6	General Plan of Kamara Bridge
Figure 4.6.7	General Plan of Phittang Bridge
Figure 4.6.8	General Plan of Buka Bridge
Figure 4.6.9	General Plan of Gadeuli Bridge
Figure 4.6.10	Plan and Profile of Approach Road for Bhogate Bridge
Figure 4.6.11	Plan and Profile of Approach Road for Karkare Bridge
Figure 4.6.12	Plan and Profile of Approach Road for Ratu Bridge
Figure 4.6.13	Plan and Profile of Approach Road for Shindhuse Bridge
Figure 4.6.14	Plan and Profile of Approach Road for Kamara Bridge
Figure 4.6.15	Plan and Profile of Approach Road for Phittang Bridge
Figure 4.6.16	Plan and Profile of Approach Road for Buka Bridge
Figure 4.6.17	Plan and Profile of Approach Road for Gadeuli Bridge
Figure 4.6.18	Location Map of Causeways
Figure 4.6.19	Standard Section of Typical Causeway

The above Figures are attached in the Appendix A.

Details for drainage, other road facilities and land acquisition are shown in Appendix B and C.

4.7 Approximate Quantities of Major Work Items

Quantities were calculated based on the above general layout plans and are summarized below in Table 4.7.1.