DEPARTMENT OF ROADS
MINISTRY OF WORKS AND TRANSPORT
KINGDOM OF NEPAL

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR CONSTRUCTION OF SINDHULI ROAD (SECTION II - 3 : NEPALTHOK - DHULIKHEL) IN KINGDOM OF NEPAL

MARCH, 1996

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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PREFACE

In response to a request from His Majesty's Government of Nepal, the Government of Japan decided to conduct a basic design study on the Project for Construction of Sindhuli Road (Section II-3: Nepalthok-Dhulikel) and entrusted the study to the Japan International Cooperation Agency (JICA).

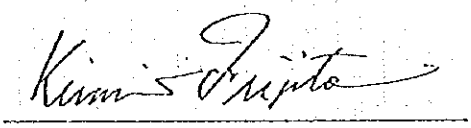
JICA sent to Nepal a study team from November 27 to December 28, 1995.

The team held discussions with the officials concerned of the Government of Nepal, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Nepal in order to discuss a draft basic design, 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 His Majesty's Government of Nepal for their close cooperation extended to the teams.

March, 1996



Kimio Fujita
President
Japan International Cooperation Agency

March , 1996

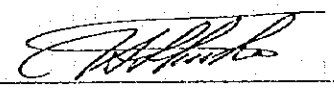
Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Construction of Sindhuli Road (Section II-3: Nepalthok-Dhulikel).

This study was conducted by Nippon Koei Co., Ltd., under a contract to JICA, during the period from November 20, 1995 to March 29, 1996. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Nepal and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

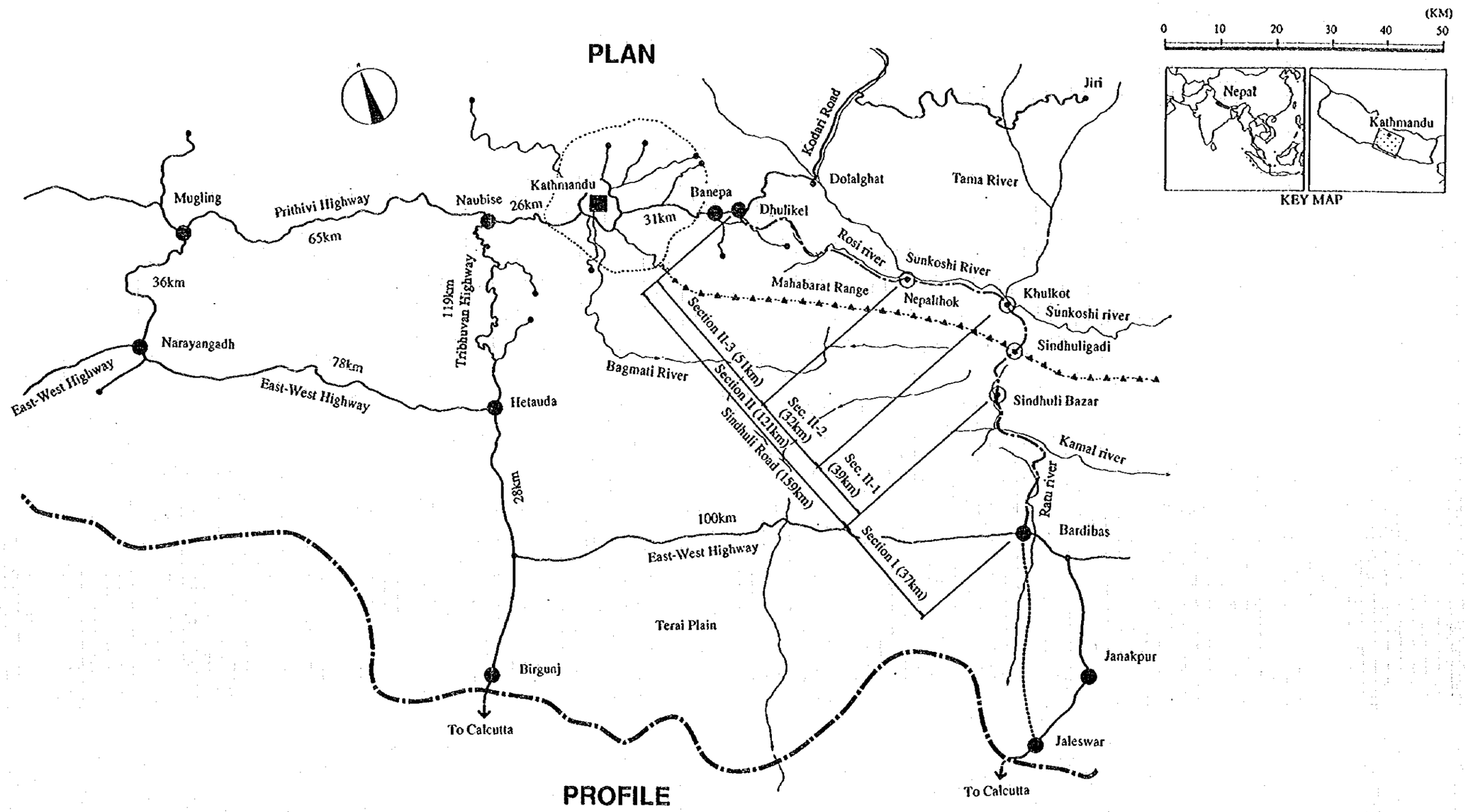
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

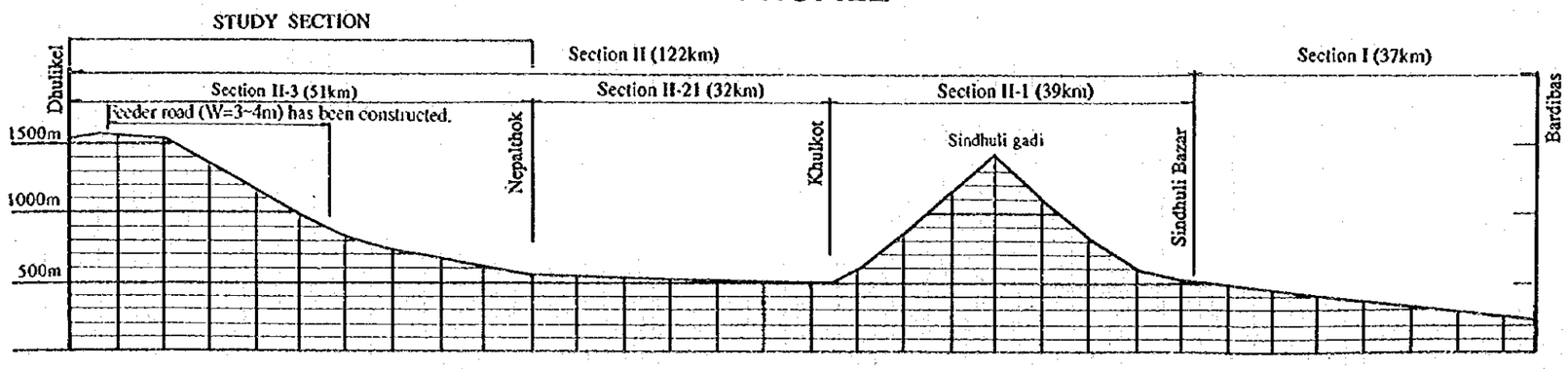


Hiroki Shinkai
Project Manager,
Basic Design study team on
The Project for Construction of
Sindhuli Road
(Section II-3: Nepalthok-Dhulikel)
Nippon Koei Co., Ltd.

PLAN

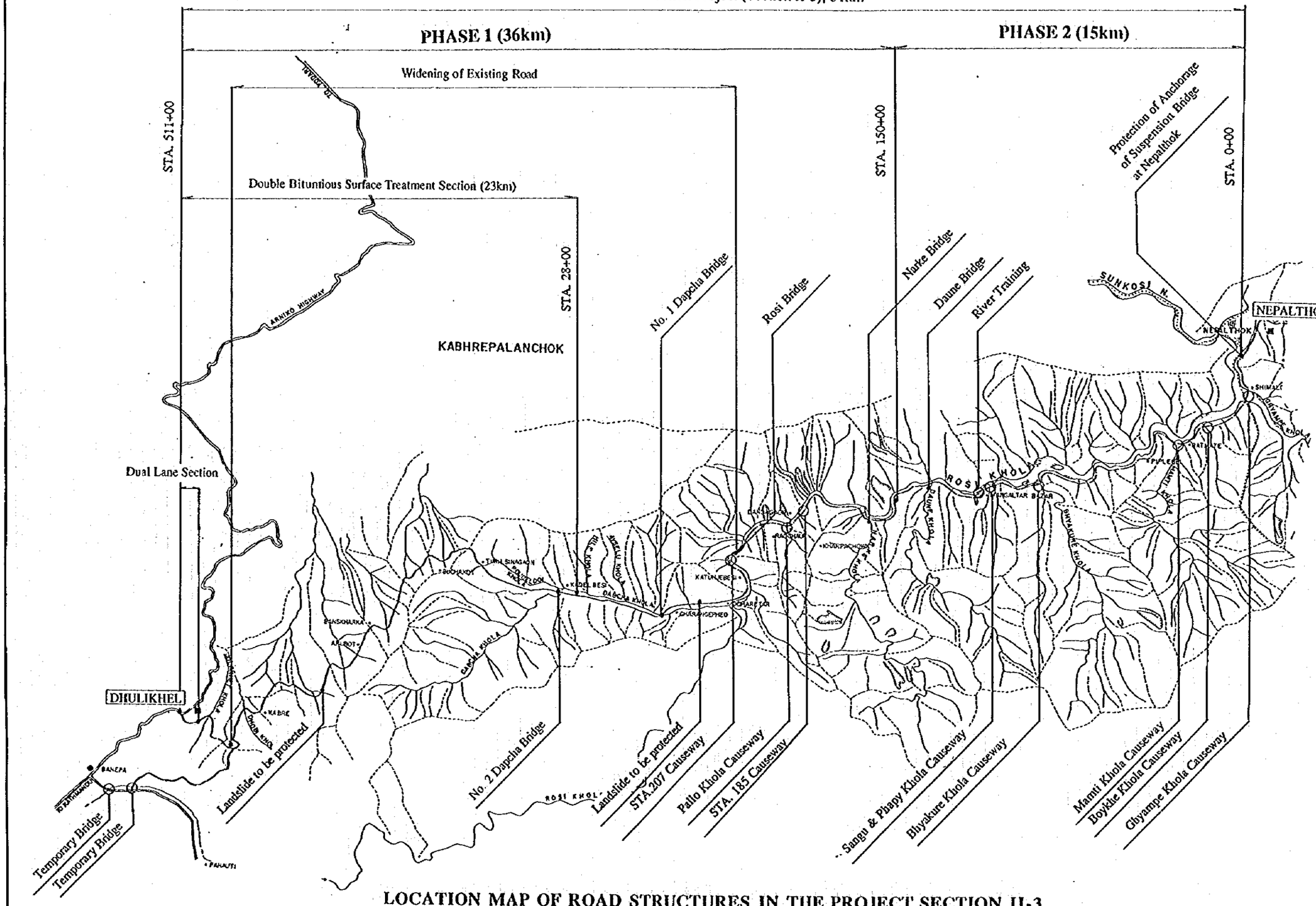


PROFILE



PROJECT LOCATION MAP

Sindhuli Road Construction Project (Section II-3), 51km



LOCATION MAP OF ROAD STRUCTURES IN THE PROJECT SECTION II-3

SUMMARY

The Kingdom of Nepal is a landlocked country, bordered on the north by China and on east, west and south by India. The population in 1991 was estimated to be 18.5 million. The country is divided into three topographical regions such as the Mountain Region, the Hill Region and the Terai Plain, and also comprises of 75 Districts. The Districts are regrouped into five Development Regions divided by south-north borders.

The Kathmandu Valley, located in the Hill Region of the Central Development Region, has been a central area of economic and administrative activities. The Valley has 1.1 million in population, comprises of the city of Kathmandu, Lalitpur and Bhaktapur.

Presently, there are the two main highways connecting Kathmandu Valley with the Terai Plain; namely, the Tribhuban Highway and the Prithiri Highway which meet at Naubise located about 26 km in west from Kathmandu and come into the Valley. The Tribhuban Highway, which crosses the Daman Pass at El 2,300 m, is not used as a main truck line because of its narrow road width and winding alignment. The Prithiri Highway which has a two lane width and relatively acceptable alignment is being used as a main transport route to the Valley for imports and agricultural products from the Terai Plain.

Although the Prithiri Highway is a main transport route, it is still in risk of interrupting the traffic flow due to landslides and/or bank erosions in rainy season as the experience of the disaster on July 1993, which disrupted traffic to and from the Valley for 20 days. And, the route is a roundabout way with many curves and slopes, traveling about 200 km to the western side of the Valley for the traffic between Kathmandu and Eastern Region in Nepal.

Taking into account the condition of the present road network linking Kathmandu Valley and the Terai Plain, His Majesty's Government of Nepal (HMG/N) recognized the necessity of ensuring of a steady supply of daily commodities for the Kathmandu Valley and promotion of the development of the Eastern Development Region and eastern area of the Terai in Central Development Region by reducing the travel distance as well as travel time for all the traffic between the Valley and the Eastern Terai Plain, 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.

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 approximate length of 122 km. The existing 2-lane road of Section I has been constructed by the HMG/N, Department of Road (DOR) adopting 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 unpaved surface. The Section II is divided into three sub-sections: Section II-1 crossing Mahabarat Range, Section II-2 along the Sun Koshi River and Section II-3 along Rosi Kohla and Section II-3 along Rosi Kohla and Dhapha Kohla up to Dhulikhel. In Section II, only foot trails and mule tracks exist except for a 24 km section near Dhulikhel where there exists a gravel road.

In response to a request from HMG/N, the Government of Japan (GOJ) decided to conduct a Feasibility Study (F/S) for the Project. Japan International Cooperation Agency (JICA) carried the F/S during the period between 1986 and 1988. The Final Report concluded that the Project is both economically and technically feasible, yet the Project has not implemented for the budgetary reason and for a political conflicts which exists between Nepal and India. However, as the need for the road be enhanced for build-up of national foundation, HMG/N gave high priority to it and was set forth in the Eighth Plan (1992 - 1997).

Based on the above background, HMG/N requested GOJ to provide technical assistance for reviewing the F/S and Grant Aid for the construction of Sindhuli Road.

In response to a request from HMG/N, the GOJ decided to conduct an Aftercare (A/C) Study for the Project. The A/C Study was carried out during the period between December 1992 and July 1993, aiming at establishing practical and realistic development scheme, and formulated an implementation program for the optimum development scheme based on a review of the F/S Report. As the result, the GOJ decided to conduct a basic design study for the Section I.

The Basic Design (B/D) Study for the Project of Section I was done by JICA during the period between September 1994 and December 1994. In the B/D Study Report, a project scheme and its implementation program for the construction of Sindhuli Road were established under Japanese Grant Aid Program.

According to the implementation plan, the GOJ decided to conduct a basic design study on the Project for Construction of Sindhuli Road (Section II-3: Nepalthok - Dhulikhel), (hereinafter called the Project (Section II-3)), following the B/D Study for Section I.

JICA dispatched a basic design study team during the period between 27 November 1995 and 28 December 1995. The study team discussed with HMG/N officials regarding to the contents of the Project (Section II-3) and scope of works to be implemented under Japanese Grant Aid Program, and carried out the field surveys including site investigation, traffic survey and so on. A basic agreement was then signed and exchanged.

After returning to Japan, based on the results of the field surveys, the study team carried out the basic design study including the road design, bridge design and slope protection works, and prepared a draft basic design report containing contents of the Project (Section II-3), implementation program, scope of works by HMG/N and so on.

JICA dispatched a mission to explain the draft report to HMG/N during the period between 26 February 1996 and 6 March 1996. A basic agreement was signed and exchanged after the contents of the draft basic design report were verified and agreed upon by both parties.

In the basic design study for Section II-3, two phase implementation plan was proposed taking into account the long construction and land acquisition period, and the handing-over procedure. The scope of work determined in the basic design study, including the measure for strengthening of DOR's maintenance capabilities for Section II-3, is summarized as follows:

A. Construction of Section II-3 (Nepalthok - Dhulikhel):

Description	Phase-1	Phase-2	Entire Section	Remarks
Road Construction	STA. 150 - Dhulikhel	Nepalthok - STA. 150	Nepalthok - Dhulikhel	
Length (km)	36	15	51	
Design Speed (km/hr)	20 - 40	30	20 - 40	
Number of Lane *1	Single	Single	Single	
Formation Width *1	4.75	4.75	4.75	
Pavement Structure *2	Gravel	Gravel	Gravel	
Bridge Construction	4 bridges	1 bridge	5 bridge	Single lane 4.25 m effective width
		Daune Bridge	Daune Bridge	Diagonal Strutted Rigid - Frame Steel Girder (53 m)
	Narke Bridge		Narke Bridge	Diagonal Strutted Rigid - Frame Steel Girder (59 m)

	Rosi Bridge		Rosi Bridge	Deck Type Steel Truss (65 m) Reinforced Concrete T-Girder (18 m) Total length 83 m
	No. 1 Dapcha Bridge		No. 1 Dapcha Bridge	Simple Steel Plate Girder (25 m)
	No. 2 Dapcha Bridge		No. 2 Dapcha Bridge	2 Span Continuous Reinforced Concrete T-Girder (24 m)
Majority Causeway Construction	3 nos.	5 nos.	8 nos.	
		Ghyampe Khola Causeway	Ghyampe Khola Causeway	Causeway: 120 m Approach: 75 m
		Boykhe Khola Causeway	Boykhe Khola Causeway	Causeway: 32 m Approach: 80 m
		Mamti Khola Causeway	Mamti Khola Causeway	Causeway: 90 m Approach: 80 m
		Bhyakure Khola Causeway	Bhyakure Khola Causeway	Causeway: 136 m Approach: 80 m
		Sangu & Phapy Khola Causeway	Sangu & Phapy Khola Causeway	Causeway: 130 m Approach: 50 m
	STA. 185 Causeway		STA. 185 Causeway	Causeway: 36 m Approach: 80 m
	Pallo Khola Causeway		Pallo Khola Causeway	Causeway: 20 m Approach: 60 m
	STA. 207 Causeway		STA. 207 Causeway	Causeway: 38 m Approach: 50 m
Other Works		Protection of Anchorage of Existing Suspension Bridge at Nepalthok	Protection of Anchorage of Existing Suspension Bridge at Nepalthok	
		River Training Works at STA. 117	River Training Works at STA. 117	
	Protection of Land-slides at STA. 240+50 and STA. 413+00		Protection of Land-slides at STA. 240+50 and STA. 413+00	

Note: *1 Dual lane will be applied as exceptional cases

*2 Double bituminous surface treatment will be applied for some part of the road taking into account the safety and environmental aspect.

B. Supply of Equipment for the Maintenance of the Section II-3 Road:

Name of Equipment	Specification	Phase-1	Phase-2	Total
Backhoe	0.6 m^3, 126 PS		1	1
Wheel Loader	1.4 m^3, 110 PS		1	1
Dump Truck	6 ton, 225 PS		3	3
Motor Grader	2.8 m, 94 PS	1		1
Three Wheel Roller	8 - 10 ton, 90 PS	1		1
Trailer	20 ton	1		1
Crane Mounted Truck	4 ton/2.9 ton		1	1
Water Tanker	5,500 litre	1		1
Generator	50 KVA 54.4 PS		1	1
Air Compressor	3.7 m^3/min., 34 PS		1	1
Jack Hammer	20 kg		2	2
Vehicle for Maintenance	4 Wheel 1 Drive, 2000 cc	1		1
Vehicle for Maintenance	Pickup Type, 2000 cc	2		2
VHF Telephone	5W, 150 MHz	1		1
Spare Parts		L.S.	L.S.	L.S.
Repair Tools			1	1

For the implementation of the Project (Section II-3) under the Japanese Grant Aid Program, the detailed design and the construction of each phase will be commenced after the Exchange of Notes between the GOJ and the HMG/N respectively. The detailed design and the construction period for each phase were estimated as follows:

	Phase-1	Phase-2	Total
Major Works	Project Road Length 36 km, Construction of 4 Bridges and 3 Major Causeways	Project Road Length 15 km, Construction of 1 Bridge and 5 Major Causeways	Project Road Length 51 km, Construction of 5 Bridge and 8 Major Causeways
Detailed Design	9 months	2 months	11 months
Construction	30 months	30 months	54 months

The Sindhuli Road, when completed, will function as a second life line of Kathmandu, stimulating economic growth for the area and providing an alternative route from the viewpoint of national security. Furthermore, it will reduce the travel distance by about 200 km in the trip between Kathmandu and Eastern Development Region. This will reduce the traffic cost of all of the national. Besides the above, the Road will provide the linkage to the isolated areas and the existing road networks thereby intensifying regional economic activities, and will improve the basic human need in the areas. The population

who receive the benefit from the Road will be great. These include 1.17 million population in the Districts along the route, 5.44 million population in the Kathmandu Valley and in Eastern Region as well as the passenger of busses and trucks between Kathmandu and the Eastern Region which is estimated at 30 thousands per day and totaling 10 million per year.

The Project (Section II-3) will be a second step to the goal of the Project completion, following the implementation of Section I. It has been justified as a linkage to the isolated areas such as northern part of Sindhuli District and southern part of Kavrepalanchok District where it takes more than two days for villagers to walk to the existing road.

The Project (Section II-3) Road has been planned to traverse the mountainous terrain which has steep slopes and fragile geology. Therefore, it is expected that the Project (Section II-3) after completion, will not function satisfactory without adequate maintenance works. Taking into account the importance of the maintenance and present maintenance capability of the DOR, the measures of strengthening the DOR's maintenance capability through such works as construction of the Maintenance office, organization of maintenance staff and procurement of maintenance equipment are to be executed as a part of the Project (Section II-3), so that, DOR could carry out the maintenance of the Project (Section II-3) by themselves.

As the about 50 percent of the road alignment passes along the existing feeder road, the Project (Section II-3) involves the demolition of about hundred of houses. However the introduction of the road planning concept with "Environment Friendly Sindhuli Road Construction Project" and adequate and judicial compensation to be provide, it was estimated that there is no serious environmental impact requiring big change of the scope of works.

The Project (Section II-3) will be implemented within five years construction period in the area with risky natural disaster. In order to reduce the risk, the following implementation plan for the Project (Section II-3) are to be applied.

- To minimize the risks during the construction, shorten the construction period to three years by dividing the Project (Section II-3) into two phases, and hand over the completed section to DOR.

- DOR will have to maintain the handed-over sections by HMG/N budget using the equipment and organization procured and formulated in the Project (Section II-3).

Therefore, it was judged that the Project (Section II-3) can be implemented under the Japanese Grant Aid Program.

As mentioned above the Sindhuli Road Construction Project will provide great effect on the nation and will improve of basic human need along the route. Therefore, it is recommendable that the Project (Section II-3), which promote the early realization of the whole of the Sindhuli Road, should be implemented under Japanese Grant Aid Program. However, taking into consideration of the circumstance of the Project and in order to ensure the smooth progress of the Project (Section II-3), it is recommended HMG/N undertake the following measure.

- To carry out adequate an judicial land acquisition and houses compensation smoothly and complete it before construction.

- To appoint a project manager, who is responsible both the construction and the maintenance of the handed-over sections, from the commencement of the detailed design to ensure the smooth implementation.

- To establish the efficient organization and prepare budget for maintenance of the handed-over sections, including the maintenance of planting on slopes, following the progress of the Project (Section II-3).

- To limit the use of quarry areas and change of drainage along the road which affect the safety and stability of the road.

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CHAPTER 1

CHAPTER 1 BACKGROUND OF THE PROJECT

The Kingdom of Nepal is a landlocked country, bordered on the north by China and on east, west and south by India. The population in 1991 was estimated to be 18.5 million. The country is divided into three topographical regions such as the Mountain Region, the Hill Region and the Terai Plain, and also comprises of 75 Districts. The Districts are regrouped into five Development Regions divided by south-north borders.

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Presently, there are the two main highways connecting Kathmandu Valley with the Terai Plain; namely, the Tribhuban Highway and the Prithiri Highway which meet at Naubise located about 26 km in west from Kathmandu and come into the Valley. The Tribhuban Highway, which crosses the Daman Pass at El 2,300 m, is not used as a main truck line because of its narrow road width and winding alignment. The Prithiri Highway which has a two lane width and relatively acceptable alignment is being used as a main transport route to the Valley for imports and agricultural products from the Terai Plain.

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Taking into account the condition of the present road network linking Kathmandu Valley and the Terai Plain, His Majesty's Government of Nepal (HMG/N) recognized the necessity of ensuring of a steady supply of daily commodities for the Kathmandu Valley and promotion of the development of the Eastern Development Region and eastern area of the Terai in Central Development Region

by reducing the travel distance as well as travel time for all the traffic between the Valley and the Eastern Terai Plain, 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.

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Recognizing the importance and necessity of the Project, HMG/N requested GOJ of providing assistance which includes following:

- Review of the Feasibility Study
- Construction of 15 bridges with approach roads in Section I

- Procurement of Construction Equipment and Materials for Section II

- Procurement of Consultant Services for Section I and Section II

In response to the request from HMG/N, GOJ has conducted an aftercare study and a basic design study, and given a Grant Aid regarding to the detailed design for the Project of Section I as follows;

A. Aftercare Study (A/C Study): January - July 1993

A study aiming at establishing of practical and realistic development schemes and formulation of an implementation program for the optimum development scheme based on the review of the previous F/S.

B. The Basic Design Study for Section I: September - December 1994

A basic design study for the request of construction of 15 bridges with approach roads in Section I.

In the Study Report, it has proposed to modify the request from HMG/N so as to follow the condition to be implemented under Japanese Grant Aid Scheme.

(1) Modifications of the HMG/N Request for Construction of Section I

The modification of the HMG/N 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.

(2) Modifications of the HMG/N 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.

Furthermore, an implementation program for the construction of Sindhuli Road were established in the B/D Study assuming that the Project will be executed under the Japanese Grant Aid Program.

C. Detailed Design on the Project for the Construction of Sindhuli Road (Section I: Bardibas - Sindhuli Bazar) under Japanese Grant Aid

August 1995	:	Signing of E/N
September 1995	:	Commencement of the Design
February 1996	:	Completion of the Design

The Basic Design on the Project for Construction of Sindhuli Road (Section II-3: Nepalthok - Dhulikel), (hereinafter called the Project (Section II-3)), has been carried out according to the implementation plan established in the B/D Study (Section I) Report on the condition that the Project (Section II-3) will be implemented under Japanese Grant Aid Program.

CHAPTER 2

CHAPTER 2 CONTENTS OF THE PROJECT (SECTION II-3)

2.1 Objective of the Project (Section II-3)

The Sindhuli Road Construction Project was formulated to link between Dhulikhel and Bardibas, passing the major cities of Nepalthok, Khurkot and Sindhuli Bazar. The Project, 159 km in total length, is consisted of Section I from Bardibas to Sindhuli Bazar of 37 km, and Section II from Sindhuli Bazar to Dhulikhel of 122 km. The objectives of the Project are as follows:

- To ensure the national security and further economic development through the utilisation of the project road as an alternative trunk way, a "second back bone", which connects Kathmandu and the frontier to India via Terai Plain.
- To reduce the travel distance/time of the traffic between the Kathmandu Valley and Eastern Terai Plain, especially of the traffic conveying agricultural products.
- To upgrade and stimulate social and economic activities in the remote hill areas of the Central Development Region, particularly in the Sindhuli, Ramechhap and Kavrepalanchok Districts, and, consequently, to satisfy the basic human needs of the villagers living in the areas.

The Sindhuli Road Construction Project of Section II-3, from Nepalthok to Dhulikhel, approximately 51 km long, (herein after called the Project (Section II-3)), is a second step to the goal of the Project completion, following the implementation of Section I which constructs mainly bridges and causeways. The Project aims at upgrading and stimulating social and economic activities as well as satisfying the basic human needs of the villagers living in the Sindhuli and Kavrepalanchok Districts.

2.2 Basic Concept of the Project (Section II-3)

2.2.1 Basic Concept of Road Planning and Project Implementation

A. Concept in Road Planning for Section II

The alignment of the Project Road (Section II from Sindhuli Bazar to Dhulikhel) has been planned to pass through the mountainous terrain

which has steep slopes and fragile geology. Therefore, the road planning should be carried out in deep consideration to mitigate any environmental impact and to avoid road disasters. Judging from the site conditions, the countermeasures for the objectives will be the application of rather expensive structures such as rock sheds, crib works with anchor, and so on. Consequently it is prospected that the adoption of these countermeasures will incur the cost increase of the Project.

However, as the Project is scheduled to be implemented under the Japanese Grant Aid Scheme, the extent of application of such countermeasures is accordingly controlled by the budgetary limit allotted to the Project. When the road planning is carried out applying the high standard, it will require heavy cutting and embankment, and, consequently, huge amount of expenditure to provide appropriate slope protection or the countermeasures against the road disaster. Therefore the application of high standard is not practical and not recommended.

The Section II of Sindhuli Road should be planned by realistic concept of the road planning taking into consideration of the limited budget and the objectives of the Project.

Therefore, a concept of "Environment Friendly Sindhuli Road Construction Project" was introduced to the road planning for the Project. This concept will be realised with the following programmes:

- Application of the stage-wise construction method (construct a single lane road at the first stage) keeping pace with the traffic demand.

- Application of rather low design speed of 20 to 40 km/hr, and the minimum 4 metres width road as exceptional case in order to avoid the big scale of earthworks and long slope treatment.

- In depth study of the project route not to pass or affect the potential hazard area with full utilisation of prepared "Hazard Map", and the application of appropriate slope protection or countermeasures against the possible road disaster.

- Application of appropriate road geometry and practical construction plan which will minimise the environmental impact.

- Provision of the proposal for operation and maintenance organisation which is to be established after the project completion.

Above mentioned programmes will be carried out in order to minimise the effect on natural environment as well as to reduce the possible road disasters or land slides, taking into account the cost comparison/savings of the Project.

B. Stage-Wise Construction

Implementation of the stage-wise construction will contribute to reduce the work quantities and consequently minimise the initial construction cost at the first stage. This construction method will also cause least effect from the environmental impact to the surrounding area. However, the following stage construction which requires the widening of the road from single lane to dual lanes in the mountainous area, will be often technically difficult and very costly. Therefore, the technical/economic feasibility of this method was assessed from the view point of the achievement of the Project target, through the study of future widening schedule from single to dual lanes and expected work for widening.

The estimated future traffic demand prepared by the Aftercare Study in March 1993 was updated by the supplemental traffic survey carried out in the B/D Study (Section II-3). Figure 2.1 shows the updated peak hour traffic (pcu/hr) on the Section II at opening time of the entire section of the Sindhuli Road (scheduled as year of 2003), after five years (2008), and after ten years (2013).

In the initial stage, single lane was proposed to Section II. The formation width was designed as 5.3 metre to 5.5 metre as shown in Figure 2.2.

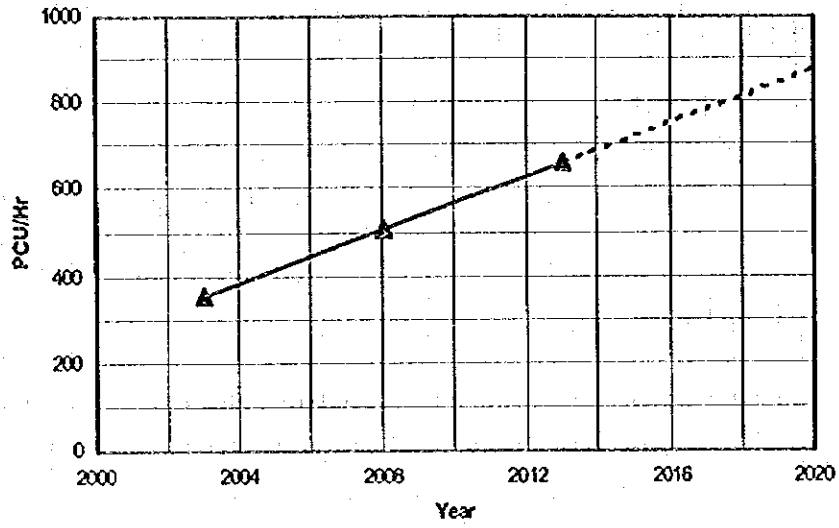


Figure 2.1 Estimated Further Peak Hour Traffic Volume on Section II

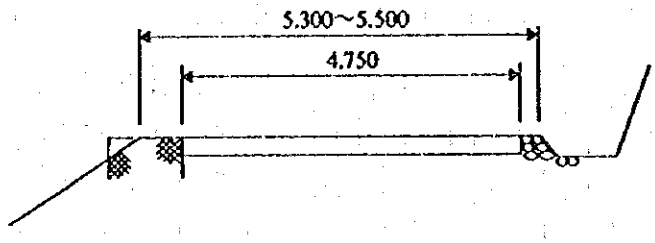


Figure 2.2 Road Width of the Project Road (Section II)

The possible traffic capacity of the single lane road having a road formation width 5.4 metre was estimated by following calculation. (Referred to "Traffic Capacity", Japan Road Association)

$$Ceo = \{600 \times (W - 3.5) / (5.5 - 3.5)\} + 50$$
$$= \{600 \times (5.4 - 3.5) / (5.5 - 3.5)\} + 50 = 620 \text{ pcu/hr}$$

where, Ceo : Traffic capacity (pcu/hr)
W : Road width (m)

Judging from the peak hour traffic growth shown in Figure 2.1, it is anticipated that the widening from single to dual lanes will be required approximately ten years after the opening in 2013. However, taking into account the fragile geology along the route, steep slope of the terrain, and the budgetary condition of HMG/N, it may be difficult to widen the road which requires large scale slope protection works and retaining wall in cutting sections at that time.

Considering the above situations, it is recommended to utilise the full width of single lane road, approximately 6 m wide, by the installation of concrete cover over the side ditch as illustrated in Figure 2.3, instead of increasing one lane at that time. Although this treatment (semi-dual-lane) does not satisfy the requirement of design standard as dual-lane road from the viewpoints of standard cross-section, required lane width in a small curvature, or sight distance, this will be the most realistic solution as the dual lane operation is safely done by lowering the running speed of vehicles.

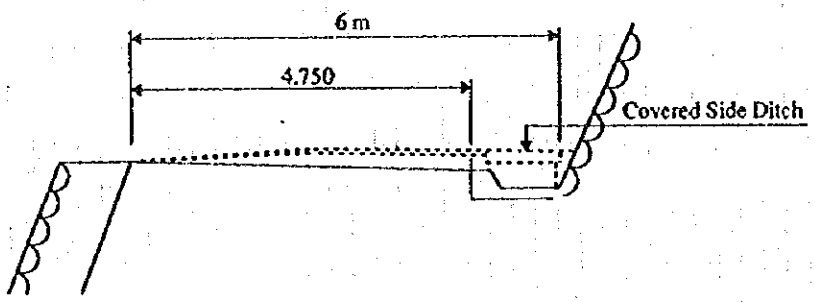


Figure 2.3 Road Width of Semi-Dual-Lane utilising the Side Ditch Cover

The possible traffic capacity of the dual-lane road having a effective width of 6 metre was estimated as follows.

$$Cc = 2{,}500 \times a \times b \times c \ldots$$
$$= 2{,}500 \times 0.88 \times 0.91 \times 0.95 = 1900 \text{ pcu/hr}$$

where, Cc : Traffic capacity of dual-lane road (pcu/hr)
a : coefficient for lane width
b : coefficient for side clearance

c : coefficient for surroundings

Considering the estimated peak hour traffic shown in Figure 2.1, this semi-dual-lane will provide the enough traffic capacity for the demand up to 20 years after the road opening or more. Based on the above study, the basic design of Section II-3 was carried out by the understanding that the stage-wise construction will be done by the following steps.

Initial stage : Single Lane

Second stage : Semi Dual Lane (After ten years of opening)

Final stage : Dual Lane (After more than 20 years of opening)

C. Implementation Plan

The Sindhuli Road Construction Project has been formulated to construct a long distance mountainous road, 159 km in length, by seven years construction period, under Japanese Grant Aid Scheme. Considering the natural conditions of the project area, the Project may have such unforeseen risks as heavy slope failures or debris flows which will cause serious damages to the project road during the construction, and will require increased project cost. However the allocation of additional construction cost to reinstate the road from unforeseen disaster is not allowed as Japanese Grant Aid Scheme does not have such a scope.

Hence HMG/N, who gives the first priority to the Project as his national project, is requested to share the appropriate portion of the cost and positive cooperation for the Project. In order to reduce the above mentioned risks, it is recommended to apply the following implementation plan for the construction of Section II.

- To minimise the risks during the construction, shorten the construction period (approximately three years) by dividing the Project into subsections, and hand over the completed section to DOR as early as possible.

- Even the short segment within the subsection, try to hand over to DOR after the completion. DOR will have to maintain the segments by HMG/N budget.

- However when the handed over section/segment is used as an access road to the construction site by the contractor, the maintenance of road surface of the said section/segment shall be conducted by the related contractor.

The above implementation plan requires HMG/N to build operation and maintenance offices, to provide equipment/materials, to organise technical/management staff for the office, and to carry out the maintenance work of the handed over sections/segments. However, as the budgetary condition of the DOR, who is presently responsible for the road maintenance, depends on loans or aid finances from international organisations or foreign aid agencies up to 60% of their total budget, it is judged that their operation and maintenance capacity is not sufficient to cope with the Project. Taking into account this situation, it is recommended to supply some equipment for the operation and maintenance work by the Project to reduce the cost which is originally expected to be shared by HMG/N from the time of initial stage construction. It is also recommended to support the HMG/N to establish his operation and maintenance system for the project road required after the completion of the Project.

2.2.2 Basic Concept of the Project (Section II-3)

According to the above concept of the implementation for the construction of Section II, the Project (Section II-3) from Nepalthok to Dhulikel of approximately 51 km length, was planned to divide into two sections and be implemented as a single lane road of 4.75 m wide at the initial stage, following the Section I construction. The Project (Section II-3) is aiming (1) to promote the completion of entire sections of the Project, and (2) to upgrade and stimulate social and economic activities as well as to satisfy basic human needs for the villagers along the project area by constructing the road.

Furthermore, the concept includes the supply of maintenance equipment which will be required for the maintenance activities by DOR during the construction period, especially in case of natural disaster, and will be expected to reinforce the operation and maintenance system of the Project Road to be established by the HMG/N after the completion of the Project.

2.3 Basic Design of the Project (Section II-3)

2.3.1 Design Concept

A. Design Concept for the Natural Conditions

The alignment of the Project (Section II-3) have been planned to traverse on fragile geology with steep slopes along Rosi River and Dapcha River. Therefore the appropriate approaches to the natural conditions has been given priority during the road design. The provision of countermeasures against the slope failure, land-slide and etc. has also been taken due considerations. Based on the basic concept for the Project, Section II, the following guidelines against the natural conditions were established in order to carry out the Basic Design.

(1) Considerations for the road planning

(a) The basic policy shall be the application of stage-wise construction method which will construct a single lane road (w = 4.75 m) at the initial stage and upgrade to dual-lane road (w = 6.5 m) in the final stage keeping pace with the future traffic demand. The policy aims to minimise the environmental impact and also to reduce the initial construction costs.

(b) To locate the single lane road alignment, which will be constructed by the Project as the first stage, at the valley side to minimise the cut slope which will induce slope failures or land slides.

(c) To locate the road alignment on the river bank, when it is judged as applicable, instead of traversing the mountainside, to avoid the cut that will be required.

(d) To apply the varied design speed of 20 km/hr to 40 km/hr flexibly depend on the terrain/geological conditions. This will enable the alignment close to the original terrain condition and avoid heavy cut works.

(2) Considerations for the planning of slope protection

(a) To provide a hazard map by special geological survey focusing the slope protection and countermeasures against the road

disaster. The hazard map will classify the project area into (i) very risky section which requires special treatments by structures, (ii) a section which needs careful design for slope protection, and (iii) other section for which a normal roadway design is applicable. The design is to be carried out referred to the Hazard Map, section by section, and every efforts shall be taken not to traverse risky areas which may require deterrent structures against potential disaster by even lowering the design standard.

(b) Design of the cut and fill slope (determination of slope gradient) will be carried out referring to both Japan and Nepal Standards. Fresh rock slopes will have no treatment, and common soil slopes will be covered by sod as commonly treated in Nepal. In case the slope is not stable by sodding because of the soil characteristics and require special treatment, special slope protection methods such as crib work, supported type retaining wall will be applied.

(c) In addition to the road disaster caused by cut slopes, disaster at the downstream of the road caused by erosion of valley or gully induced from inappropriate treatment of road drainage outlet shall be considered. Therefore, conducting site investigation of valleys or gullies scheduled to install drainage outlet, the design will provide appropriate structures such as check dam and water channel at the down stream of cross-drainage out-let to prevent the erosion.

(3) Consideration for the construction

(a) Sometimes it is observed that side disposals of excavated materials from retaining wall construction or road excavation damages the downstream slope and accelerate slope disaster during the construction of mountainous road. In order to avoid such disaster, the road design will be carried out applying retaining wall type at valley side which requires less excavation, and, at the construction period, the contractor will be supervised his earth moving based on the pre-defined schedule which classifies the section allowing side disposal and the section not allowed.

(b) To review the design which have been planned using 1000 ~ 2000 scale map, by 1/500 scale maps on the construction stage to avoid making heavy cutting and filling due to aberration on maps.

(c) The Project will be implemented taking into consideration the possible countermeasures for minimising of environmental impact and road disaster from all angles as mentioned above. However, even implementing the Project with such approach, disaster might occur due to the natural conditions. Therefore, maximisation of DOR's maintenance force should be called for against the road disaster on the partial handed-over sections during the construction and completed section.

B. Special Considerations for Social Conditions

Along the project route, many irrigation canals and water channels for the water mill are located which support the fundamentals of people's living. In case of the project road obstructs these regional water facilities, adequate countermeasures shall be provided to recover the expected functions.

Regarding the religious facilities or sacred trees which are scattered along the project area, the alignment shall be arranged to avoid these.

At the end point of the Project—Dhulikhel, the proposed route will pass the suburban area. As this area has been anticipated to make rapid urbanisation, the road will be designed as dual-lane road in this area to secure the safety and smooth traffic.

C. Maximum usage of Local Contractor and Local Materials

The construction methods commonly used in Nepal or structures using local materials of cement, galvanised wires or stones are low costs and familiar for Nepalese contractor. Huge amount of boulders, cobble stone and sand have been deposited on the riverbeds along the route. Therefore, the local construction method using the locally available materials should be applied for road design to realise the cost minimum and smooth construction progress.

D. Considerations for DOR Maintenance Capabilities

Due to the budgetary limitation, DOR cannot extend his capabilities to his satisfaction as the executing agency or the responsible organisation for operation and maintenance over the national roads. Therefore it is essential to design the road structures/facilities to be easily maintained with relatively low cost by utilising local materials and construction methods except the special structures such as bridges.

E. Concept for the Road Structures Design and Selection of Maintenance Equipment to be Supplied

As mentioned in Section 2.2.1 B, the project road of single lane which will be constructed in the initial stage will be used for more than 20 years after the opening with minor modification-widening by utilising the cover of side ditches. Therefore, the project road should be designed taking into consideration the long period usage as below;

(1) Even the retaining structures at the mountain side, which is scheduled to be demolished at the time of full widening, will be designed as permanent structures.

(2) The pavement structure will be designed considering the future overlay.

However, the single lane (width: 4.25 m) bridges will be applied by the following reasons:

(1) Within the limitation of budget, minimisation of environmental impact and prevention of road disaster shall be given the priority.

(2) Even in the road sections, the exceptional minimum width of 4 m will be applied as a permanent section width due to the terrain conditions. The bridge section shall follow this concept.

The maintenance equipment to be supplied by the Project (Section II-3) will be selected considering the following conditions:

(1) Previous hazard data of existing roads in Nepal

(2) Required scope of maintenance for Section II-3 during the construction period

(3) Anticipated type of road disaster and its magnitude

The tool sets which will be provided to the workshop by the Project (Section II-3) will be selected to satisfy the purpose of routine maintenance and minor repair. It was assumed that the heavy repair can be carried out by the existing heavy equipment centre of DOR during the construction period.

F. Implementation Plan

The Project (Section II-3) should be implemented by staged construction of two phases as shown in Figure 2.4 taking into consideration the minimising of risk due to heavy rain during monsoons, construction schedule, survey and detailed design period, land acquisition and house compensation period, levelling of annual expenditure for Project borne by DOR, partial hand-over of the completed sections, and schedule of formation of maintenance structure by DOR.

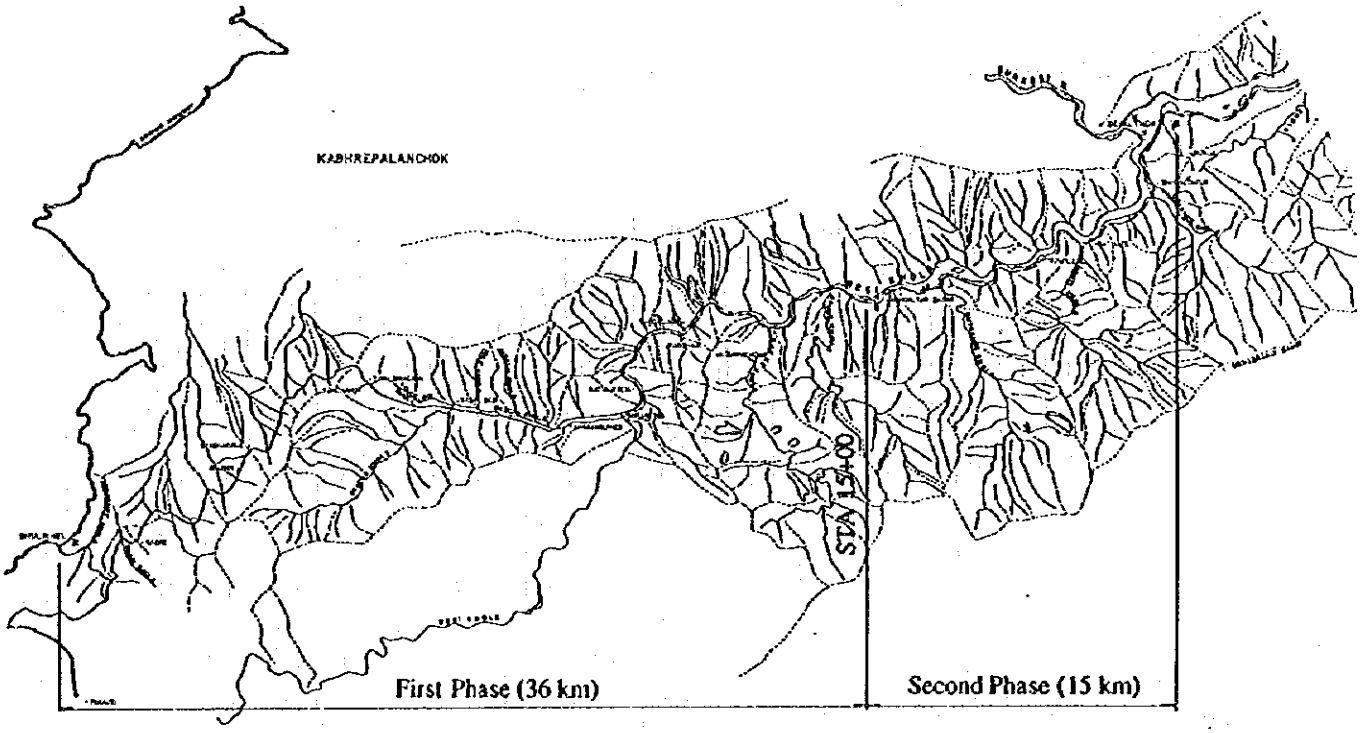


Figure 2.4 Division of Section II-3

Table 2.1 Tentative Construction Schedule of First Phase and Second Phase

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
First Phase (36 km)						
Second Phase (15 km)						

2.3.2 Basic Design

A. Road Design

(1) Design Criteria

The design criteria for Section II-3 as listed below was adopted based on the National Road Standards (NRS) No. 2027, Classification and Design Standards for Feeder Roads (Second Revision), February 1994, Japan Road Standards (JRS) and discussion with the DOR staff.

Right of way	: 50 m
Design Speed	: 20~40 km/hr
Formation width	: 4.75 m (Exceptional 4 m)
Carriageway width	: 4.75 m (Exceptional 4 m)
Camber	: 4% (Gravel), 2.5% (Double surface treatment)
Minimum curvature	: 15 m (20 km/hr), 25 m (30 km/hr), 45 m (40 km/hr)
Widening on curves	: To be widened by adequate width for semi-trailer
Minimum vertical curve radius	: 300 m
Maximum grade	: 9%
Limit length of the maximum grade	: 300 m (Recover section (4%, 150 m) will be followed)
Interval of passing place	: To be constructed by adequate interval according to the site conditions

[Design Speed applied for Section II-3]

The design speed (20~40 km/hr) was applied as shown in Figure 2.5.

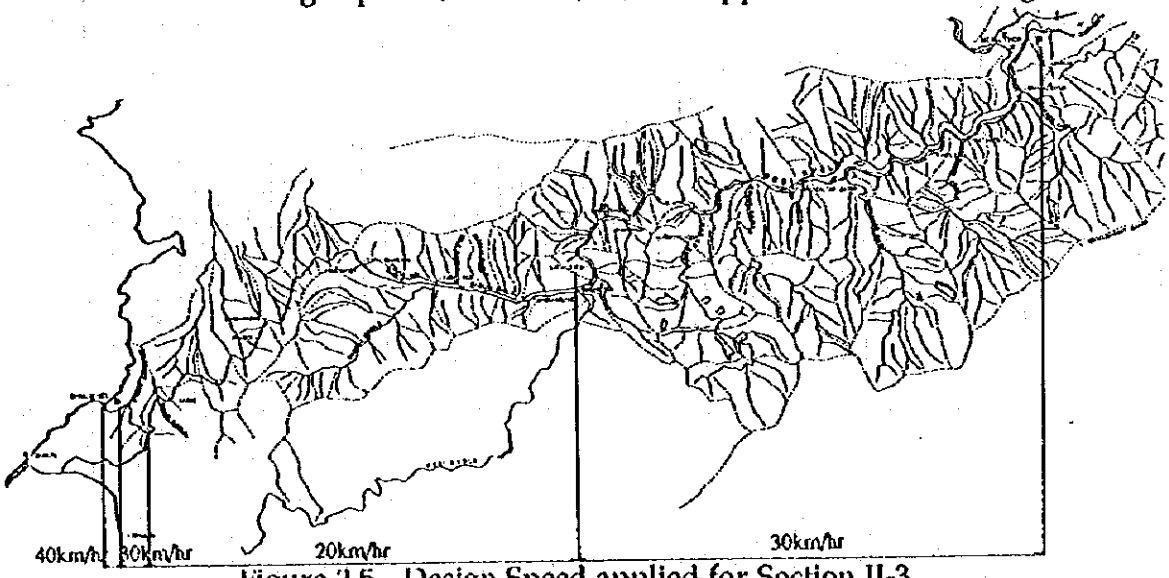


Figure 2.5 Design Speed applied for Section II-3

[Horizontal Alignment]

The horizontal alignment proposed in the A/C study have been reviewed according to the concept of minimising the environment impact and road disaster on the B/D as follows;

- To change the alignment along the existing road section to follow the existing road alignment closely for minimising the cutting slopes.
- To site the alignment along the Rosi River to river side to minimising the cutting slopes.
- To change the crossing point of Rosi River to 500 metre down stream from the previous site to avoid the big cutting of the slope as shown Figure 2.6.

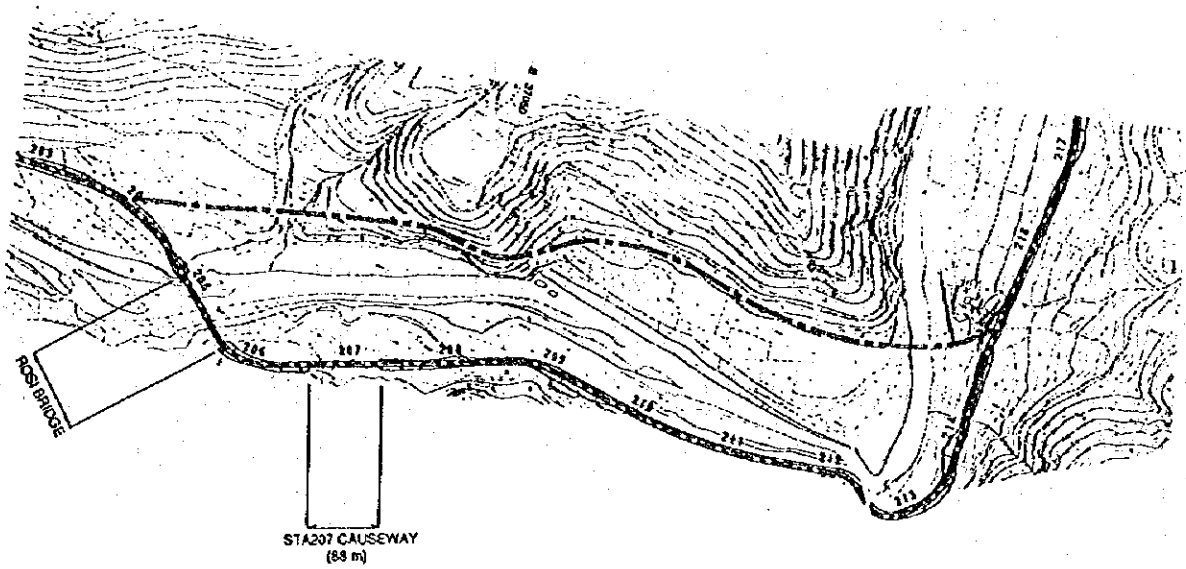


Figure 2.6 Reviewed Alignment at Crossing Point of Rosi River

[Vertical Alignment]

According to the review of the horizontal alignment, specially the shifting of the centre line to the river side, the vertical alignment also has been reviewed by the control of the high water level of Rosi River. The high water level was estimated by the hearing from the villagers, and the road elevation was set minimum 1.5 m above from the high water level.

[Dual Lane Section]

The section from station 504 to the junction with Kodari Road, the length is about 700 metre, will be constructed as double lane road even in the first part of stage-wise construction for the safety and smooth traffic control.

[The exceptional Sections]

According to extremely steep and/or very fragile geology, the following three sections have been planned to construction the road by 4 metre formation width.

-	STA. 131+50 ~ 138+00	450 m
-	STA. 256+50 ~ 259+50	300 m
-	STA. 262+00 ~ 264+00	200 m
	Total	950 m

[Provision of Bus-stop Area at Dhulikel]

The existing bus-stop at Dhulikel has been in confusion due to narrow space. The situation will be worse at the time of the opening of the Sindhuli Road. Therefore, the future bus-stop space should be prepared in the Project using the disposal material at the junction of Kodari Road.

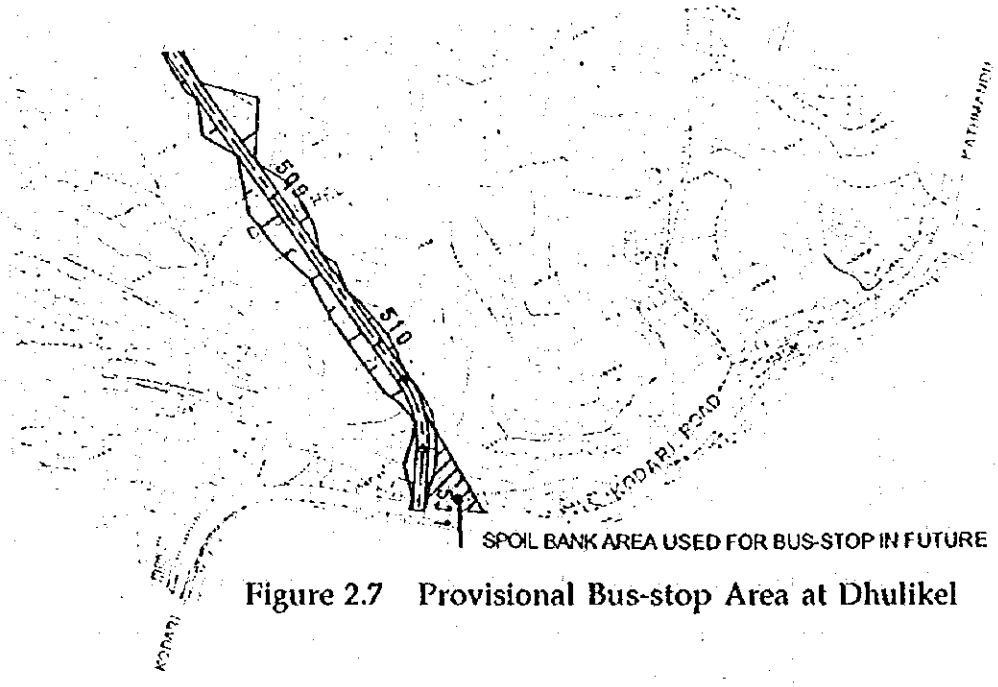


Figure 2.7 Provisional Bus-stop Area at Dhulikel

(2) Earth Works

Cut and embankment slopes will be selected from following table according to the Earth Work Manual, Japan Road Association.

[Cut slope]

		Range	Applied slope
Rock		1:0.3~1:0.8	1:0.5
Soft Rock		1:0.5~1:1.2	1:0.8
Sandy Soil	Dense	1:0.8~1:1.0	1:1.0
	Loose	1:1.0~1:1.2	1:1.2
Gravel, Soil	Dense	1:0.8~1:1.0	1:1.0
	Loose	1:1.0~1:1.2	1:1.2

[Embankment slope]

	Height	Range	Applied slope
Good grading sand, Gravel	<5 m	1:1.5~1:1.8	1:1.5
Poor grading sand	5~15 m	1:1.8~1:2.0	1:0.8
Poor grading sand	<10 m	1:1.8~1:2.0	1:1.8
Crushed Rock	<10 m	1:1.5~1:1.8	1:1.5
	10~20 m	1:1.8~1:2.0	1:1.8
Sandy Soil	<5 m	1:1.5~1:1.8	1:1.5
	5~10 m	1:1.8~1: 2.0	1:1.8

(3) Slope Protection Works

The first step on counter measure of slope protection is to reduce the slope. The road design has been carried out based on the concept of counter measure for nature conditions minimising the cuttings. The total area of embankment slopes and cut slopes are reached to 141,0000 sq. m and 56,000 sq. m respectively by the road design. The figure means that average embankment slopes and cut slope are 2.8 m and 1.1 m per one metre of road length, and the concept applied successfully in the condition of the terrain along the route.

(Design Policy of Slope Protection)

The slope protection design should be carried out taking into consideration of the following site conditions.

- Dry field during the dry seasons
- Sterile land
- Attacking by goats, cattle and human

In the above issues, the attacking by goats and cattle is the most severe effect to the slope plants. Therefore, the concept of quick bushing by shrub which will survive in the conditions, will be introduced.

Less maintenance in planting is not desirable to grow thick plantations in the slopes. However, the budget limitation will be selected and applied for the slopes.

From the above point of view, manual planting commonly used in Nepal will be applied with the policy of village participantion as follows:

- To apply local planting methods such as seeding, laying live cuttings, containerised trees, and sodding using locally available materials.

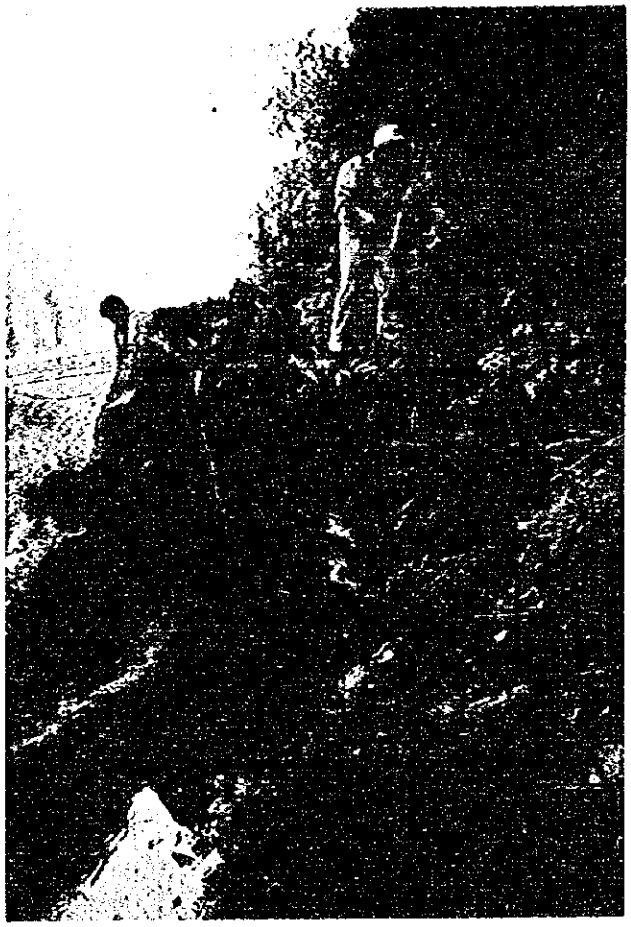
- To requests the villagers for collection of seeds, live cuttings and sod, and operation of nursery.

- To buy the materials from villagers and plant then on slopes.

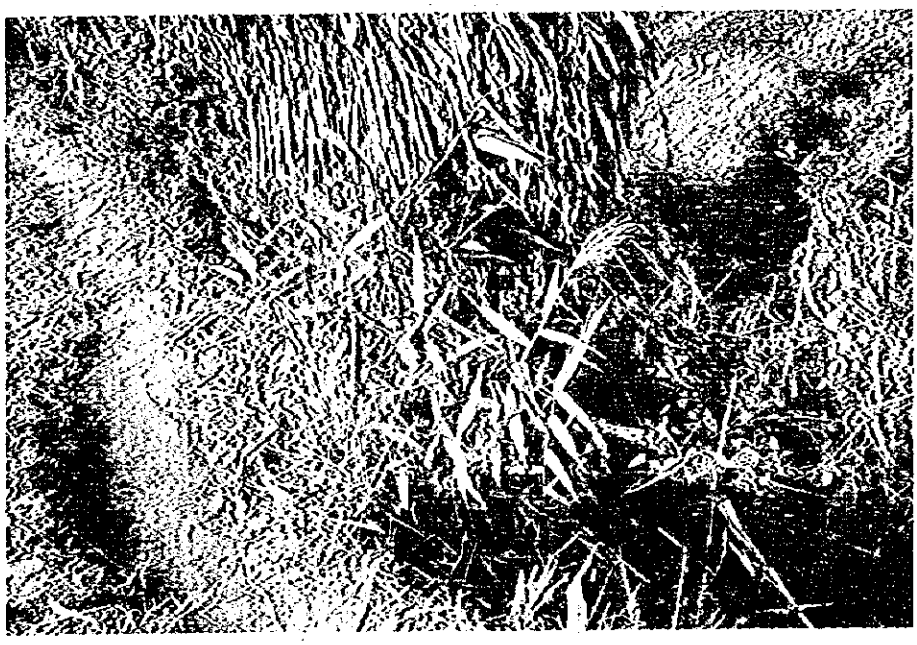
- To employ the villagers for the maintenance of slopes to avoid the attacking by goats and cattle

The details of the planting methods will be planned using following references.

- Interim Rate Analysis Norms of Bio-Engineering and Guidelines on Bio-Engineering, (DOR)
- Vegetation Structures of Stabilising Highway Slopes, (DOR)
- Mountain Risk Engineering Handbook, (ICIMOD)
- Highway Earthwork Manual, (Japan Road Association)



Khotg Sallo



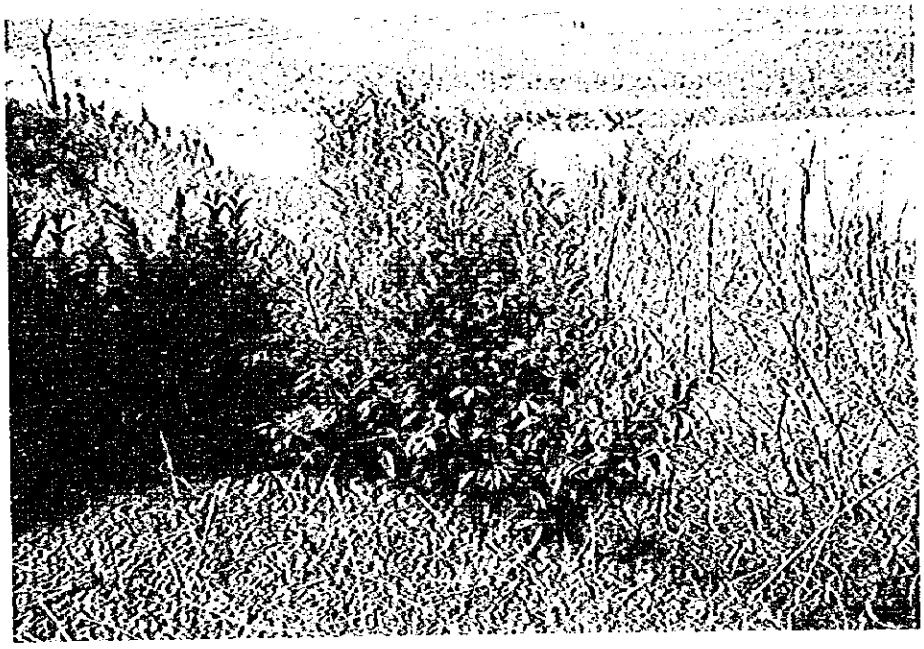
Nigalo

Photograph 2-1 Grass and trees useful for plantation and available along the site.

Dhursel

Sajiwan

Photograph 2-2 Grass and trees useful for plantation and available along the site.



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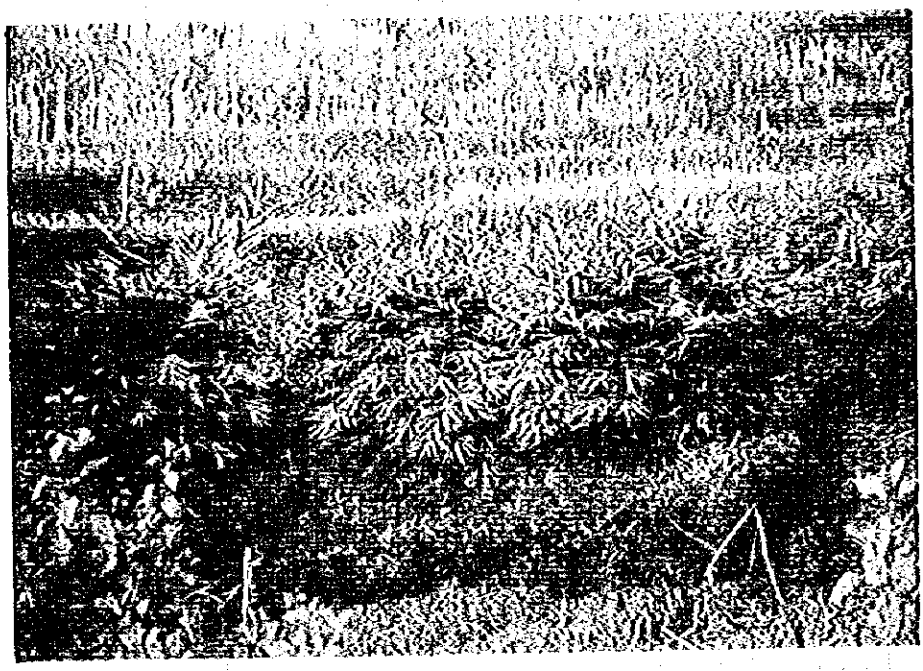


Broom Grass (Amliso)

Photograph 2-3 Grass and trees useful for plantation and available along the site.

The types of slope in Section II-3 are divided as follows:

(a) Common embankment slopes (Slope 1:1.5 ~ 1:1.8)

(b) Embankment slopes covered by river gravel (Slope 1:1.5 ~ 1:1.8)

(c) Common cut slopes (Slope 1:1.0 ~ 1:1.2)

(d) Cut slope of weathered gneiss (Slope 1:1.0)

(e) Cut slope on river terrace or colluvium (Slope 1:1.2)

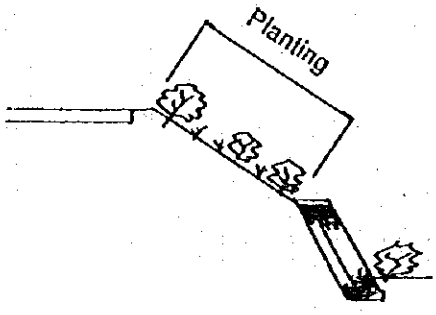
(f) Cut slope on cranky and lose rock (Slope 1:0.5)

(g) Cut slope on hard rock (Slope 1:0.5)

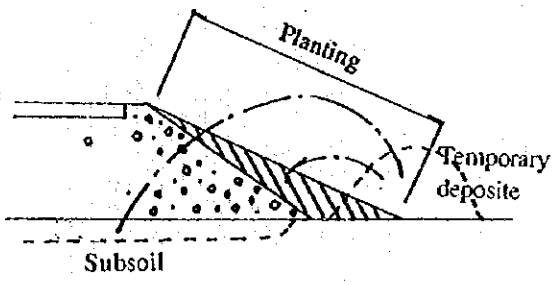
In the above types, the slopes of (a) to (d) will be protected by planting, the slope (e) and (f) will be protected by special slope protection such as crib works and retaining wall, and the slope (g) will be untreated. The typical slope protections works are shown in figures below.

[Planting]

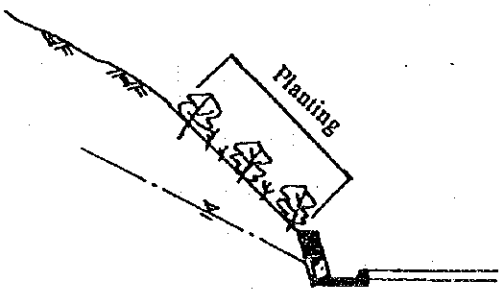
Common embankment slope (Slope 1:1.5~1:1.8)



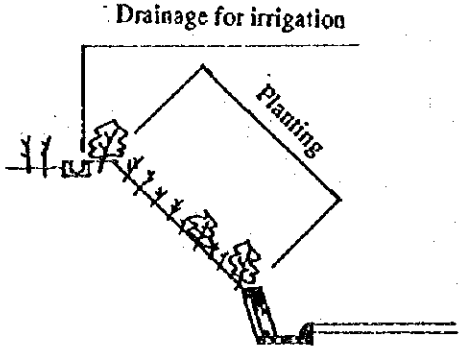
Embankment slopes covered by river gravel (Slope 1:1.5~1:1.8)



Common cut slope (Slope 1:1.0)



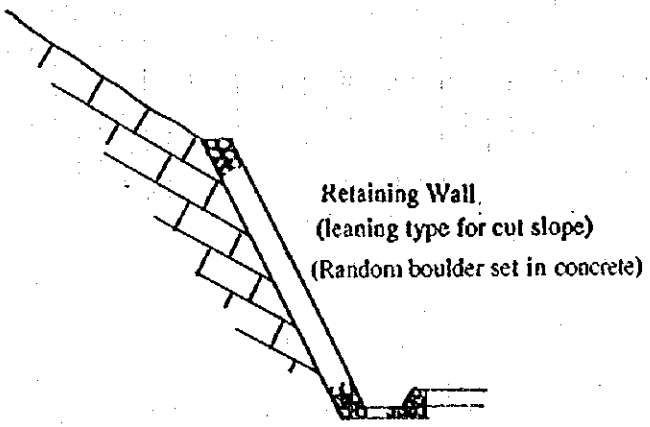
Cut slopes on weathered gneiss (Slope 1:1.0)



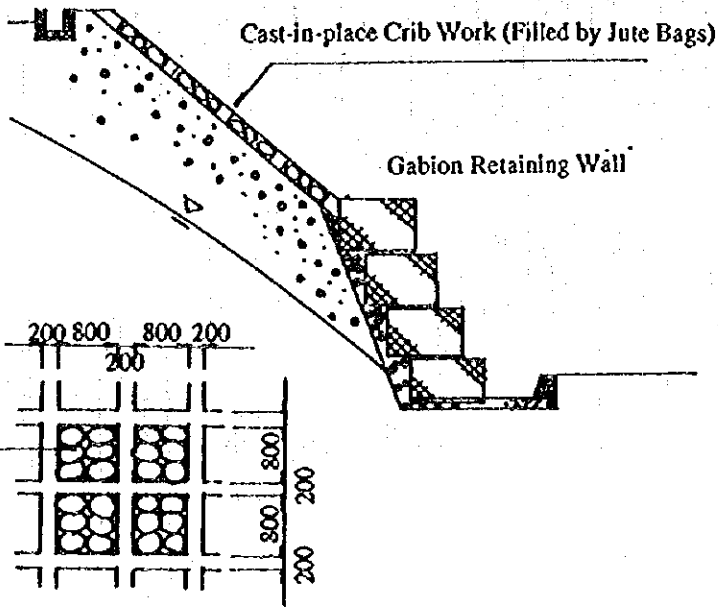
- Side ditch with 1m height of retaining wall constructed basically to avoid the slope foot erosion.
- Planting by sodding, seeding, laying of live cuttings will be carried out on slopes.

[Special Slope Protection]

Cut slopes on cranky and lose rock

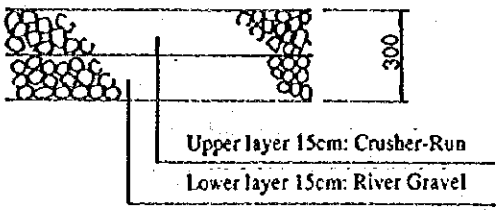


Cut slopes on river terrace or colluvium



(4) Pavement Structure

The gravel pavement structure of river gravel in the 15 cm thick lower layer and crusher-run in the 15 cm thick upper layer will be applied for Section II-3, taking into account the widening to semi-dual-lane which will be implemented 10 years after the opening.

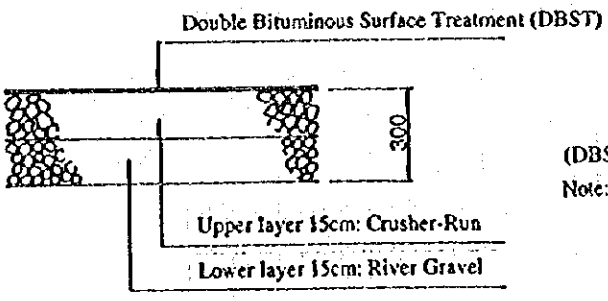


(Gravel Road Section)
Note: In the sections where subgrades are constructed by the river gravel, the lower layer will be canceled.

Figure 2.8 Pavement Structure applied in Section II-3

[Double Bituminous Surface Treatment (DBST)]

Double bituminous surface treatment (DBST) will be applied to the STA. 280~END section and steep gradient (>5%) sections taking into consideration the minimisation of environmental impact and traffic safety.



(DBST Section)
Note: DBST will be applied to the STA.280 - End Section and steep gradient (>5%).

Figure 2.9 Pavement Structure of DBST

(5) Side Ditches

As shown in Figure 2.10, the L-shaped side ditch of 1 m width by 0.3 m depth will be applied as a standard ditch type from the viewpoint of traffic safety. In case more flow area is required the sectional area of ditch will be adjusted by depth change and the width will be kept as constant. When the project route passes paddy field, blind drainage will be installed in order to lower the ground water level.

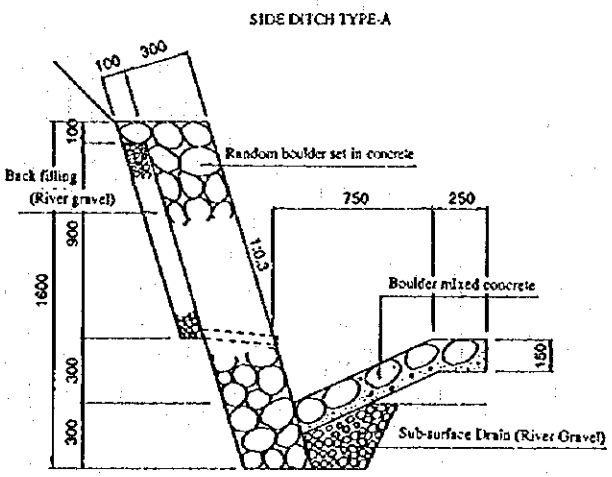


Figure 2.10 Standard (L-Shaped) Side Ditch

In the section where the road width is designed as 4 m (exceptional) due to so steep terrain or weak geological condition, small size side ditches (30 × 30 cm), as shown in Figure 2.11, will be applied to minimise the construction width.

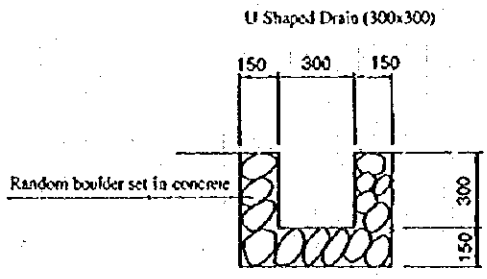
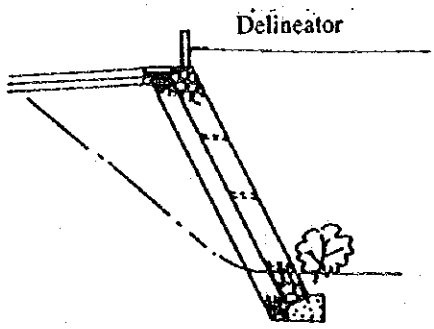


Figure 2.11 Small Size Side Ditch applied in the Exceptional Section

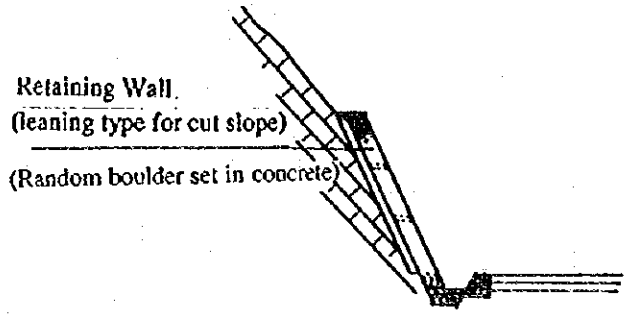
(6) Retaining Wall

The retaining walls will be designed to be constructed by the local materials and techniques such as gabion, random boulder set in concrete, stone masonry as shown in Figure 2.12. At the Rosi River side, gabion mattresses and big boulders will be placed at the slope toe to protect the bank slope from the scour caused by the river flow.

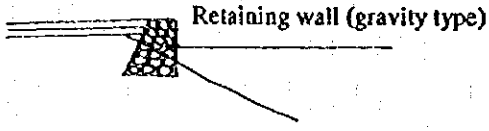
Retaining Wall (leaning type)
(Random boulder set in concrete)



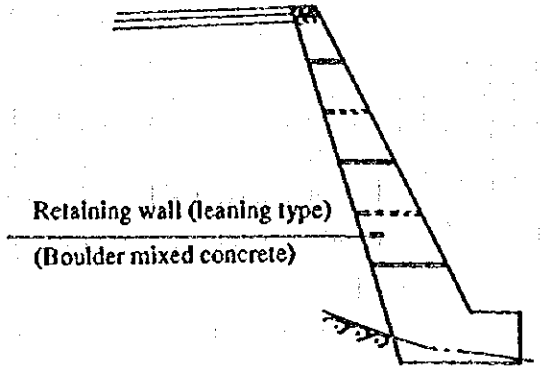
Breast Wall (leaning type)
(Random boulder set in concrete)



Retaining Wall (Gravity type)
(Random boulder set in concrete)



Breast Wall (leaning type)
(Boulder mixed concrete)



Toe Protection work in River Side

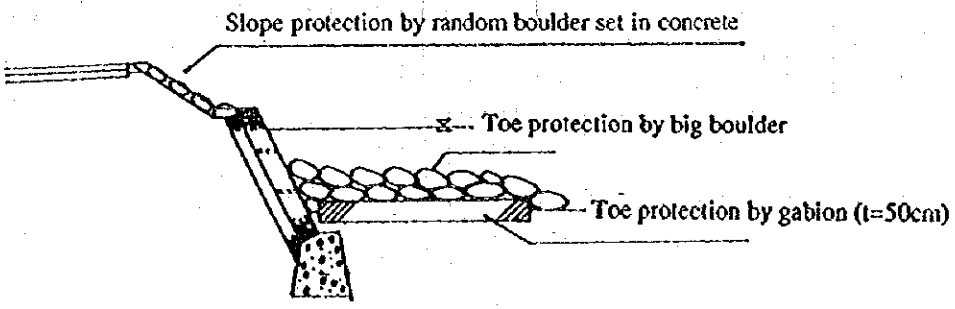
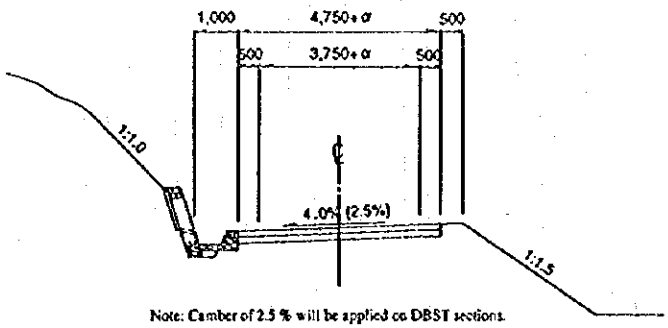


Figure 2.12 Retaining Walls applied at Valley Side

(7) Typical Road Cross-section

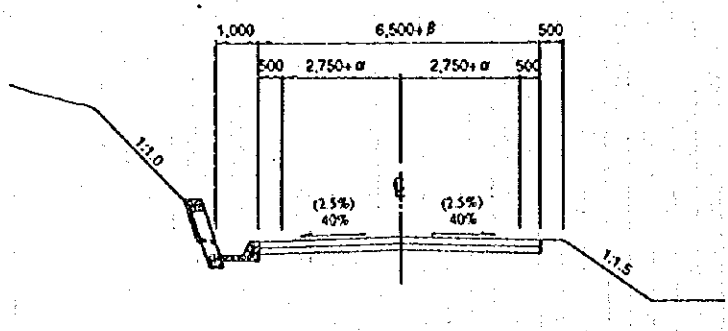
According to the road elements, the typical cross-sections adopted in Section II-3 are shown below.

(Single Lane Sections)



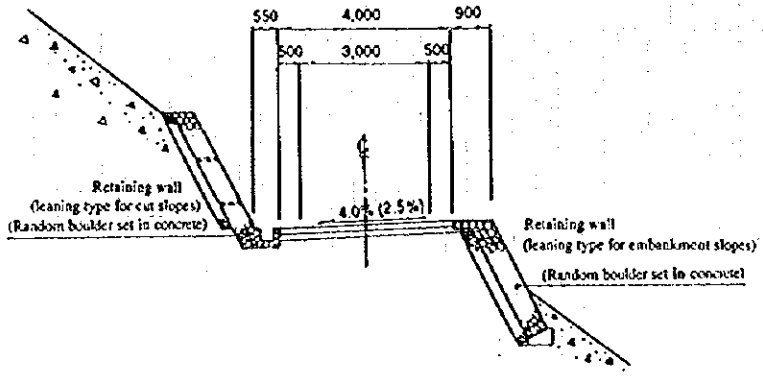
Note: Camber of 2.5 % will be applied on DBST sections.

(Double Lane Sections and Bus-stop)

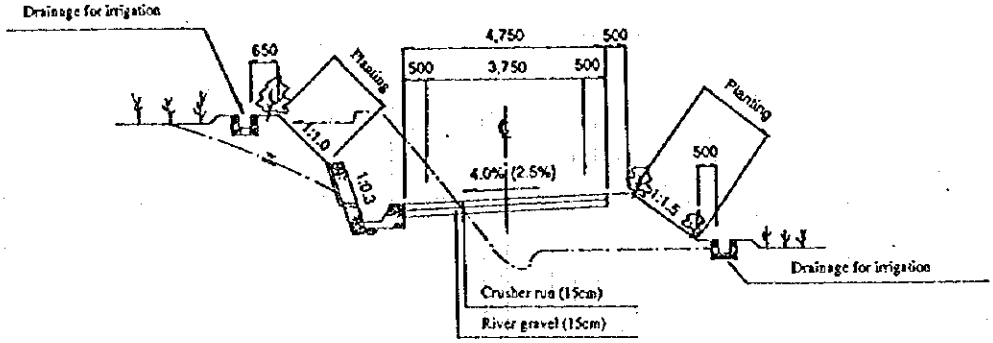


Note: Dual lane sections will be applied to the section STA. 504 to the junction with Kodari Road and Bus-stops.

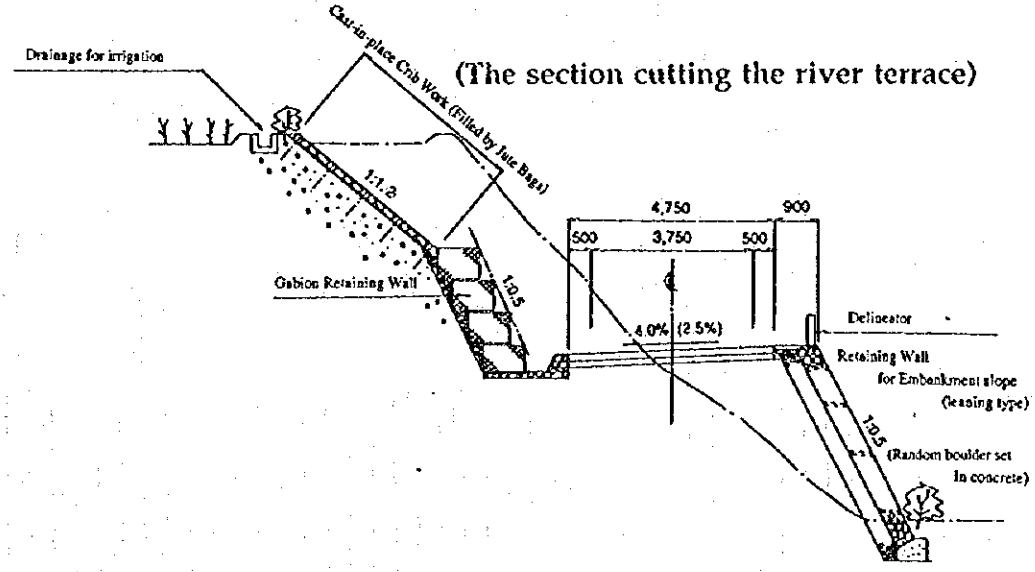
(Exceptional Sections by extremely steep terrain and/or fragile geology)



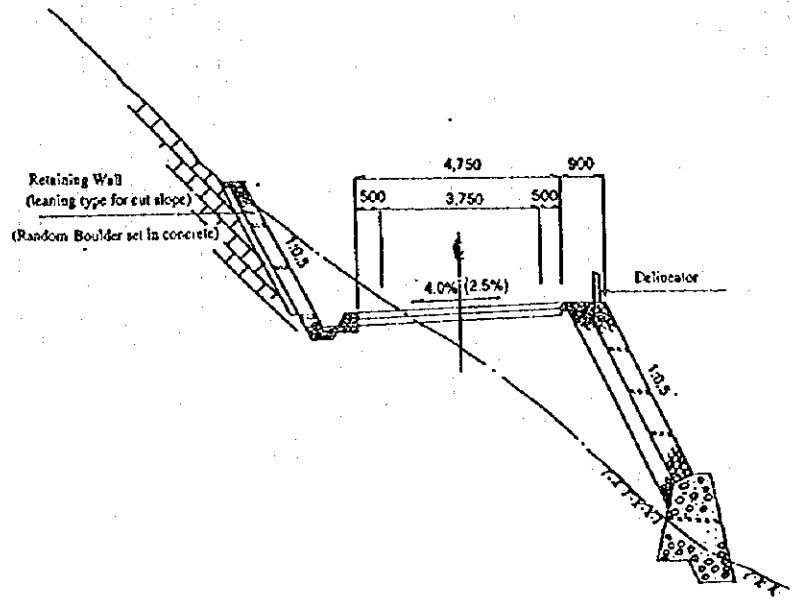
(The section passing through rice field)



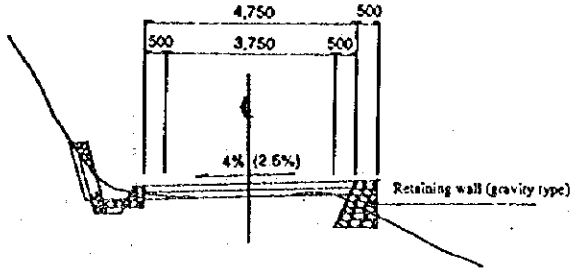
(The section cutting the river terrace)



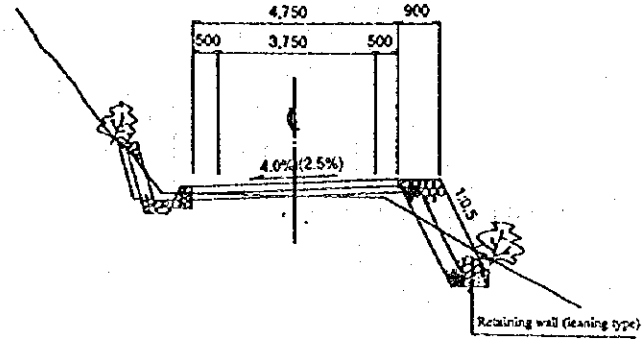
(Section cutting the cranky and lose rock)



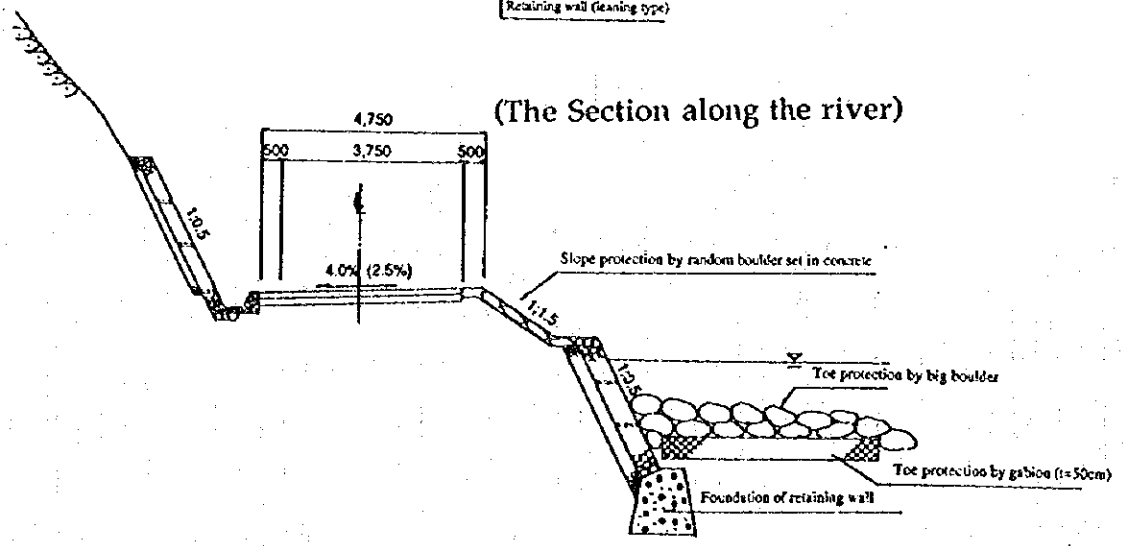
(Widening Section: narrow existing road)



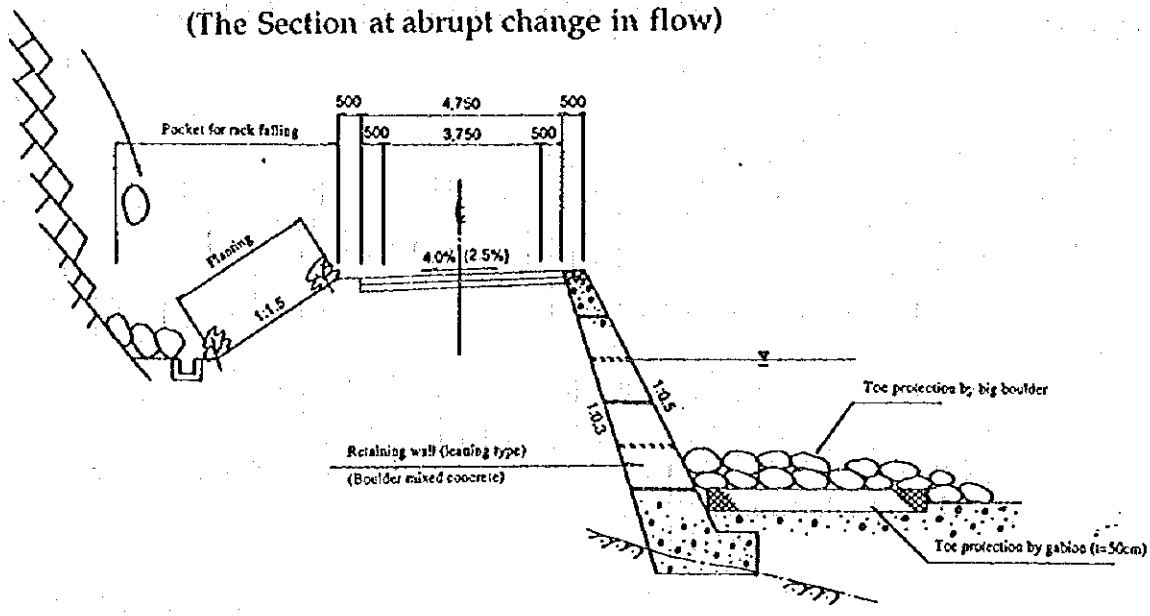
(Widening Section: wide existing road)



(The Section along the river)



(The Section at abrupt change in flow)

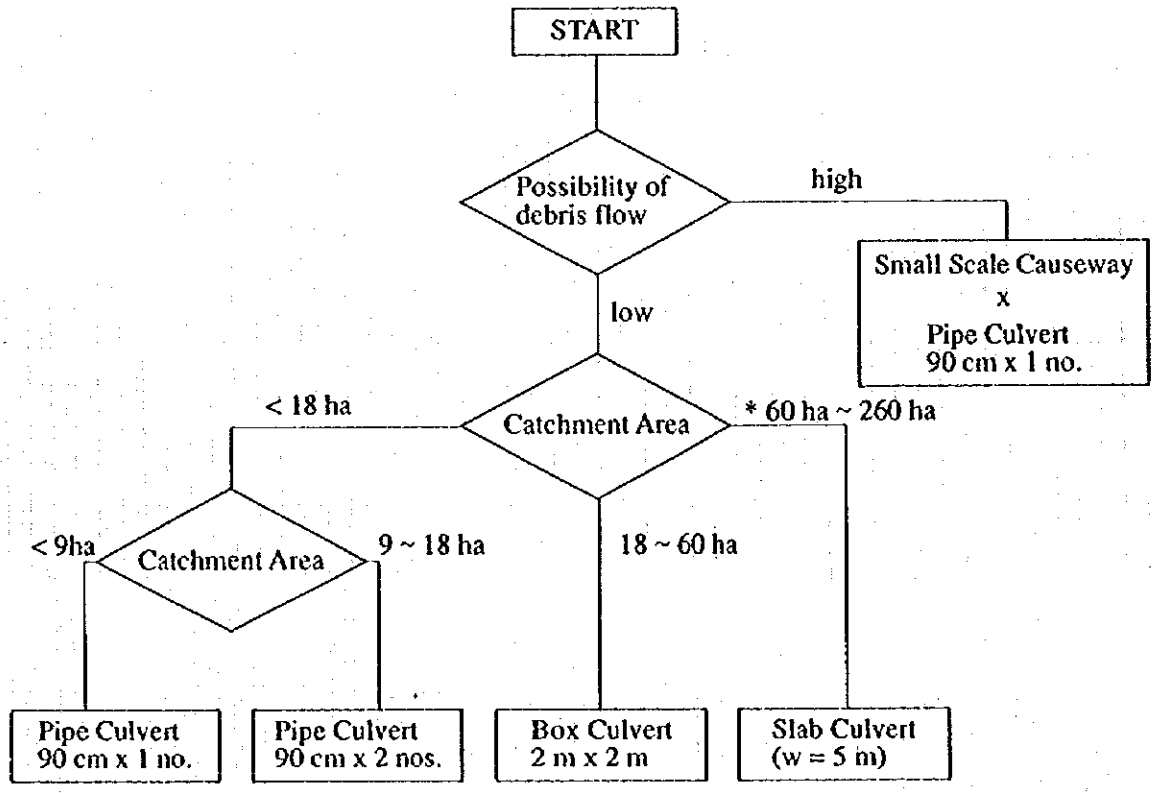


(8) Cross Drainage

The cross drainage structures applied in Section II-3 are the following 5 types.

- Small scale causeway with pipe culvert (900 mm)
- Pipe culvert (900 mm × 1 no.)
- Pipe culvert (900 mm × 2 nos.)
- Box culvert (2 m × 2 m)
- Slab culvert (W = 4 m)

Selection criteria of the above structures depends on possibility of debris flow, catchment area, and terrain as shown in Figure 2.13.



* The catchment area of cross drainage are less than 260 ha.

Figure 2.13 Flow Chart for the Selection of Cross Drainage

Adequate inlet and outlet structure will be constructed according to the site conditions.

(9) Existing Water Channels

As the necessity of relocation of the existing water channel along the project route is caused by the project construction, and its relocation plan has to be established in conjunction with the project drainage systems, such works required for the relocation of the existing water channels shall be included in the project scope. However, the relocation works shall be extended within the limit of ROW, and the required negotiation with the villagers shall be conducted by the DOR.

The site investigation identified 3 types of existing water channels along the project route as follows:

(a) Water channel (average size: 300 × 600) for water mill

(b) Irrigation canal leading water from river to villages (average size: 300 × 300)

(c) Tributary canal distributing water into small areas (average size: 200 × 200)

The channel (a) are mostly crossing the project road. Therefore the relocation will be done by laying new pipe culvert at the crossing points. The channel (b) are the major channel relocated by the Project as they are running the same trace of the proposed alignment. The relocation will be carried out by constructing additional channel (size: 300 × 300~500 × 500) on the slopes and utilising the project side ditch taking into account the relation between the channel bed gradient/target area elevation and the project road formation. The channel (c) will be relocated by providing drainage (size: 200 × 200~300 × 300) on the edge of the paddy fields and install pipe culverts (size: 200~300 mm) at adequate interval.

(10) Land-Slide

On the site investigation, two active land-slide block were observed at STA. 240+50 and STA. 413+00. The land-slide blocks should be protected using gabion wall, sub-surface drain pipes and adequate channel works as shown in Figure 2.14.

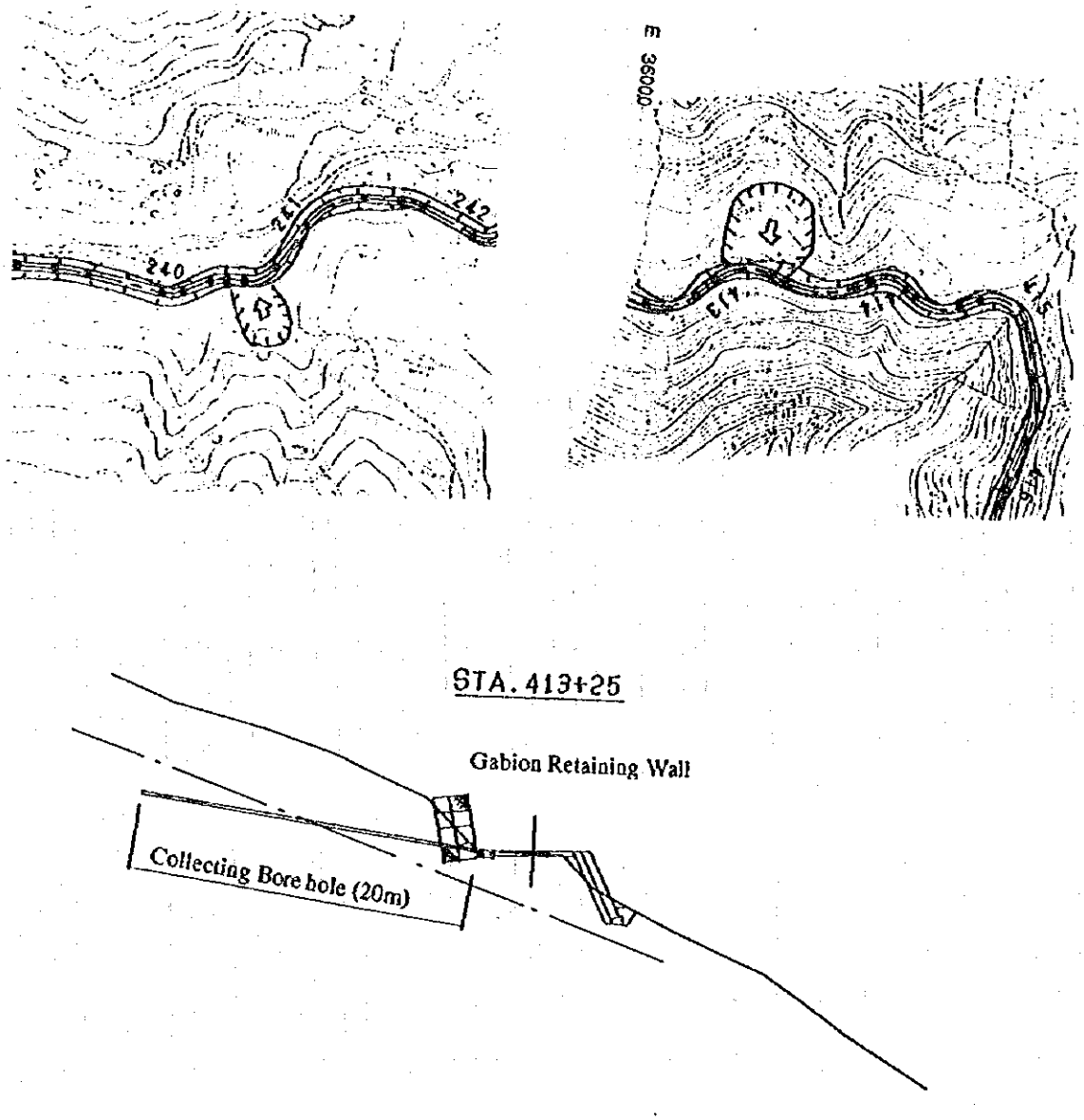


Figure 2.14 Conceptional Plan of Land-Slide Protection

(11) Associated Facilities

According to the STANDARD DESIGNS, January 1978, DOR, delineators road traffic signs and distance signs will be install. Ten portion of bus-stop having 6.5 m width and 30 m length will be constructed as shown in Figure 2.14.

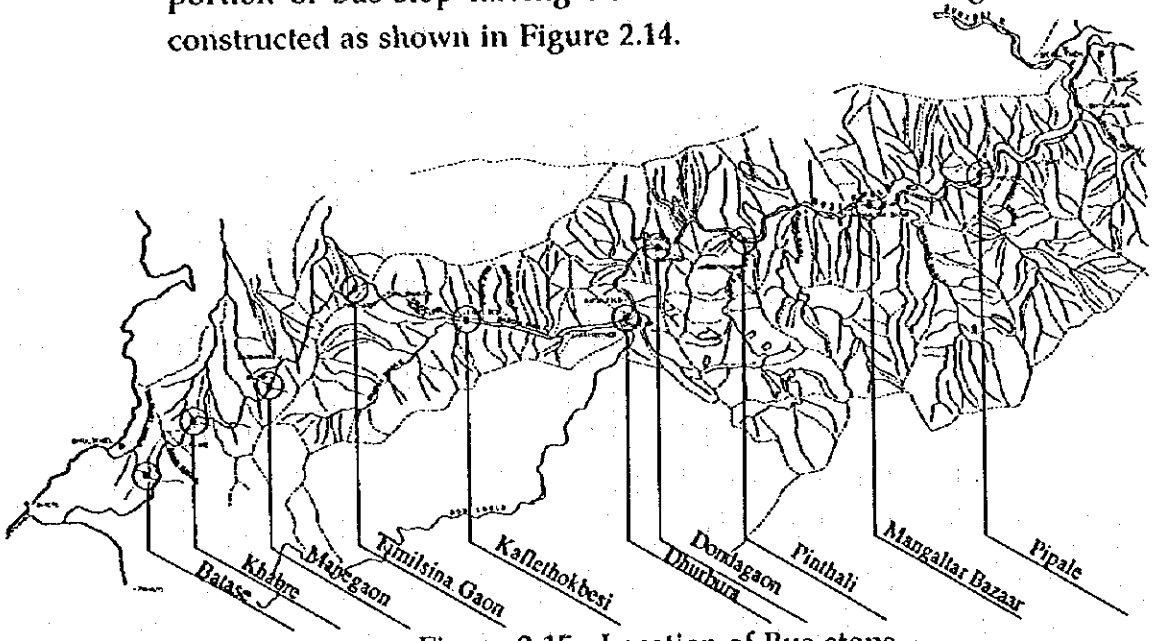


Figure 2.15 Location of Bus-stops

(12) River Training Works

At STA. 117+00, the alignment has plan in the Rosi River to avoid the rock fall and slope failures due to abrupt change in flow. On river training works by T-head spurs are adopted referring the Design Manual for River Training Works in Nepal, Report No. 4/4/2306888/1/1, SEQ. No. 305, Water & Energy Commission Secretariat, Ministry of Water Resources, HMG/N, June 1988 as shown in Figure 2.16.

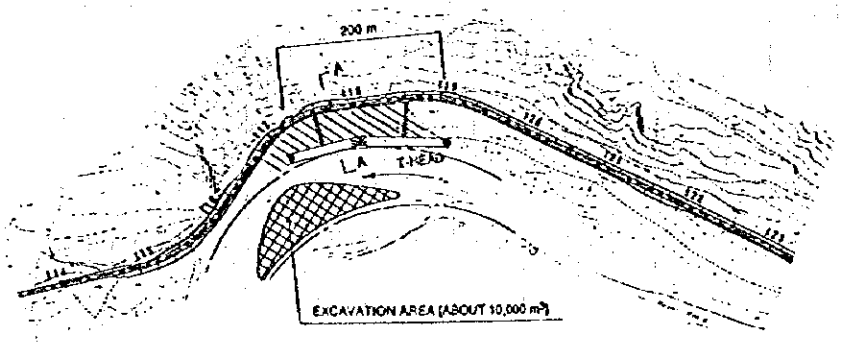


Figure 2.16 Layout Plan of River Training Works at STA. 117+00

B. Bridges

(1) Locations of Bridges

The A/C Study proposed six bridges for the Project (Section II-3) namely STA. 32 Bridge, Daune Bridge, Narke Bridge, Rosi Bridge, No. 1 Dapcha Bridge and No. 2 Dapcha Bridge, as the river crossing structures instead of causeways. Based on the latest site investigation, STA. 32 Bridge has been changed to the causeway as it becomes practical by the modification of the alignment, shifting to the river side and lowering the formation height, and it was judged that the river conditions will allow it. The construction site of the Rosi Bridge has been shifted to approximately 500 m downstream from the original due to the alignment change which was required to avoid the deep cut sections. The proposed locations of the five bridges are shown in Figure 2.17.

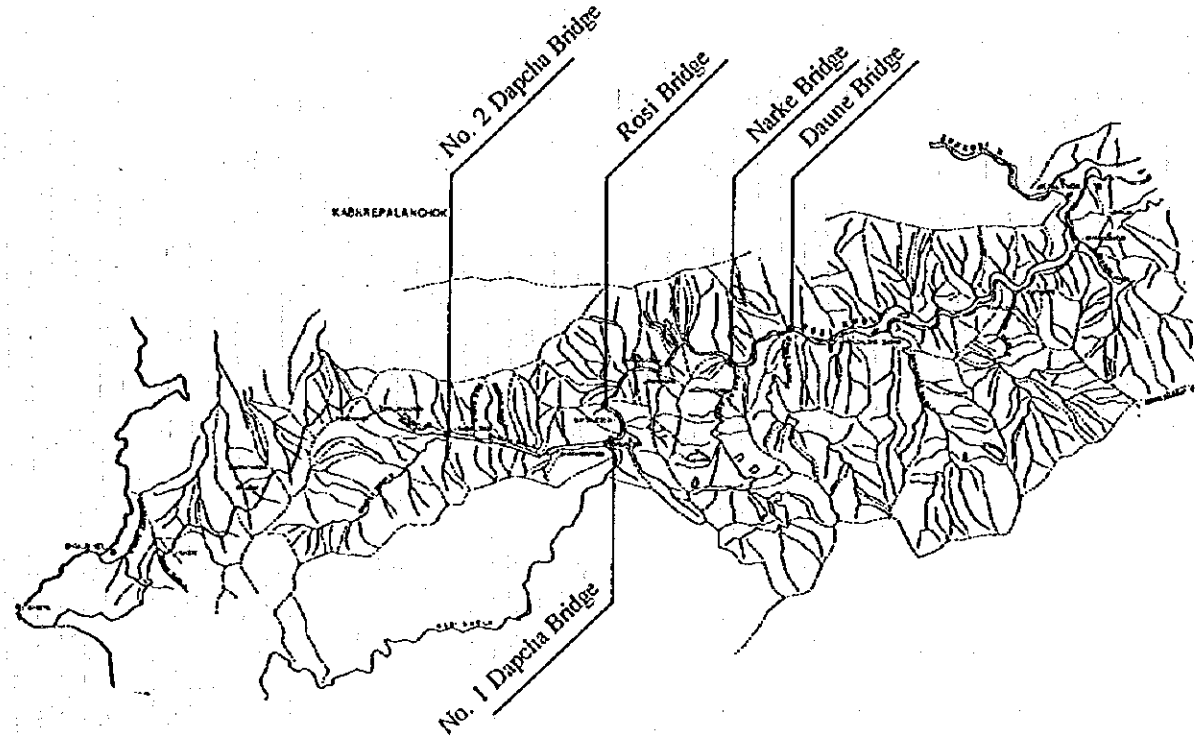


Figure 2.17 Location of Bridge Site

(2) Design Conditions

(a)	Appreciable Standard	Specifications for Highway Bridge I, II, III, IV, V, Japan Road Association Standard Specifications for Design and Construction of Concrete Structures to Japan Society of Civil Engineering		
(b)	Design loads	Live Load	Class A Live load	
		Impact coefficient	Steel Bridge	i = 20/50+L
			Concrete bridge	i = 7/20+1
(c)	Horizontal Seismic Coefficient	The design value of horizontal seismic coefficient kh = 0.15		
(d)	Freeboard	h > 2.0 m (above H.W.L.)		
(e)	Allowable Stress			
	(Concrete)			
	Superstructure	Allowable bending compressive stress		68.5 kgf/cm^2
	Substructure	Allowable bending compressive stress		80.0 kgf/cm^2
		Allowable bending shear stress		3.9 kgf/cm^2
		Allowable bond stress		8.0 kgf/cm^2
	(Reinforcement Bars)	Superstructure		1,200 kgf/cm^2
		Substructure		1,400 kgf/cm^2
	(Steel Materials)	SS400 Allowable tensile stress		1,400 kgf/cm^2
		SM490Y Allowable tensile stress		2,100 kgf/cm^2

(3) Cross Section

DOR has applied a 4.25 m effective width to the single-lane bridge in his revised Design Standard which is still under processing. Referred to this width, the cross-section of the project bridges has been proposed to have the said effective width as shown in Figure 2.18.

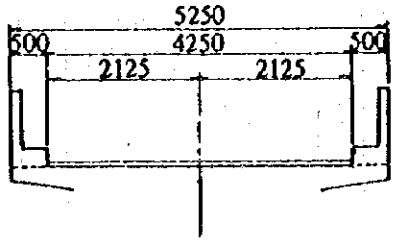


Figure 2.18 Standard Cross-section of Bridges in Section II-3

(4) Superstructure Plan

(a) Major bridges (Rosi Bridge, Narke Bridge, Daune Bridge)

The Project (Section II-3) will construct three major bridges of more than 50 m bridge length to cross over Rosi River and its tributaries, Narke River and Daune River. As the cross points is anticipated to suffer high flood discharge in the rainy season and to have possible debris flows, it is not recommended to design piers within the river channel from the viewpoints of river maintenance or stability of bridge structures. Therefore, it was judged for major bridges to apply a single span bridge and the alternative study on the bridge types was carried out.

[Rosi Bridge]

The Rosi Bridge has been planned to cross the Rosi River at the following topographical conditions:

- on the right riverbank: existing of rock outcrop
- on the left riverbank: cultivated river terrace

The bridge span was proposed as 85 m long in total (L = 65 m + 18 m) locating the abutments on the rock outcrop at the right riverbank and the outer edge of the river reservation at the left riverbank with a pier beside the irrigation canal which runs the left side of the river channel, taking into account the estimated H.W.L.

For the bridge type of 65 m span, both of a deck type steel truss or a pre-stressed concrete T girder (PCT bridge) will be applicable. Judging from the economical point of view and potential of debris flow, the deck type steel truss was selected as the optimum type according to the comparisons shown in Table 2.2.

As for the side span of 18 m in length, reinforced concrete T girder was selected from the economical view point.

As it was anticipated that the truss bridge will have a higher position of the gravity centre due to bridge width of 4.25 m, the interval of main truss was set as 3.5 m in order to reinforce the structural stability.

[Daune bridge]

The proposed bridge will cross over Daune River which has rather deep river channel at the site near the merging point where Daune River run into Rosi River. Judging from many huge boulders observed in the river channel, the river is used to suffer floods having strong flow. therefore it is not recommended to have piers within a river channel.

Table 2.2 Comparison Table of Rosi Bridge Alternatives

Type of Bridge	Description	Judgement
Deck Type Steel Truss	- Low transportation cost & easy erection - Small size substructure due to light superstructure - Economical but high maintenance cost	Applicable
PCT Bridge	- Requiring pier in the middle of river - Long construction period, problem in rainy seasons - Not economical in case of requiring special erection method	Not applicable

On the right riverbank, rock outcrop was observed. Although the left riverbank was covered by the weathered rock, it was expected to have adequate bearing capacity by excavating the top stratum.

The width of river was approximately 50 m. Alternative study of a simple span deck type steel truss and a diagonal strutted rigid-frame steel girder, which will utilise the original terrain condition, was carried out for the selection of bridge type. As shown in Table 2.3, the diagonal strutted rigid-frame steel girder was selected as recommendable.

This bridge type will utilise the original terrain conditions effectively and have advantages of structural strength and seismic stability. There are two possible structural type for the main frame i.e. a continuous type and a girder type. For the Project, the continuous type was selected from structural view point and easier maintenance.

Table 2.3 Comparison Table of Daune Bridge Alternatives

Type of Bridge	Description	Judgement
Steel Truss (Deck type)	- Low transportation cost & easy erection - Small size substructure due to light superstructure - Economical but long construction period	Not applicable
Diagonal Strutted Rigid-frame Steel Girder	- Strong structure due to rigid-frame - More economical comparing the truss bridge - Requiring special technique for erection	Applicable

[Narke Bridge]

The bridge has been planned at the similar site condition of the Daune Bridge which has deep V-shaped river channel of approximately 50 m wide and many huge boulders scattered in the river channel. Both riverbank at left and right has rock outcrops which was judged to have enough bearing capacity as bridge foundation. Therefore, the diagonal strutted rigid-frame steel girder was also applied for the Narke Bridge considering the application of same bridge type to reduce the fabrication cost.

(b) Medium and Minor Bridge

[No. 1 Dapcha Bridge]

The No. 1 Dapcha bridge was planned with bridge length of 25 m having 2.5 m allowance for abutment constructions at both end to cross over the river width of 20 m, by single span due to the narrow site condition.

The steel plate girder type was applied for the superstructure compared with the prestressed concrete T-girder due to the lack of sufficient construction yard for making pre-cast beams or erection.

[No. 2 Dapcha Bridge]

At the proposed site of this bridge, Dapcha River, approximately 20 m wide, runs over rather flat terrain condition. As the river has shallow river channel and observed boulders within the channel were small sizes, the flood flow at this site is not expected so powerful. Therefore, a continuous two spans of reinforced concrete T-girder was adopted as the most economical bridge type installing a pier within the river channel. The bridge length will be 24 m considering the required free board above H.W.L. and have 75 degree skewed angle against the river alignment.

(5) Painting Plan

As the bridge sites were considered as appropriate to provide common countermeasures against the corrosion of steel, the type A-2 painting, which have an additional layer of phenol resin M10, will be applied taking into account the interval of painting at fabricator and at construction site will exceed six months.

(6) Erection Plan

[Diagonal Strutted Rigid-frame Steel Girder]

The erection was assumed to be done by the truck crane supported by cable-stay for the rigid-frame blocks.

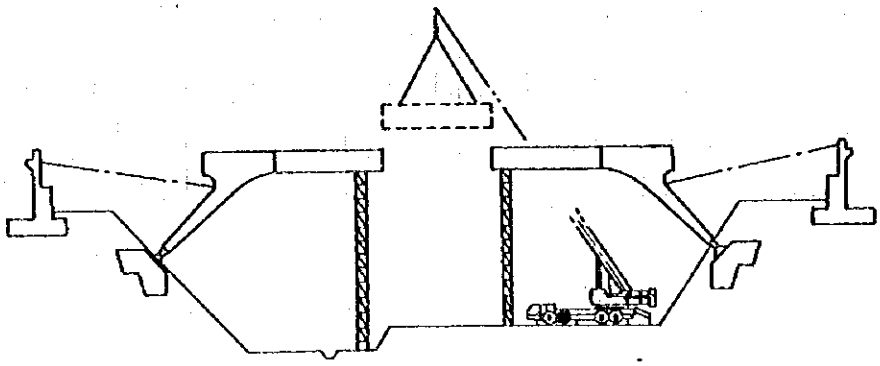


Figure 2.19 Erection Method for Diagonal Strutted Rigid-frame Steel Girder

[Steel Truss Bridge]

The erection by combination of truck crane and bent will be applied for the truss bridge.

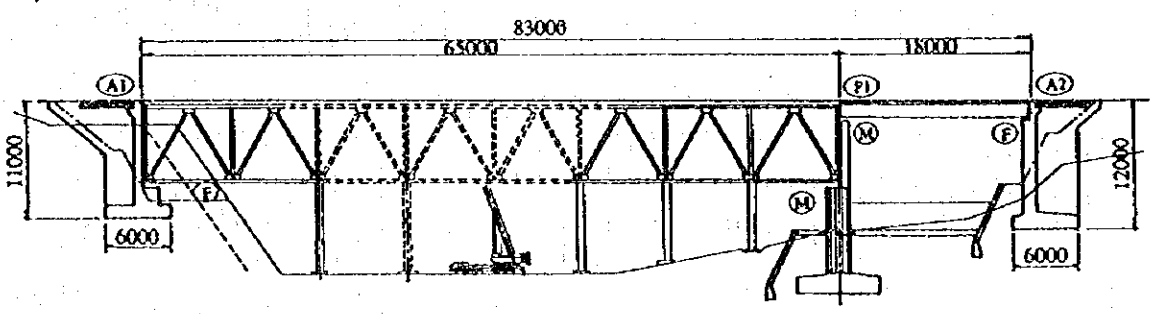


Figure 2.20 Erection Method for Truss Bridge

(7) Substructure Plan

Substructures—abutments and pier—will be designed as follows:

[Abutment]

(a) Type and required allowable bearing capacity

- Inverted T type abutment was adopted as standard and was designed to keep the height lower than 12 m.

- Foundation was designed as spread footing type assuming the bearing stratum as fresh rock, weathered rock, or river terrace.

- As the N values obtained in the field survey were about 50 or more, the unconfined compression strength of the foundation ground was estimated as 8 kgf/cm^2 or more. Therefore, the maximum bearing capacity of the foundation ground was decided as 40 tf/m^2 taking into account the cracked and heterogeneous foundation rock conditions.

(b) Location of abutment at V-shaped terrain condition

- Abutment which is designed to be placed on fresh rock or weathered rock and locate in a slope of V-shaped terrain, the offset, at least half of the footing width, was secured as illustrated in Figure 2.21.

(d) Abutment of rigid-frame bridge

- The abutment of rigid-frame bridge have to be constructed on fresh rock or weathered rock. In order to minimise the settlement of abutment and, at the same time, to avoid the excessive expansion of footing area which will increase the construction difficulties at slope site, the design was carried out to keep the reaction force of bearing stratum as less than or equal to 30 tf/m^2 in normal condition.

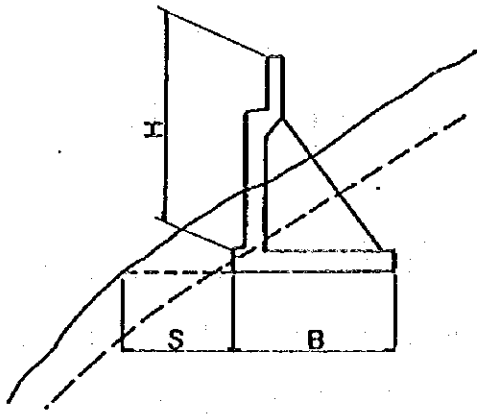


Figure 2.21 Abutment in Slope

(8) Overview of Bridges Design

Table 2.4 shows the summary of bridge design for the Project.

Table 2.4 Bridge Design List for Section II-3

Station	Name of Bridge	Bridge Length	Superstructure Type	Substructure Type
STA. 133+25	Daune Bridge	53 m	Diagonal Strutted Rigid-frame Steel Girder	A1 abutment: Inverted T-type A1-1 abutment: Gravity type A2-2 abutment: Gravity type A2 abutment: Inverted T-type
STA. 158+00	Narke Bridge	59 m	Diagonal Strutted Rigid-frame Steel Girder	A1 abutment: Inverted T-type A1-1 abutment: Gravity type A2-2 abutment: Gravity type A2 abutment: Inverted T-type
STA. 205+00	Rosi Bridge	83 m (65 m + 18 m)	Deck type Steel Truss (65 m) Reinforced Concrete T-Girder (18 m)	A1 abutment: Inverted T-type P1 pier: Circular column type A2 abutment: Inverted T-type
STA. 251+25	No. 1 Dapcha Bridge	25 m	Simple Steel Plate Girder	A1 abutment: Inverted T-type A2 abutment: Inverted T-type
STA. 287+40	No. 2 Dapcha Bridge	24 m	2 Span Continuous Reinforced Concrete T-Girder	A1 abutment: Inverted T-type P1 pier: Wall type A2 abutment: Inverted T-type

C. Major Causeway

(1) Location of Causeways

The A/C Study had proposed six major causeways as river crossing structures. Based on the latest site investigation conducted by B/D

Team, it was revised to (a) change the STA. 32 bridge to the causeway, (b) change the STA. 102 causeway to the small size causeway judging from its small catchment area and no occurrence of debris flow in recent 10 years, (c) change the cross drainage at STA. 185 passing the tributary of Rosi River to the major causeway due to the occurrence of debris flow confirmed by the site observation, and (d) add a new major causeway at STA. 207 to pass the tributary of Rosi River due to the alignment modification which was required following the change of Rosi Bridge site. Figure 2.22 shows the location of eight major causeways finalised by the B/D.

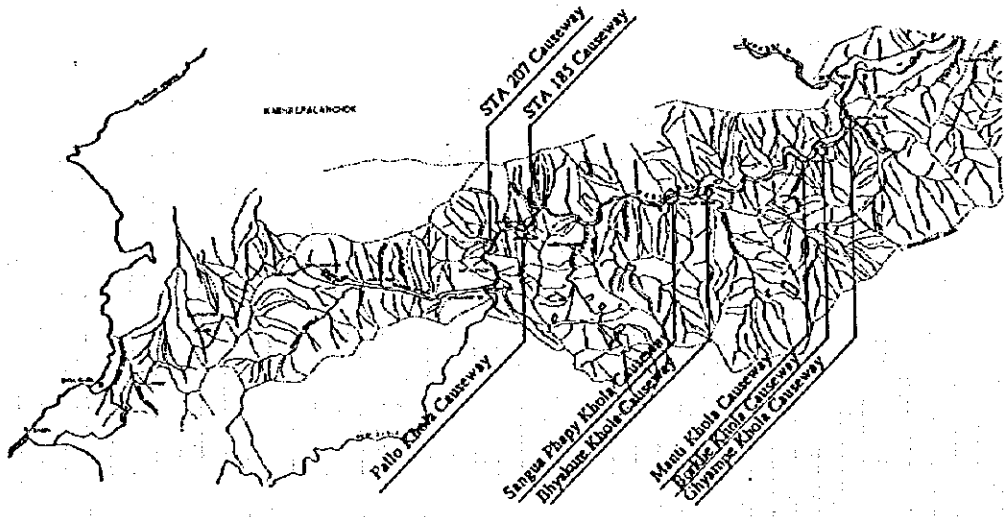


Figure 2.22 Location of Major Causeways

(2) Design Standard

The causeways were designed referring to Design Specification for the river bed protection works stipulated in Technical Specification for River and Sabo Works published by Ministry of Construction of Japan.

(3) Width of Causeway

As recommended by the A/C Study, the causeways should have the width of 6.5 m taking into account the allowance for the piles of drift, and the required spaces for the clearing works.

(4) Structural Types of Causeway

Based on the design experience obtained from the detailed design for Section I, the overflow type causeway was also applied for Section II-3. The structural details were varied depending on the characteristics of each river at the project site as described below. When the river has constant water flow, pipe culverts will be embedded in appropriate places to secure the water courses.

(a) The river with flat river bed slope

Standard overflow type causeway will be applied.

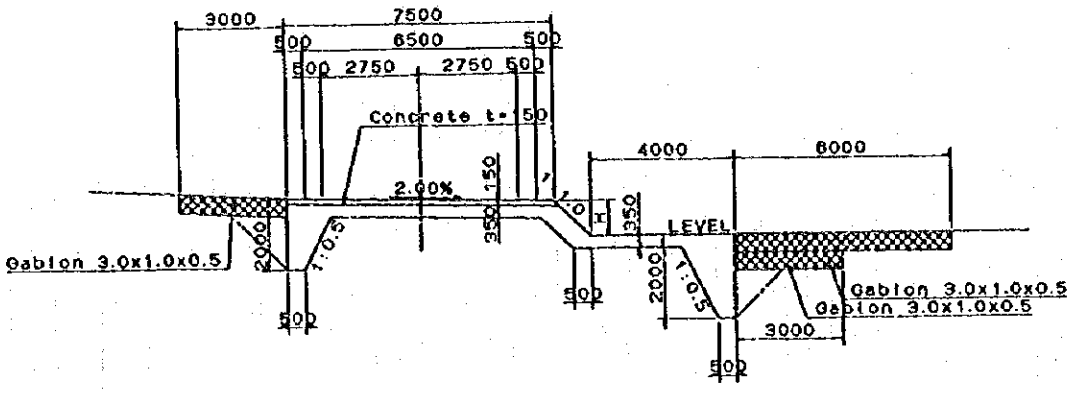


Figure 2.23 Overflow Type Causeway applied on Flat River Bed (Type-1)

(b) The river with relatively steep slope and unstable stream line due to alluvial fan terrain but steep river bed slope is constant.

The causeway is intended to function as a drop structure having a gravity type retaining wall at the upstream and the portion of the project road will act as a apron. The continuity of the river channel will be obtained by adjusting the height or place of gabion provided upstream of the retaining wall. In order to absorb the river bed fluctuation, retaining wall made by gabion was provided at the downstream which has good permeability and is easily maintained.

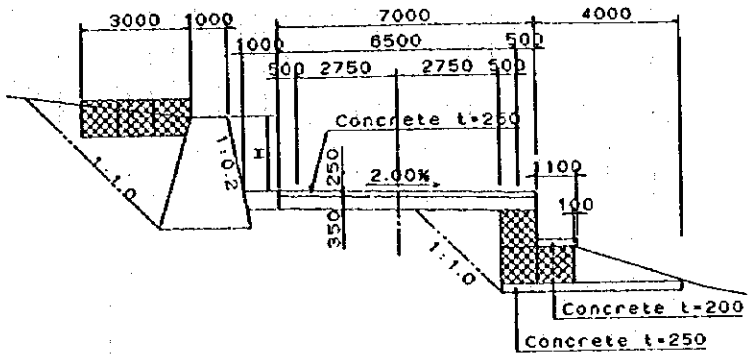


Figure 2.24 Drop structure type causeway with consolidation gabion block applied on the river having relatively steep, stable river bed and alluvial fan terrain (Type-2)

(c) The river with relatively steep slope, stable stream line and steep river bed slope is constant

The causeway is intended to function as a drop structure having a gravity type retaining wall at the upstream and the portion of the project road will act as a apron. The continuity of the river channel will be obtained by forming the wall top to fit the river channel. In order to absorb the river bed fluctuation, retaining wall made by gabion was provided at the downstream which has good permeability and is easily maintained.

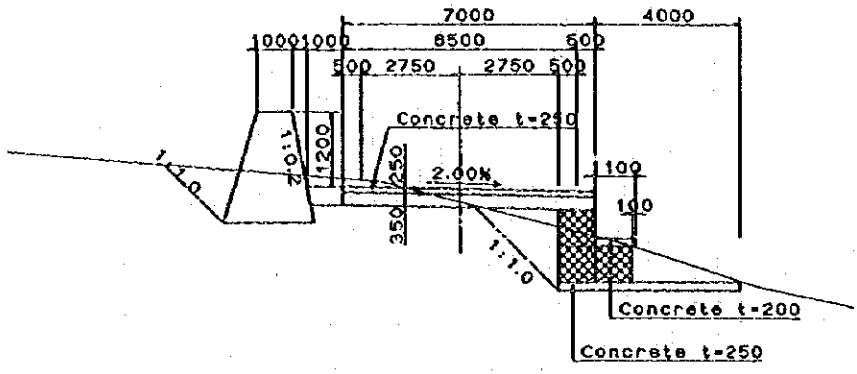


Figure 2.25 Drop structure type causeway applied on the river having relatively step, stable river bed and stream (Type-3)

(d) The rivers which is changing the river bed level drastically due to continuous debris flow and conveys huge amount of drift.

It is judged that this type of river bed can not be controlled. Therefore minimum scale of causeway to keep the road was applied. The retaining wall provided at upstream and downstream of the project road (apron) will be made by gabion cheaply.

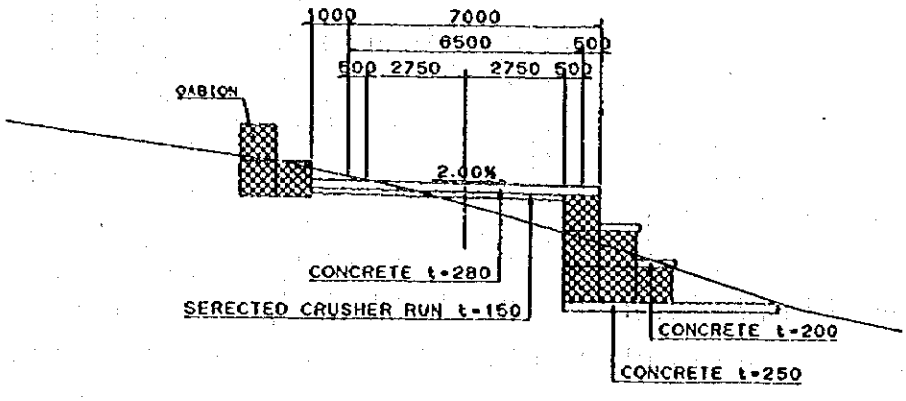


Figure 2.26 Minimum scale causeway applied on the river changing the river bed drastically

(5) Causeway Approach

The required length of causeway approach was applied as 40 m to accommodate the vertical transition by inserting the S-curve. The approach will be treated by the concrete pavement to avoid the damages which may be caused by debris flow as shown in Figure 2.27.

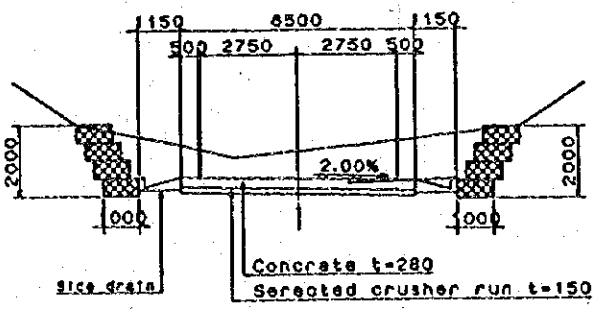


Figure 2.27 Standard Section of Causeway Approach

(6) Overview of Major Causeway Design

The major causeways in Section II-3 were designed as listed Table 2.6.

Table 2.6 Listed of Major Causeway

Station	Name of River	Type of Causeway	Length	
STA. 14	Ghyampe Khola	Type-4	Causeway:	120 m = 35 m + 85 m
			Approach:	75 m = 35 m + 40 m
STA. 32	Boykhe Khola	Type-1	Causeway:	32 m
			Approach:	80 m = 40 m + 40 m
STA. 40+50	Mamti Khola	Type-1	Causeway:	90 m
			Approach:	80 m = 40 m + 40 m
STA. 98+50	Bhyakure Khola	Type-4	Causeway:	136 m
			Approach:	80 m = 40 m + 40 m
STA. 113	Sangu & Phapy Khola	Type-3	Causeway:	130 m
			Approach:	50 m = 20 m + 30 m
STA. 185	NA	Type-2	Causeway:	36 m
			Approach:	80 m = 40 m + 40 m
STA. 191	Pallo Khola	Type-1	Causeway:	20 m
			Approach:	60 m = 20 m + 40 m
STA. 207	NA	Type-2	Causeway:	38 m
			Approach:	50 m = 30 m + 20 m

D. Protection of Anchorage of Existing Suspension Bridge at Nepalthok

Nepalthok is the beginning point of the Project (Section II-3). The project route has been designed to pass under the existing suspension bridge, used for pedestrians over Rosi River in Nepalthok, between the tower and anchorage at the right bank side. Therefore reinforcement works of the anchorage shall be considered to protect it against the possible slope failure which may be provoked by the excavation works of the Project to prevent the damages on the existing bridge.

(1) Method of Reinforcement

There will be two alternative countermeasures such as (a) demolish the existing bridge and reconstruct it after the completion of project construction, or (b) carry out the reinforcement works of the anchorage, then start the project construction. As it was observed that (i) the existing suspension bridge is relatively small scale, hence, (ii) the cable tension (or anchorage reaction force) is expected as relatively small, (iii) the existing slope (river bank) is judged as in good condition (stable and dense), and (iv) the alternative (b) is much economical than (a), the alternative (b) was selected for the Project.

As for the reinforcement works, the cast-in-situ concrete deep shaft method was selected from the three alternatives of reinforcing method taking into consideration the safety, reliability and cost.

- cast-in-situ concrete deep shaft method
- Earth Anchor method
- Earth Nailing method

(2) Reinforcement by Cast-in-situ Concrete Deep Shaft Method

The two cast-in-situ concrete deep shaft (dia. 2 m, depth 7 m) will be installed at the both side of anchorage. After the installation of cast-in-situ concrete shaft, anchorage will be connected by chemical anchors and cap concrete. The cut slope which is in front of anchorage will be protected by the earth nailing method.

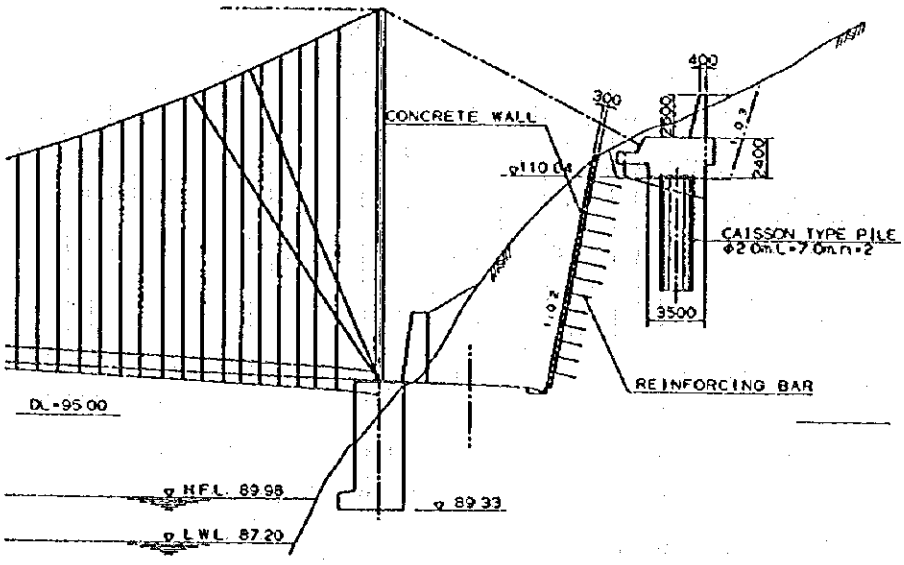


Figure 2.28 Reinforcement for Anchorage of Existing Suspension Bridge at Nepalthok by Cast-in-situ Concrete Deep Shaft

2.3.3 Basic Design Drawings

The following drawings have been prepared for the cost estimation and construction planning purpose.

Plan and Profile	Appendix A-1-1 ~ A-1-40
Standard Cross Sections	Appendix A-2-1 ~ A-2-3
General Plan of Daune Bridge	Appendix A-3
General Plan of Narke Bridge	Appendix A-4
General Plan of Rosi Bridge	Appendix A-5
General Plan of No. 1 Dapcha Bridge	Appendix A-6
General Plan of No. 2 Dapcha Bridge	Appendix A-7
General Plan of Ghyampe Khola Causeway	Appendix A-8
General Plan of Boykhe Khola Causeway	Appendix A-9
General Plan of Mamti Khola Causeway	Appendix A-10
General Plan of Bhayakure Khola Causeway	Appendix A-11
General Plan of Sangu & Phapy Khola Causeway	Appendix A-12
General Plan of STA. 185 Causeway	Appendix A-13
General Plan of Pallo Khola Causeway	Appendix A-14
General Plan of STA. 207 Causeway	Appendix A-15
General Plan of Protection of Anchorage of Suspension Bridge at Nepalthok	Appendix A-16
General Plan of River Training Works	Appendix A-17
Standard Plan of Cross Drainage	Appendix A-18-1 ~ A-18-5
Location Map of Existing Irrigation Channel to be Relocated	Appendix A-19
Detail of Side Ditch	Appendix A-20
Detail of Associated Facilities	Appendix A-21

2.3.4 Approximate Quantities of Major Work Items

Quantities were calculated based on the Drawings and are summarised in Table 2.6.

Table 2.6 Approximate Quantities

Items	Unit	Quantities
Cut and Filling (Common)	Cu. m	220,000
Cut and Filling (Rock)	Cu. m	17,000
Filling by Borrow Materials	Cu. m	158,000
Cut and Spoil (Common)	Cu. m	49,000
Structural Excavation (Common)	Cu. m	90,000
Structural Excavation (Rock)	Cu. m	47,000
Back Filling	Cu. m	43,000
Planting	Sq. m	175,000
Cast-in-place Crib Wall	Sq. m	13,000
Drainages	lin. m	89,000
Pavement Works (Gravel)	Sq. m	107,000
Pavement Works (DBST)	Sq. m	141,000
Concrete	Cu. m	5,000
Gabions	Cu. m	84,000
Random Boulder Set in Concrete	Cu. m	62,000
Boulder Mixed Concrete	Cu. m	34,000
Steel Members	ton	265
Form Works	Sq. m	73,000
Cement	ton	17,000
Reinforcement Bar	ton	300

2.3.5 Selection of Maintenance Equipment

A. Concept of Selection

As stated in Section 2.3.1 F, the Project (Section II-3), will be implemented by two phases (the Phase-1 is from STA. 150 to end, totalling about 36 km, the Phase-2 is from the beginning point to STA. 150, totalling 15 km). The project of Section II-1 and II-2 may be implemented during the construction of Section II-3. The tentative implementation schedule of Section II-3 and Section II-1 and II-2 are illustrated in Figure 2.30.

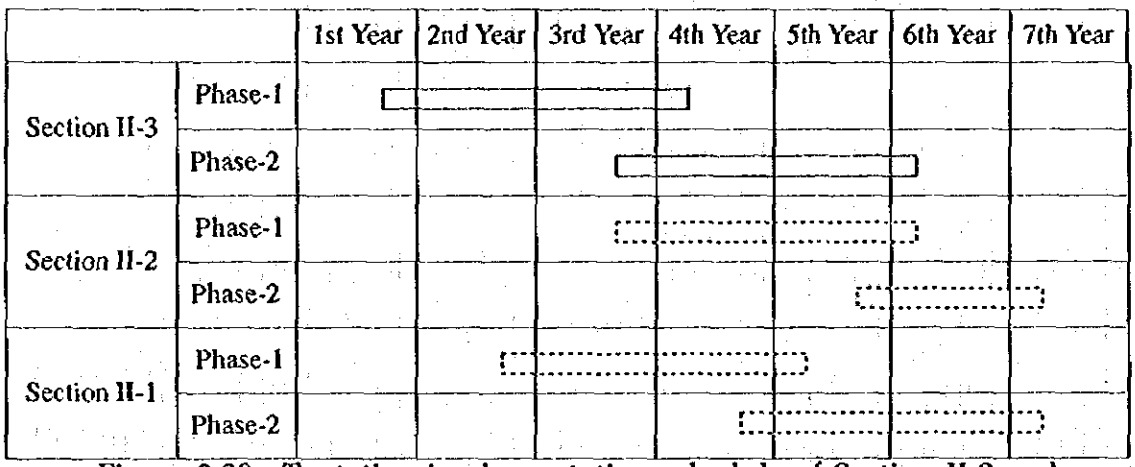


Figure 2.30 Tentative implementation schedule of Section II-3 and Section II-1 and II-2 construction

As the Phase-1 of Section II-3 construction will be carried out mostly along the existing road, the construction can start at the whole section. Therefore the construction may not be completed step by step basis from Dhulikhel side to the other. So the partial hand-over may not be applicable in this section. Due to the short project length, the partial hand-over of Phase-2 may not be practical as well.

The maintenance work by DOR will start after completion of the Phase-1 construction. However when the contractors use the handed-over section maintained by DOR for the purpose of access to the construction site, the contractors shall maintain the road surface of the said section. Approximately 6 years after the starting of construction of Section II-3, which is the expected completion of Section II-3 and Section II-2, DOR will start the total maintenance work by himself. Above maintenance schedule are illustrated in Figure 2.31.

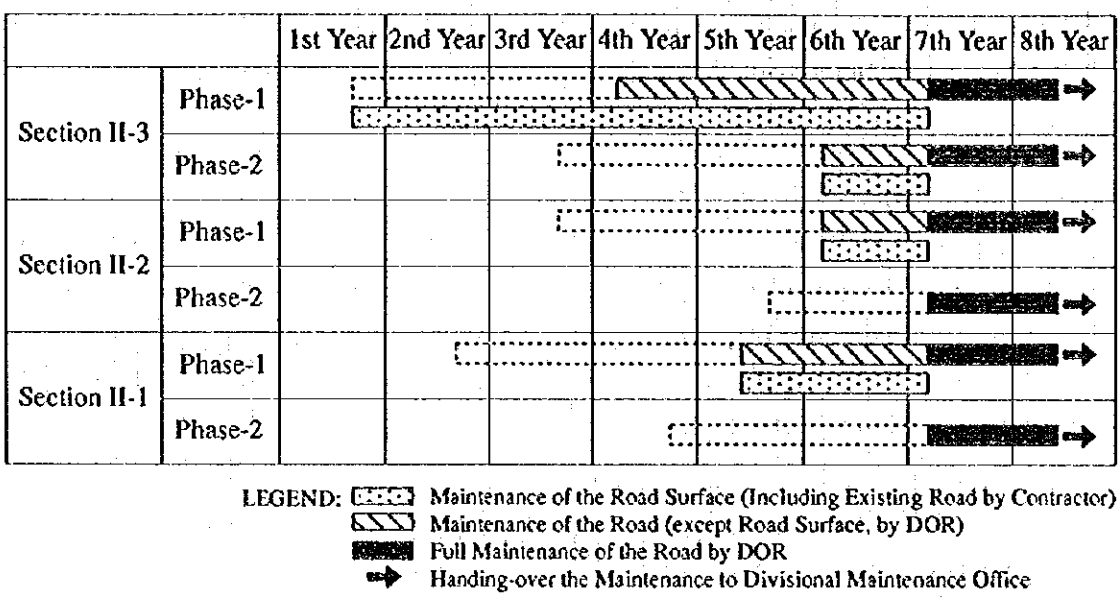


Figure 2.31 Content of Maintenance and Schedule

Based on the above study regarding the scope of maintenance and schedule, the equipment to be used for maintenance of the Section II-3 shall be selected by following concept;

- The equipment used for the maintenance of road surface and transportation will be provided in the Phase-1 of Section II-3 construction. DOR will lend the equipment for the maintenance of road surface to the contractor of Phase-1 of Section II-3 with no charge. The contractor shall carry out the road surface maintenance using the equipment.

- The maintenance equipment used by DOR for the handed over/ completed sections will be procured when the Banepa maintenance office is established by DOR after the completion of Phase-1 of Section II-3.

- Types and number of equipment will be selected within the scope of maintenance required for the Phase-1 of Section II-3 which has 35 km in length.

- Tools to be procured in the scope of the Project will be selected from minor repair tools such as welding set, type tools set, and so on for the equipment provided by the Project.

B. Scope of Maintenance Work and Work Quantities

The first phase of the Project (Section II-3), 36 km long, includes two major bridges, two medium and minor bridges, three major causeways and 230 cross-drainage. The required maintenance works were identified as follows;

(1) Maintenance of road surface for DBST section and gravel road section (This maintenance will be carried out by the contractor who uses the road as access road.)

(2) Removal of slope failure deposits on road and restoration of slopes and road surface

(3) Removal of debris in cross-drainage and repair

(4) Removal of sediment in the side ditches and repair

(v) Removal of debris on the causeways and repair

(6) Repair of associated facilities

The work quantities for the above maintenance works are estimated as follows;

(1) Maintenance of road surface

[DBST Section]

DBST area is 141,000 m^2. The required repair work volume is estimated 14,000 m^2/year with the condition that the 10% of the paved area is to be repaired annually.

[Gravel Road Section]

Gravel road area is 110,000 m^2. The required work is grading, watering and laying additional gravel material (3.6% annually).

(2) Removal of slope failure deposits on road and restoration of slopes and road surface

According to Multi-Agency Seminar Paper, it is reported that 400 to 700 m^3 due to slope failure per km per year are occurring in the hill

roads in Nepal. the removal volume are calculated taking into consideration of the relatively gentle terrain in Section II-3 as follows;

35 km × 400 m^3/km ·) year = 14,000 m^3/year

(3) Removal of debris in the cross drainage and repair

The required work volume is estimated at 690 m^3/year with the condition that the 10 m^3 of debris are deposited per place at once, and the debris flow occur at 30% of cross drainage in the rain season.

10 m^3 × 230 place × 30%/year = 690 m^3/year

The repair works volume can not be estimated, therefore, the amount and type of equipment to be provided will be estimated considering the needs for maintaining 36 km of road length.

(4) Removal of sediment materials in the drainage repair

The required work volume is estimated at 3,500 m^3/year with the condition that the 25% of sectional area of drainage are filled by sediment materials as follows;

35 km × 0.1 m^3/m ·} year = 3,500 m^3/year

The amount and type of equipment to be provided will be estimated considering the needs for maintaining 36 km of road length.

(5) Removal of debris on the causeways and repair

The required work volume is estimated on the condition that the sediment volume is 250 m^3/place and it to be carried out four times per year at each of 3 causeways as shown below.

250 m^3 × 3 place × 4 time/year = 3,000 m^3/year

The repair works volume can not be estimated, therefore, the amount and type of equipment to be provided will be estimated considering the needs for the works.

(6) Repair of associated facilities

This work comprises repair of delineators, road traffic sign and distance sign. Since it is difficult to estimate the work volumes, the amount and type of equipment to be provided will be estimated considering the roads for the works.

C. Selection of Maintenance Equipment

(1) Maintenance of Road Surface (DBST and Gravel Road)

DBST Section

Repair Area: 14,000 m^2/year

As the repair works have no restriction of time limit, the amount of equipment are estimated for one party of equipment combination.

Dump Truck (6 ton)	1 no.
Three-Wheel Roller (8~10 ton)	1 no.
Distributor (200 litre)	1 no.

Gravel Road Section

The repair works can be carried out without time limitation. Therefore, the amount of equipment are estimated as follows;

Dump Truck (6 ton)	1 no.
Motor Grader (2.8 m)	1 no.
Water Tanker (5,500 litre)	1 no.

(2) Removal of slope failure deposits on road and restoration

Volume of deposits to be removed was estimated on the condition that the 14,000 m^3 of deposits will fall down per week during the rainy season as shown below.

14,000 $m^3 \times 1/16$ times = 900 m^3/time

The amount of equipment are estimated on the condition that the 900 m^3 of deposits removed within 3 days.

Back hoes (0.6 m^3) 1 no. (900 m^3/300 m^3/ days)

Dump Truck (6 ton)	3 no.

(3) Removal of debris in the cross drainage and repair

Since, this work can be done without time limitation, the amount of equipment are estimated by a party of combination.

Back hoes (0.6 m^3)	1 no.
Jack Hammers (20 kg)	2 no.
Air Compressor (3.7 m^3/min)	1 no.
Dump Truck (6 ton)	1 no.

(4) Removal of sediment material in the drainage and repair

Since, this work is done by man power and dump-truck, and can be done without time limitation, a dump truck is sufficient

Dump Truck (6 ton)	1 no.

(5) Removal of debris on the causeway and repair

Since a party of equipment combination can work due to narrow space, the amount of equipment estimated as below.

Wheel Type Loader (2.1 m^3)	1 no.
Back hoes (0.6 m^3)	1 no.

(6) Repair of associated facilities

No special heavy equipment is required

(7) Transportation of equipment and materials

Low Bed Trailer (20 ton)	1 no.
Crane Mounted Truck (4 ton, 2.9 ton)	1 no.

(8) Transportation of Labours and Engineer

4 wheel driver inspection vehicle	1 no.
Pickup Truck	2 nos.

Among the above maintenance work, the work of removal of slope failure deposit on road have to be carry out as emergency. Since, other maintenance works can be done without time limitation, DOR can manage the working schedule of equipment. Therefore, the total amount of equipment will be estimated taking into account the sharing of equipment in the maintenance works, DOR's stock equipment, and DOR's experience for maintenance works.

Table 2.7 show the selected equipment for maintenance work of Section II-3 taking into consideration of the above.

Table 2.7 List of Equipment to be supplied by the Project of Section II-3

		Recommend on A/C Study	Recommend by DOR	Selected Equipment on the B/D Study	Reason of Selection
Backhoe	0.1 m3	0	1	0	Least requirement
Backhoe	0.35 m3	0	0	0	Least requirement
Backhoe	0.6 m3, 126PS	1	0	1	Useful
Truck Dozer	14 ton	1	0	0	Least requirement
Wheel Dozer	200 HP	0	1	0	Least requirement
Wheel Loader	1.4 m3, 110PS	1	1	1	Useful
Crawler Loader	1.5 m3	1	0	0	Least requirement
Dump Truck	6 ton, 224PS	3	3	3	Useful
Motor Grader	2.8 m, 94PS	1	1	1	To be lent for contractor
Vibrating Roller	4 ton	1	0	0	Least requirement
Tire Roller	8~20 ton	0	1	0	Least requirement
Three Wheel Roller	8~10 ton, 90PS	0	1	1	To be lent for Contractor
Plate Compactor	80 kg	3	0	0	DOR have stock
Concrete Mixer	0.3 m3	1	0	0	DOR have stock
Truck Crane	5 ton	1	1	0	Least requirement
Trailer	20 ton	0	0	1	To be lent for Contractor
Crane Mounted Truck	4 ton/2.9 ton	0	0	1	Useful
Water Tanker	5,500 litre	0	1	1	To be lent for Contractor
Generator	50 kVA, 54.4PS	2	1	1	Useful
Air Compressor	3.7 m3/min, 34PS	0	1	1	Useful
Jack Hammer	20 kg	0	2	2	Useful
4-Wheel Drive	2000 cc	3	1	1	Useful
Pickup Truck	2000 cc	0	2	2	Useful
Mobil Workshop		0	1	1	Least requirement
Motorcycle		0	7	0	Least requirement
Wireless Set		0	1	0	Least requirement
VHF Telephone		0	1	1	To be lent for Contractor

* Least requirement means least required for maintenance during the implementation period of the Project

D. Repair Tools

Table 2.8 show the list of tools selected according to the concept of selection.

Table 2.8 List of Tools to be supplied by the Project (Section II-3)

		(A/C)	(DOR)	(B/D)	Reason of Selection
Gas Welding Set		1	1	1	Applicable for minor repair
Arc Welding Set	300A	1	1	1	Applicable for minor repair
Welding Generator	300A	1	1	1	Applicable for minor repair
Battery Charger	72V	1	1	1	Applicable for minor repair
Drilling Machine	Bench Type	0	1	0	To be procured by DOR
Drilling Machine	10 mm	1	1	1	Applicable for minor repair
Electric Grinder	HD	0	1	0	To be procured by DOR
Electric Grinder	LD	1	1	1	Applicable for minor repair
Air Compressor	Stationary	0	1	0	To be procured by DOR
Air Compressor	Portable	1	1	1	Applicable for minor repair
Tire Tools Set		1	1	1	Applicable for minor repair
Chain Block	5 t	1	1	1	Applicable for minor repair
Tachometer		1	1	1	Applicable for minor repair
Compression Gauge		1	1	1	Applicable for minor repair
Filler Gauge		1	3	1	Applicable for minor repair
Thickness Gauge		1	0	0	Least required
Hydraulic Jack	10 t	1	2	1	Applicable for minor repair
Multimeter		1	1	1	Applicable for minor repair
Hydraulic Gauge		1	1	1	Applicable for minor repair
Bench Vice	120 mm	2	3	1	Applicable for minor repair
Torque Wrench	HD	0	1	0	To be procured by DOR
Torque Wrench	LD	0	1	0	To be procured by DOR
Trolley Jack	10 t	0	2	0	To be procured by DOR
Lathe		0	1	0	To be procured by DOR
Lathe Tools Set		0	1	0	To be procured by DOR
Lubricant Transfer Pump		0	6	0	To be procured by DOR
Puller Set	Mechanical	1	1	1	Applicable for minor repair
Puller Set	Hydraulic 20 t	0	1	0	To be procured by DOR
Garage Crane	Hydraulic 5 t	0	1	0	To be procured by DOR
Grease Gun	HD	0	2	0	To be procured by DOR
Grease Gun	LD	0	3	0	To be procured by DOR
Lubricant Dispensing Pump		0	4	0	To be procured by DOR
High Pressure		0	1	1	Applicable for minor repair
Washing Plant Weighing Scale	10 kg	0	1	0	To be procured by DOR
Tool Set	Master	2	2	2	Applicable for minor repair
Tool set	Light	2	3	2	Applicable for minor repair
Assorted Blacksmith Tool		0	1	0	To be procured by DOR
Armature Growth		0	1	0	To be procured by DOR
Winch	50 t	0	1	0	To be procured by DOR
Work Bench Set		0	5	0	To be procured by DOR
Spare Parts Rack		0	1	0	To be procured by DOR

Remarks, (A/C) : Recommend by A/C Study
(DOR) : Recommend by DOR
(B/D) : Selected Equipment by the B/D Study

E. Procurement Plan

As the equipment and repair tools are not produced in Nepal, those were scheduled to procure from Japan or Singapore. However such equipment as trailers, truck cranes or water tanker will be procured from India because those truck-base equipment manufactured in India are prevailed in Nepal.

CHAPTER 3

CHAPTER 3 IMPLEMENTATION PLAN

3.1 Implementation Plan

The Implementation Plan has been studied assuming that the Project of Section I and II will be executed under the Grant Aid Scheme of the Japanese Government.

3.1.1 Operational Structure for the Project of Section II

The operational structure should be planned taking into consideration the following conditions:

(1) As stated in Section 2.2.1, the Project of Section II will be implemented by the partial hand-over basis dividing the Project into several segments. Therefore the Project (from Sindhuli Bazar to Dhulikhel) will have the segments which were handed over to the DOR's control and the segments which are still under the construction concurrently.

(2) As the Project is to be implemented by the Japan Grant Aid, the executing unit will be organised under DDG of Foreign Cooperation of DOR. In the present system of DOR the handed-over section should be maintained by the Maintenance Section, and the equipment supplied by the Project should be managed by the Mechanical Section of DOR. Therefore it is anticipated that the maintenance works by DOR will require subtle internal adjustments since three sections of DOR will be involved into the Project.

(3) The handed-over sections will be controlled by DOR. However, these sections will still be used by the contractor as these are the sole access to the construction sites. Therefore, it is absolute condition for the implementation of the Project of Section II to secure the smooth access for the contractor.

(4) Judging from the present system of DOR, the handed-over sections from Bardibas to Nepalthok will be maintained by Janakpur Division office and from Nepalthok to Dhulikhel by Bhaktpur Division office. However both division offices have maintained existing roads of more than 100 km in length already, it will be

difficult to expect them to perform additional maintenance works for the Project road giving the priority.

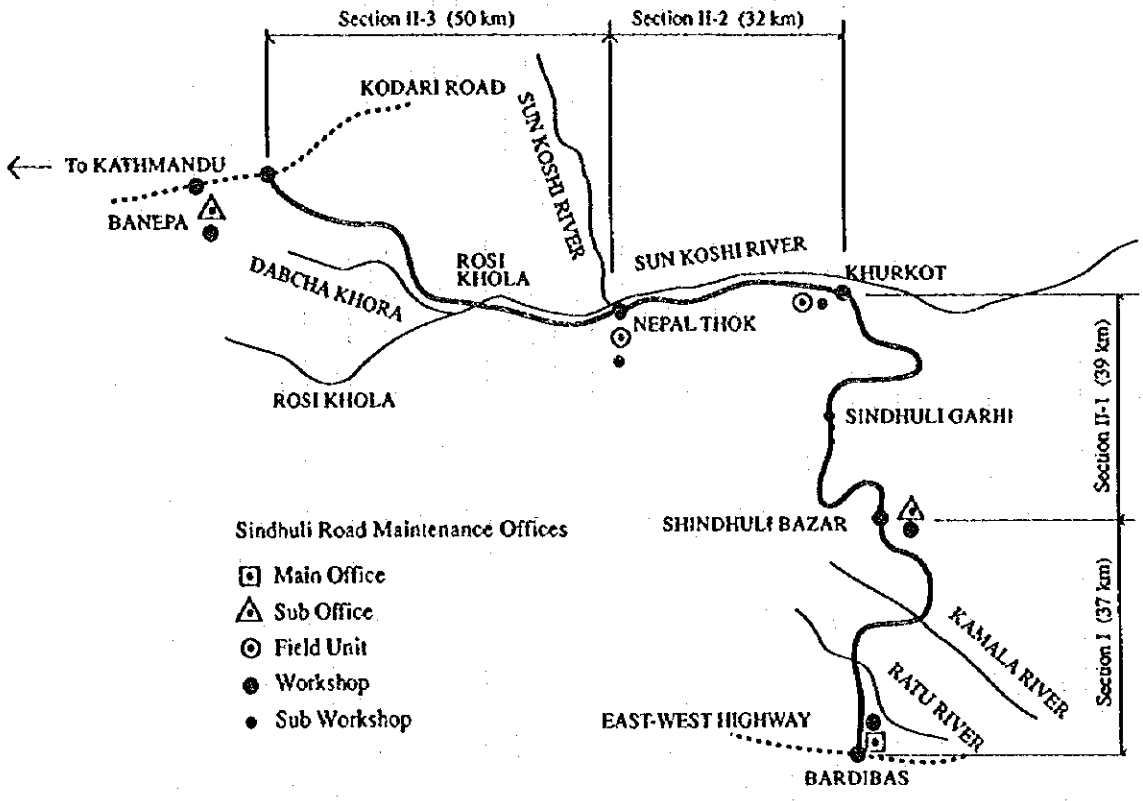
(5) Therefore it is recommended that the executing unit of DOR will be organised to have the Project Manager (PM) who has the responsibilities of supervising the Sindhuli Road Project, and of the operation and maintenance works for the handed-over sections by the project completion.

(6) The opening of the Sindhuli Road will give additional work loads to the Janakpur and Bhaktapur Division office. Furthermore, it is anticipated to be difficult to establish the maintenance system of Sindhuli Road, inclusive of the provision of required infrastructures, immediately after the project completion, because of the less possibility of drastic increase of DOR staff or the insufficient budgetary conditions.

(7) It is therefore recommended to establish the maintenance system from the beginning of the Project and reinforce it including the required infrastructures and staff to the ultimate system keeping pace with the construction.

(8) Referred to the current staffing in the existing Division offices, the Sindhuli Road may require 2 or 3 Maintenance Engineers and 5 or 6 Maintenance Overseers.

Based on the above considerations, the proposed organisation chart of the executing unit (final figure) for the project implementation was prepared as shown in Figure 3.2 which was adjusted from the proposed organisation for the operation and maintenance by the A/C Study (see Figure 3.1).



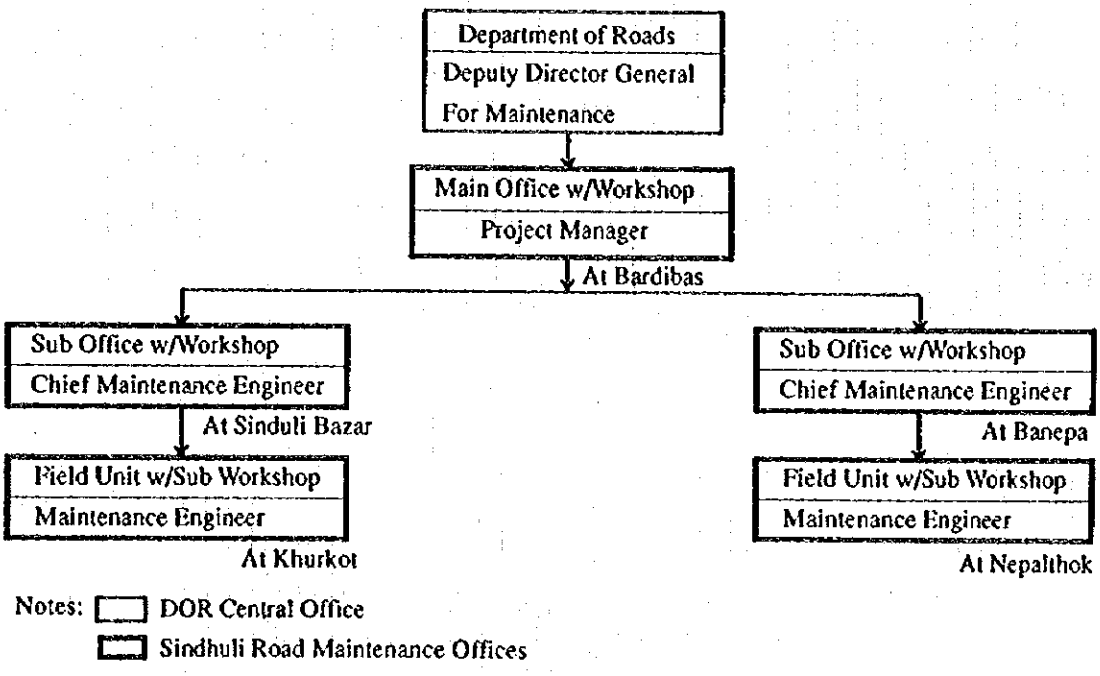


Figure 3.1 Office Allocation of the Operation and Maintenance Body for the Sindhuli Road Proposed by the A/C Study

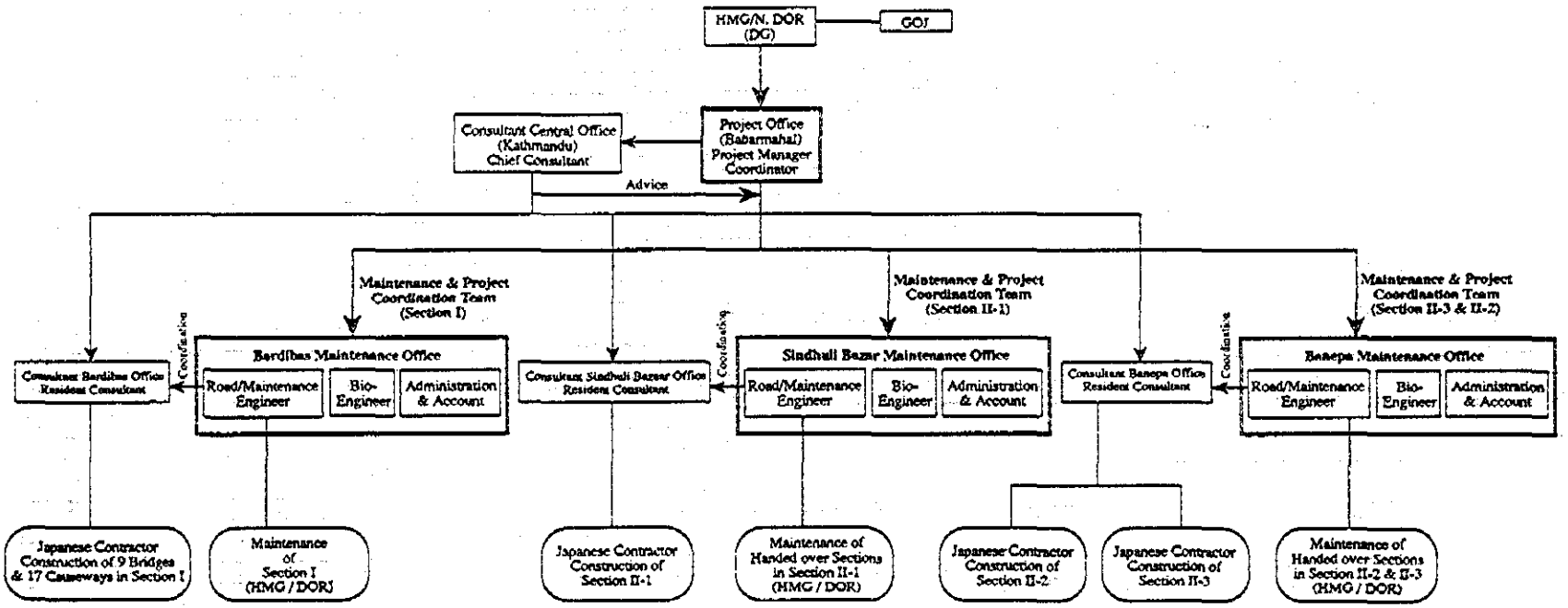


Figure 3.2 The Organisation Chart for the Project Implementation

The organisation chart shown in Figure 3.2 has been prepared by the following understandings:

(1) The executing unit will be organised under Foreign Cooperation Section of DOR.

(2) The Project Office of DOR for Sindhuli Road Construction Project will be established in Kathmandu. The Project Manager (PM) who is responsible to the both construction management and maintenance of handed-over sections, the Project Coordinator and other officer will be stationed there.

(3) The Consultant's Central Office will be also established in Kathmandu and a consultant team headed by the Chief Consultant will be stationed to conduct the overall supervision of the Project including the issuance of change orders, control of construction qualities and quantities, and control of the construction progress. The Chief Consultant will be responsible for the consulting services for the Project and give the advice to the PM regarding the partial hand-over of the project road or operation and maintenance works for the handed-over sections.

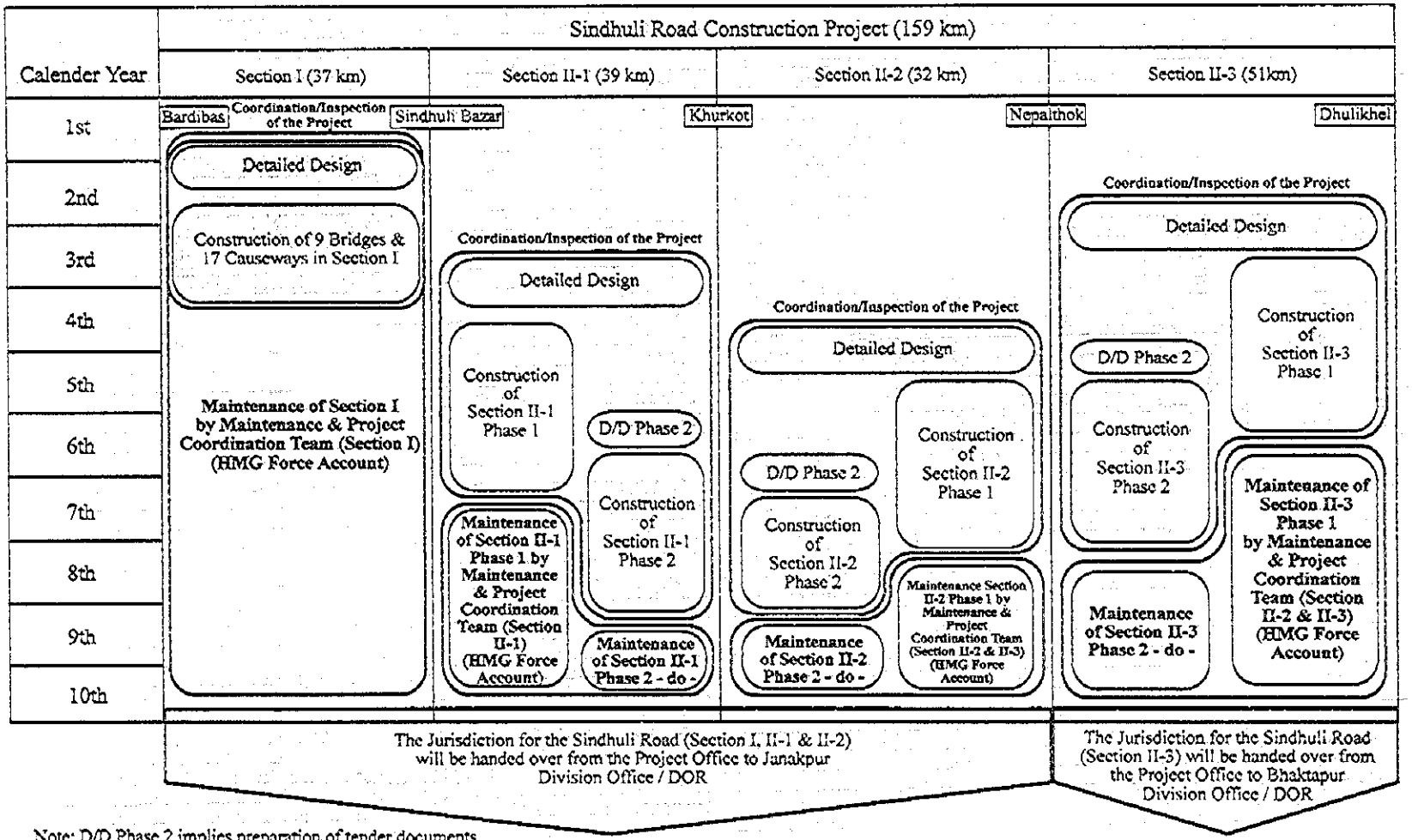
(4) Based on the project progress and requirements, the maintenance offices attached with small workshops will be established in Bardibas, Banepa and Sindhuli Bazar, and the site offices will be established in Khurkot and Nepalthok. These field offices will carry out the operation and maintenance works for the handed-over/completed sections and perform the assistance of project coordination. Appropriate number of technicians, mechanics and equipment will be stationed in these offices.

(5) Chief Maintenance Engineer will be appointed in Bardibas side (Section I and Section II-1) and Dhulikhel side (Section II-2 and II-3). Based on the PM's direction, he will carry out the coordination works to ensure the project implementation, and operation and maintenance works required for the handed-over/completed sections.

(6) Consultant team will have his site offices in Bardibas (Bhiman), Sindhuli Bazar and Banepa (Dhulikhel), and appointed resident engineer in each office will supervise the project construction.

Figure 3.3 shows the relation between construction schedule and proposed activities by the executing unit on the assumption that, following the commencement of construction in Section I, the construction of Section II-3 will start the next year, the Section II-1 and Section II-2 will start its construction after 2 years and 3 years respectively.

Tentative Progress / Program of the Sindhuli Road Construction Project
Showing the Construction Schedule and the Project Office Activities



Note: D/D Phase 2 implies preparation of tender documents and contract documents and also cost estimation

Figure 3.3 Construction Schedule and Proposed Activity by the Executing Unit

3.1.2 Executing Unit for the Project (Section II-3)

Based on the proposed Overall Organisation required for the execution of the Project as shown in Figure 3.2, the organisation chart of executing unit for the Project (Section II-3) was prepared as illustrated in Figure 3.4.

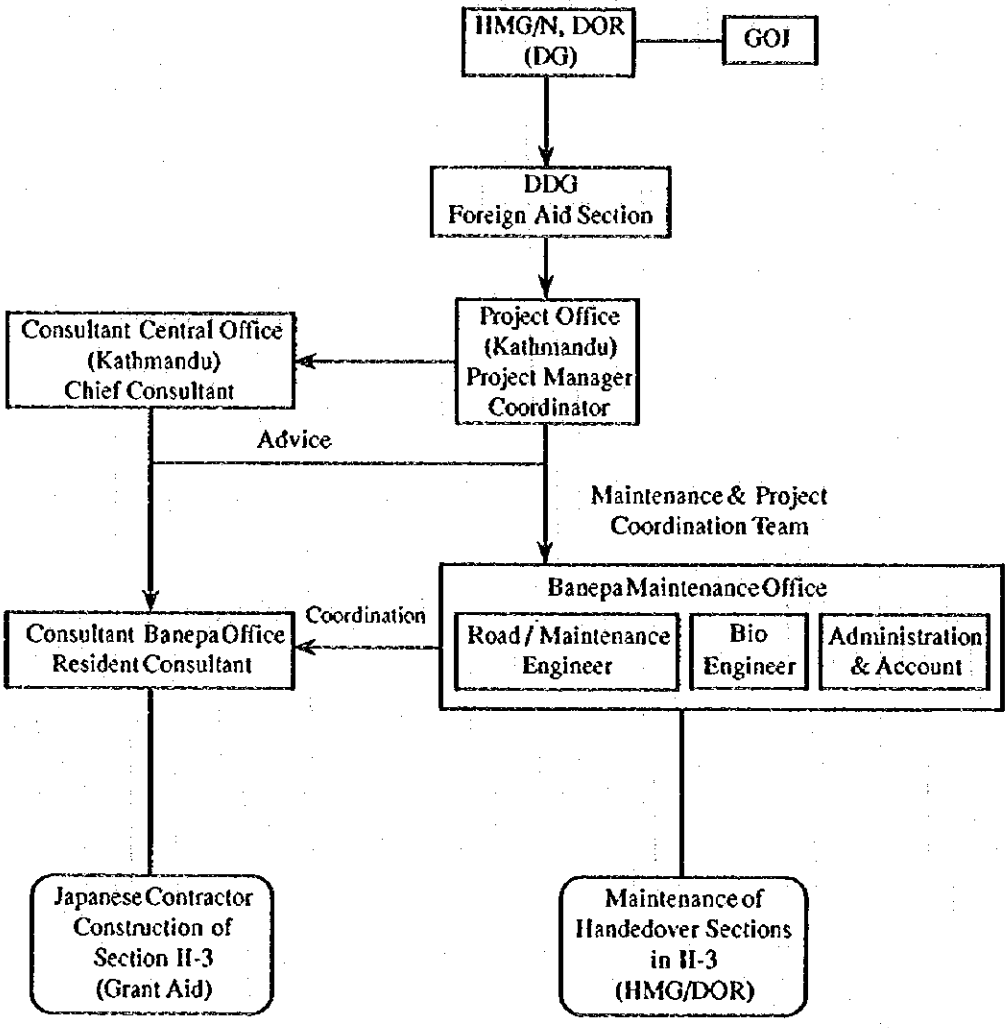


Figure 3.4 Organisation Chart of the Project (Section II-3) Implementation

3.2 Implementation Concept for Section II-3

A. Implementation Method and Plan

The Project (Section II-3) will be implemented with the following steps on the condition that the Project (Section II-3) executed under the Japanese Grant Aid Scheme.

(1) The Department of Roads, Ministry of Works and Transport will be the executing agency.

(2) When the Exchange of Note (E/N) between GOJ and HMG/N regarding the detailed design of the Project (Section II-3) is signed, DOR will designate the Project Manager, under DDG of the Foreign Corporation Section, who will be responsible to the management and a coordinator of the Project. DOR will establish the Project Office (or Unit) in Kathmandu. The Project Office will consists of the PM, Project Coordinator and office supporting staff, and will be in charge of negotiation with villager regarding design aspects, carrying out the land acquisition/compensation procedure, or clear the required regulation for tree/bush cutting works.

(3) A Japanese consultant, recommended by JICA and entrusted by DOR after contract signing, will carry out the detailed design of Section II-3 and prepare the contract documents for Phase-1 construction of Section II-3.

(4) DOR will start the land acquisition, house compensation and management required for tree/bush cutting.

(5) Before signing of the E/N between GOJ and HMG/N regarding the Phase 1 construction of Section II-3, DOR should make sure the successful acquisition works by getting approval from the land and house owners. The Japanese consultant entrusted by DOR after contract signing of project supervision, will start the procedure of tender. DOR will give an authority for the PM to conduct the operation and maintenance works over the existing road and handed-over/completed sections of the Project (Section II-3) along with the establishment of coordinating team. Furthermore, DOR will start to formulate the organisational arrangement to cope with

the expected operation and maintenance works extended over the handed-over/completed sections of the Project (Section II-3).

(6) A Japanese contractor, after contract signing, will undertake the Phase-1 construction work of Section II-3 and the consultant will carry out the construction supervision. The contract with the contractor will include the procurement of equipment for the surface maintenance of existing roads where the contractor will use as access road to the construction site and transportation equipment for the use of field offices of DOR.

(7) Prior to the commencement of construction, DOR will hand over the Project area to the contractor. Therefore the land acquisition and house compensation for the Phase 1 section shall be completed by this time or DOR shall promise the date of hand over which shall not affect the committed construction period.

(8) The equipment for the surface maintenance of the existing road supplied by the Project (Section II-3) will be lent from DOR to the contractor with no charge. The contractor will be responsible for the maintenance of the existing road (except Kodari Road) to be used for access road.

(9) When the existing road is handed over to the contractor for the use of the project construction, the road will be access controlled and vehicles without permission will not be allowed to pass through.

(10) When DOR requires the partially completed segment of the project road to be opened to the public and the contractor accepts it, that segment will be handed-over to DOR. By this hand-over, the maintenance obligation required for the said section will be also transferred to DOR. However in case the contractor continues to use the said section after the hand-over in order to access to his construction site, the contractor will be responsible for the surface maintenance of the said section during his use.

(11) The E/N regarding the detailed design for Phase-2 construction of Section II-3 will be signed during the Phase-1 construction. A Japanese consultant entrusted by DOR after contract signing, will

prepare the tender documents, technical specifications and estimate the construction costs.

(12) After the E/N regarding the Phase-2 construction of Section II-3 is signed, the same procedures described from (5) to (9) will be taken to the Phase-2 construction.

(13) The contract for the Phase-2 construction of Section II-3 will include the procurement of the maintenance equipment for the handed-over/completed sections of Section II-3. Therefore DOR shall provide the Banepa maintenance offices with workshop where the equipment is scheduled to be received, before the contract signing.

(14) After the completion of the Phase-1 construction, the maintenance obligation will be transferred to DOR. However, when the contractor uses the Phase-1 road for the purpose of access to his construction site of Phase-2 or the Project of Section II-2, the maintenance of the road surface will be carried out by the contractor. In this case DOR shall lend the equipment supplied by the Project to the contractor with no charge.

(15) DOR will carry out the operation and maintenance works of the completed sections of the Project (Section II-3) utilising the equipment for the maintenance supplied by the Project (Section II-3) by the time of project completion designating the PM to be responsible. In order to execute the maintenance works, the PM and the Chief Consultant will have a close cooperation to determine the required work items and equipment management.

(16) Approximately a year after the completion of the project construction, the responsibilities for the operation and maintenance works of the project road will be transferred to the ordinary maintenance section. Then the Sindhuli Road Construction Project Office will be closed and the Project will terminate.

B. Formation of the construction

Several Japanese contractors have performed their activities in Nepal undertaking the Japanese Grant Aid Projects, mainly. These contractors have trained the local contractors and employed them as subcontractor in the projects. The common type of this subcontract is a partial

subcontract with which the subcontractor offer his labours and carry out the work utilising the equipment and materials supplied by the main contractor.

Judging from the project scale of Section II-3 and estimated number of labours (thousands of labours will be required for the project construction), the main contractor can not execute the work with a sole subcontractor, and has to use several subcontractors. Therefore, the Project (Section II-3) will be implemented by the formation of a Japanese main contractor and several local subcontractors (partial subcontract) with the provision of equipment and materials (cement, galvanised heavy coating steel wire, plywood form, etc.) supplied by the main contractor and labours from subcontractors.

C. Necessity of Japanese Experts

It is considered that the capability of Nepalese skilled labour has developed through the previous grant aid or loan projects. Furthermore, as the project construction was intended to apply the local materials and local construction method as much as possible, there is little incentive to dispatch Japanese Experts for the assistance of general civil works. However, in order to construct the steel bridges and due to the characteristics of the Project (Section II-3), Japanese Experts are required to be dispatched for the following works:

- Three major steel bridges were designed as strutted steel beam bridge type and steel truss bridge type. A skilled labour for erection or painting of these bridge types are very rare in Nepal. Therefore, Japanese Experts of erection and painting shall be assigned during the construction of bridges.

- In order to achieve the steady progress of a large scale of project, it is essential to maintain heavy equipment, crushing plant or batcher plant in good condition and well functioned. As it is difficult to recruit skilled technicians in Nepal who can maintain variety of equipment or plants flexibly, a Japanese senior mechanic and senior electrician shall be assigned for operation, maintenance and repair the equipment and plants.