8.5 Mapping and Topographic Survey

8.5.1 General

The works conducted by Mapping Team of the Study Team are as follows:

8.5.2 Preparation of Topographic Map (scale: 1/10,000)

The topographic map with a scale of 1/10,000 was prepared using the existing aerial photograph and topographic map of 1/50,000 with 2 to 3 km in width along the route selected by the Road Planning Team in the initial route study.

The map was prepared by the Mapping Group in Tokyo during the period from December, 1986 to January, 1987.

8.5.3 Preparation of Topographic Map (scale: 1/2,000)

The Mapping Team conducted aerial photographic survey with a scale 1/10,000 and ground control survey for preparing the topo. map of 1/2,000 in scale.

Aerial photograph survey was done by hiring an aircraft and crew from Nepalese Organization in late December, 1986 when it was fine weather for shooting photographs.

Ground control survey consisting of traverse survey, leveling and field classification survey, were conducted in parallel with aerial photographic survey during the period from Novembver, 1986 to February, 1987.

Topographic map in a scale of 1/2,000 was prepared in Tokyo with 200 to 300 m in width along the optimum route selected by Road Planning Team considering on the topographic map of 1/10,000 in scale.

This topographic map with a scale of 1/2,000 was used by the Road Planning Team in preliminary design work of Sindhuli Road.

8.5.4 Preparation of Topographic Map for Bridge Design (1/500)

Detailed topographic survey was carried out by Mapping Team for preparing topographic map with a scale of 1/500 which was used for preliminary design of bridges.

The survey was conducted in June, 1987 at the proposed bridge site listed in the Appendix 8.5.1.

CHAPTER 9 PRELIMINERY DESIGN

9.1 General

In this chapter, a preliminary design is presented for Sindhuli Road on the basis of comprehensive engineering analysis made in the Chapter 8.

The size of and dimension of the road facilities is determined in order to make quantity calculation, estimation of the project cost and construction schedule.

The whole route is divided into the four sections for easy identification and for the convenience of preparing preliminary design and implementation schedule as follows:

Section I	Bardibas - Sindhuli Bazar	37 km
Section II-1	Sindhuli Bazar - Khurkot	39 km
Section II-2	Khurkot - Nepalthok	30 km
Section II-3	Nepalthok - Dhulikhel	49 km
	Total Length of the Project	155 km

9.2 Highway Design

9.2.1 General

Preliminary highway design was conducted using a topographic map with a scale of 1/2,000.

Design speed to be applied for each section is determined in accordance with the classification of terrain condition. Many of the other geometric design features, such as minimum radius, maximum gradient, minimum sight distance, etc. are derived from the design speed.

Horizontal and vertical alignments were selected on the basis of the design speed determined above and shown on the alignment drawings (plan and longitudinal sections) contained in Volume III, including the coordinates of intersection points and the radius, length and deflection angle of each curve.

9.2.2 Design Speeds

On the basis of geometric design criteria established in Chapter 7, the design speeds ranging from 50 km/hr to 30 km/hr were adopted according to the terrain conditions as shown in Table 9.1:

Table 9.1 Summary of Design Speeds Applied for Sindhuli Road

	Stretch	Length	Design Speed adopted
Section I	STA 0 - STA 29	29 km	50 km/hr
	STA 29 - STA 35	6 km	40 km/hr
	STA 35 - STA 37	2 km	50 km/hr
Section II-1	STA 0 - STA 7	7 km	40 km/hr
	STA 7 - STA 37/*	30 km	30 km/hr
	STA 37 - STA 39	2 km	40 km/hr
Section II-2	STA 0 - STA 6	6 km	40 km/hr
	STA 6 - STA 14/*	8 km	30 km/hr
	STA 14 - STA 30	16 km	40 km/hr
Section II-3	STA 0 - STA 31	31 km	40 km/hr
	STA 31 - STA 42/*	11 km	30 km/hr
	STA 42 - STA 47	5 km	40 km/hr

/*: The design speed of 20 km/hr was adopted for the hairpin bends and the places where construction work is extremely difficult due to steep terrain.

9.2.3 Alignment Design

(1) Section I (Bardibas - Sindhuli Bazar: 37 km)

Section I has been constructed by DOR since 1983 with the exception of bridges and pavement employing equipments granted by the aid of Japanese Government.

In the Section I, works to be done under this Project are therefore the construction of bridges and pavement, and the improvement of existing roadway including widenning of carriageway, slope protection, reconstruction of drainage, improvement of sharp curve and steep gradient, and so on.

In the stretch between STA 192 and STA 273, the route crosses over plenty numbers of tributaries of Kanala River. The alignment of the Project Road in this section is shifted from the existing road toward hillside in order to minimize the length of bridges to be constructed.

The existing road between Kamala River (STA 294) and Sindhuli Bazar (STA 374) has been constructed and substantially completed by DOR, however, the alignment as well as the carriageway width has to be improved under this Project to meet the requirement of design standard of the Project Road. Slope protection might be required in this section.

(2) Section II-1 (Sindhuli Bazar - Khurkot: 39 km)

The route, starting from Sindhuli Garhi, follows the right bank of Gwangu Khola. After Gwangu Khola, the route starts ascending with loops on the very steep southern slope of Mahabhrat Range up to Sindhuli Garhi with a gradient of 6.2% in average.

The route, after crossing Sindhuli Garhi, continues ascending on the northern slope of the Range up to STA 225 (EL.1,450 m) in order to avoid the existing landslide area located nearby STA 220.

After passing through this landslide area, the road starts descending and goes down up to the Andheri River making loops on the very steep slope. The maximum gradient of 9% was applied in the steep slope stretches in order to minimize the dangerous section through which the route has to pass.

30 km/hr of design speed was adopted considering the steep terrain condition, however, it was reduced up to 20 km/hr at the hairpin bends and the place where the slope is extremely steep.

(3) Section II-2 (Khurkot - Nepalthok: 30 km)

The route, starting from Khurkot, passes through relatively stable slope on the left bank of Sun Kosi River up to Nepalthok.

The alignment was determined considering the following control points:

- connection with villages located along Sun Kosi River, such as Ratmate, Bazar, Thanga Tholi, Dumja
- river crossing points from the engineering view point
- steep topography and potential land slide area
- high water level of Sun Kosi River

Vertical alignment was determined to keep 10 m above the highest water level of Sun Kosi River.

(4) Section II-3 (Nepalthok - Dhulikhel: 49 m)

In the section between Nepalthok and the confluence of Dabcha Khola, the route has to pass through many landslide areas as shown below:

1) STA 33+00 - STA 37+00 (L = 400 m)
2) STA 54+00 - STA 58+00 (L = 400 m)
3) STA 66+00 - STA 74+00 (L = 800 m)
4) STA 81+00 - STA 84+00 (L = 300 m)
5) STA 119+00 - STA 122+00 (L = 300 m)
6) STA 143+00 - STA 145+00 (L = 200 m)

The alignments in the above sections are unavoidably deterdmined to locate on the river bed on Rosi Khola. The vertical alignment is designed to keep 10 m above the river bed and the roadway is protected by the rigid concrete retaining wall considering scouring action of river flow. Slope protection works are also provided to keep the safety of traffic.

After passing through the gorge of Dabcha Khola, the route proceeds on flat terrain and reaches Buchakot. From Buchakot up to Phaskot, the route has to pass through well developed cultivated hillside. Design speed is therefore reduced to 30 km/hr in this section in order to minimize the effect on crops and vegitable along the project road.

9.2.4 Cross Sectional Design

Cross sections were taken off from the contoured topographical map with a scale of 1/2,000 and drawn in a scale of 1/200. The distance between successive cross sections was typically chosen to be 50 m.

The areas of cut and fill at each cross section were computed, and volumes were derived from them by the End Area Method.

9.3 Bridge Design

9.3.1 General

General concepts to determine bridge types and alternative study are presented in Clause 7.5 of Chapter 7.

In this section, bridge types and demensions were refined and determined using a topographic map with a scale of 1/500.

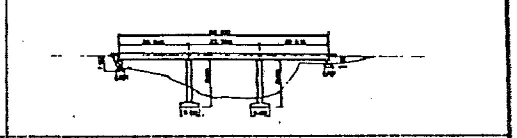
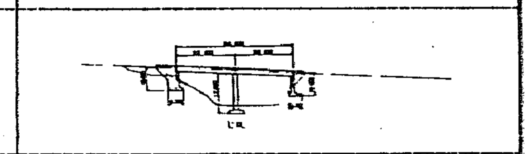
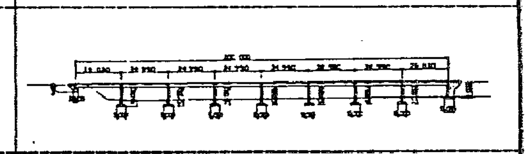
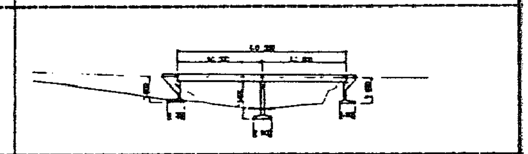
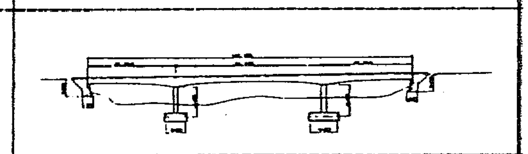
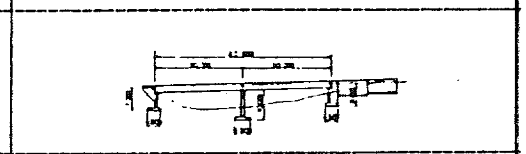
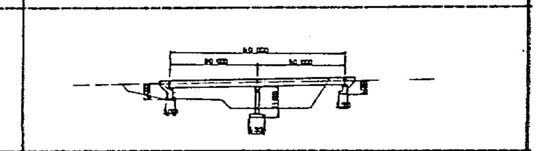
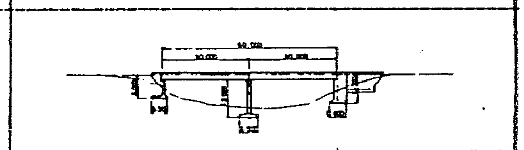
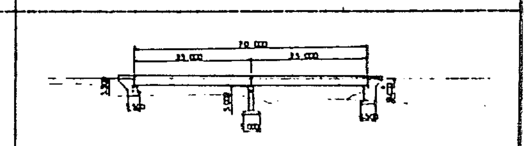
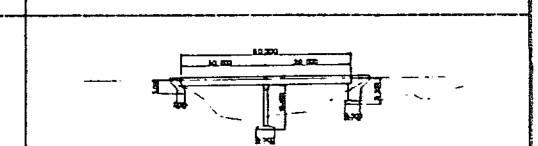
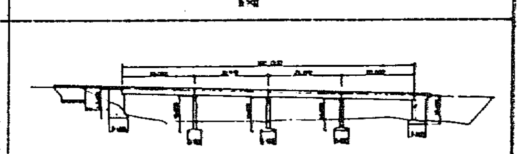
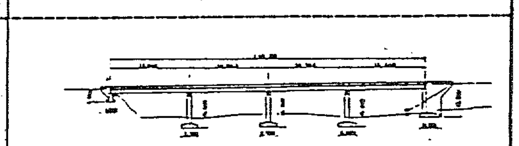
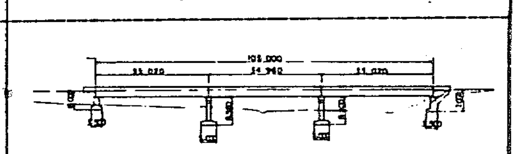
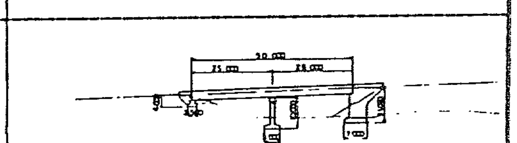
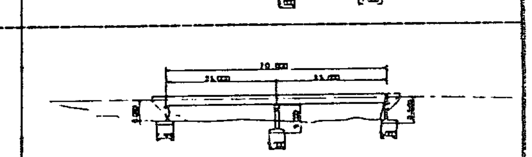
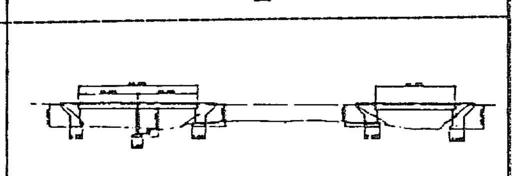
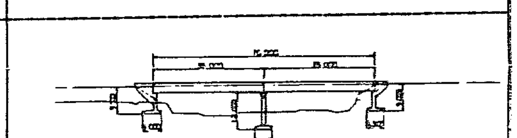
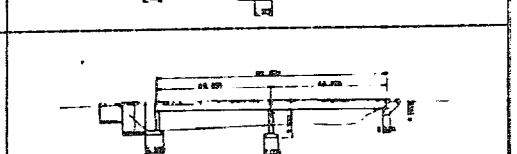
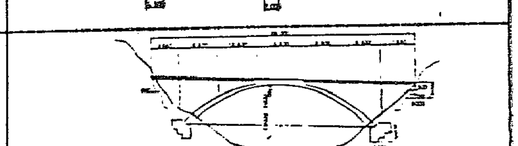
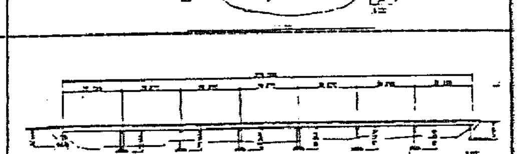
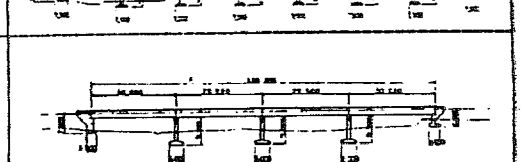
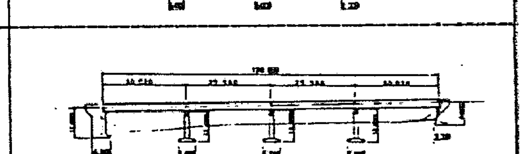
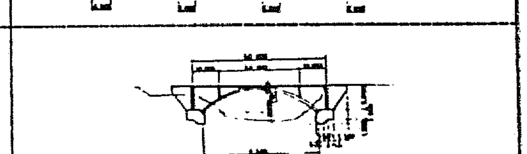
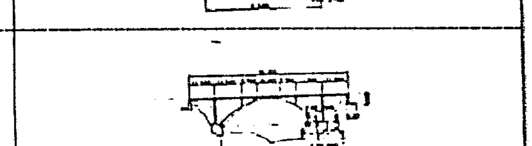
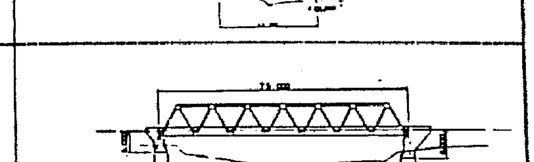
Bridge structures are devided into three groups depending on bridge length as follows:

Major bridge .... total bridge length > 50 m
Medium bridge .... 20 m < total bridge length < 50 m
Minor bridge .... 5 m < total bridge length < 20 m

9.3.2 Major Bridge Design

25 major bridge area proposed in the Project is as shown below and the detailed list of major bridges is presented in Table 9.2.

Table 9.2 List of Major Bridges

SEC	NAME OF BRIDGE	STA. NO.	TOTAL BR. LENGTH (m)	SPAN ARRANGEMENT (m)	TYPE OF BRIDGE	APPROX. CONST.COST (10 Rs.)	APPROX CONST. PERIOD (Month)	CONST. METHOD	TEMPORARY-YARD	RUN OFF PEAK	FLOTING-DEBRIS	BASIN SLOPE	PREVAILING REASONS OF BRIDGE SELECTION	PROFILE
I	BHOGATE	77+99.0 78+80.0	90.0	3@30.0	PC -SIMPLE -T-BEAM	15,700	13	GIRDER-ELECTION TOWER-ELECTION	GOOD	199m3/sec	DRIFTING LOGS (DRIFTING-WOOD) ø30x6 m	1/24	ECONOMIC-VIEW-POINT STRUCTURAL-VIEW-POINT	
	KAREKARE	82+05.0 82+55.0	50.0	2@25.0	PC -SIMPLE -T-BEAM	10,200	9	GIRDER-ELECTION TOWER-ELECTION	GOOD	157m3/sec	DRIFTING LOGS (DRIFTING-WOOD) ø20x5 m	1/37	ECONOMIC-VIEW-POINT STRUCTURAL-VIEW-POINT	
	RATU	125+25.0 127+00.0	175.0	8@25.0	PC -SIMPLE -T-BEAM	35,600	23	GIRDER-ELECTION TOWER-ELECTION	GOOD	960m3/sec	DRIFTING LOGS (DRIFTING-WOOD) ø30x12 m	1/50	ECONOMIC-VIEW-POINT STRUCTURAL-VIEW-POINT	
	SHINDHUSE	282+10.0 282+70.0	60.0	2@30.0	PC -SIMPLE -T-BEAM	11,000	12	GIRDER-ELECTION TOWER-ELECTION	GOOD	80m3/sec	DRIFTING LOGS (DRIFTING-WOOD) ø30x8 m	1/10	ECONOMIC-VIEW-POINT STRUCTURAL-VIEW-POINT	
	KAHALA	289+60.0 291+25.0	165.0	45.0+75.0 +45.0	PC -CONTINIOUS -BOX.GIRDER	50,000	15	CANTILEVER-ELECTION	GOOD	2,857m3/sec	DRIFTING LOGS ø80x12 m BOULDER ø80	1/29	FLOTING-DEBRIS STRUCTURAL-VIEW-POINT	
	PHITTANG	323+65.0 324+25.0	60.0	2@30.0 ø=60°	PC -SIMPLE -T-BEAM	11,000	13	GIRDER-ELECTION TOWER-ELECTION	GOOD	240m3/sec	DRIFTING LOGS ø30x8 m BOULDER ø70	1/10	ECONOMIC-VIEW-POINT STRUCTURAL-VIEW-POINT	
	BUKA	344+40.0 345+00.0	60.0	2@30.0	PC -SIMPLE -T-BEAM	11,000	13	GIRDER-ELECTION TOWER-ELECTION	GOOD	406m3/sec	DRIFTING LOGS ø30x5 m BOULDER ø20	1/22	ECONOMIC-VIEW-POINT STRUCTURAL-VIEW-POINT	
	GADEULI	352+60.0 353+20.0	60.0	2@30.0	PC -SIMPLE -T-BEAM	11,000	13	GIRDER-ELECTION TOWER-ELECTION	GOOD	779m3/sec	DRIFTING LOGS ø50x8 m BOULDER ø50 - ø80	1/18	ECONOMIC-VIEW-POINT STRUCTURAL-VIEW-POINT	
II-1	GWANGU	79+55.0 80+25.0	70.0	2@35.0	STEEL -SIMPLE GIRDER	14,900	11	CABLE-ELECTION	NO-GOOD	410m3/sec	DRIFTING-LOSS ø50x8 m BIG-BOULDER	1/7	STRUCTURAL-VIEW-POINT ACCESS ROAD	
	SIURANI	82+00.0 82+60.0	60.0	2@30.0	STEEL -SIMPLE GIRDER	10,700	10	CABLE-ELECTION	NO-GOOD				STRUCTURAL-VIEW-POINT ACCESSIBILITY	
	ARDLERI	401+40.1 402+60.0	120.0	4@30.0	STEEL -SIMPLE GIRDER	23,000	13	GIRDER-ELECTION TOWER-ELECTION	GOOD	390m3/sec	DRIFTING-LOSS ø30x8 m BIG-BOULDER	1/6	STRUCTURAL-VIEW-POINT ACCESSIBILITY	
II-2	NIGAULI	43+80.0 45+20.0	140.0	4@35.0	STEEL -SIMPLE GIRDER	27,000	13	GIRDER-ELECTION TOWER-ELECTION	GOOD	405m3/sec	BIG-BOULDER 8m/15Yr UP	1/6	STRUCTURAL-VIEW-POINT ACCESSIBILITY	
	ARUBOTE	93+80.0 94+85.0	105.0	3@35.0	STEEL -SIMPLE GIRDER	20,900	12	GIRDER-ELECTION TOWER-ELECTION	GOOD	301m3/sec	DRIFTING-LOSS BIG-BOULDER 2m/5Yr UP	1/7	STRUCTURAL-VIEW-POINT ACCESSIBILITY	
	KHAHARE	106+95.0 107+45.0	50.0	2@25.0 ø=70°	STEEL -SIMPLE GIRDER	10,400	8	TOWER-ELECTION	GOOD	108m3/sec	DRIFTING-LOSS (DRIFTING-WOOD)	1/6	STRUCTURAL-VIEW-POINT FLOTING-DEBRIS	
	BHOTE	153+25.0 153+95.0	70.0	2@35.0	STEEL -SIMPLE GIRDER	14,900	11	GIRDER-ELECTION TOWER-ELECTION	GOOD	267m3/sec	SLIDING BIG-BOULDER	1/10	STRUCTURAL-VIEW-POINT ACCESSIBILITY	
	GANGATE	183+85.0 185+45.0	60.0	2@30.0	STEEL -SIMPLE GIRDER	10,700	10	GIRDER-ELECTION TOWER-ELECTION	GOOD	343m3/sec	BIG-BOULDER	1/8	ACCESSIBILITY STRUCTURAL-VIEW-POINT	
		185+35.0 185+75.0	40.0	40.0	STEEL -SIMPLE GIRDER	9,500	8							
	DHAMILE	202+05.0 202+75.0	70.0	2@35.0	STEEL -SIMPLE GIRDER	14,900	11	GIRDER-ELECTION TOWER-ELECTION	GOOD	500m3/sec	DRIFTING-LOSS ø500x15 m	1/18	STRUCTURAL-VIEW-POINT ACCESSIBILITY	
	SANDI	230+50.0 231+30.0	80.0	2@40.0	STEEL -SIMPLE GIRDER	18,000	12	GIRDER-ELECTION TOWER-ELECTION	GOOD	170m3/sec	BIG-BOULDER	1/8	STRUCTURAL-VIEW-POINT ACCESSIBILITY	
	STA 240	239+30.0 240+15.0	85.0	8.950 +11.500 +4@12.500 +14.500	R.C -ARCH	23,400	15	TRUSS-TIMBERING STEEL-ARCH-SUPPORT	NO-GOOD				STRUCTURAL-VIEW-POINT HARD-ROCK	
II-3	GHYAMPE	12+20.0 14+95.0	275.0	7@39.0	P.C -SIMPLE -T-BEAM	59,000	24	GIRDER-ELECTION	GOOD	332m3/sec	BIG-BOULDER	1/4	BOULDER STRUCTURAL-VIEW-POINT	
	MAMTI	41+80.0 43+00.0	120.0	4@30.0	P.C -SIMPLE -T-BEAM	21,600	15	GIRDER-ELECTION TOWER-ELECTION	GOOD	319m3/sec	BIG-BOULDER	1/6	ECONOMIC-VIEW-POINT STRUCTURAL-VIEW-POINT	
	BHYAKURE	100+80.0 102+00.0	120.0	4@30.0	P.C -SIMPLE -T-BEAM	21,600	15	GIRDER-ELECTION TOWER-ELECTION	GOOD	442m3/sec	SLIDING BIG-BOULDER	1/6	ECONOMIC-VIEW-POINT STRUCTURAL-VIEW-POINT	
	DAUNE	135+85.0 136+35.0	50.0	50.0	R.C -ARCH	12,000	11	TRUSS-TIMBERING STEEL-ARCH-SUPPORT	NO-GOOD	213m3/sec	BIG-BOULDER	1/6	STRUCTURAL-VIEW-POINT HARD-ROCK	
	NARKE	159+50.0 160+20.0	70.0	70.0	R.C -ARCH	19,400	13	TRUSS-TIMBERING STEEL-ARCH-SUPPORT	NO-GOOD	343m3/sec	BIG-BOULDER	1/8	STRUCTURAL-VIEW-POINT HARD-ROCK	
	ROGI	213+15.0 213+90.0	75.0	75.0	STEEL -SIMPLE -TRUSS	29,500	15	TRUSS-TIMBERING	NO-GOOD	3,258m3/sec	DRIFTING-LOSS (DRIFTING-WOOD) ø30x10 m	1/34	STRUCTURAL-VIEW-POINT HARD-ROCK	

Section	Total Numbers & Bridge Length	PC Bridge	Steel Bridge	RC Bridge
Section I	8 (720 m)	8 (720 m)	-	-
Section II-1	3 (250 m)	-	3 (250 m)	-
Section II-2	8 (700 m)	-	7 (615 m)	1 (85 m)
Section II-3	6 (710 m)	3 (515 m)	1 (75 m)	2 (120 m)
Total	25 (2,380 m)	11 (1,235 m)	11 (940 m)	3 (205 m)

(1) Section I (Bardibas - Sindhuli Bazar: 37 km)

The existing road runs through flat area in the Terai Plain. In Section I between Bardibas and Sindhuli Bazar, the route crosses over 8 major rivers and tributaries where no bridge is serving at present. The vehicles are obliged to cross the river bed which has been frequently impassable due to flood in the rainy season.

Out of 8 major bridges, 7 bridges were selected to be PC simple T-beam type taking into consideration of topographic condition as well as easy accessibility to the construction site.

PC continious box girder type were selected for the remaining bridge, namely Kamala bridge, considering minimization of hydraulic effect against the piers since the bridge are located at the confluence of Kamala River and its tributary. Cantilever method was employed for election of the bridge.

Ratu bridge is the longest one in Section I, with a bridge length of 175 m. PC simple T-beam was selected for this bridge taking into consideration of sufficient election space around the river. Spread footing type pier was adopted for all the bridges in Section I.

(2) Section II-1 (Sindhuli Bazar - Khurkot: 39 km)

Three major bridges were proposed in Section II-1. Steel simple girder type was selected for these bridges considering the difficulty of accessibility due to steep slope of Mahabhrat Range.

(3) Section II-2 (Khurkot - Napalthok: 35 km)

The route passes on the left bank of Sun Kosi River and crosses over 8 major tributaries in this section.

This section is isolated entirely from Kathmandu and Terai Plain due to Mahabhrat Range. The access road to the Section II-2 might be required temporarily in either Section II-3 or Section II-1 for earlier commencement of Section II-2. It would be essensial for smooth implementation of the Project.

Considering not only the difficulty in transporting materials from outside but also the topographic condition of the bridge site, steel simple girder type bridge was adopted for these bridges with the exception of the bridge at STA 24+000. RC arch bridge with a bridge length of 80 m or so was adopted for the bridge at STA 24+000 since the route crosses very wide and deep tributary where election of pier might be very difficult.

(4) Section II-3 (Nepalthok - Dhulikhel: 49 km)

6 major bridges were proposed in Section II-3 between Nepalthok and Dhulikhel.

Out of them, three bridges were proposed for PC simple T beam and two bridges for RC arch bridges taking into consideration of the bridge site conditions as well as the economy of the construction costs.

Steel truss bridge with 75 m in length were selected for the bridge across Rosi Khola from the technical view points as follows:

- RC arch bridge is technically not feasible due to small vertical clearance.
- Steel box bridge is considered as an alternative, however, construction cost will be 20% higher than that of steel truss bridge. Moreover, the election of steel box bridge is difficult in the rainny season because of the flood of Rosi Khola.
- Members of steel truss can be transported easier than that of steel box on the existing Kodari road as well as on the access road.
- Steel truss by weather coat processing does not require regular maintenance of painting so that maintenance cost can be reduced remarkably.

9.3.3 Medium and Minor Bridges

60 of medium and minor bridges are designed in the Project as shown below:

Section	Total Nos. & Bridge Length	RC Slab L<10m	RCT L=15m	PCT L=20~30m	STH L=15-20m	STG L=25-4
Section I	7 (150m)	-	2 (30m)	5(120m)	-	-
Section II-1	20 (510m)	-	5 (75m)	-	4 (75m)	11(360
Section II-2	14 (310m)	-	-	-	10(185m)	4(125
Section II-3	19 (530m)	1(10m)	-	-	8(150m)	10(370
Total	60(1,500m)	1(10m)	7(105m)	5(120m)	22(410m)	25(855

(1) Section I (Bardibas - Sindhuli Bazar)

7 of medium and minor bridges were planned in Section I, and out of them, 2 bridges were selected to be RC T beam and the remaining 5 bridges were PC T beam taking into consideration of working area for the election of bridges.

In the stretch between STA 19 and STA 24, the route crosses over many tributaries of Kamala River which contains huge amount of sedimentary boulders transported from the deposit of Silwalik. Min. 5 m of vertical clearance is kept for crossing these tributaries considering the sedimentation.

(2) Section II-1 (Sindhuli Bazar - Khurkot)

The route crosses over the steep slope of Mahabrat Range. Out of 20 numbers of medium and minor bridges in this section, steel H beam and steel girder bridges were selected for 15 bridges considering the difficulty in constructing access road.

RC T beam bridge was adopted for the remaining 5 bridges which are located near Sindhuli Bazar where the election of staging are relatively easy.

(3) Section II-2 (Khurkot - Napalthok)

Taking into consideration of the difficulty in constructing access road, all the medimum and minor bridges were selected to be steel bridges.

(4) Section II-3 (Nepalthok - Dhulikhel)

18 bridges were planned in this Section, and out of them 17 bridges were selected for steel bridges considering site conditions and access road. The remaining bridge was adopted for RC slab bridge.

9.3.4 Summary of Bridges

Summary of bridges including major, medium and minor bridges were presented in Table 9.3:

Table 9.3 Summary of Bridges

Section	Major	Medium & Minor	Total
Section I	8 (720 m)	7 (150 m)	15 (870 m)
Section II-1	3 (250 m)	20 (510 m)	23 (760 m)
Section II-2	8 (700 m)	14 (310 m)	22(1,010 m)
Section II-3	6 (710 m)	19 (530 m)	25(1,240 m)
Total	25(2,380 m)	60(1,500 m)	85(3,880 m)

9.4 Drainage Structure

9.4.1 General

Drainage structure is one of the most important factors to keep all weather condition of road, especially such a mountainous road as Sindhuli Road.

9.4.2 Design of Drainage Structure

Drainage design was conducted employing the following criteria:

(1) Culvert Design

a. Minimum pipe culvert diameter should be 600 mm for easy maintenance.

b. Pipe or box culverts should be designed using concrete headwalls, wing walls, protective aprons and toes as scour protection.

c. The minimum allowable velocity should be 0.8 m/sec. to prevent siltation and the maximum velocity 3.5 m/sec. to avoid excess scour.

d. All culverts should be designed to free outlet conditions.

e. Corrugated metal pipe (either circular or semi-circular arch types) should be used in case of difficulty in constructing access road.

(2) Ditches

a. Roadside ditch on steep gradient should be covered with grouted riprap to prevent erosion of road-structure and cut slope.

b. Minimum dimensions of roadside ditch should be 50 cm x 75 cm (Height x Width) taking into consideration of debris and falling stone from the cut slope.

c. Interceptor drain at the tops of cutting slope are necessary to prevent erosion of the exposed face of the cutting and cut slope faifure.

d. At the toe of embankment, the drain should be provided to prevent embankment scour.

(3) Protective Works

a. Subsoil drain should be provided beneath the embankment in order to attain its stability.

b. Scour protection should be provided at bridge abutments and piers and be incorporated with the bridge design.

c. Gabion and revetment should be provided in the area of river flow where embankment would required protections against scouring action.

d. Energy dissipating devices such as riprap outlet apron and step chute should be provided at culvert outlet.

9.5 Pavement Design

9.5.1 General

The pavement of the Project Road were designed in accordance with the methodology as described in "AASHTO INTERIM GUIDE FOR DESIGN OF PAVEMENT STRUCTURES, 1972".

The elements of design used are daily traffic volume, serviceability of the pavement, value of soil support and a regional factor.

9.5.2 Alternative Pavement Type Considered

Two types of pavement design have been considered as follows:

(1) Duble Bitumen Surface Treatment (DBST)

DBST is a common form of pavement construction in underdeveloping countries because of easy maintenance and lower capital cost when compared with other forms of pavement.

However, it will not perform satisfactorily throughout its design life unless regular maintenance in the form of re-sealing can be conducted properly and periodically.

It can be maintained by relatively unskilled labour, however, construction requires experience and skill to produce good work quality.

In the design manual of "Low Cost Asphalt Concrete" published by Japan Road Association in 1975, DBST is recommended to apply for the low standard road with a carriageway width of less than 5.5 m and numbers of average truck (heavy) of less than 150 vehicles per day.

Strict traffic control is necessary during the construction of DBST to prevent damage to the newly laid surface by traffic.

(2) Asphaltic Concrete (AC)

Asphaltic concrete is currently used in Nepal, particularly on trunk roads and urban roads.

This type is particularly suited to heavy traffic roads since it can be opened on traffic immediately after laying.

Durability, waterproofing and stability of asphaltic concrete are reliable and superior to DBST surfacing, since the materials of asphaltic concrete are mixed up and measured properly in the plant.

Initiall investment cost is relatively high comparing with DBST because it requires asphalt mix plant as well as high skilled labour for operating plants.

9.5.3 Alternative Pavement Design

Indices and engineering value to be used for the pavement design for Sindhuli Road Project are calculated and presented in Appendix 9.5.1, summary of which is shown below:

	Section I	Section II
- Serviceability Index	2.5	2.5
- Soil Support Value	5.7	4.8
	(CBR 15)	(CBR 8)
- Total Equivalent Axle Loads	$2.0x10^6$	$1.8x10^6$
- Layer Coefficient		
AC Surface	0.44	0.44
DBST Surface	0.20	0.20
Crushed Stone Base	0.14	0.14
Sandy Gravel Subbase	0.11	0.11
- Regional Factor	1.5	1.5
- SN	3.1	3.5

For the design of pavement, the required structure number (SN) over each of the component materials is determined from the design chart.

SN Value is obtained assuming soil support value, total 18 kip (80 KN) equivalent single-axle load and regional factor in each section as shown in Fig. 9.1. The resulting SN's were 3.1 for Sec. I and 3.3 for Sec. II respectively.

Based on the total required SN, alternative designs with variations in the thickness and types of surface, base and subbase are carried out, and detailed of which are presented in Appendix 9.5.2.

The summary of the alternative pavement design is shown in Fig. 9.2.

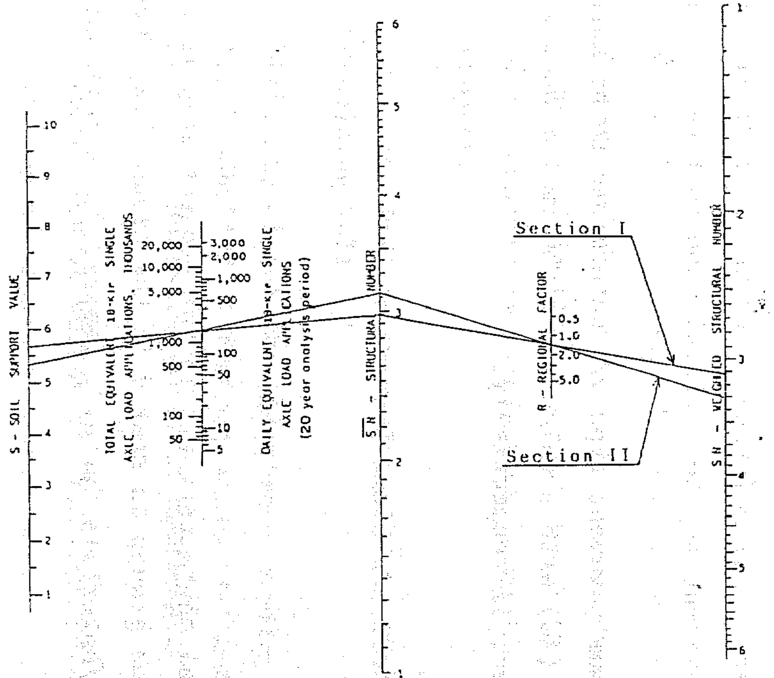


Fig. 9.1 Design Chart for Flexible Pavements Pt = 2.5

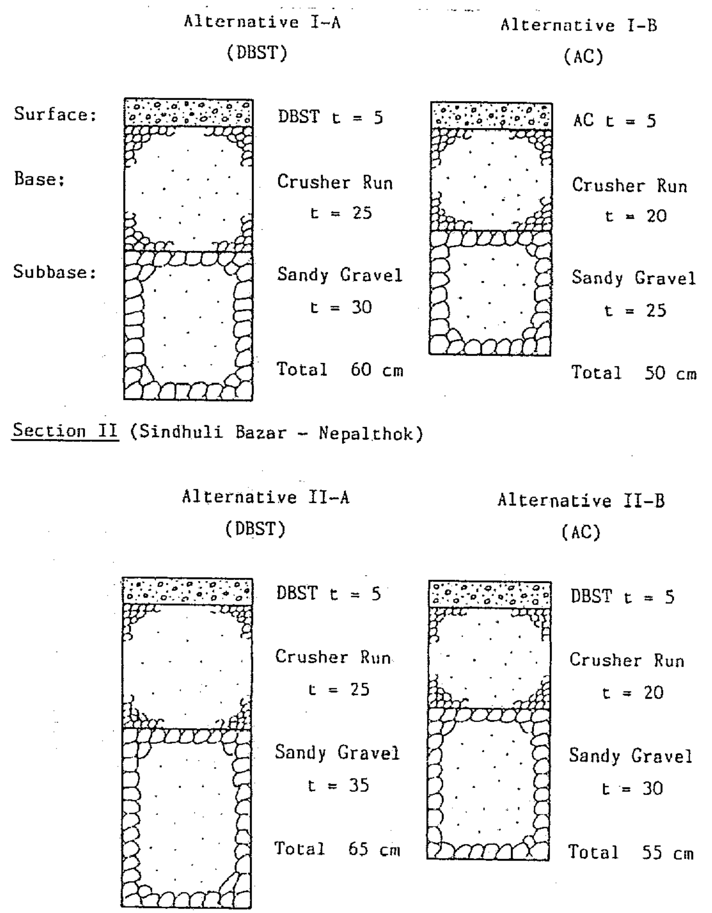


Fig. 9.2 Alternative Pavement Design

9.5.4 Selection of Pavement Type

The type of pavement is selected by studying the comprehensive factors, such as roadbed and sub-soil conditions, meteorological conditions, economy in construction and maintenance, and experience.

In this Project, the pavement type is studied and selected to be asphaltic concrete (AC) from the following engineering points of view:

- Share of heavy vehicles (truck and bus) is considerable high with the rate of 60%.
- Project road runs through mountainous terrain with steep gradient where surface of road requires high durability against abraision by heavy traffic.
- It is difficult to employ skilled and experienced labour for processing DBST work in Nepal.
- Periodical maintenance which is critical for DBST pavement may be difficult due to financial problem.

The optimum pavement type was determined to be asphaltic concrete (AC) with a thickness of 50 cm for Sec. I and 60 cm for Sec. II respectively.

9.6 Retaining Wall and Slope Protection Work

9.6.1 General

Geological characteristic in the project area is classified into three groups as stated in the clause 2.2, "Geological and Soil/Materials Survey", Chapter 2, as follows:

- Siwalik Hill Zone consisting of sandy gravel, boulder gravel and overburden of sandy and silty soil.
- Mahabharat Range Zone consisting micha chists, quartzite, and overburden formed by fine non-plastic silty sand.
- Kathmandu Zone consisting of micha chists and soil of alluvial origine.

The route crosses Mahabharat Ranzge with peaks up to 3,600 m high and runs along the Sun Kosi and Roshi Khola, where the construction of road is very difficult primerly due to extreme steepness of slopes and enormous landslides caused by poor and unstable geological formation of Mahabharat Range Zone.

Slope protection structures as well as retaining wall are very important factors and indispensable for such a mountainous road as this Project in order to keep not only the safety of road structure itself but also the safety of vehicles running on the road.

Various type of retaining walls and slope protection works are introduced and applied to this project considering the transfer of technology, especially in the field of land slide engineering, to Nepalee's engineers through the project.

9.6.2 Retaining Wall

Stability of cut and embankment slopes are essential factor for Sindhuli Road Project since it runs through extremely steep and unstable slope on Mahabharat Range.

Minimization of height for cut and embankment slopes by provision of retaining walls is quite effective to the stability of their slopes.

Maximum height of cut slope was determined therefore to be 10 to 15 m as stated in Chapter 8. The retaining wall is provided in principle on both fill and cut sides in order to reduce the height of cut slope if it become more than 15 m.

Four kinds of retaining walls are provided as shown in Fig. 9.3 according to the site conditions as follows:

(1) Gabion Wall (rock-filled wire baskets):

- to provide at the toe of road embankment where the ground profile is relatively gentle.

(2) Gravity Concrete Wall:

- to retain the lower slope of embankment (Max. height less than 5.0 m) in steep slope area.
- to retain and protect the embankment in the area of river flow where it requires protection against scouring action.

(3) Cantilever Wall of Reinforced Concrete

- to retain the high embankment in the steep slope area where the height of retaining wall is from 5.0 m up to 10.0 m.

(4) Stone Masonry (Cut type and Fill type)

- to retain the cut slope in the possible landslide area
- to minimize the cut slope height in steep topographic section. 2 steps of the stone masonry walls are to be provided with 1.5 m berm in between, if required to reduce the height of cut slope within 15 m.

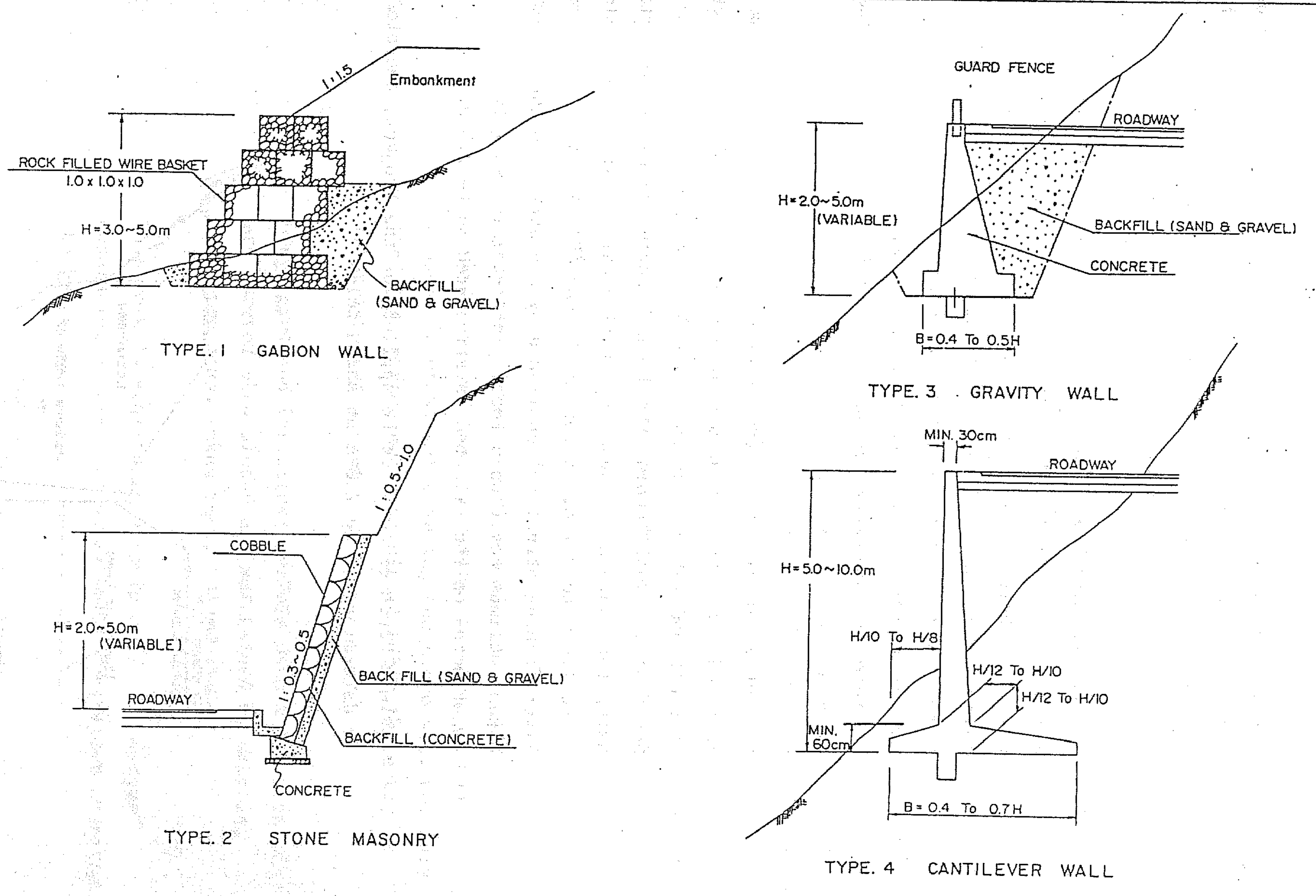


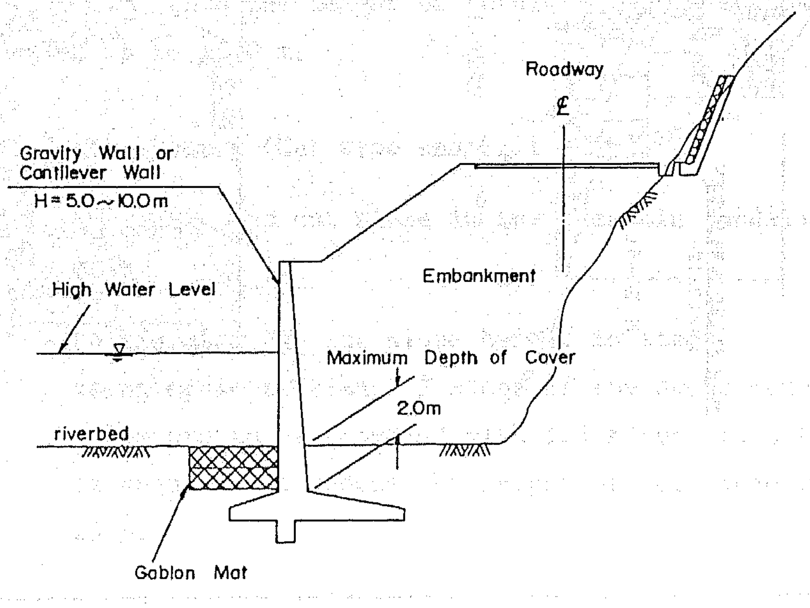
Fig. 9.3 Types of Retaining Wall

In the stretch between Khrukot and the confluence of Dabcha Khola through Nepalthok (Section II-2 and a half of Section II-3), the Project Road is planned to run mostly on the hillside of the river banks of the Sun Kosi and Rosi Khola.

In order to avoid existing and potential landslide areas, however, the Project Road is routed on the riverbed in some stretches where topographycal and geological conditions are etremely difficult and complicated due to steep and unstable slope. In this stretches, the road embankment has to be protected properly with the retaning walls, either gravity concrete wall orcantilever wall, from hydraulic reaction of the Sun Kosi and Rosi Kolha.

The retaining wall to be constructed on the riverbed should be designed carefully paying due attention to the hydraulic effect of the flood water, especially local scouring effect. In case of Sun Kosi and Rosi Khkola, the local scouring depth is calculated using the Andru's or Lausen's experimental formula and estimated to be 1.8 m to 2.1 m. According to the 'Design Mannual for the River Traning Structure' published by Ministry of Construction, Japan, maximum cover on a footing of retaining wall to be constructed on the riverbed is stipulated to be 2.0 m.

Maximum depth of cover to be applied for the Project, therefore, is determined to be 2.0 m as shown below:



9.6.3 Slope Protection Work

The slope protection structures are provided to support a soil and rock slopes that has been failed by cut and filling of the road construction.

Slopes in soil and soft rock suffer serious erosion during heavy rain and some rock slopes deteriorate due to wheathering when exposed. Embankment slopes constructed in the area of river may be damaged by scouring action of the water flow. Adequate slope protections should be provided taking into consideration local conditions, scale of damage and availability of materials.

The following slope protections are provided in the project according to the site conditions: (See Fig. 9.4)

(1) Vegetation

It is very common and effective form of slope protection, particulary against erosion of soil slopes. A grass mat covering the slope will not only bind the surface soil but also inhibit the entry of water into the slope.

Grass seed and fertilizer pellets with a latex coating are sprayed onto slopes and maintained by watering until the grass takes root.

This work is applied in principle for the slopes consisting of clay and sandy soils overburden covering the bed rock.

(2) Gunite Shooting with Cement Mortar

In case that vegetation will not provide sufficient surface protection, gunite shooting with cement mortar can be considered.

It is effective to the slopes in materials such as mica schist and shales which are proved to rapid weathering and breakdown upon exposure.

This slope protection work therefore is appliied for the cut slopes in weathered soft rock consisting of mica schist which are developed widely along the bank of Sun Kosi River in Section II-2 between Khrukot and Nepalthok.

(3) Concrete Frame Crib Wall

This structure is constructed by forming inter-connected boxes from precast concrete and then filling the box with crushed stone or boulder.

It is quite effective countermeasures to stop the movement of sliding masses consisting of clay and sandy soils with high water content.

This structure is applied as the countermeasure for the existing large land slide located at approximately STA 21 nearby Sindhuli Garhi in the Section II-1 and for other land slide areas if necessary.

(4) Rock Bolts

Rock bolt is adopted for the prevention of movement in rocky slopes and the stabilization of rock slides. It is also applied to the stabilization of soil slopes in association with retaining structures.

Rock bolt is quite effective in dilatation rocks, such as weathered limestone and tertiary marls.

This work is applied for the slopes in weathered rock developed in the southern slopes of Mahabharat Range, especially Sindhuli Garhi area.

(5) Rock Fence

One of the dangers associated with mountainous road in that of falls of loose rocks and boulders from the face of the cut slope.

Rock fence is provided on the head of stone masonry wall to prevent the rock from bouncing onto the roadway.

(6) Rock Net

Rock net is draped over a steep rock face to prevent rockfalls in a small critical slopes. Any rocks which break loose from the face are contained between the rock face and the net.

(7) Rock Shed (or Protective Canopy)

Rock shed is built over roadway to prevent the public traffic from rockfalls in a critical area due to land slide.

It is very effective protection when the route has to pass through enormous land slide area, however, the construction cost in very high comparing with another slope protection structures.

In order to dissipate the energy of the falling stone, waste sand is placed on the top of rock shed.

(8) Protection System of Rockfalls

The project road has to pass through numerous land slide areas due to steep topography and unstable geology along Sun Koshi and Rosi Korha.

Under such a condition, protection system of rockfalls as shown in Fig. 9.5 are introduced to the project as the effective countermeasures when the route passes through the dangerous area of rockfalls due to land slide.

A ditch, 5 to 15 m wide depending on the site conditions, and 3 to 5 dm deep for 30 to 50 m high slope, is provided at the foot of the sliding slope to dissipate the energy of rockfalls and a chain link fence is installed on the shoulder of the trench to prevent the rock from bouncing onto the roadway.

9.7 Preliminary Right of Way

The right-of-way width is not same by sections and varies with the embankment and cut slope heights.

Minimum width of right-of-way to be required for the Project Road shall be discussed with DOR and the government agency concerned.

The following is the minimum right-of-way widths proposed by the Study Team for this project.

	Minimum Width
Rural Area	30 m
Town Area	40 m

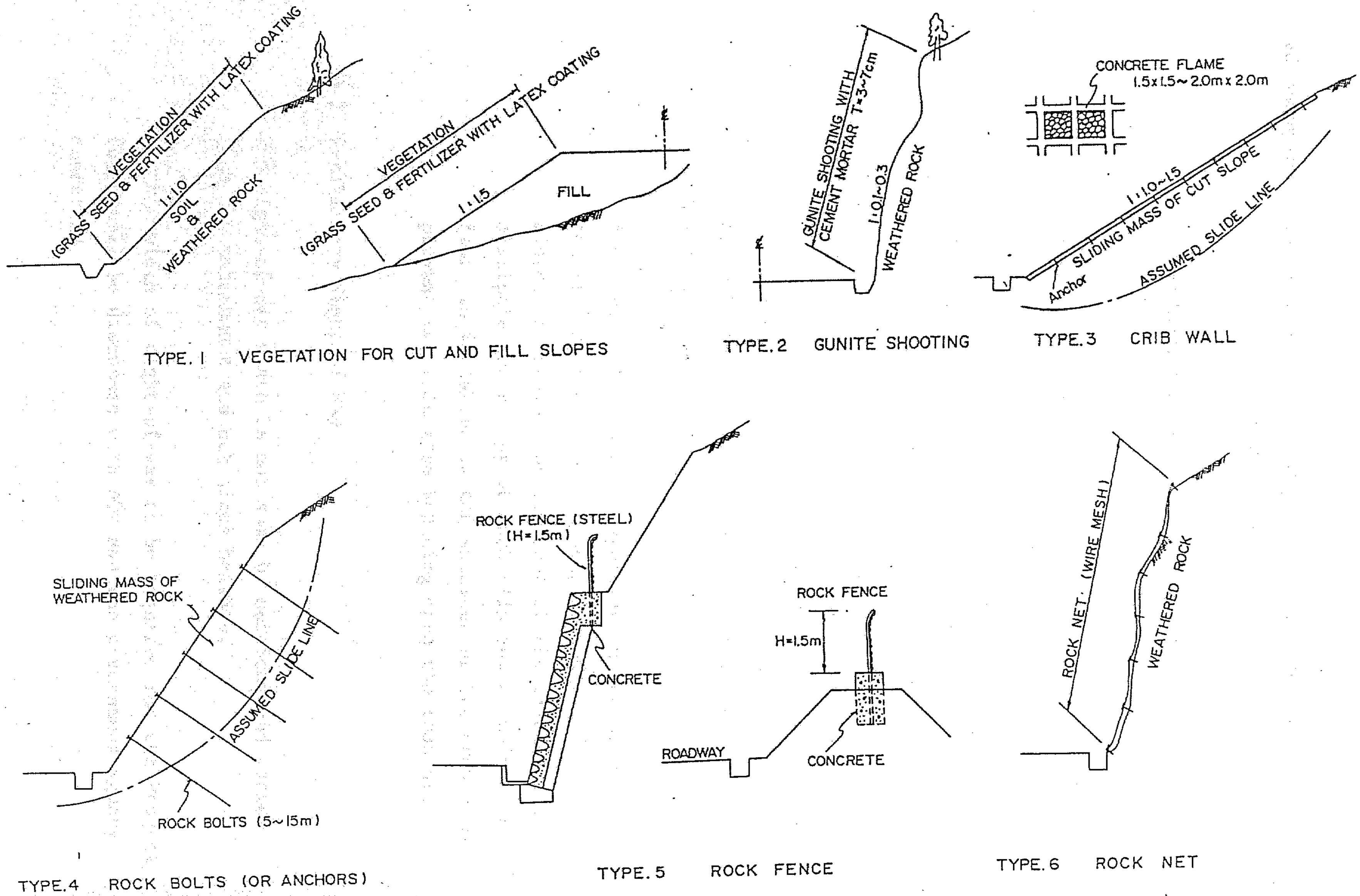
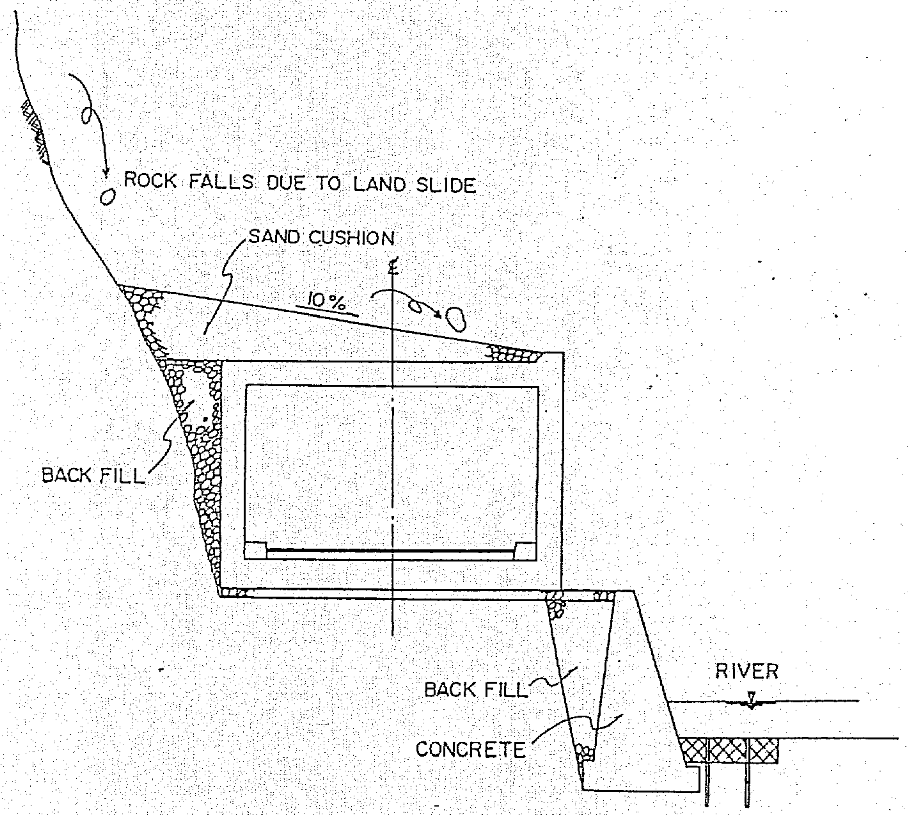
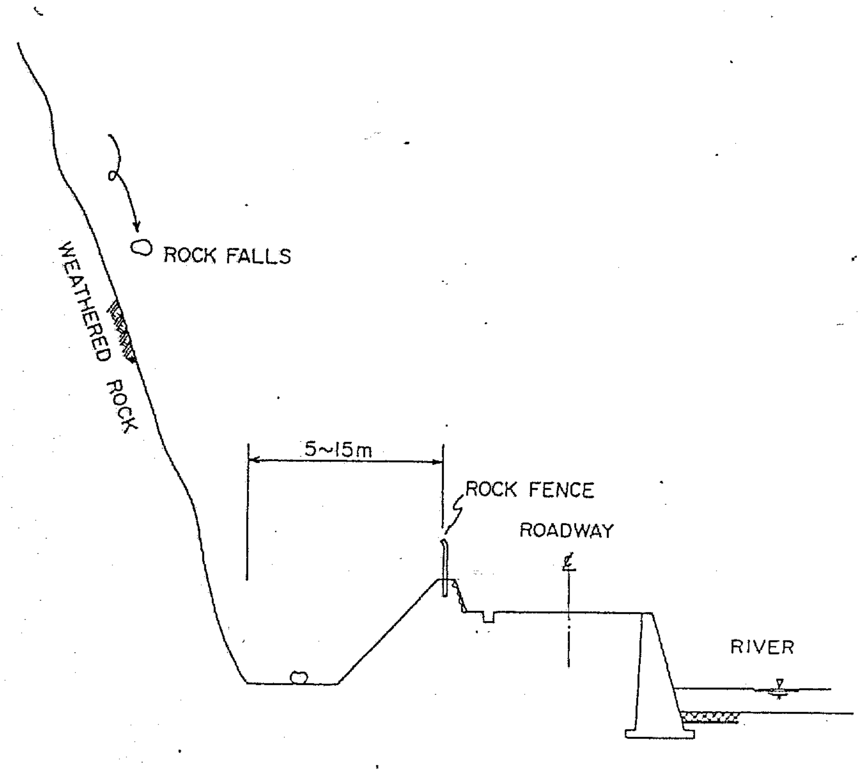


Fig. 9.4 Type of Slope Protection Work (1)



TYPE. 7 ROCK SHED



TYPE. 8 PROTECTION SYSTEM OF ROCKFALLS

Fig. 9.5 Type of Slope Protection Work (2)

CHAPTER 10 CONSTRUCTION AND MAINTENANCE COST

10.1 General

The construction cost for the Sindhuli Road Construction Project has been estimated on the basis of the preliminary design and construction plan and schedule. For the cost estimate, availability of local equipment and materials has been taken into consideration. The unit price were computed in accordance with the following basic assumptions and conditions:

(1) The cost estimate is made based on the assumption that all construction works will be executed by an international contractor.

(2) The unit prices of labor, material and equipment are computed under the economic conditions prevailing in January, 1988.

(3) The rate of exchange used to convert the US Dollar to Japanese Yen and Nepalese Rupees are;

US$1.00 = Yen130 = NRs.21 (NRs.1.0 = Yen6.19).

(4) The costs are classified into foreign currency (indicated in NRs.) and local currency (indicated in NRs.) portions. The foreign and local currency components of each unit price are computed based on the following classification of basic cost elements.

The foreign currency component includes the cost of:

- Imported equipment, materials and supplies;
- Imported materials in the local market;
- Wages of expatriate personnel; and

- Overhead and profit.

The local currency component includes the cost of:

- Domestic materials and supplies;
- Wages of local personnel;
- Overhead and profit; and
- Duties and tax.

(5) The unit price of each work item is obtained by adding the labor cost, equipment cost, material cost and overhead and profit, and the result is checked against recent actual figures for construction work in Nepal and the similar road projects.

(6) Major materials items included in the unit costs are fuel, reinforcing bars, prestressing wire, prestressing bars, structural steel for bridge, cement, asphalt and asphalt emulsion.

(7) Imported equipment and materials are assumed to be exempted from tax and duty by Nepalese Government with the exception of fuel. The tax and duty for fuel are estimated separately in term of local currency portion.

(8) Land acquisition and compensation are estimataed on the basis of unit cost data obtained from DOR.

(9) For all unit prices, a constant allowance of 20% for overhead and profit is added to the direct unit prices.

(10) Physical contingency are assumed to be 15% of the total of construction cost.

(11) The cost of engineering services for detailed design and supervision is estimated at 10% of the total construction cost, and the breakdown is as follows:

- Detailed design: 2%
- Supervision: 8%

(12) The cost of price escalation is estimated for the sum of construction cost, physical contingency, engineering service and land aquisition costs.

The price escalation to be applied for the Project is calculated on the basis of price increase ratio of materials in each country as shown below:

	Materials/ Labour	Source (Country)	Annual Increase Ratio
A. Improted Portion:			
	Cement/ Reinforcement Bar	Koria ,	3%
	Fuel and Asphalt	Singapore	1%
	Structural Steel/ PC Wire/PC Bar	Japan	1%
	Fuel	India	7%
B. Local Portion:			
	Labour	Nepal	10%

The cost of price escalation is estimated for each alternative implementation schedule shown in Chapter 11.5.

(13) The cost for the contract tax added to total construction cost is excluded in this estimate.

10.2 Unit Price

10.2.1 Unit Cost of Materials

Most of construction materials are imported in Nepal. The cost of imported materials include the CIF Calcutta Price, inland transportation cost in India and Nepal. The costs are assumed to be exempted in this cost estimate with the exception of fuel. The unit costs of the major material items are as shown in Table 10.1.

Table 10.1 Construction Material Cost

Unit: NRs.

Description	Unit	Foreign Currency	Local Currency	Duty.Tax	Total
Cement	ton	2,520	105	-	2,625
Reinforcement	ton	8,253	147	-	8,400
Fuel, diesel	lit	5.6	-	1.9	7.5
Gasoline	lit	6.1	-	6.8	12.9
Lubricant	lit	37.5	-	12.5	50
Grease	kg	52.5	-	17.5	70
Asphalt bitumen	ton	6,174	126	-	6,300
Bitumen emulsion	kl	8,064	126	-	8,190
Explosive	kg	-	47	-	47
Detonator	pc.	-	3.9	-	3.9
Timber	m3	-	3,300	660	3,960
Plywood	m3	15,572	175	-	15,747
Structural steel	ton	55,133	420	-	55,553
PC wire	ton	47,128	147		47,275
PC bar	ton	45,426	147	-	45,573
Water reducing agent	kg	51.9	1.5	-	53.4
Air-entraining agent	kg	86.4	2.4	-	88.8
Annealed iron wire	kg	15.8	0.2	-	16
Form oil	lit	48.5	1.4	-	49.9
Metal form	pc.	432.1	12.1	-	444.2
Nail	kg	20.7	0.6	-	21.3
Joint filler,	m2	276.6	7.8	-	284.4
Gabion wire mesh	m2	116.3	2.9	-	119.2

10.2.2 Unit Cost of Labors

The unit labor cost has been developed based on daily wage rate obtained from the DOR. The following are the costs broken down by major labor classification.

Table 10.2 Labor Cost (Wage Rate)

Unit: NRs.

Description	Unit	Wage Rate
Foreman	M.D.	70
Skilled labor	M.D.	40
Unskilled labor	M.D.	25
Operator, light	M.D.	50
Operator, heavy	M.D.	70
Assist. operator	M.D.	40
Driver, dump truck	M.D.	45
Driver, vehicle	M.D.	40
Assit. driver	M.D.	30
Electrician	M.D.	50
Assist. electrician	M.D.	30
Mechanic	M.D.	50
Assist. mechanic	M.D.	30
Carpenter	M.D.	50
Concrete worker	M.D.	50
Reinforcement worker	M.D.	50
Masonry worker	M.D.	50
Pavement worker	M.D.	50
Driller	M.D.	50
Blaster	M.D.	50

10.2.3 Equipment Cost

The prices of construction equipment are the prevailing prices in Japan on January, 1988. The equipment cost is divided into foreign and local portions. The foreign currency portion includes depreciation cost, spare parts and comsumable cost, while the local portion includes the cost of mechanic for the repair and administration expenses. The hourly equipment costs are shown in Table 10.3.

10.3 Unit Cost for Work Items

The unit costs are calculated from the material cost, labor cost, equipment cost and overhead taking into consideration the local conditions in Nepal. The unit costs of each work items are listed in Table 10.4 and 10.5.

10.4 Land Acquisition and Compensation Costs

The land acquisition and compensation costs are calculated based on the data on land prices obtained from DOR.

	Unit Cost
Land compensation	
Highly cultivated area	NRs. 30,000/ha
Less cultivated area	NRs. 10,000/ha
House compensation	NRs. 50,000/No.

The unit costs shown above shall be reviewed in the detailed design stage on the basis of actual land acquisition and prices to be prepared by the Nepalese government concerned.

Table 10.3 Equipment Cost per Hour

Unit: NRs.

Description	Foreign Currency	Local Currency	Total
Bulldozer w/ripper, 32 ton	1,431	314	1,745
Bulldozer, 21 ton	774	164	938
Bulldozer, 11 ton	350	74	424
Bulldozer, w/ripper, 21 ton	924	203	1,127
Backhoe, 0.6 m3	488	103	591
Backhoe, 2.0 m3	1,233	260	1,493
Tractor shovel 2.3 m3	591	125	716
Dump truck 11 ton	220	45	275
Truck crane 20 ton	618	109	727
Truck crane 30 ton	441	89	530
Crawler drill 10 m3/min	415	76	491
Jack hammer 20 kg	224	18	242 (D)
Motor grader 3.7 m	377	76	453
Macadam roller 10 ton	226	40	266
Tandem roller 10 ton	201	35	236
Tire roller 8-20 ton	247	43	290
Vibrating roller 4 ton	261	52	313
Vibrating roller 8 ton	585	116	701
Rammer, tamper, 60-100 kg	185	25	210 (D)
Concrete plant 20 m3/hr	737	134	871
Agitator truck 3.2 m3	224	45	269
Asphalt plant 60-80 t/hr	4,352	797	5,146
Aspahlt finisher, 2.4-5 m	987	174	1,161
Asphalt kettle, 6 kl	578	53	631
Distributor, 4 kl	453	80	533
Engine sprayer 600 l	953	97	1,050 (D)
Line marker	21	3	24
Water sprinkler, 5.5 kl	151	31	183
Air compressor, 10 m3/min	1,787	294	2,081 (D)
Air compressor, 13.5 m3/min	2,216	365	2,581 (D)
Cram shell, 0.8 m3	860	182	1,042
Diesel generator, 100 kVA	758	109	867 (D)
Concrete mixer, 0.1 m3	63	12	75 (D)
Concrete bucket, 0.75 m3	337	55	392 (D)
Concrete vibrator, 50 mm	84	10	94 (D)
Crushing plant 50 t/hr	2,317	422	2,739
Soil plant, 100 t/hr	716	30	846
Seed spray equipment	456	94	550
Mortar spray equipment	352	68	420

Note: (D) means Daily cost.

Table 10.4 Unit Cost for Work Item

Unit: NRs.

Description	Unit	Foreign Currency	Local Currency	Duty & Tax	Total
Clearing and stripping	m2	3.2	0.7	0.2	4.1
Removal of top soil	m3	12.8	2.5	0.8	16.1
Excavation, common, side spoil	m3	20.3	3.1	1.1	24.5
Excavation, rock, side spoil	m3	117.9	24.7	3.4	146.0
Excavation, common, l=1,000m	m3	58.9	11.3	4.3	74.5
Excavation, rock, l=1,000m	m3	169.0	34.3	7.7	211.0
Cross filling, common	m3	27.6	5.9	1.5	35.0
Cross filling, rock	m3	115.4	24.3	3.5	142.2
Cutting and filling, common, l=500m	m3	59.2	14.2	4.8	78.2
Cutting and filling, rock, l=500m	m3	157.4	32.6	6.8	196.8
Borrow filling	m3	56.5	11.2	4.4	72.1
Subgrade preparation	m2	2.8	0.6	0.1	3.5
Subbase course	m3	243.4	45.8	15.9	305.1
Base course	m3	349.6	65.2	20.5	435.3
Prime coat	lit	10.2	0.2	0.1	10.5
Asphalt concrete	m3	2,082.6	189.5	110.9	2,383.0
Corrugated arch culvert, R=1.5m	m	12,538.1	746.8	57.0	13,341.9
Corrugated arch culvert, R=2.5m	m	19,785.6	1,094.5	80.3	20,960.4
Corrugated pipe culvert, D=0.6m	m	2,627.0	112.8	5.7	2,745.5
Corrugated pipe culvert, D=1.0m	m	4,994.7	179.7	7.7	5,182.1
Box culvert	m	71,427.0	10,650.0	1,037.0	83,114.0
Pipe culvert, D=0.6m	m	1,297.6	483.8	47.1	1,828.5
Pipe culvert, D=1.0m	m	2,311.5	864.8	80.9	3,257.2
Side drain, stone pitching, 0.5m	m	139.6	47.8	5.0	192.4
Side drain, stone pitching, 0.9m	m	252.0	86.6	9.0	347.6
Channel stone pitching, 3.0m	m	432.8	140.0	16.7	589.5
Channel stone pitching 6.0m	m	843.0	263.4	33.0	1,139.4
U-drain ditch	m	324.4	101.2	11.1	436.7
Stone masonry (H=2-10m)	m	2,664.0	701.0	80.0	3,445.0
Concrete gravity wall (H=3-5m)	m	16,661.0	2,743.0	425.0	19,829.0
Retaining wall and rock fence	m	5,402.0	912.0	106.0	6,420.0
Gabiion wall (H=2-5m)	m	3,989.0	631.0	17.0	4,637.0
Reversed T wall (H=4-10m)	m	22,016.0	3,781.0	314.0	26,111.0
Stripe sodding, vegitation	m2	-	7.3	-	7.3
Seed spraying, vegitation	m2	37.5	3.0	1.2	41.7
Concrete frame	m2	451.2	176.6	18.2	646.0
Spray application of concrete	m2	806.0	106.2	20.0	932.2
Rock bolt and shotcrete frame	m2	421.6	78.4	10.7	510.7
Rock net	m2	284.8	14.4	1.0	300.2
Rock shed	m	110,137.0	12,621.0	1,501.0	124,259.0
Major bridge work					
- PC simple T-beam bridge	m	176,050	13,900	1,520	191,470
- PC continuous box bridge	m	339,350	34,470	2,960	376,780
- RC arch bridge	m	232,650	27,310	2,050	262,010
- Steel simple girder bridge	m	188,170	9,780	800	198,750
- Steel simple truss bridge	m	322,650	20,800	600	344,050
Medium and minor bridge					
- PC simple T-beam bridge	m	185,770	14,980	2,040	202,790
- RC T-beam bridge	m	105,780	12,740	2,030	120,550
- RC slab bridge	m	140,400	16,330	2,780	159,510
- Steel girder bridge	m	214,930	11,040	1,170	227,140
- Steel H-beam bridge	m	207,690	12,100	1,600	221,390

10.5 Construction Quantity

Construction quantities are calculated on the basis of the preliminary design made from 1:2000 scale of topographic map.

Earthwork quantities was obtained by preparing road cross sections along the alignment of proposed road on the basis of the above mentioned 1:2000 scale topo-map and applying the average cross section method.

Quantities of major bridges were estimated from the preliminary design using the topographic map with a scale of 1:500, while medium and minor bridge's quantities were estimated using the map with a 1:2000 scale.

Retaining walls and slope protection works which account for neary 25% of total construction cost were provided properly taking account of unstable geological conditions of the project site.

Preliminary calculations of construction quantities were made for major work items and are shown in Table 10.5.

Table 10.5 Work Quantities for Major Work Items

Description	Unit	Section I	Section II-1	Section II-2	Section II-3	Total
Clearing and stripping	m2	210,000	760,000	580,000	860,000	2,410,000
Removal of top soil	m3	42,430	152,240	115,120	173,030	482,820
Excavation, common, side spoil	m3	35,360	21,660	208,420	216,320	481,760
Excavation, rock, side spoil	m3	-	9,280	81,540	54,080	144,900
Excavation, common, L = 1000 m	m3	-	333,440	-	32,160	365,600
Excavation, rock, L = 1000 m	m3	-	139,150	-	8,040	147,190
Cross filling, common	m3	18,720	181,200	76,260	190,180	466,360
Cross filling, rock	m3	1,450	65,730	25,760	37,840	130,780
Cutting and filling, common, L = 500 m	m3	128,080	385,420	315,600	756,640	1,585,740
Cutting and filling, rock, L = 500 m	m3	10,110	127,590	81,010	156,110	374,820
Borrow filling	m3	-	-	-	171,010	171,010
Subgrade preparation	m2	275,830	289,440	202,270	344,750	1,112,290
Subbase course	m3	33,870	86,830	60,680	103,420	284,800
Base course	m3	27,100	57,890	40,450	69,150	194,590
Prime coat	lit	275,830	289,440	202,270	344,750	1,112,290
Asphalt concrete	m3	13,790	14,480	10,110	17,240	55,620
Corrugated arch culvert, R = 1.5 m	m	30	453	127	508	1,118
Corrugated arch culvert, R = 2.5 m	m	-	312	434	499	1,245
Corrugated pipe culvert, D = 0.6 m	m	-	2,460	-	1,630	4,090
Corrugated pipe culvert, D = 1.0 m	m	225	860	-	449	1,534
Box culvert	m	360	35	20	145	560
Pipe culvert, D = 0.6 m	m	410	243	1,710	936	3,299
Pipe culvert, D = 1.0 m	m	320	36	487	758	1,601
Side drain, stone pitching, 0.5 m	m	6,620	58,290	36,020	55,390	156,320
Side drain, stone pitching, 0.9 m	m	12,450	39,030	26,040	42,390	119,910
Channel stone pitching, 3.0 m	m	30	375	105	300	810
Channel stone pitching, 6.0 m	m	1,080	345	330	735	2,490
U-drain ditch	m	5,000	20,000	10,000	10,000	45,000
Stone masonry (2-10 m)	m	3,600	43,661	25,847	36,597	109,705
Concrete gravity wall (3-5 m)	m	-	870	435	1,306	2,611
Retaining wall and rock fence	m	-	-	-	140	140
Gabion wall (2-5 m)	m	2,620	1,470	5,520	3,571	13,181
Reversed T wall (4-10 m)	m	180	120	370	3,925	4,595
Strip sodding, vegitation	m2	66,130	138,830	104,940	212,930	522,830
Seed spraying, vegitation	m2	14,630	35,990	35,250	38,520	124,390
Concrete frame	m2	8,000	12,000	4,000	20,000	44,000
Spray application of concrete	m2	-	25,150	66,630	68,990	160,770
Rock bolt and shotcrete frame	m2	-	30,000	20,000	30,000	80,000
Rock net	m2	8,460	34,120	18,400	77,590	138,570
Standard regulatory signs	nr	8	8	6	14	36
Standard warning signs	nr	134	297	147	321	899

Table 10.5 Work Quantities for Major Work Items (Cont'd)

Description	Unit	Section I	Section II-1	Section II-2	Section II-3	Total
Standard hazard signs	nr	37	39	30	51	157
Permanent informal signs	nr	2	2	-	4	8
Guardrails, stone manonry	m	3,600	29,000	21,610	39,440	93,650
Road marking lines	m	37,790	39,980	30,690	51,000	159,460
Rock shed	m	-	-	-	170	170
Major bridge work						
- PC simple T-beam bridge	m	555	-	-	515	1,070
- PC continuous box bridge	m	165	-	-	-	165
- PC arch bridge	m	-	-	85	120	205
- Steel simple girder bridge	m	-	250	615	-	865
- Steel simple truss bridge	m	-	-	-	75	75
Medium and minor bridge						
- RC simple T-beam bridge	m	120	-	-	-	120
- RC T-beam bridge	m	30	75	-	-	105
- RC slab bridge	m	-	-	-	10	10
- Steel girder bridge	m	-	360	125	370	855
- Steel H-beam bridge	m	-	75	185	150	410

10.6 Construction Cost

The construction cost has been computed based on the quantities estimated in the preliminary design and on the unit prices for work item. The costs are split into foreign and local currency components.

The cost of miscellaneous work is estimated at 15% of the sum of above work items for the construction cost. The miscellaneous work comprises the following work items:

- Construction access roads and temporary bridges
- Transportation cost for the construction equipment and plants
- Engineer's offices, houses, vehicles
- Contractor's temporary offices, houses, workshop, etc.
- Hiring helicopter
- Laboratory equipment and survey equipment
- Medical facilities
- Radio communication system
- Water supply and electric supply systems
- Other temporary works

The total construction cost estimated based on January, 1988 prices are presented in Table 10.6 and summarized as follows:

		Foreign Currency (10^6 NRs.)	Local Currency (10^6 NRs.)	Total (10^6 NRs.)
1.	Construction cost			
	Section I	355.08	50.95	406.03
	Section II-1	665.07	132.63	797.70
	Section II-2	605.47	99.32	704.79
	Section II-3	1,008.67	180.23	1,188.90
	Sub-total	2,634.29	463.13	3,097.42
2.	Physical contingency	395.14	69.47	464.61
3.	Engineering serivces	309.74	-	309.74
4.	Land acquisition and compensation	-	12.00	12.00
	Total	3,339.17	544.60	3,883.77
	Currency Ratio	(86%)	(14%)	(100%)

The construction costs by currency for each section are listed in Table 10.7 through Table 10.10. The breakdown of construction costs for each section are listed in Appendix 10.5.1.

Table 10.6 Detailed Construction Cost

Unit: NRs. 1,00

	Section I	Section II-1	Section II-2	Section II-3	Total
I. Construction Cost					
1. Site clearance and topsoil stripping	1,544	5,567	4,232	6,312	17,65
2. Earthwork	14,698	128,121	64,697	132,783	340,29
3. Pavement work	57,888	89,251	62,338	106,357	315,83
4. Drainage work	48,976	62,766	39,539	75,323	226,60
5. Retaining wall	22,183	182,583	127,614	279,391	611,77
6. Slope protection work	8,801	59,275	82,670	119,006	269,75
7. Rock shed work	-	-	-	21,124	21,12
8. Road furniture	3,409	11,402	18,915	14,604	48,33
9. Bridge work	195,572	154,692	212,852	278,923	842,03
10. Miscellaneous work	52,960	104,049	91,929	155,074	404,01
Total (I)	406,031	797,706	704,786	1,188,897	3,097,42
II. Physical Contingency	60,905	119,656	105,718	178,334	464,61
III. Engineering Services	40,603	79,770	70,479	118,890	309,74
IV. Land Acquisition and Compensation	2,000	3,000	4,000	3,000	12,00
Total	509,539	1,000,132	884,983	1,489,121	3,883,77

Table 10.7 Construction Cost of Section I

Unit: NRs. 1,000

Description	Foreign Currency	Local Currency: Local Currency	Local Currency: Duty & Tax	Local Currency: Sub-Total	Total
I. Construction Cost	355,076	43,733	7,222	50,955	406,031
II. Physical Contingency	53,261	6,560	1,084	7,644	60,905
III. Engineeirng Serivces	40,603	-	-	-	40,603
IV. Land Acquisition and Compensation	-	2,000	-	2,000	2,000
Total	448,940	52,293	8,306	60,599	509,539

Table 10.8 Construction Cost of Section II-1

Unit: NRs. 1,000

Description	Foreign Currency	Local Currency: Local Currency	Local Currency: Duty & Tax	Local Currency: Sub-Total	Total
I. Construction Cost	665,075	112,368	20,263	132,631	797,706
II. Physical Contingency	99,761	16,856	3,039	19,895	119,656
III. Engineering Services	79,770	-	-	-	79,770
IV. Land Acquisition and Compensation	-	3,000	-	3,000	3,000
Total	844,606	132,224	23,302	155,526	1,000,132

Table 10.9 Construction Cost of Section II-2

Unit: NRs. 1,000

Description	Foreign Currency	Local Currency: Local Currency	Local Currency: Duty & Tax	Local Currency: Sub-Total	Total
I. Construction Cost	605,465	85,427	13,894	99,321	704,786
II. Physical contingency	90,820	12,814	2,084	14,898	105,718
III. Engineering Serivces	70,479	-	-	-	70,479
IV. Land Acquisition and Compensation	-	4,000	-	4,000	4,000
Total	766,764	102,241	15,978	118,219	884,983

Table 10.10 Construction Cost of Section II-3

Unit: NRs. 1,000

Description	Foreign Currency	Local Currency: Local Currency	Local Currency: Duty & Tax	Local Currency: Sub-Total	Total
I. Construction Cost	1,008,672	154,608	25,617	180,225	1,188,897
II. Physical Contingency	151,301	23,191	3,842	27,033	178,334
III. Engineering Services	118,890	-	-	-	118,890
IV. Land Acquisition and Compensation	-	3,000	-	3,000	3,000
Total	1,278,863	180,799	29,459	210,258	1,489,121

10.7 Maintenance Cost

The road maintenance cost is estimated for the following items;

Road Maintenance Cost	Cleaning cost for the road surface, drainage facilities, guard rail, signs, removal of debris, etc.
	Repair cost for road surface repair, overlays, painting of bridges & guard rail, treatment of cut and fill slope failure, etc.

The unit cost of road maintenance is developed making reference to the existing data on the following projects:

(1) Jiri Road: 110 km

- Financed by : Swiss
- Construction period : 1976-1985 9 years
- Project cost : NRs. 250 x 10^6
- Maintenance guarantee : 1985-1992 8 years
- Terrain condition : mountainous terrain
- Maintenance cost : NRs. 5.2 x 10^6/year or NRs. 47,000/km.year

(2) East-West Highway (Kohalpur-Mahakali): 204 km

- Financed by : IDA, UK & SAUDI FUND
- Under implementation as Third Highway Project
- Construction Period : 1985-1989 5 years
- Project Cost estimated : NRs. 1,832 x 10^6
- Terrain condition : flat terrain
- Maintenance cost : NRs. 3.6 x 10^6/year or NRs. 18,000/km.year

According to the "ICIMOD OCCASIONAL PAPER NO.8" regarding the road construction of JIRI ROAD (published in March, 1987), it is reported that the estimated unit cost amounting NRs. 47,000/km.year has been justified after one year experience. It is also reported that the unit cost could be reduced if investment in the construction phase was a bit more.

Based on the above data, the unit cost of maintenance for Sindhuli Road is estimated to be NRs. 45,000/km.year and total maintenance cost is calculated as follows:

Annual Maintenance cost: NRs. 45,000/km.year x 155 km
= NRs. 6,975,000/year

It is noted that, in addition to the above routine or regular annual maintenance, periodic maintenance of overlay has to be considered in its design life of pavement as follows:

Periodic Maintenance cost: 50% of surface course
= NRs. 109,618 x 10^3 x 0.5
= NRs. 54,809 x 10^3

This overlay work is assumed to be conducted 15 years after completion of the whole Project.

CHAPTER 11 IMPLEMENTATION PLAN

11.1 General

Department of Roads (DOR) would be the Government Agency responsible for the execution of the Project.

To complete the construction, it is assumed that the Government will engage the contractor by international bidding. For the implementation of the Project, four alternative construction schedules were considered.

11.2 Construction Section

The Project Road is routed through mountainous terrain of which topographic and geological conditions are extremely complicated and difficult. It is therefore impossible to contract the construction work as one single construction section.

The Project Road has been divided into four construction sections. Sections were determined with consideration to such factors as topographical features, section length, difficulty of construction, towns and villages. Principal town and village constitute boundaries between the sections as follows;

Section I	Bardibas - Sindhuli Bazar	(37 km)
Section II-1	Sindhuli Bazar - Khurkot	(39 km)
Section II-2	Khurkot - Nepalthok	(30 km)
Section II-3	Nepalthok - Dhulikhel	(49 km)
		(Total 155 km)

Quantities of major works for each construction section is shown in Table 11.1.

Table 11.1 Major Work Quantities in Each Construction Section

Construction Section	Location	Project Length (km)	Total Road Construction Cost(NRsx10^6)	Quantities of Major Work	
Section I	Bardibas - Sindhuli Bazar	37	406	Earthwork	236x10^6 m3
				Bridge	870 m
				Gabion & Retaining Wall	6,400 m
				Pipe & Box	1,345 m
				Slope Protection	97,220 m2
Section II-1	Sindhuli Bazar - Khurkot	39	798	Earthwork	1,416x10^6 m3
				Bridge	760 m
				Gabion & Retaining Wall	46,120 m
				Pipe & Box	4,400 m
				Slope Protection	276,090 m2
Section II-2	Khurkot - Nepalthok	30	705	Earthwork	904x10^6 m3
				Bridge	1,010 m
				Gabion & Retaining Wall	32,170 m
				Pipe & Box	2,780 m
				Slope Protection	249,220 m2
Section II-3	Nepalthok - Dhuhkhel	49	1,189	Earthwork	1,795x10^3 m3
				Bridge	1,240 m
				Gabion & Retaining Wall	45,540 m
				Pipe & Box	4,925 m
				Slope Protection	448,030 m2
	Total	155	3,097	Earthwork	4,351x10^3 m3
				Bridge	3,880 m
				Gabion & Retaining Wall	130,230 m
				Pipe & Box	13,450 m
				Slope Protection	1,070,560 m2

11.3 Construction Plan and Method

11.3.1 General

The construction plan and method must be formulated so as to ensure completion of the works safely and economically paying attention to such local conditions as topography, geology, workable days, etc. Especially in regards to the those construction works which have a critical effect on the construction schedule, the optimum construction method must be carefully selected and determined.

The main features to be considered in the construction plan and method for the Project Road are as follows;

1. The Project Road is routed through mountainous terrain of which topographical and geological conditions are extremely complicated and unstable.

2. There are no existing mortable roads in Section II between Sindhuli Bazar and Dhulikhel. Current mortable access to the project site is available only in Section I between Sindhuli Bazar from Bardibas.

3. Project Road length is great (155 km).

4. There are 85 nos. (3,880 m in length) of bridges across the rivers in Sections I and II, and out of which 25 nos. (2,380 m in length) are major bridges having a span length of more than 50 m.

5. Rainy season starts from June and continues up to the end of September.

11.3.2 Workable Day

An average workable days per month for earthwork and concrete structure work are estimated based on the meteological data as follows:

Major works		Workable days per month
Earthwork	:	18 days (12 days in wet season and 21 days in dry season)
Concreete Structure Work	:	23 days (21 days in wet season and 24 days in dry season)

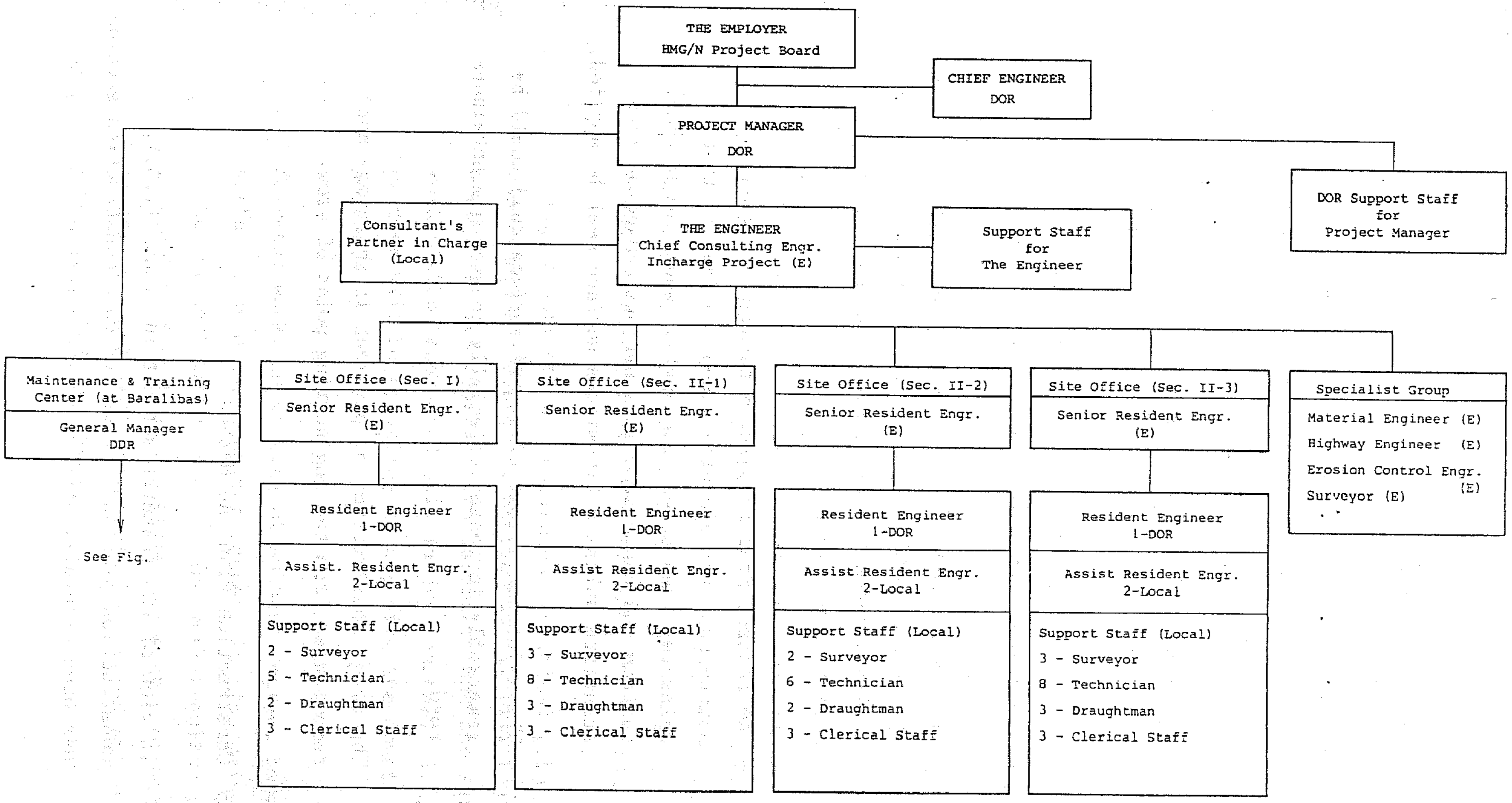
Detailed data on raining days used for estimation of workable days are presented in Appendix 11.3.1.

Construction schedule is made assuming that the earthwork is suspended during the rainy season starting from the middle of June and ending at the middle of September.

11.3.3 Project Organization

The DOR would be responsible for the project implementation. Direct supervision would be undertaken by international consultant for the four construction contracts comprizing Sindhuli Road Construction Project.

It is proposed to utilize the service of DOR engineers and staff to form a part of the project organization as shown in Fig. 11.1 in order to ensure the maximum training impact on DOR staff through execution of the Project.



Note : 1. "E" indicates post to be filled by Expatriate

2. "Local" indicates post to be filled from staff seconded from DOR or local consultant

Fig.11.1 Organizational Structure of Project of Sindhuli Road Construction Project