16.4 Throughway of Gwalior Bypass

16.4.1 Review of Pre-F/S Alignment

16.4.1.1 Detailed Field Investigation

The Study Team carried out the detailed field investigation along the Pre-F/S alignment between 4 and 8 November 1997 to review the Pre-F/S alignment and re-identify major controls for the establishment of survey corridor. A complete photo album was prepared by taking shots of all necessary objects in the fields. This was referred while the horizontal alignment was being prepared and finally verified.

16.4.1.2 Three Major Controls Newly Identified

Three major controls were newly identified during the detailed field investigation as described below:

1) Waste Water Basin (STA. 2+100 - 2+500)

Waste water basin from distillery is located at STA. 1+500 with a size of 1 km wide and 1.5 km long. The Pre-F/S alignment crosses this area at the centre.

2) Independent Rocky Hill (Approximately STA. 4+500 - 7+000)

Independent Rocky Hill, where specified as Reserved Forest Area, exists at Approximately STA. 4+500 - 7+000. The height of the top flat area of the hill is approximately 30 m from the surrounding cultivated areas. The Pre-F/S alignment crosses this hill around 3 km in distance and the cut work will necessitate a considerable hard rock excavation.

3) Sojina Village and a Lake (STA. 13+200 - 14+000)

Sojina village is located at STA. 13+500 and a lake, 200 m wide and 300 m long exists approximately 500 m Southeast of the village. This lake is the only watering place of livestock in this area and also are some daily traffic between the village and the lake was observed. The Pre-F/S alignment will cut the access between the village and the lake, and it will damage the local community which should involve the access to the lake.

16.4.1.3 Summary of Major Controls

Including the above mentioned new controls, the wide-area controls within approximate 1 km either side were summarised in Table 16-39. There are eight(8) villages, six(6) major roads including NH3 at the beginning and end point of the proposed bypass, two(2) railways, and four(4) watercourses including two(2) natural rivers. It shall be noted that there are 10 topographic controls, hills and valleys, in the project area.

Table 16-39 Major Controls

No.	STA	Side	Description
1	0	—	NH3
2	0.2	—	Railway (Narrow Gauge)
3	0.7	Right	Village(Niraoli)
4	1.5	Left	Village(Gajupura)
5	2.4	Left	Waste Water Pond
6	2.7	Left	Village(Jinaoh)
7	2.8	Left	Distillery
8	3.5	—	Major Village Road
9	5	Right	Rocky Hill(Reserved Forest Area)
10	7.7	—	Major Canal
11	8	Right	Village(Kulalth)
12	9.4	—	Major Village Road
13	10.3	—	Natural River
14	12.8	—	Natural River
15	12.9	Right	Village(Rai ka pura)
16	13.4	Left	Village(Sojina)
17	13.6	Left	Lake
18	15	Left	Village(Banjara ka pura)
19	15.2	—	Valley(Cultivation Area)
20	15.8	—	Major Village Road(Reserved Forest Area)
21	15.8-1	Left	Village Road(Reserved Forest Area)
22	17	Left	Valley(Reserved Forest Area)
23	19.7	Right	Valley(Reserved Forest Area)
24	20	Left	Hill(Reserved Forest Area)
25	20.5	Left	Valley(Reserved Forest Area)
26	21	Left	Valley(Reserved Forest Area)
27	22.5	Right	Valley(Reserved Forest Area)
28	23.1	Right	Hill(Reserved Forest Area)
29	23.4	Left	Hill(Reserved Forest Area)
30	24.2	Left	Lake(Raipur Kurd)
31	24.2	Right	Village(Raipur Kurd)
32	25.6	—	Major Canal
33	26.1	—	Railway (Broad Gauge)
34	26.5	—	NH3

16.4.2 Alignment Designed

16.4.2.1 Basic Data

The following basic data were obtained and/or prepared by the Study Team for the alignment design of Gwalior Bypass:

1) Topographic Map of Survey of India (Scale 1:50,000/250,000)

These maps were used to identify the name of villages and to obtain wide area information such as locations of major rivers, main roads and railways.

2) Topographic Map prepared in the F/S

Topographic map prepared in the F/S was submitted to the Study Team at the end of February 1998. All controls were identified and work quantities were estimated based on this map.

3) Digital ASCII data of topographic survey

Digital ASCII data of topographic survey was also submitted from the entrusted local subcontractor. Digital Terrain Model (DTM) was established from the data in order to make the earthwork volume calculation.

4) Satellite Photographs

Satellite photographs obtained from National Remote Sensing Agency (NRSA) were utilised for identification of the controls. As dense forest area are located from STA. 19+500, Satellite Photographs was useful in order to identify the possible route alternatives.

5) Photographs

During the detailed site investigation by the Study Team, a complete photo album was prepared by taking shots of all necessary objects in the fields. This was referred while the horizontal alignment was being prepared and finally verified.

16.4.2.2 Designed Alignment

(1) Horizontal Alignment

Horizontal alignment was formulated applying radii of 600 - 3,000 m. Sixty-two (62) percent of the alignment is circular curves and spiral elements and the other forty-eight (38) percent is tangent elements. Spirals were attached between tangents and circular curves properly and superelevation was attained where required.

Figure 16-15 shows the relationship between the PWD alignment and JICA alignment. Figure 16-16 shows design element of the bypass.

Table 16-40 Summary of Horizontal Alignment

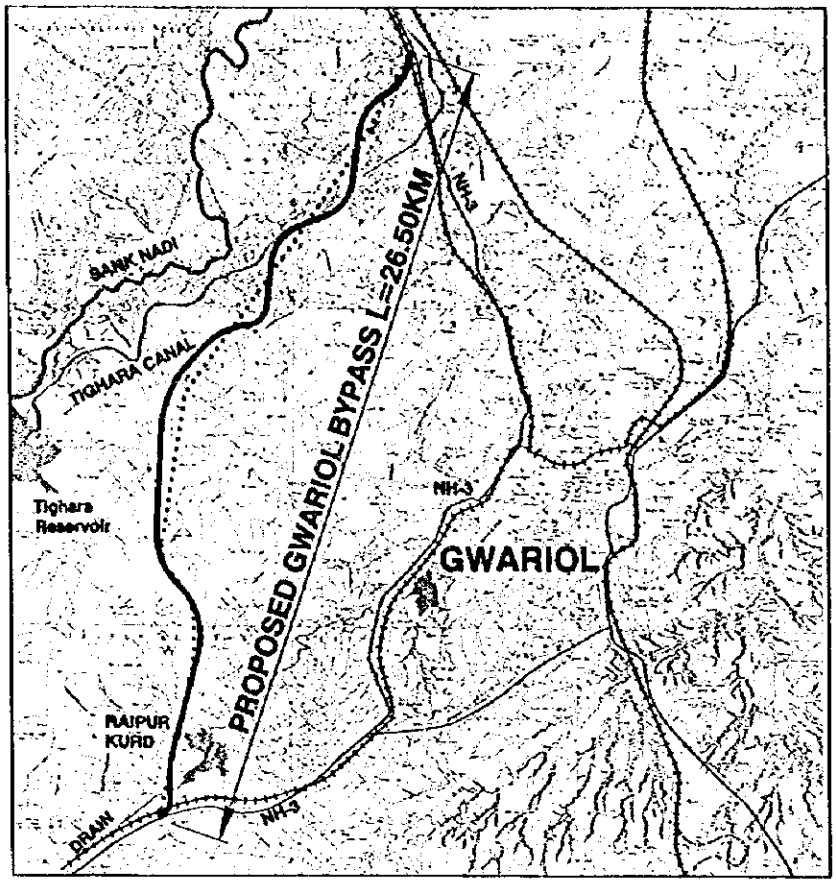
Design Element	Length (m)	Ratio (%)
Tangent	10,095.5	38
Curve	11,831.7	44
Spiral (Clothoide)	4,720.0	18
	26,647.2	100

(2) Vertical Alignment

In the section of flat terrain area, especially, at the beginning and end section of the bypass, fill type structures were mainly applied. In the hilly section, cut and fill structures were applied to enable the minimisation of the earthwork volume. As the bypass is intended to operate as full control of access, all crossing with the main existing roads were designed as the grade separated intersections.

Maximum grade of 3.3 percent was applied for the vertical alignment and level grade was allowed where the height of filling is lower than 3 m, and the normal crossfall is applied.

ROUTE MAP OF GWALIOR BYPASS

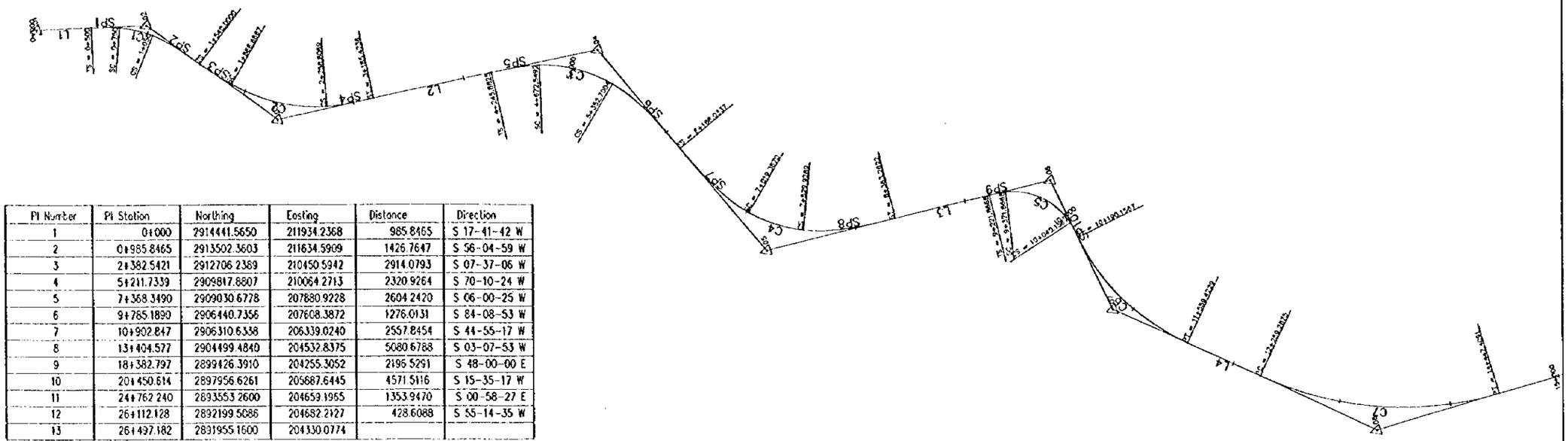


LEGEND

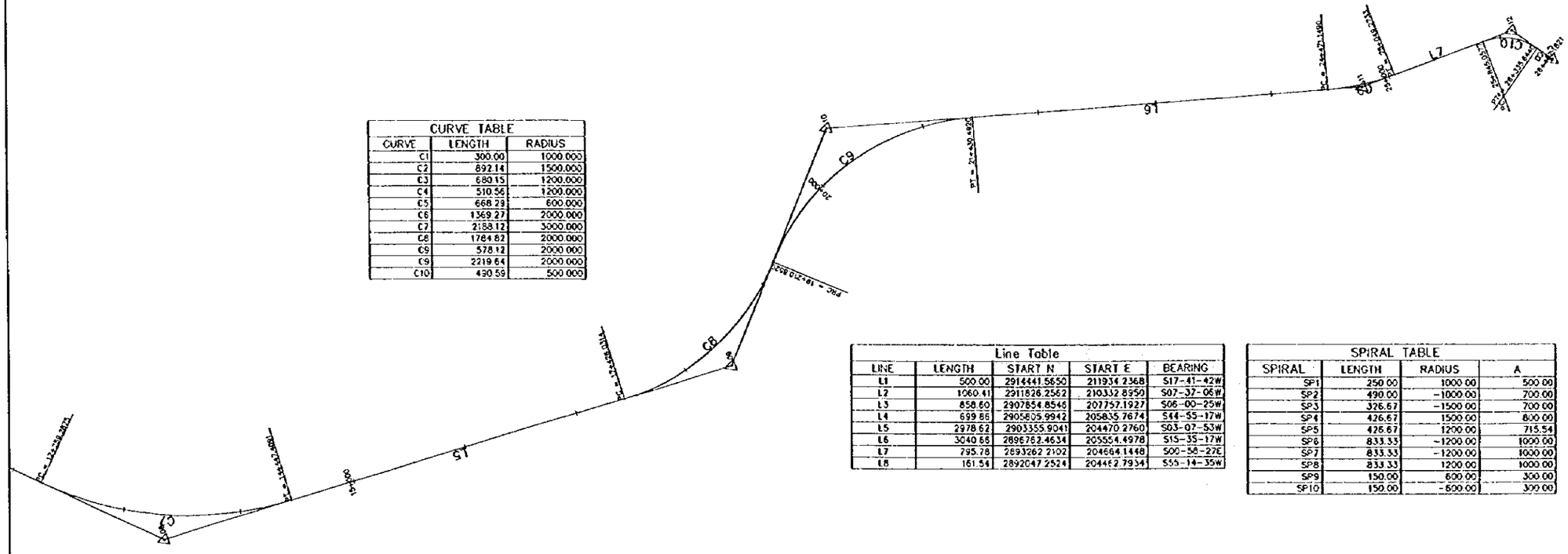
———	PROPOSED BY JICA STUDY TEAM
.....	PROPOSED BY STATE PWD
NH3	NATIONAL HIGHWAY
———	OTHER ROAD
++++++++	RAILWAY
~~	RIVER, CANAL, DRAIN

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE FEASIBILITY STUDY ON NATIONAL HIGHWAY BYPASSES IN INDIA

DWG TITLE :
Figure 16-15 Route map of Gwalior Bypass



PI Number	PI Station	Northing	Easting	Distance	Direction
1	0+000	2914441.5650	211934.2368	985.8465	S 17-41-42 W
2	0+985.8465	2913502.3603	211634.5909	1426.7647	S 56-04-59 W
3	2+382.5421	2912706.2389	210450.5942	2914.0793	S 07-37-06 W
4	5+211.7339	2909817.8807	210064.2713	2320.9264	S 70-10-24 W
5	7+368.3490	2909030.6778	207680.9228	2604.2420	S 06-00-25 W
6	9+785.1890	2906440.7356	207608.3872	1276.0131	S 84-08-53 W
7	10+902.847	2906310.6358	206339.0240	2557.8454	S 44-55-17 W
8	13+404.577	2904499.4840	204532.8375	5080.6788	S 03-07-53 W
9	18+382.797	2899426.3910	204255.3052	2196.5291	S 48-00-00 E
10	20+450.614	2897956.6261	205687.6445	4571.5116	S 15-35-17 W
11	24+762.240	2893553.2600	204659.1955	1353.9470	S 00-58-27 E
12	26+112.128	2892199.5086	204682.2127	428.6088	S 55-14-35 W
13	26+497.182	2891955.1600	204330.0774		



CURVE TABLE		
CURVE	LENGTH	RADIUS
C1	300.00	1000.000
C2	892.14	1500.000
C3	680.15	1200.000
C4	510.56	1200.000
C5	668.29	600.000
C6	1369.27	2000.000
C7	2188.12	3000.000
C8	1784.82	2000.000
C9	578.12	2000.000
C9	2219.64	2000.000
C10	430.59	500.000

Line Table				
LINE	LENGTH	START N	START E	BEARING
L1	500.00	2914441.5650	211934.2368	S17-41-42W
L2	1060.41	2911826.2562	210332.8959	S07-37-06W
L3	858.60	2907854.8546	207757.1927	S06-00-25W
L4	699.86	2905605.9942	205835.7674	S44-55-17W
L5	2978.62	2903355.9041	204470.2760	S03-07-53W
L6	3040.68	2896762.4634	205554.4978	S15-35-17W
L7	795.78	2893262.2102	204664.1448	S00-58-27E
L8	161.54	2892047.2524	204462.7934	S55-14-35W

SPIRAL TABLE			
SPIRAL	LENGTH	RADIUS	A
SP1	250.00	1000.00	500.00
SP2	490.00	-1000.00	700.00
SP3	326.67	-1500.00	700.00
SP4	426.67	1500.00	800.00
SP5	426.67	1200.00	715.54
SP6	833.33	-1200.00	1000.00
SP7	833.33	-1200.00	1000.00
SP8	833.33	1200.00	1000.00
SP9	150.00	600.00	300.00
SP10	150.00	-600.00	300.00

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) THE FEASIBILITY STUDY ON NATIONAL HIGHWAY BYPASSES IN INDIA	DWG TITLE : DESIGN ELEMENNTS OF HORIZONTAL ALIGNMENT	DWG SCALE : S = 1 : 40,000	DWG NO. : B-2

Figure 16-16 Horizontal Design Element of Gwalior Bypass

Table 16-41 Summary of Vertical Alignment

Grade (%)	Length (m)	Ratio (%)
G = 0.0	3,050	11.5
0.0 < G <= 0.3	1,850	7.0
0.3 < G <=1.0	4,400	16.6
1.0 < G <= 2.0	13,197.182	49.8
2.0 < G <= 3.0	3,350	12.6
(Max. = 3.3)	(650)	(2.5)
Total	26,497.182	100.0

16.4.3 Pavement Design

16.4.3.1 Traffic Analysis and Determination of Design MSAL

As category of truck was not sub-divided in to LCV, HCV and MAV in the forecast, all volume was assumed as HCV, considering the current proportion (LCV: 10%, HCV: 87%, MAV: 3%) in to account, in order to estimate appropriate damage incurred by the vehicles. Table 16-42 shows the future traffic projection for commercial vehicles for Gwalior Bypass.

Table 16-42 Future Traffic Projection for Commercial Vehicles

Year 2002		Total (A)	Year 2012		Total (B)	Growth Rate(%/yr)
Bus	Truck		Bus	Truck		
124	3,983	4,107	220	8,000	8,220	7.19%

The design traffic volume recalculated as shown in Table 16-43.

Table 16-43 Design Traffic Volume

Year 2002		Total (A)	Design Traffic (B:75% of A)	Directional Traffic (C)
Bus	Truck			
124	3,983	4,107	3,080	1,540

On the basis of the traffic projection and VDF, 6.69 for Gwalior, cumulative equivalent standard Axle Loads in Millions (MSAL) for Gwalior Bypass was calculated in following table.

Table 16-44 Million Equivalent Standard Axle Loads (MSAL)

Directional Traffic (C)	Growth Rate(%/yr)	Design Life	VDF	MSAL
1,540	18.23%	10	6.69	89

The design MSAL value is determined as 90 for the Feasibility Study.

16.4.3.2 Composition of the Pavement

Taking into account that the design CBR value of subgrade was more than 30 percent, the total depth of the pavement is probably able to reduce to around 500 – 600 mm, based on Japanese experience.

However, the similar composition of the pavement is not clearly specified in IRC's guideline, the Study Team leaves the total depth of the pavement as 800 mm in the Feasibility Study. Further study to reduce the thickness of the pavement structure is strongly recommended in the detailed design phase. This will make a considerable cost-down of the construction.

Table 16-45 Pavement Composition in Gwalior Bypass

No.	Depth (mm)	Acc. Depth (mm)	Sign	Description
1	40	40	AC	Asphalt Concrete
2	160	200	DBM	Dense Bituminous
3	300	500	WMM	Wet Mix Macadam
4	300	800	GSB	Granular Sub-Base

16.4.4 Drainage Design

1) Longitudinal Drainage

Following longitudinal drainage was installed:

0 Kerb ditch at the fill section, higher than 3 m;

1 Berm ditch at the cut section, deeper than 7m;

2 Side ditch at the top of cut slope;

3 Side ditch at the bottom of cut slope; and

4 Side ditch along the service road;

Necessary locations to install the above drainage were identified based on the result of the alignment design.

2) Cross-sectional Drainage

Following cross-sectional drainage was installed:

0 Vertical drain at fill section where the height is more than 3 m;

1 Vertical drain at cut section where the height is more than 7 m; and

2 Transversal drain at superelevated section

Necessary locations to install above drainage were identified based on the result of the alignment design.

16.4.5 Utility Relocation

According to the concept and criteria, all utilities which have a potential to be affected by ROW were identified using the topographic map in a scale of 1:5,000.

High Tension Lines (HTL) is the biggest utilities when it is required the relocation. HTL will cross the proposed alignment at two places, STA. 1+800 and STA. 6+300.

16.4.6 Work Quantities

Overall work quantities derived from this preliminary design of throughway was summarised in Table 16-46.

Table 16-46 Quantities of Throughway Works

Item	Unit	Amount
Bypass Length	Km	26.497
Earthwork Section	Km	26.360(99.5%)
Structure Section	Km	0.137(0.5%)
Earthwork Balance		-1,335,328
Fill	M^3	1,686,172
Cut	M^3	350,844
Pavement		
AC	M^3	20,138
DBM	M^3	75,516
WMM	M^3	151,033
GSB	M^3	151,033
Service Road	Km	24.87
Slope Protection	M^2	323,200
Drainage		
Kerb	M	19,600
Berm	M	800
Side Ditch	M	32,270
Vertical Drain	M	15,110
Transversal Drain	M	1,908
Utility Relocation		
HTL	M	200
Power Line	M	1,590
Telecom. Line	M	1,590
Well/Pump	M	10

16.5 Design of Intersection in Gwalior Bypass

16.5.1 General

The Gwalior Bypass has two link points with the existing NH3 at the beginning point (BP) and end point (EP) of the throughway. These link points need to secure smooth and safe traffic flow for the road users as far as possible.

16.5.2 Intersection at the Beginning Point

16.5.2.1 Characteristics of Traffic Flow

Traffic Flow between NH3 (Agra side) and the Bypass

In the bypass section near BP, just after the diversion from NH3 to the bypass, the installation of tollgate was proposed. The tollgate section will require the length of 150 m as minimum including transition section to the throughway.

The design speed of section between the tollgate and BP does not need to the same design speed of the throughway because this section is regarded as a part of intersection, or the transition section between NH3 and the bypass. Consequently, the geometric design of the horizontal alignment does not require the adoption of a large curvature as required for the throughway.

Traffic Flow on NH3, between Agra side and Gwalior side

As the traffic flow from Gwalior side to Agra side will be crossed by the flow from the bypass to NH3 (Gwalior side), the careful study regarding the intersection layout is required.

The flow from Agra side to Gwalior side may utilise the existing NH3 as it is. However, this directional flow will receive the traffic flow which runs from the bypass to the NH3 (Gwalior side). Therefore, this traffic flow will require an appropriate merging section, which may necessitate an additional lane, to secure the smooth and safe traffic.

Traffic Flow between NH3 (Gwalior side) and the bypass

Based on the future traffic demand forecast, this directional traffic flow showed very small amount compared to other traffic flows. However, the traffic which tries to enter NH3 (Gwalior side) from the bypass is to at-grade cross two times on the bypass and on NH24. Intersection layout design shall be carried out carefully, taking into account this traffic movement, to minimise the adverse influence to the overall traffic management in this intersection.

16.5.2.2 Selection of Intersection Type of BP

Four alternative layouts were prepared for the intersection design as illustrated below.

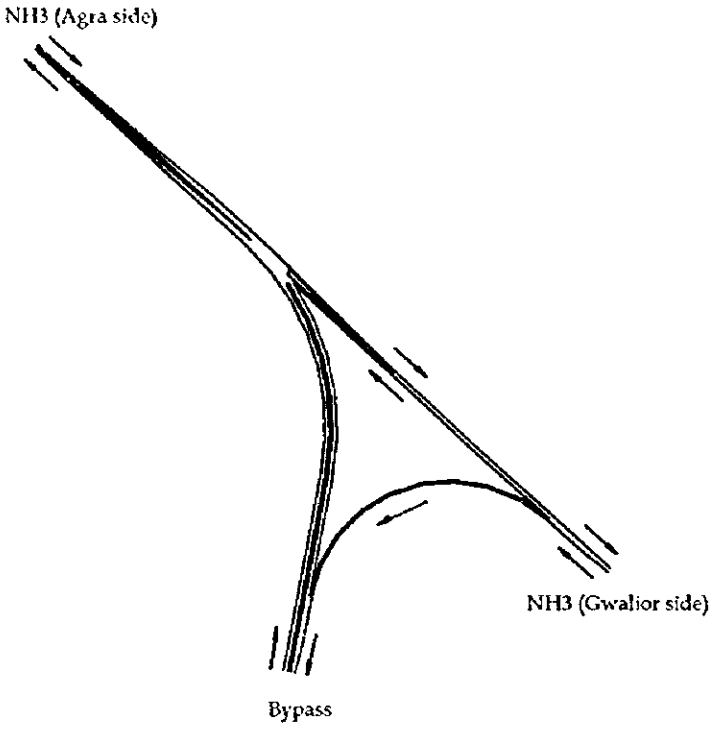


Figure 16-17 Intersection Type of Alternative 1

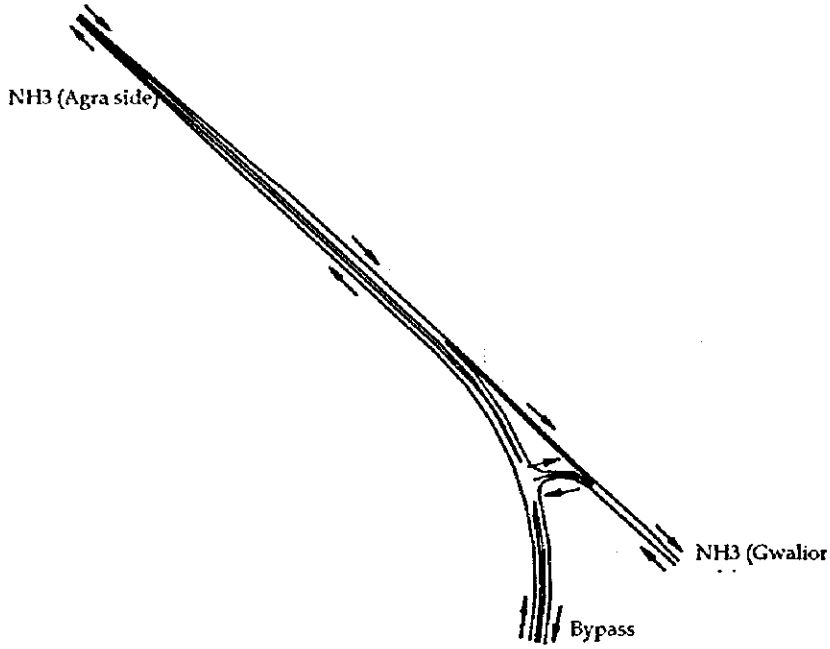


Figure 16-18 Intersection Type of Alternative 2

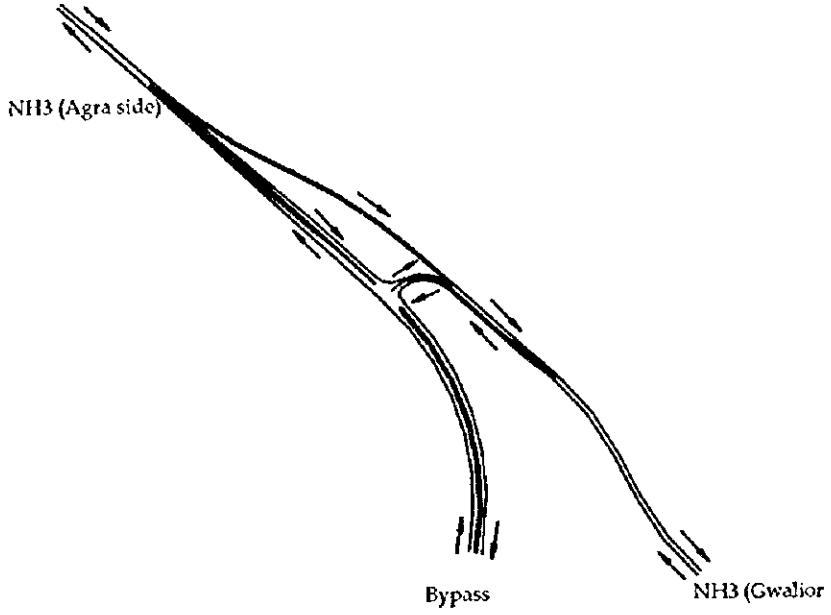


Figure 16-19 Intersection Type of Alternative 3

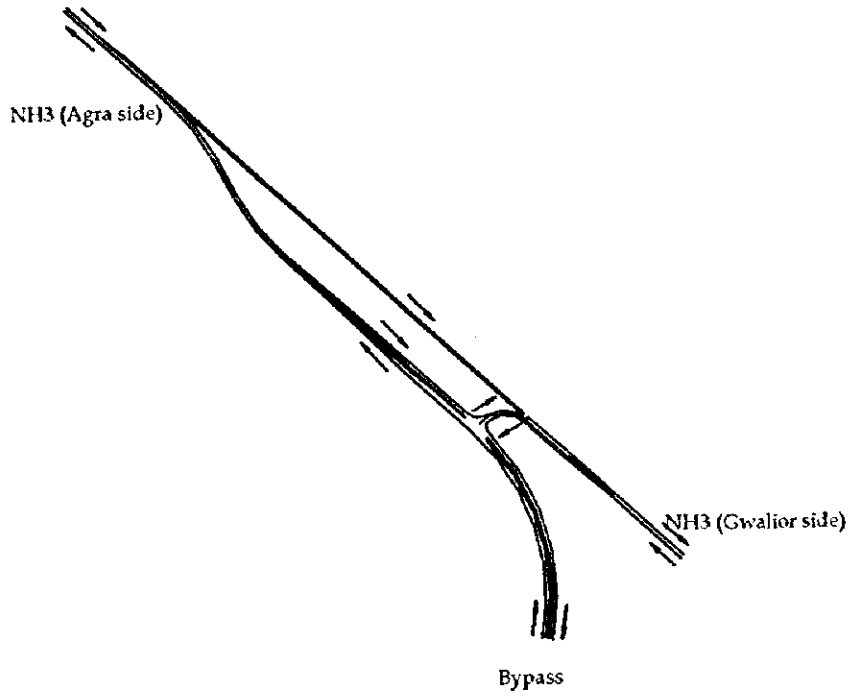


Figure 16-20 Intersection Type of Alternative 4

Table 16-47 Alternative of Intersection Type

	Merit	Demerit
Alternative 1	•Less civil work will be required for the existing NH.	•Large additional land will be required.
Alternative 2	•Less additional land will be required. •Less civil work will be required for the existing NH. •Intersection angle between Bypass and the approach from NH is 90 degrees.	•Intersection between Bypass and the approach from NH is located on the curve
Alternative 3	•Intersection angle between Bypass and the approach from NH is 90 degrees. •Intersection between the bypass and the approach from the NH is located on the tangent section of the bypass alignment.	•Additional land will be required for relocation of NH. •Alignment of NH will be worse than the present.
Alternative 4	•Less affection to NH during the construction. •Intersection angle between Bypass and the approach from NH is 90 degrees. •Intersection between the bypass and the approach from the NH is located on the tangent section of the bypass alignment.	•Alignment of bypass is worse than other alternatives. •Additional land will be required for the bypass.

16.5.2.3 Proposed Intersection type at BP of Gwalior Bypass

Based on the consideration described in the previous section, the Study Team recommends to apply the Alternative 2 as the proposed intersection layout for the project.

Figure 16-21 shows the recommended layout of the intersection at BP of Gwalior Bypass.

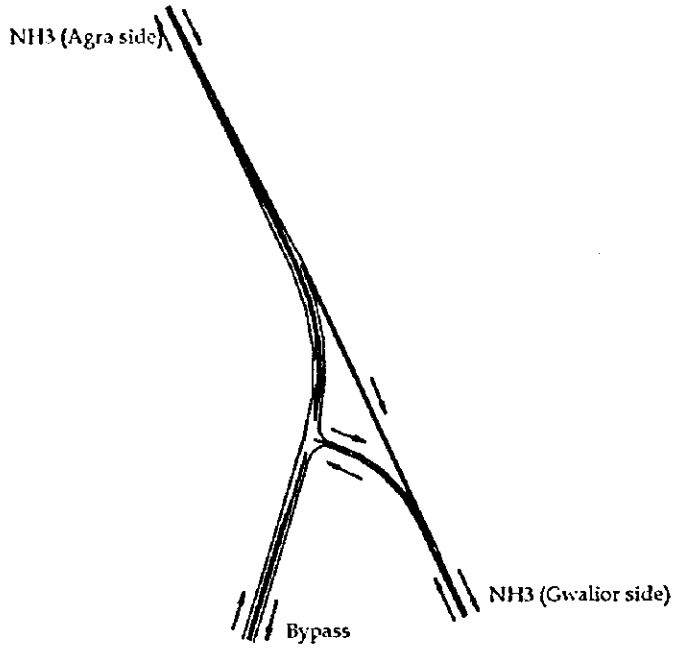


Figure 16-21 Layout of the Intersection at the Beginning Point of Gwalior Bypass

16.5.3 Intersection at the End Point

16.5.3.1 Characteristics of Traffic Flow

Based on the future traffic demand forecast, the majority of traffic flow at this intersection will be given by the movement between the bypass and NH3 (Mumbai side), 25,400 pcu/day in 2012. The traffic movement on NH3 between Gwalior side and Mumbai side gave the second traffic volume. The third (the smallest) traffic is between the bypass and NH3 (Gwalior side). The Study Team gave the priority to the directional traffic flow between the bypass and NH3 (Mumbai side).

16.5.3.2 Proposed Intersection type of EP

The alternative study of this intersection layout was quite similar to the study stated in Section 6.2.2 as the site situation is in mirror symmetry. Accordingly, the Alternative 2 type, similar to Figure 16-18, was judged as the most appropriate layout for the intersection at this location. The recommended layout of the intersection at EP of Gwalior Bypass is shown in Figure 16-22.

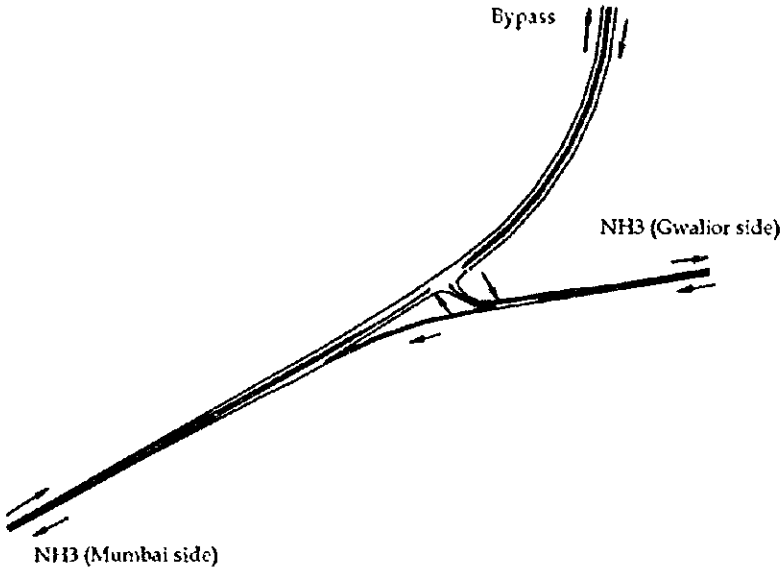


Figure 16-22 Layout of the Intersection at the End of Point of Gwalior Bypass

16.5.4 Work Quantities

16.5.4.1 Work Quantities of BP Intersection

Work quantities of the proposed intersection at the BP of Gwalior Bypass is summarised in Table below.

Item	Unit	Amount
2 Lane Approach Road	m	230
Earth filling	m3	39100
Pavement	m2	2990

Work quantities of toll barrier at BP is as follows:

Item	Unit	Amount
Toll barrier	Each	1
Earth filling	m3	880
Pavement	m2	440
Toll booth	Each	3

16.5.4.2 Work Quantities of EP Intersection

Work quantities of the intersection at the EP is shown in the table below.

Item	Unit	Amount
2 Lane Approach Road	m	130
Earth filling	m3	2210
Pavement	m2	1690

Work quantities of toll barrier at EP is as follows:

Item	Unit	Amount
Toll barrier	Each	1
Earth filling	m3	880
Pavement	m2	440
Toll booth	Each	3

16.6 Structure Design of Gwalior Bypass

16.6.1 General

Methodology of structure planning and design was described in Chapter 15.11, "Design Standard and Criteria of Structures".

16.6.2 Crossing Facilities

16.6.2.1 Roads

There is no highway or district road which cross the proposed bypass, and 12 village roads and 2 cart tracks were identified to cross the proposed bypass.

16.6.2.2 Railways

Two railway lines cross the bypass at near the beginning point. The current feature is single track, narrow gauge. However, according to the discussion with state PWD and Ministry of Railway, it will be abandoned in near future.

The other one near the end point is single track, non-electrified meter gauge, and in future, it will be upgraded to double track, non-electrified broad gauge in the future.

16.6.2.3 Water Channels

6 rivers and 3 canals were identified to cross the proposed bypass. Some of their hydrological feature were investigated and analysed.

16.6.2.4 Summary of Crossing Facilities

Crossing facilities are summarised as shown in Table 16-48.

Table 16-48 Major Crossing Facilities in Gwalior Bypass (1/2)

No.	STA	Type and Class	Present Condition	Remarks
1	0+190	Railway	Narrow Gauge Single Track Non-electrified	Scheme of Ministry of Railway was accepted by PWD Gwalior.
2	0+510	RD - VR	Width : 7.7m (Non-paved) Height: 1.0m	
3	1+150	RD – VR		
4	2+510	RD - VR		
5	3+580	RD - VR	Width : 4.5~6.0m (Paved) C.W.: 2.5m Height: 0.7m	Drainage is at one side.
6	4+400	RD - VR	Width: 3.5m (Non-paved) Height: 0.6m	
7	4+735	WC – Minor Canal	Width: 10.5m Depth: 2.0m from G.L.	Jigsauli Minor Design Discharge 10~12m³/sec
8	7+470	RD - CT	Width: 2.5m (Non-paved)	
9	7+760	WC – Major Canal	Width: 12.4m Depth: 2.3m from G.L.	TIGHARA CANAL Design Discharge 20m³/sec
10	7+925	RD – VR		
11	8+170	RD - VR	Width: 6.4m (Paved) C.W.: 2.9m Height: 1.0m	
12	8+190	WC - River	Width: 7.0m Depth: 5.0m	Kharai nala 3rd order of River Water only in rainy season
13	9+370	WC – Minor Canal	Width: 5.3m Depth: 2.0m from G.L.	Tighara east of Rai Ka Pura Village Design Discharge 20m³/sec (Presently abandoned)
14	9+370	RD - VR	Width: 7.0m (Non-paved) Height: 2.0m	

Note: Present Condition RD: Height is measured from existing ground level.
WC: Width is distance between inside top of embankments.
G.L.: Existing Ground Level

Table 16-48 Major Crossing Facilities in Gwalior Bypass (2/2)

No.	STA	Type and Class	Present Condition	Remarks
15	10+340	WC - River	Width: 25.0m Depth: 5.0m from G.L.	Bandha Nala (Babukapura) Water only in rainy season
16	12+720	WC - River	Width: 14.0m Depth: 6.3m from G.L.	Rai ka Pura (Sojina)
17	15+150	RD - CT	(Not clear)	To Rai ka Pura
18	15+280	RD - VR	Width: 6.5m (Paved) C.W.: 2.5m Height: 1.0m	Connection of Tighara and Bithohi
19	18+230	RD - VR	Width: 4.5m (Paved) C.W.: 3.0m Height: 1.0m	To Deokhon
20	23+710	RD - VR		To Raipur Khuid
21	23+960	WC - River	Width: 12.0m Depth: 4.0m from G.L.	Raipur Khurd
22	24+120	RD - VR	(Non-paved)	
23	25+070	WC - River		
24	25+650	WC - River	Width: 13.3m Depth: 5.8m from G.L.	Raipur Tighara Nala *Village Road Bridge at vicinity
25	26+100	Railway	Broad Gauge Single Track Non-electrified	*Future Programme is confirmed by Ministry of Railway. (Broad Gauge, 2 Track, Non-electrified)

Note: Present Condition RD: Height is measured from existing ground level.
WC: Width is distance between inside top of embankments.
G.L.: Existing Ground Level

16.6.3 Design Condition (1), Hydrology

16.6.3.1 General

Hydrological analysis was carried out for individual crossing facility of water channel identified.

Scope of work and applied formula of hydrological analysis were described in Chapter 15.11, "Design Standard and Criteria of Structure".

16.6.3.2 Summary of Hydrological Analysis

(1) Maximum Design Discharge

a) River

Table 16-49 Maximum Design Discharge of Rivers

No. of CF	STA	River	Catchment Area	Rational formula				Dieken's formula		Design Discharge
			A (hectare)	f	p	Ic	Q (m^3/sec)	Cd	Q (m^3/sec)	Qd (m^3/sec)
12	8+190	Kharai nala	1,200	0.93	0.52	9.12	148.2	6	1223.3	222.3
15	10+340	Bandha nala	100	0.98	0.52	9.12	13.0	6	189.7	19.5
16	12+720	Rai ka Pura	2,200	0.85	0.52	9.12	248.3	6	1927.4	372.5
21	23+960	Raipur Khurd	100	0.98	0.52	9.12	13.0	6	189.7	19.5
23	25+070	-	-	-	-	-	-	-	-	-
24	25+650	Raipur Tighara nala	300	0.96	0.52	9.12	38.2	6	432.5	57.3

b) Canal

Table 16-50 Maximum Design Discharge of Canals

No.	STA	Name of Canal	Design Discharge (m^3/sec)	Other Additional Information
7	4+735	Jigsauli Minor	10~12	
9	7+760	TIGHARA CANAL	20	Village Road Bridge at vicinity
13	9+370	Tighara east of Rai Ka Pura Village	20	Presently abandoned, and filled with rainy water

(2) Design Highest Flood Level (DHFL) of Rivers

Table 16-51 Design Highest Flood Level

No. of CF	STA	River	M.O.D. Qd (m^3/sec)	Application of Manning's Formula					DHFL. (m)
				R (m)	S	n	V (m/sec)	A (m^2)	
12	8+190	Kharai nala	222.3	2.7	1 / 182	0.045	3.2	70.8	6.5
15	10+340	Bandha nala	19.5	0.8	1 / 182	0.045	1.4	23.2	2.5
16	12+720	Rai ka Pura	372.5	1.8	1 / 62.5	0.035	5.3	90.5	5.0
21	23+960	Raipur Khurd	19.5	1.0	1 / 40	0.040	4.0	8.3	1.5
23	25+070	-	-	-	-	-	-	-	-
24	25+650	Raipur Tighara nala	57.3	1.3	1 / 164	0.040	2.4	13.7	2.5

Note: R: hydraulic mean depth S: bed slope
n: rugosity co-efficient V: velocity considered uniform throughout the cross-section
A: available throughout area DHFL: from deepest bed

(3) Minimum Vertical Clearance

a) River

Table 16-52 Minimum Vertical Clearance

No. of CF	STA	River	M.D.D. Qd (m^3/sec)	Applicable Type of Structure	Minimum Vertical Clearance (mm)
12	8+190	Kharai nala	222.3	WCCBL	600
15	10+340	Bandha nala	19.5	WC-BR	600
16	12+720	Rai ka Pura	372.5	WC-BR	1,200
21	23+960	Raipur Khurd	19.5	WCCBM	600
23	25+070	-	-	WCCBM	600
24	25+650	Raipur Tighara nala	57.3	WC-BR	900

Note: No. of CF: Number of Crossing Facility

b) Canal

0 Major Canal

Applied structure is bridge type structure, and minimum required clearance is defined with M.D.D. of each canal. However, in most case, vertical clearance was controlled by the village road along with canal.

1 Minor Canal

Applicable structure is Culvert Box (WCCBS), and 600mm of vertical clearance was applied for flow obstruction caused by sediment in the future.

(4) Afflux

Afflux is required to consider for river at which the bridge structure was proposed.

Table 16-53 Afflux

No.	STA	River	M.D.D. Qd (m^3/sec)	Orifice Formula				H (m)	Obstructions
				L (m)	W (m)	e	C_0		
15	10+340	Bandha nala	19.5	25.0	25.0	0.00	1.000	0.000	No pier
16	12+720	Rai ka Pura	372.5	42.6	45.6	0.16	0.948	0.360	2 piers
24	25+650	Raipur Tighara nala	57.3	15.3	16.3	0.15	0.952	0.140	1 pier

Note: L: Sum of bridge spans
W: Unobstructed width of stream
e: Coefficient of Orifice Formula (Defined by L / W)
C_0: Coefficient of Orifice Formula (Defined by L / W)

(5) Maximum Depth of Scour

Maximum depth of scour is also required to consider for water channel at which the bridge structure was proposed.

Table 16-54 Maximum Depth of Scour

No.	STA	River	M.D.D. Qd (m^3/sec)	E.L.W. (m)	D_b (m^2/sec)	K_{sf}	d_{sm} (m)	M.D.S. (m)
15	10+340	Bandha nala	19.5	25.0	0.8	2.000	0.9	Abut; 1.1 Pier; 1.8
16	12+720	Rai ka Pura	372.5	21.5	17.3	2.000	7.1	Abut; 9.0 Pier; 14.2
24	25+650	Raipur Tighara nala	57.3	15.3	3.7	1.750	2.7	Abut; 3.4 Pier; 5.4

Note: E.L.W.: Effective linear waterway which is the width of water surface caused by M.D.D.
D_b: Discharge divided by E.L.W.
K_{sf}: Silt factor of bed material
d_{sm}: Mean depth of Scour
M.D.S: Maximum depth of scour

(6) Application of Structures for Water Channel

With considering M.D.D. and other design condition, structure for individual water channel were applied.

a) River

Reported H.F.L. was applied for only the reference with DHFL. This is because it was the interviewed value from domestic residences, and not recorded value.

1) Facility No.12 (STA. 8+190, Location: Kharai nala)

Table 16-55 Hydrological Condition of Facility No.12

Item	Condition
M.D.D. (m^3/sec)	222.3
Velocity of flow (m/sec)	3.2
DHFL	6.5m above water bed level
Reported H.F.L.	6.5m above water bed level
Other information	Water only in rainy season, and flow sometimes occupies 400m on each side and area gets flooded.

Water is only in rainy season. River alignment is plainly depressed.

Considering above condition and also bypass alignment, culvert box is desirable as the applicable structure, and finishing level of bypass is required to be higher than the DHFL and reported H.F.L..

2) Facility No.15 (STA. 10+340, Location: Bandha Nala)

Table 16-56 Hydrological Condition of Facility No.15

Item	Condition
M.D.D. (m^3/sec)	19.5
Velocity of flow (m/sec)	1.4
DHFL	2.5m above water bed level
Reported H.F.L.	6~7m above water bed level
Other information	Water only in rainy season. Soil of water bed is sand stone.

Bridge type structure is applied, and reported H.F.L. is more than DHFL, so soffit level of superstructure is required higher than reported one, and also protection of embankment around abutment and approach road is required.

3) Facility No.16 (STA. 12+720, Location: Rai ka Pura)

Table 16-57 Hydrological Condition of Facility No.16

Item	Condition
M.D.D. (m^3/sec)	372.5
Velocity of flow (m/sec)	6.7
DHFL	5.0m above water bed level
Reported H.F.L.	8~9m above water bed level
Other information	Soil of water bed is hard and compact sand stone.

Bridge type structure is applied. Reported H.F.L. is more than DHFL, so soffit level of superstructure is required higher than that DHFL, and also protection of embankment around abutment and approach road is required.

4) Facility No.21 (STA. 23+960, Location: Raipur Khurd)

Table 16-58 Hydrological Condition of Facility No.21

Item	Condition
M.D.D. (m^3/sec)	19.5
Velocity of flow (m/sec)	5.2
DHFL	2.5m above water bed level
Reported H.F.L.	6m above water bed level
Other information	Water only in rainy season

It was found that bank of river is not well defined after site survey.

Culvert box is defined as the applicable structure.

5) Facility No.23 (STA. 25+070)

This natural river is indicated on topographic map of s:1/5,000, and considering catchment area, M.D.D. will be small like previous facility No.22 or less. Culvert box is applied.

6) Facility No.24

(STA. 25+650, Location: Raipur Tighara Nala)

Table 16-59 Hydrological Condition

Item	Condition
M.D.D. (m^3/sec)	57.3
Velocity of flow (m/sec)	2.4
Estimated H.F.L.	2.5m above water bed level
Reported H.F.L.	8.0m above water bed level
Other information	Water only in rainy season Over bridge of village road locates in vicinity.

Bank of river is well defined, and weedy. Considering M.D.D., bridge type structure is applied.

b) Canal

1) Major Canal

Major canal has the village road in parallel with it. With considering that local connection divided by bypass, bridge type structure is applied as described in Part 1, General.

2) Minor Canal

Culvert box type structure is applied with considering M.D.D. of each canal.

Applicable type of culvert box for water channel and number of internal cell is defined also with M.D.D..

(7) Summary of Hydrological Condition for Structure Design

Summary of hydrological condition of rivers is tabulated in Table 16-60.

Table 16-60 Summary of Hydrological Condition of Gwalior

No.	STA	River	AS.	M.D.D. (m^3/sec)	DHFL (m)	M.V.C. (m)	Afflux (m)	M.D.S. (m)
12	8+190	Kharai nala	WCCBL	222.3	6.5	0.6	-	-
15	10+340	Bandha nala	WCBR	19.5	2.5	0.6	0.00	Abut: 1.1 Pier: 1.8
16	12+720	Rai ka Pura	WCBR	372.5	5.0	1.2	0.00	Abut: 9.0 Pier: 14.2
21	23+960	Raipur Khurd	WCCBM	19.5	1.5	0.6	-	-
23	25+070	-	WCCBM	-	-	-	-	-
24	25+650	Raipur Tighara nala	WCBR	57.3	2.5	0.9	0.14	Abut: 3.4 Pier: 5.4

Note: AS.: Applied Structure
H.F.L.: Design Highest Flood Level
M.D.S.: Maximum Depth of Scour
M.D.D.: Maximum Design Discharge
M.V.C.: Minimum Vertical Clearance

16.6.4 Design Condition (2), Geology

16.6.4.1 Three Geological Groups in Gwalior Bypass

The general geological formations are alluvium, Gwalior shale, Gwalior sandstone. Soil is shallow and stony strata which varies from sandy loam on the escarpments to stiff clayey loam on the plateau. At the foot on the hill, soil is generally deeper due to the erosion or weathering of exposed rocky joints.

15 boring points were categorised in three (3) groups, and summarised in Table 16-61.

Table 16-61 Three Geological Groups in Gwalior Bypass

Group	BH	Depth of Bearing Strata (Approx. m)	Soils
I	1 ~ 7	15	silty sand medium to fine sand clay of low plasticity(BH-2 & BH-3, only) sandy silt of low plasticity(BH-2 & BH-3, only)
II	8 ~ 11	5-10	gravely sand sandy gravel sandstone (BH-10 & BH-11, only)
III	12 ~ 15	10	fine grained clays of low to medium plasticity

16.6.4.2 Ground Water Level

Ground water level was measured when the bore holes were drilled. Throughout the bypass area, the ground water level was observed approximately 6 to 8 m deep. This is almost same elevation with we could observe at wells which locate at whole stretch of the proposed bypass except the rock hill.

16.6.5 Applied Structures

16.6.5.1 General

Proposed locations of each structure was determined based on the site investigation and prepared topographic map of 1:5,000. There are some new crossing structures which planned their location to secure the current local traffic.

As the major structures, there are one railway over bridge and four bridges over rivers. Summary of applied structure for individual crossing facility is shown in the Table 16-62.

Table 16-62 Summary of Applied Structures (1/2)

No. of AS.	No. of CF.	STA	Applied Structure Type	Type and Class of Crossing Facility	Remarks
	1	0+190	(Level Intersection)	Railway	Railway will be abandoned soon.
1	2	0+510	RDCBM	RD - VR	L = 33.4m
2	3	1+150	RDCBM	RD – VR	L = 33.4m
3		1+900	RDCBS	(New)	L = 33.4m
4	4	2+510	RDCBM	RD – VR	
5	5	3+580	RDCBL	RD - VR	L = 33.4m Drainage is settled at one side.
6	6	4+400	RDCBM	RD - VR	L = 33.4m
7	7	4+735	WCCBM (No. of Cell:3)	WC – Minor Canal	L = 33.4m
8		6+000	RDCBS	(New)	L = 33.4m
9	8	7+470	RDCBS	RD – CT	L = 33.4m

Note: CF.: Crossing Facility
AS.: Applied Structure
Code of Applied Structures are summarised and described in Part A: General.

Table 16-62 Summary of Applied Structures (2/2)

No. of AS.	No. of CF.	STA	Applied Structure	Type and Class of Crossing Facility	Remarks
10	9	7+760	WCBR (RC-Slab) 2 @ 9.0 = 18.0m	WC – Major Canal	Foundation: Abut: Pile Pier: Pile
11	10	7+925	RDCBM	RD – VR	L = 33.4m
12	11	8+170	RDCBL	RD – VR	L = 33.4m
13	12	8+190	WCCBL (No. of Cell:6)	WC - River	L = 33.4m
14	13	9+370	WCCBM (No. of Cell:2)	WC – Minor Canal	L = 33.4m
15	14	9+370	RDCBL	RD - VR	L = 33.4m
16	15	10+340	WCBR (PC-Hollow) 1@25.0 = 25.0m	WC - River	Foundation: Abut: Pile
17		12+150	RDCBS	(New)	L = 33.4m
18	16	12+720	WCBR (RC-T beam) 14.0 + 19.0 + 14.0 = 47.0m	WC - River	Foundation: Abut: Pile Pier: Well
19		12+900	RDCBS	(New)	L = 33.4m
20		13+600	RDCBS	(New)	L = 33.4m
21	17	15+150	RDCBM	RD – CT	L = 33.4m (Alignment of Crossing Facility will be replaced.)
22	18	15+280	RDCBL	RD - VR	L = 33.4m (Alignment of Crossing Facility will be replaced.)
23	19	18+230	RDCBM	RD - VR	L = 33.4m
24		22+450	RDCBS	(New)	L = 33.4m
25	20	23+710	RDCBM	RD – VR	L = 33.4m
26	21	23+960	WCCBM (No. of Cell:2)	WC - River	L = 33.4m
27	22	24+120	RDCBM	RD – VR	L = 33.4m
28	23	25+070	WCCBM (No. of Cell:2)	WC - River	L = 33.4m
29		25+120	RDCBS	(New)	L = 33.4m
30	24	25+650	WCBR (RC-Slab) 3 @ 10.0 = 30.0m	WC - River	Foundation: Abut: Well Pier: Well
31	25	26+100	ROB (Hollow Slab) 1 @ 17.0 = 17.0m	Railway	Foundation: Abut: Pile

Note: CF.: Crossing Facility
AS.: Applied Structure
Code of Applied Structures are summarised and described in Part A: General.

16.6.5.2 Railway Over Bridge (ROB) (STA. 26+100)

One railway over bridge was planned and designed near the bypass end point. Design conditions are summarised in Table 16-63, and site photograph is presented in Figure 16-23.

Table 16-63 Design Condition of Over bridge (STA. 26+100)

Item		Condition
Throughway Alignment	Vertical Alignment	i = 1.4% ~ -1.2%
	Horizontal Alignment	R = 500
	Cross Section	Type – I of Bridge Section (L<100m)
Crossing Facility	Classification of Project	Railway (CF No.25)
	Present Condition	Broad Gauge, Single Track, Non-electrified
	Future Programme	Broad Gauge, Double Track, Non-electrified
	Lateral Clearance	9.445m (for Future Programme)
	Vertical Clearance	5.030m
	Other Information	
Geology	Depth of Bearing Strata	9.0m from G.L.
	Type of Bearing Strata	Clay (N>20)

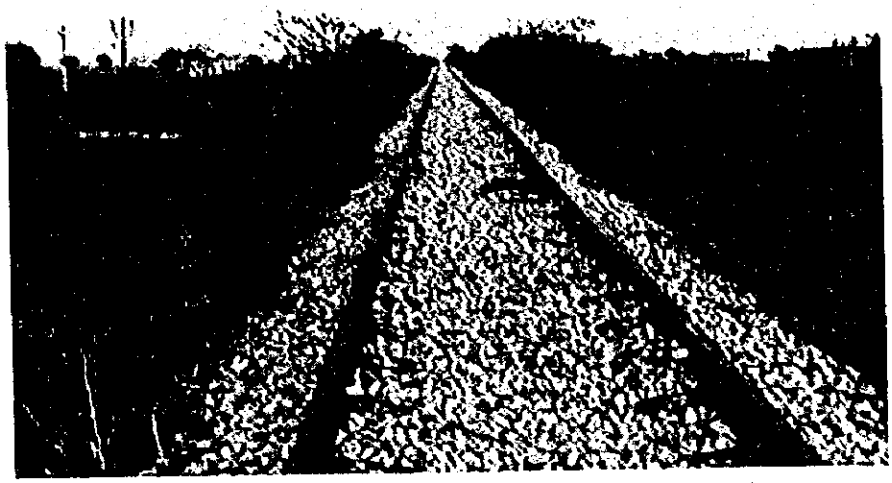


Figure 16-23 General View of Crossing Point

Composition of applied ROB is summarised in Table 16-64.

Table 16-64 Applied Railway Over bridge (STA. 26+100)

Item	Conditions	
AS. No.	No. 31	
Superstructure	PC Hollow Slab	Total Length 17.0m, 1 @ 16.0m = 16.0m
Substructure	Abutment : Inversed T – type	Height of Abutment: 12.0m Width of Footing: 7.5m x 26.5m
Foundation	Abutment	Cast-in-Situ Pile Foundation Length: 10.0m Diameter 1.0m 3x 6 for each abutment

16.6.5.3 Bridge Over Major Canal (WCBR) (STA. 7+760)

Design condition is summarised in Table 16-65.

Table 16-65 Design Condition of Bridge (STA. 7+760)

Item		Condition
Throughway Alignment	Vertical Alignment	i = -1.5% ~ 2.3%
	Horizontal Alignment	R = 1,000
	Cross section of Throughway	Type – I of Bridge Section (L<100m)
Crossing Facility	Classification of Project	WC - Major Canal (CF No.9) Tighara Canal
	M.D.D.	20.0 m³/sec
	Other Information	
Geology	Depth of Bearing Strata	15.0m from G.L.
	Type of Bearing Strata	Sand (N > 30)
	Other Additional Information	

Considering local traffic, bridge type structure was applied.

Composition of applied bridge is summarised in following Table 16-66.

Table 16-66 Applied Bridge (STA. 7+760)

Item		
AS No.	No.9	
Superstructure	RC-Slab (2 x simple span)	Total Length 19.0m, 2 @ 9.0m = 18.0m
Substructure	Abutment : Inversed T – type	Height of Abutment: 8.5m Width of Footing: 5.0m x 26.5m
	Pier: Wall type	Height of Pier: 7.0m Width of Footing: 5.0m x 5.0m
Foundation	Abutment	Cast-in-Situ Pile Foundation Length: 11.0m Diameter 1.0m 3x 6 for each abutment
	Pier	Cast-in-Situ Pile Foundation Length: 11.0m Diameter 1.0m 2x 3 for each abutment

16.6.5.4 Bridge Over River (WCBR) (STA. 10+340)

Design condition is summarised in Table 16-67.

Table 16-67 Design Condition of Bridge (STA. 10+340)

Item		Condition
Throughway Alignment	Vertical Alignment	Ii = -3.0%
	Horizontal Alignment	R = 2,000
	Cross section of Throughway	Type – I of Bridge Section (L<100m)
Crossing Facility	Classification of Project	WC - River (CF No.15), Bandha Nala
	M.D.D.	222.3 m^3/sec
	DHFL	2.5m from water bed
	Linear Waterway	25.0m
	Afflux	0mm
	Vertical Clearance	600mm from DHFL + Afflux
	Maximum Depth of Scour	Abutment: 1.1m Pier 1.8m from DHFL
	Other Additional information	
Geology	Depth of Bearing Strata	BP side: 10.0m from G.L. EP side: 5.0m from G.L.
	Type of Bearing Strata	BP side: Sandy Gravel EP side: Sand Stone (Rock)
	Other Additional Information	Group II described in section 7.4 Design Condition (2), Geology

Composition of applied bridge is summarised in following Table 16-68.

Table 16-68 Applied Bridge (STA. 10+340)

Item		Composition
AS No.	No.16	
Superstructure	PC-Hollow	Total Length 26.0m, 1 @ 25.0m = 24.0m
Substructure	Abutment : Inversed T – type	Height of Abutment: 10.0m Width of Footing: 7.0m x 26.5m
Foundation	Abutment	Cast-in-Situ Pile Foundation Length: 10.0m Diameter 1.0m 3 x 6 for each abutment

Protection of embankment in front of abutment is required to prepare the flow in spate in rainy season.

16.6.5.5 Bridge Over River (WCBR) (STA. 12+720)

Design condition is summarised in the following Table 16-69, and site photograph is shown in Figure 16-24.

Table 16-69 Design Condition of Bridge (STA. 12+720)

Item		Condition
Alignment	Vertical Alignment	i = -1.7%
	Horizontal Alignment	R = 3,000
	Cross section of Throughway	Type – I of Bridge Section
Crossing Facility	Classification of Project	WC - River (Facility No.16), Rai ka Pura (Sojina)
	M.D.D.	372.5 m³/sec
	H.F.L.	5.0m from water bed
	Linear Waterway	42.6m
	Afflux	0.36m
	Vertical Clearance	1,200mm from H.F.L.+Afflux
	Maximum Depth of Scour	Abutment: 5.7m Pier: 9.0m from DHFL
	Other Additional information	Water flow bed is hard and compact sand stone.
Geology	Depth of Bearing Strata	10.0m from G.L. (Estimated)
	Type of Bearing Strata	Sandy Gravel (Estimated)
	Other Additional Information	Group II described in section 7.4 Design Condition (2), Geology

Figure 16-24 General View of Crossing Point

Composition of applied over bridge is summarised in following Table 16-70.

Table 16-70 Applied Bridge (STA. 12+720)

Item		
AS No.	No.18	
Superstructure	RC-T beam	Total Length 48.0m, 14.0+19.0+14.0 = 47.0m
Substructure	Abutment : Inversed T – type	A1 & A2 Height of Abutment: 10.0m Width of Footing: 8.0m x 26.5m
	Pier: Wall type	P1 & P2 Height of Pier: 12.0m Width of Footing: 6.0 x 6.0m
Foundation	Abutment	Well Foundation A1: Diameter: 6.0m Depth 5.0m x 3 A2: Diameter 6.0m Depth 5.0m x 3
	Pier	Well Foundation P1: Diameter: 6.0m Depth: 5.0m x 2 for 2 piers P2: Diameter 6.0m Depth: 5.0m x 2 for 2 piers

Protection of embankment in front of abutment is required to prepare the flow in spate in rainy season.

16.6.5.6 Bridge Over River (WCBR) (STA. 25+650)

Design condition is summarised in the following Table 16-71, and site photograph is shown in Figure 16-25.

Table 16-71 Design Condition of Bridge (STA. 25+650)

Item		Condition
Alignment	Vertical Alignment	-0.5% ~ 1.4%
	Horizontal Alignment	R = ∞
	Cross section of Throughway	Type – I of Bridge Section
Crossing Facility	Classification of Project	WC - River (Facility No.24), Raipur Tighara Nala
	M.D.D.	57.3 m³/sec
	H.F.L.	2.5m from water bed
	Linear Waterway	15.3m
	Afflux	0.14m
	Vertical Clearance	1,200mm from H.F.L. + Afflux
	Maximum Depth of Scour	Abutment: 3.4m Pier: 5.4m from DHFL
	Other Additional information	Water flow bed is hard and compact sand stone.
Geology	Depth of Bearing Strata	10.0m from G.L. (estimated)
	Type of Bearing Strata	Sandy Gravel (estimated)
	Other Additional Information	Group III described in section 7.4 Design Condition (2), Geology

Figure 16-25 General View of Crossing Point

Composition of applied over bridge is summarised in following Table 16-72.

Table 16-72 Applied Bridge (STA. 25+650)

Item		
AS No.	No.30	
Superstructure	RC- Slab (3 x simple span)	Total Length 31.0m, 3 @ 10.0 = 30.0m
Substructure	Abutment : Inversed T – type	A1 & A2 Height of Abutment: 10.0m Width of Footing: 7.5m x 26.5m
	Pier: Wall type	P1 & P2 Height of Pier 12.0m Width of Footing 6.0m x 6.0m
Foundation	Abutment	Cast-in-Situ Pile Foundation Length: 10.0m Diameter 1.0m 3 x 6 for each abutment
	Pier	Well Foundation P1: Diameter: 6.0m Depth: 8.5m x 2 for 2 piers P2: Diameter 6.0m Depth: 8.5m x 2 for 2 piers

Protection of embankment in front of abutment is required to prepare the flow in spate in rainy season.

16.6.5.7 Culvert Box for Roads (RDCBL, RDCBM, and RDCBS)

At 23 crossing points, Culvert Box for road were applied. Summary is shown in Table 6-73

Table 16-73 Summary of Culvert Box for Road

Type of Culvert	No. of AS.	STA	Remarks	Type of Culvert	No. of AS.	STA	Remarks
RDCBL	5	3+580	L = 33.4m	RDCBS	3	1+900	L = 33.4m
	12	8+170	L = 33.4m		8	6+000	L = 33.4m
	15	9+370	L = 33.4m		9	7+470	L = 33.4m
	22	15+280	L = 33.4m		17	12+150	L = 33.4m
	Total Length		L = 133.6m		19	12+900	L = 33.4m
RDCBM	1	0+510	L = 33.4m		20	13+600	L = 33.4m
	2	1+150	L = 33.4m		24	22+450	L = 33.4m
	4	2+510	L = 33.4m		29	25+120	L = 33.4m
	6	4+400	L = 33.4m		Total Length		L = 267.2m
	11	7+925	L = 33.4m				
	21	15+150	L = 33.4m				
	23	18+230	L = 33.4m				
	25	23+710	L = 33.4m				
	27	24+120	L = 33.4m				
	Total Length		L = 300.6m				

16.6.5.8 Culvert Box for Water Channel (WCCBL, WCCBM, and WCCBS)

At 7 crossing points, Culvert Box for water channel were applied. Summary is shown in Table 16-74.

Type of culvert and number of cell was defined with M.D.D. of each canal.

Table 16-74 Summary of Culvert Box for Water Channel

Type of Culvert	No. of AS.	STA	No. of Cell	Length (m)	Remarks
WCCBL	13	8+190	3 x 2	L = 33.4m	*2 Culverts applied
WCCBM	7	4+735	3	L = 33.4m	
	14	9+370	2	L = 33.4m	
	26	23+960	2	L = 33.4m	
	28	25+070	2	L = 33.4m	

16.6.6 Suggestion for Detail Design

There is a railway which crosses with the proposed bypass alignment near the beginning point.

Crossing plan in this study is assumed as at grade intersection, and this is because railway alignment is planned to be abandoned. This was discussed and confirmed by Ministry of Railway and State PWD Gwalior.

However, the target year of this abandon is still not definitive, and it is anticipated that it would be still operated when the bypass opens to public.

In detail design, the future programme of railway and crossing plan should be reviewed.

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17 Construction Programme

The Scope of Works provided for this Feasibility Study specifies the year of 2002 as the target year (short term) for the completion of the construction of high priority projects. In order to enable the construction start, it was understood that the following procedures should be carried out, beforehand.

(1) Further detailed engineering design (assumed one year).
(2) Process to obtain the project sanction.
(3) Process to select the civil work contractor.
(4) Land acquisition and compensation.

Judging from the above required procedures, the construction period for the proposed bypass was assumed as 3 years, from 1999 to 2002.

17.1 Major Project Features

17.1.1 Bareilly Bypass

The following were taken into account as the major project features:

- As the concrete structures, 13 bridges/viaducts and 29 culvert boxes were proposed. Amongst these structures, three bridges with 49 m long were proposed to cross over the Deonarain River at STA 7+900, SH 37 and railways at STA 9+090, and the Nakatia River at STA 14+270. Two interchange bridges were proposed with 30 m long at the crossing points of SH337 at STA 8+700, and SH 33 at STA 13+300, respectively;

- The required quantities for road embankment was estimated as approximately 2,700 $\times 10^3$ m^3. The maximum height of embankment will be approximately 10 m at STA 9+065 for the approach section to the ROB, and STA. 10+015 to install a middle size culvert box. According to the information given by the State PWD, the practical supply of fill material in the project area is carried out by "Side Borrow". Referring to this information, this Study also expected to supply the fill material by this "Side Borrow" method. When this method was applied for the whole stretch of the bypass with 90 m width at both side, side borrow excavation will require around 50 cm depth;

- Two interchanges of a Y-type with at-grade intersection were proposed to connect the bypass traffic to SH 37 at STA 8+700, and to SH 33 at STA 13+300; and,

- The proposed alignment will cross under the High Tension Line (HTL) at seven locations. As the actual height of the conductors of the HTL at the exact crossing point was not measured in the Study, it is recommended to measure the conductor's height at the crossing point, at the time of detailed engineering

design phase, to check whether the vertical clearance from the proposed level of bypass fulfil the required specification or not.

17.1.2 Gwalior Bypass

The followings were taken into account as the major project features:

- As the concrete structures, 5 bridges and 26 culvert boxes were proposed. The bridge over the river at STA 12+720 has the longest length of 47 m;

- It was understood the proposed ROB at STA 26+100 will be separated from the civil work contract for the bypass project to the jurisdiction of Ministry of Railways;

- The required quantities for road embankment was estimated as approximately 2,200 $\times 10^3$ m^3. By the excavation work at the cut section, around 330 $\times 10^3$ m^3 will be generated. Therefore approximately 1,900 $\times 10^3$ m^3 of fill material will be required supplied from the outside. As recommended by the State PWD, Gwalior, existing borrow pits are located in adjacent area of the project. The geotechnical survey conducted at the proposed borrow pits proved the appropriateness for the fill material. The hauling distance was assumed as 13 km in average;

- Although the project alignment was arranged to avoid the crossing of waste water basin at STA 2+400, the possibility of settlement of road embankment by the old deposit is suspected. The further study including the countermeasures of soft ground treatment may be required; and

- The old water supply canal and current water main, supplies water from Tighara Reservoir to Gwalior city, are crossing the proposed bypass at around STA 9+400. During the construction of structures to cross over these utilities, careful attention shall be taken, not to make any interruption of its function.

17.2 Workable Days at the Project Area

17.2.1 Bareilly Bypass

The number of workable days was estimated as shown in Table 17-1. The calculation of Non Workable days was based on the rainfall data of Revenue Department of Uttar Pradesh, 1995~1997. Non-Workable day was estimated by the following formula referred to the Manual of Earthwork for Road Construction, Japan Road Association.

Non-Workable day by Rainy day $=(B \times 0.5 + C \times 1.0 + D \times 1.5) \times 0.5$

where, B : number of rainy day having 1 mm to 10 mm rainfall
C : number of rainy day having 10 mm to 30 mm rainfall

D : number of rainy day having more than 30 mm rainfall

Table 17-1 Number of Workable Days at Bareilly Bypass Area

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
A) Rainy day total	2	4	2	2	2	13	14	20	12	4	2	2	
B) Rainy day 1mm to 10mm	1	1	1	1	1	7	4	9	6	2	2	1	
C) Rainy day 10mm to 30mm	0	2	1	1	1	5	4	6	3	2	0	1	
D) Rainy day above 30mm	1	1	0	0	0	1	6	5	3	0	0	0	
E) Holiday	5	4	4	4	5	4	4	5	4	5	4	4	
F) National Holiday	5	1	1	3	2	0	1	1	1	3	1	4	
G) Non-Workable day by Rainy day	1	2	1	1	1	5	8	9	5	2	1	1	
H) Total Non-Workable day	11	7	6	8	8	9	13	15	10	10	6	9	
I) Workable day	20	21	25	22	23	21	18	16	20	21	24	22	253

Source : Revenue Department of Uttar Pradesh Government Rainfall Data of Baheri, 1995,1996

17.2.2 Gwalior Bypass

The number of workable days was estimated as shown in Table 17-2. The calculation of Non Workable days was based on the rainfall data of Climatological table of observation in India, 1931~1960, and rainfall data in monsoon season (June to October), 1995-1997.

Table 17-2 Number of Workable Days at Gwalior Bypass Area

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
A) Rainy day total	1.5	0.9	1	0.5	0.9	6	18	19	10	3	0.2	0.7	
B) Rainy day 1mm to 10mm	0	0.9	0	0.5	0.9	2	10	10	4	2	0	0	
C) Rainy day 10mm to 30mm	1.5	0	1	0	0	3	2	4	4	0	0.2	0.7	
D) Rainy day above 30mm	0	0	0	0	0	1	6	5	2	1	0	0	
E) Holiday	5	4	4	4	5	4	4	5	4	5	4	4	
F) National Holiday	5	1	1	3	2	0	1	1	1	3	1	4	
G) Non-Workable day by Rainy day	1	0	1	0	0	3	8	8	5	1	0	0	
H) Total Non-Workable day	11	5	6	7	7	7	13	14	10	9	5	8	
I) Workable day	20	23	25	23	24	23	18	17	20	22	25	23	263

Source : Climatological table of observations in India (1931-1960), monsoon season (June to October), 1995~1997

17.3 Construction Schedule

17.3.1 Calculation of the Construction Period Required

The construction period was calculated based on the ability of the construction equipment by the following formula:

$$\text{Construction Period (month)} = \frac{\text{Work Quantity}}{\text{Construction Ability} \times \text{Ratio of Workable Days} \times 30 \text{ days}}$$

Construction ability was assumed on the basis of "Handbook on Road Construction Machinery".

17.3.2 Tentative Construction Schedule of Bypasses

As the both bypass projects have no particular structures which require high construction technology or time consuming construction period, the earthwork and the pavement work was judged as a critical-path to accomplish the project with in 3 years. Since the road length and work items/quantities were not differ much between both bypasses, the similar construction schedules were assumed. Tables 17-3 and 17-4 show the tentative construction schedule for Bareilly Bypass and gwalior bypass, respectively.

Table 17-3 Tentative Construction Schedule of Bareilly Bypass

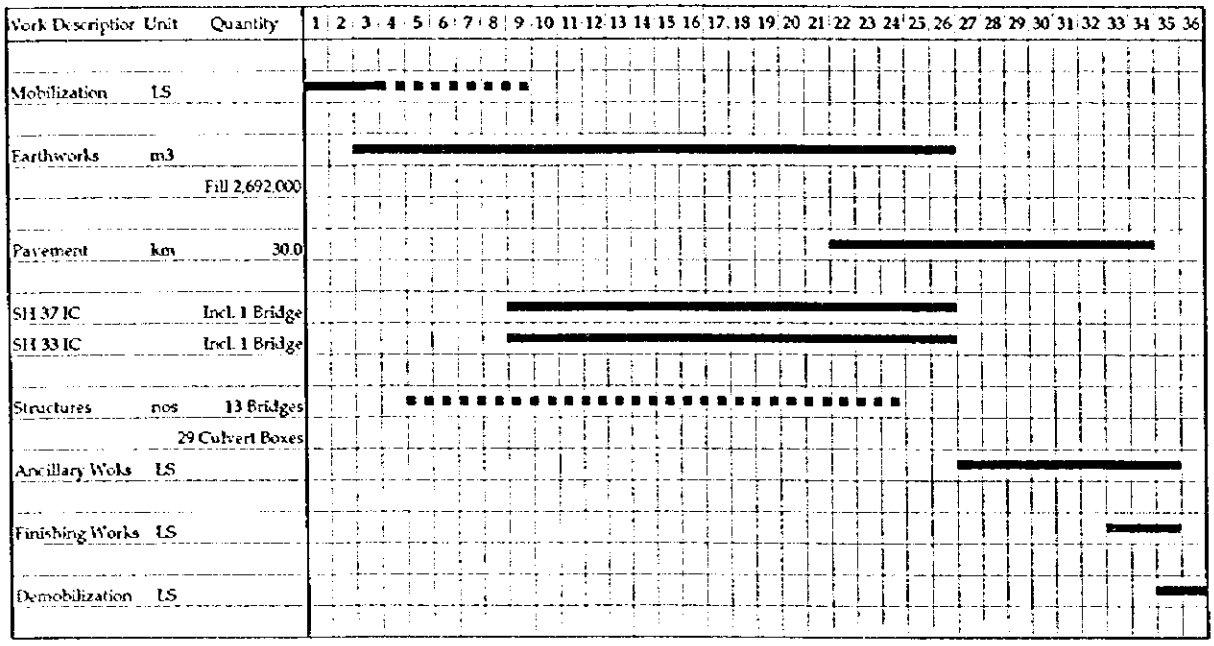
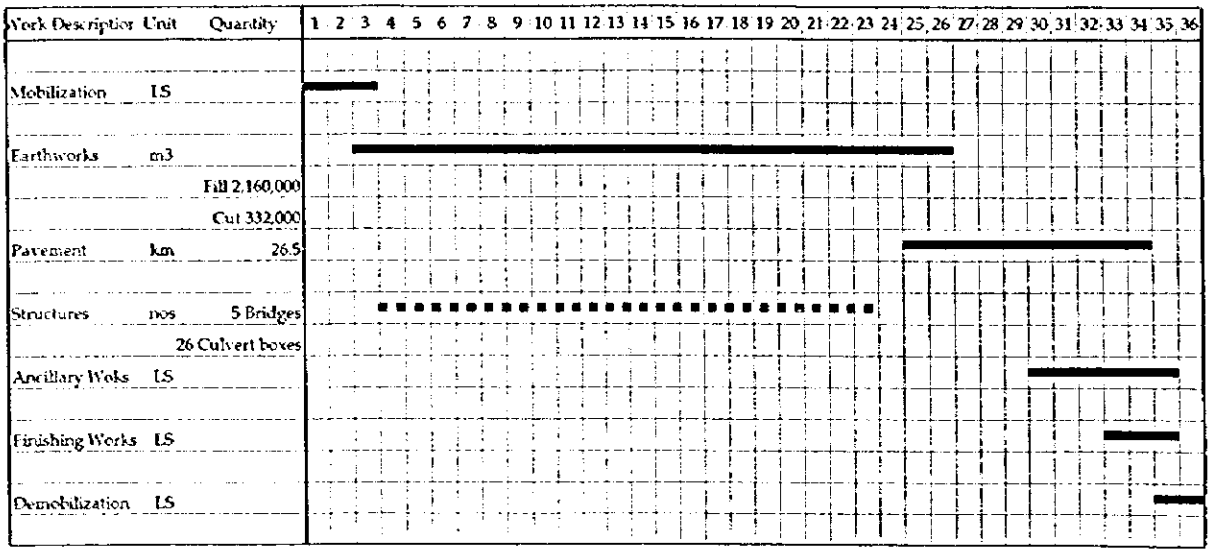


Table 17-4 Tentative Construction Schedule of Gwalior Bypass



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18 Toll Collection System

The proposed Bareilly Bypass and Gwalior Bypass will provide major advantages in terms of improved communications, accessibility and environmental benefits. On the other hand, the scheme is intended to recover the invested project cost by means of toll collection. So it is necessary to make the Project as attractive as possible to the traffic in order to maximise the toll revenues.

The main factors, which attract the traffic to toll roads, are in reduction of travel time, distance travelled and operational costs (maintenance cost, fuel charge, etc). Because the road user is not always rational in the assessment of his travel costs, it is also essential to minimise delays on the bypass system including the passing time of interchanges and tollgates. Otherwise, potential users will be deterred from the toll roads. Thus, as the time savings are one of the main attractive features for a toll road, the toll plazas must be designed to accommodate the traffic flows on the bypass with the minimisation of delay and inconvenience to the user.

18.1 Comparison of Toll Collection System

There are two types of toll collecting system, the Open Toll System and the Closed Toll System.

(1) Open Toll System

Open Toll System allows to use the toll road free of charge in some trip patterns. This system does not provide toll collecting facilities in every access points. The trip allowed for free of charge traffic is generally short distance, for partial passing of minor traffic flows.

Generally, vehicles can enter a toll road without stopping, and when they reach a tollgate on the throughway, they must stop to pay toll and receive a receipt. Toll collectors at tollgates identify the vehicle type and issue a receipt.

(2) Closed Toll System

In case of a fully access-controlled road with toll levy, the JICA Study Team recommends the application of Closed Toll System as the most appropriate one. In this system, road users have to stop at least once at toll facilities and pay the toll.

In a typical case where the toll rates are distance dependent, vehicles have to stop at the tollgate, usually located in the interchange before entering the toll road, to receive a ticket, and then drive to the exit interchange. At the exit interchange, drivers hand over the ticket to the toll collector, pay a toll and receive a receipt. The toll collector at the entry interchange gives the ticket to the passing vehicles. Toll collectors at the exit interchange receive the ticket

and collect the prefixed toll often dependent on the distance travelled and vehicle type. After receiving payment, toll collectors give back the receipt and the change, if any, to drivers.

A general comparison of these systems is presented below.

Table 18-1 Comparison of Toll System

	Open Toll System	Closed Toll System
Access control	Not necessarily needed	Fully needed
Toll collection at all IC's	Not necessary	In principle
Rogue vehicle check	Difficult	Easy
Road closure	Not possible (difficult)	Possible (easy)

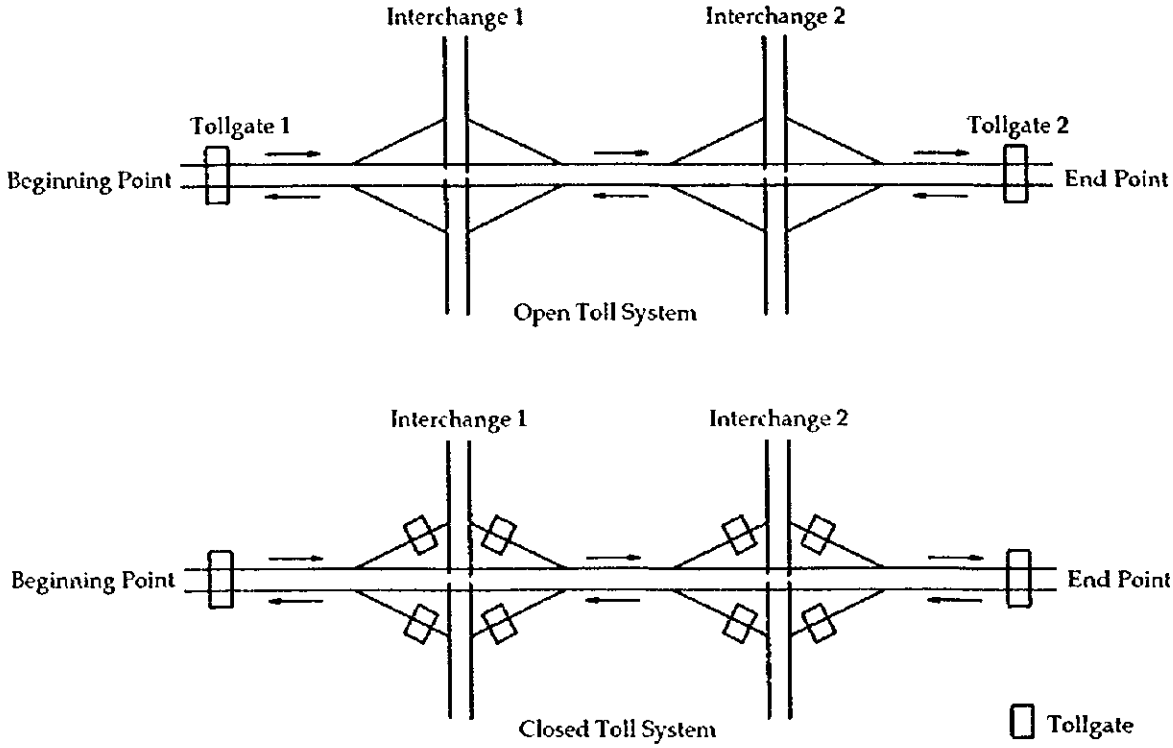

Figure 18-1 Open Toll System and Closed Toll System

18.2 Rogue Vehicle Check

To prohibit the entry of rogue vehicles is extremely important from the viewpoint of operation and maintenance of the tollway. There may be two reasons in this requirement.

The first reason is to avoid the damages of pavement or structures, especially bridges, by rogue vehicles having an overloaded freight. Although pavement or structures are designed for design loads inclusive of allowance by a safety factor, the

repetitive overloading will lead to deterioration of the strength of pavement and structures. As a result of repetitive overloading, the life of pavement and structures will be shorten. This will make the maintenance cost high.

The second reason is that rogue vehicles such as bicycles and auto-rikshaws disturb high-speed traffic flow. This will diminish the time saving benefit by using the bypass. They may cause traffic congestion and traffic accidents.

(1) Rogue Vehicle Control under Open Toll System

It is difficult to check rogue vehicles under the Open Toll System because the highway is opened to ordinary roads connected and adjacent lands. Any type of vehicles can enter the toll road. To prevent the entry of rogue vehicles to the tollway, the special task force will be required to control the entry of vehicles at each access points.

(2) Rogue Vehicle Control under Closed Toll System

It is easy to check rogue vehicles under the Closed Toll System as every user is captured somewhere at least once on the highway.

18.3 Proposed Toll Collection System

In this Study, the Closed Toll System was recommended as a toll collection system of Bareilly Bypass and Gwalior Bypass. This System was judged as more appropriate than the Open Toll System by the reasons mentioned above.

The Gwalior Bypass with the total length of 26.0 km has only two connecting points with the existing NH3, at the beginning (BP) and end points (EP) of the throughway. Therefore it is rather simple to allocate the toll collection system. The following Figure 18-2 illustrates the toll barrier location proposed for Gwalior Bypass. There are two toll barriers near the BP and EP on the throughway. Road users will stop at the toll barrier and pay a toll, just after his entry into the bypass section. It is not necessary to stop thereafter.

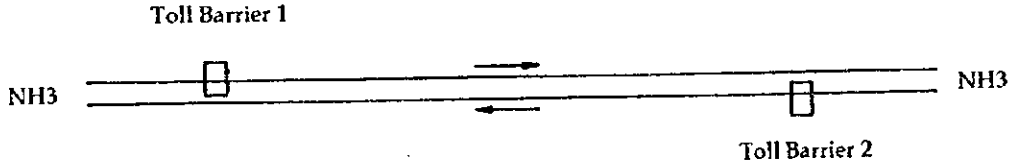

Figure 18-2 Toll Collection System proposed for Gwalior Bypass

On the other hand, Bareilly Bypass was designed to have two additional link points to the existing SH37 and SH33. Therefore, the bypass may form three sections; 1) Section 1 from NH24 to SH37, approximately 9.1 km, 2) Section 2 from SH37 to SH33,

approximately 4.5 km, and 3) Section 3 from SH33 to NH24, approximately 17.5 km. It is essential to establish the simple and efficient system for the both toll collection and road users.

In order to achieve this, the JICA Study Team proposed a toll collection system for Bareilly Bypass as shown in the Figure 18-3. Table 18-2 indicates the toll rates at each toll barrier/tollgate.

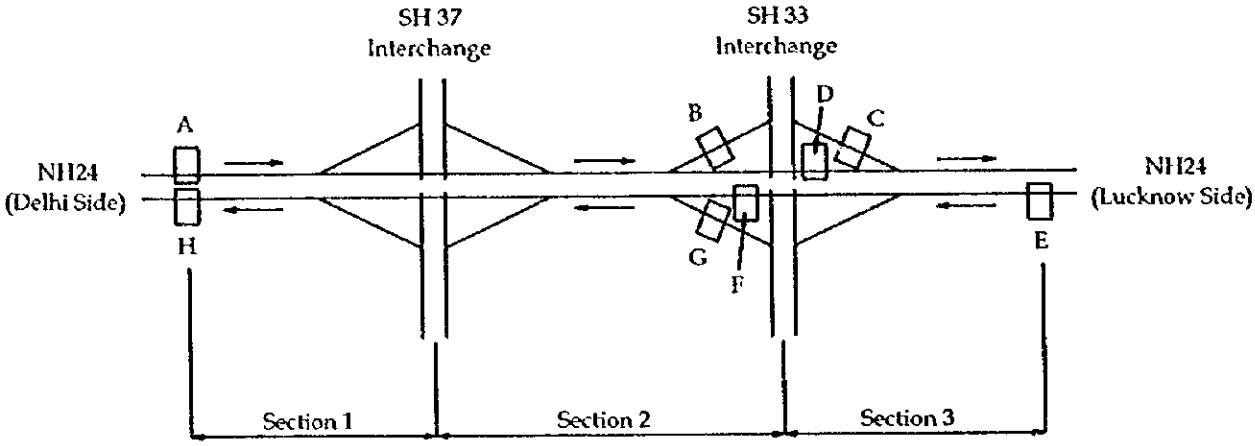

Figure 18-3 Toll Collection System proposed for Bareilly Bypass

Table 18-2 Charged Toll Rates at Toll Barrier/Tollgate at Bareilly Bypass

Direction	Toll gate	Toll Rate
Delhi → Lucknow	A	Rate for Section 1
	B	Rate for Section 2
	C	Rate for Section 3
	D	Rate for Section 2 & Section 3
Lucknow → Delhi	E	Rate for Section 3
	F	Rate for Section 2
	G	Rate for Section 2
	H	Rate for Section 1

18.4 Location of Facilities related to Toll Collection

18.4.1 Location of Toll Barriers on the Bypass Throughway

The toll barriers on the throughway of the bypass is recommended to allocate near the beginning point and end point. The visible existence of toll barrier at near the entrance is expected to prohibit the entry of slower vehicles such as auto-rikshaws, bicycles, and carts into the bypass.

The layout of the toll barriers on the throughway may be arranged as shown in

Figure 18-4. A toll office in which toll collection system is controlled will be constructed nearby the toll barrier.

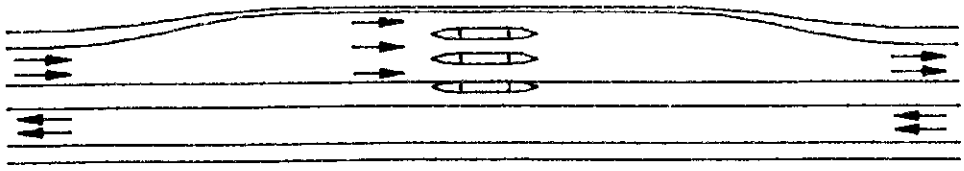

Figure 18-4 Typical Layout of Toll Barrier on Bypass Throughway

18.4.2 Location of Tollgate on the Ramp Way

As described in the previous section, 18.3, the installation of tollgates was recommended at the interchange for SH33 of Bareilly Bypass. The typical layout of the tollgates on the ramp way was illustrated in Figure 18-5. The location of tollgate will be selected on vacant land, away from villages and other settlements as far as possible.

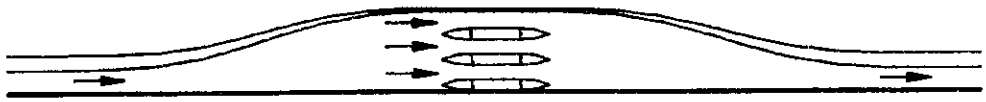

Figure 18-5 Typical Layout of Tollgate on Ramp Way

18.4.3 Required Number of Lanes for the Toll Barrier/Tollgate

In this Study, the required number of lanes for toll barrier/tollgate were decided referring to the Interchange Design Standards of the Japan Highway Public Corporation (JH). JH provides Table 18-3 for selecting the number of tollgate lanes from the relevant elements of time for service (sec), average queue and Design Hourly Volume (DHV).

The Study Team employed the elements for the service time of 8.0 seconds and 3 vehicles for average queue. This condition is generally adopted for selecting the number of tollgate lanes in case of the manual toll collection. Number of toll lanes for the proposed toll barriers/tollgates are summarised in Table 18-4.

Table 18-3 Guide to determine Number of Lanes for Toll Barrier/Tollgate

Time of Service	6.0 sec		8.0 sec		10.0 sec		14.0 sec		18.0 sec	
Average Queue (No. of Vehicle)	1	3	1	3	1	3	1	3	1	3
Number of Lanes	Design Hourly Volume (DHV)									
1	300	450	230	340	180	270	130	190	100	150
2	850	1,040	640	780	510	620	360	440	280	350
3	1,420	1,630	1,070	1,230	850	980	610	700	480	550
4	2,000	2,230	1,500	1,670	1,200	1,340	860	960	670	740
5	2,590	2,830	1,940	2,210	1,550	1,700	1,110	1,210	860	940
6	3,180	3,430	2,380	2,570	1,910	2,060	1,360	1,470	1,060	1,140

Table 18-4 Proposed Number of Lanes for Toll Barrier/Tollgate

Bypass	Toll Barrier/ Tollgate	Direction	ADT	DHV	Estimated Number of Lanes	Proposed Number of Lanes
Bareilly	A (BP)	entry	17,800	1,070	3	3
	B (SH33IC)	exit	13,100	790	3	3
	C (SH33IC)	entry	5,200	310	1	2
	D (SH33IC)	pass	8,100	490	2	3
	E (EP)	entry	13,300	800	3	3
	F (SH33IC)	pass	8,100	490	2	3
	G (SH33IC)	entry	13,100	790	3	3
	H (BP)	exit	17,800	1,070	3	3
Gwalior	Barrier A	entry	9,000	540	2	3
	Barrier B	entry	9,000	540	2	3

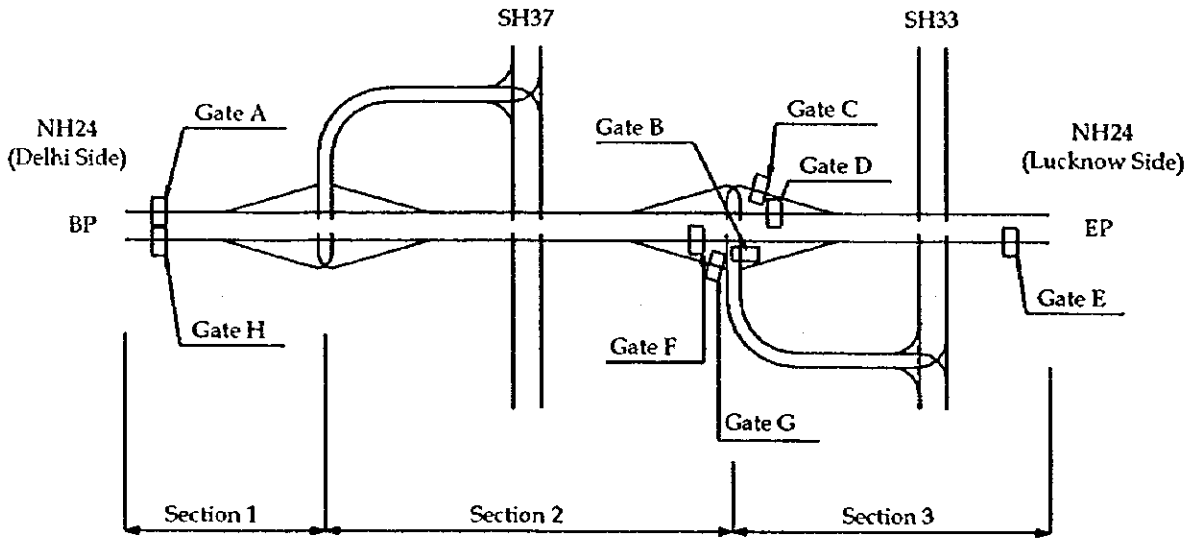

Figure 18-6 Proposed Location of Tollgate in Bareilly Bypass

18.5 Toll Related Management Plan

18.5.1 Toll Rate

In this Feasibility Study, the following toll rates in 1997 price were assumed as the very basic condition of the study for future traffic demand forecast and economic/ financial analysis.

Vehicle Type	Toll Rate (Rs./km) in 1997 price
Cars/Jeep/Van	1.00
Light Commercial Vehicle	1.75
Truck and Bus	3.50
Heavy Construction machinery	7.50
Two wheelers	0.50

Bicycles and pedestrians should be banned from the bypass. Slow speed traffic such as bullock cart or auto-rickshaw is also not permitted to enter, to avoid the reduction of traffic capacity. Otherwise, these transportation mode should be charged the same toll rates as cars.

Based on the above unit toll rates in 1997 price, the applied toll rate in 2002, when the proposed bypass is expected to open to the public, was estimated as shown in Table 18-5.

Table 18-5 Toll Rate at the Bypass Opening in 2002

Unit : Rs. (2002 price)

Vehicle Type	Bareilly Bypass (L=30.0 km)	Gwalior Bypass (L=26.5 km)
Car	44	36
Light Commercial Vehicle	76	64
Truck/Bus	153	128
Two Wheelers	21	18

In case of the Bareilly Bypass, there are three sections as stated in Section 18.3. Therefore, the tolls for traffic using each section of the bypass would be as shown in the Table 18-6.

Table 18-6 Toll Rate of Bareilly Bypass at the Bypass Opening in 2002

Vehicle Type	Section 1 BP→ SH37	Section 2 SH37→ SH33	Section 3 SH33→ EP	Section 2 & 3 SH37→ EP	BP→ EP
Car	13	6	25	31	44
Light Commercial Vehicle	22	11	43	54	76
Truck/Bus	45	22	86	108	153
Two Wheelers	6	3	12	15	21

18.5.2 Methods of Toll Collection

As the most practical and simple method, the manual toll collection method with fixed toll rate at each toll barrier/tollgate was proposed for the project. Under the manual methods, payment will take place as the vehicle passes through the toll barrier/tollgate. As Gwalior Bypass only links to the existing road, NH3, at both ends, a toll collector will receive a fixed toll as listed in Table 18-5, give back the change, if any, and issue a receipt.

In case of Bareilly Bypass, the location layout of toll barriers/tollgates was established as shown in Figure 18-6. This arrangement enable to construct toll related facilities with the minimum cost, and to charge a toll to every vehicle who uses the bypass from NH24, SH37 and SH33. Furthermore, instead of additional tollgate arrangement to SH37 Interchange, it will be recommended from the viewpoint of administration of tollway bypass, by centralising toll related facilities including a operation & maintenance station to one location.

Although the vehicle who uses whole section of the bypass needs to stop two or three times for a toll payment, all toll barriers/tollgates will receive a fixed toll as shown in Table 18-6, by this arrangement. A fixed toll operation does not cause confusion to both drivers and toll collectors. Therefore it is strongly recommended to apply this method to avoid any mishandling of toll collection.

18.6 Justification of Installation of Tollgates at SH33 Interchange in Bareilly Bypass

By the basic concept of this Feasibility Study—the beneficiaries (driver) of the bypass ought to share the expenses for the bypass, toll barriers/tollgates were proposed to install in SH33 Interchange, to catch every bypass user from/to SH37 and SH33 Interchanges. However when the cost, related to toll collection from the user through interchanges, exceeds the revenue, it will be not recommendable to install toll barriers/tollgates at SH33 Interchange.

In this section, the feasibility of toll barriers/tollgates installation at SH 33 Interchange for the bypass users through interchanges was assessed. According to the future traffic demand forecast, the details of bypass traffic behaviour were estimated as shown in Tables 18-7 and 18-8. In the tables, toll barrier/tollgate name was presented in parentheses, where the bypass user through interchanges will pay the toll.

As illustrated in Figure18-2, at least two toll barriers at the entry point to the bypass will be required for the through traffic user of whole bypass section. Therefore the toll revenue from Gate B to D, and Gate F to H, which is related to bypass user through interchanges, were counted for this assessment purpose. The subjected traffic was shadowed in the Tables 18-7 and 18-8.

Table 18-7 Traffic Flows from Interchange - to Interchange in 2002

(Total Vehicles/day)

No.	Year 2002 Off IC / On IC	1 NH 24 (Delhi side)	2 SH 37	3 SH 33	4 NH 24 (Lucknow side)	Total
1	NH24 (Delhi side)		973 (Gate A)	1,125 (Gate A, B)	1,159	3,257
2	SH 37	1,105 (Gate H)		1,924 (Gate B)	1,067 (Gate D)	4,096
3	SH 33	1,151 (Gate G, H)	1,846 (Gate G)		805 (Gate C)	3,802
4	NH24 (Lucknow side)	1,030	1,105 (Gate E, F)	841 (Gate E)		2,976
Total		3,286	3,924	3,890	3,031	14,131

	On off Total of SH37 (4096+3924)		On off Total of SH33 (3802+3890)	
Car	2,588	32.3%	2,572	33.4%
Bus	1,023	12.8%	1,029	13.4%
Truck	2,592	32.3%	2,279	29.6%
2 Whls	1,817	22.7%	1,812	23.6%
Total	8,020	100.0%	7,692	100.0%

Table 18-8 Traffic Flows from Interchange - to Interchange in 2012

(Total Vehicles/day)

No.	Year 2012 Off IC / On IC	1 NH 24 (Delhi side)	2 SH 37	3 SH 33	4 NH 24 (Lucknow side)	Total
1	NH24 (Delhi side)		3,754 (Gate A)	2,804 (Gate A, B)	2,289	8,847
2	SH 37	4,107 (Gate H)		3,550 (Gate B)	1,855 (Gate D)	9,512
3	SH 33	2,841 (Gate G, H)	3,923 (Gate G)		2,517 (Gate C)	9,281
4	NH24 (Lucknow side)	2,050	1,913 (Gate E, F)	2,724 (Gate E)		6,687
Total		8,998	9,590	9,078	6,661	34,327

	On off Total of SH37 (9512+9590)		On off Total of SH33 (9281+9078)	
Car	6,100	31.9%	5,944	32.4%
Bus	2,651	13.9%	2,300	12.5%
Truck	5,814	30.4%	5,910	32.2%
2 Whls	4,538	23.8%	4,205	22.9%
Total	19,103	100.0%	18,359	100.0%

Based on the toll rate, presented in Table 21-19, "Toll Rates of Bareilly Bypass at Current Prices of Each Year", Chapter 21, and traffic volume with vehicle type shown in Tables 18-7 and 18-8, toll revenue from the bypass user through interchanges by additional toll barriers/tollgates were estimated as shown in Tables 18-9 and 18-10.

Table 18-9 Interchange Related Toll Revenue from Additional Toll Facility in 2002

($\times 10^6$ Rs./Year)

No.	Year 2002 Off IC / On IC	1 NH 24 (Delhi side)	2 SH 37	3 SH 33	4 NH 24 (Lucknow side)	Total
1	NH24 (Delhi side)			14.71 (from Gate B)		14.71
2	SH 37	9.98 (from Gate H)		8.33 (from Gate B)	23.19 (from Gate D)	41.50
3	SH 33	15.05 (from Gate H)	7.99 (from Gate G)		11.74 (from Gate C)	34.78
4	NH24 (Lucknow side)		24.01 (from Gate F)			24.01
Total		25.03	32.00	23.04	24.03	115.00

Table 18-10 Interchange Related Toll Revenue from Additional Toll Facility in 2012

($\times 10^6$ Rs./Year)

No.	Year 2012 Off IC / On IC	1 NH 24 (Delhi side)	2 SH 37	3 SH 33	4 NH 24 (Lucknow side)	Total
1	NH24 (Delhi side)			69.20 (from Gate B)		69.20
2	SH 37	68.99 (from Gate H)		27.57 (from Gate B)	74.26 (from Gate D)	170.82
3	SH 33	70.11 (from Gate H)	30.46 (from Gate G)		71.30 (from Gate C)	171.87
4	NH24 (Lucknow side)		76.58 (from Gate F)			76.58
Total		139.10	107.04	96.77	145.56	488.47

The construction cost for the additional toll related facilities intended to collect the toll from the bypass user through interchanges were extracted from Table 20-18, "Construction Cost of Bareilly Bypass (3/3)", Chapter 20, as follows.

Table 18-11 Construction Cost of Additional Toll Related Facilities

Unit : Rs. in 1997 price

Item	Sub item	Unit	Qty.	Ammount
Additional Toll Related Facilities	Toll barrier(Gate H)	Nos.	1	266,065
	Toll barrier(Gate D, F)	Nos.	2	532,131
	Toll gate(2booth) (Gate C)	Nos.	1	104,997
	Toll gate(3booth) (Gate B, G)	Nos.	2	279,826
	Sub operation office	Nos.	1	1,083,509
Total				2,266,528

Operation and Maintenance Cost required additionally was estimated as follows.

Operation Costs

(1) Personnel

As the scale (length) of Gwalior Bypass is very close to that of Bareilly Bypass, the difference of estimated personnel cost between two bypasses was counted. Referred to the estimated personnel costs in Chapter 20.4.2.1 and 20.4.3.1, the additional annual personnel costs was given as Rs. $5{,}270 \times 10^3$ in 1997 price.

(2) Toll machine maintenance and repair costs

The estimated additional annual toll machine maintenance and repair costs was Rs. 189×10^3 in 1997 price.

(3) Utilities and other operation expenses

The estimated additional annual utilities and other operation expenses was Rs. 56×10^3 in 1997 price.

(4) Overhead cost for corporate management

The additional annual overhead cost for corporate management was estimated as 0.5% of interchange related toll revenue which was listed in Tables 18-9 and 18-10.

Maintenance Costs

As for the additional maintenance costs, the lighting cost was counted out of three items listed in routine maintenance cost, i.e., Highway routine maintenance, Equipment maintenance and fuel, and Lighting. The additional maintenance cost was estimated as Rs. 78×10^3 in 1997 price.

Therefore the additional costs related to the toll collection from the bypass user through interchanges will be summarised as follows.

- Construction cost	:	Rs. $2{,}267 \times 10^3$ Construction was assumed to take place in 2001
- Operation and Maintenance Costs excluding Overhead	:	Rs. $5{,}593 \times 10^3$
- Overhead charge	:	0.5% of toll revenue related to the traffic through interchange

The justification of additional installation of toll barriers/tollgates at SH33 Interchange in Bareilly Bypass was conducted in financial basis considering 7%

annual inflation rate, and compared the net present value of Costs and Benefit (Toll Revenue) with the discount rate of 20%. Table 18-12 shows the assessment results.

Table 18-12 Financial Assessment Result for the Justification

Unit : Rs. $x10^3$

Fiscal Year	Benefit (B)	Cost (C)			Total Cost	Balance	Present Value		
	Toll Revenue	Construction Cost	Operation & Maintence	Overhead			B	C	B-C
1998							0	0	0
1999							0	0	0
2000							0	0	0
2001		2,972			2,972	-2,972	0	1,433	-1,433
2002	115,000		7,844	575	8,419	106,581	46,216	3,383	42,833
2003	152,347		8,393	762	9,155	143,192	51,021	3,066	47,955
2004	189,694		8,981	948	9,929	179,765	52,940	2,771	50,169
2005	227,041		9,609	1,135	10,744	216,297	52,802	2,499	50,304
2006	264,388		10,282	1,322	11,604	252,784	51,240	2,249	48,991
2007	301,735		11,002	1,509	12,511	289,224	48,732	2,021	46,711
2008	339,082		11,772	1,695	13,467	325,615	45,636	1,812	43,824
2009	376,429		12,596	1,882	14,478	361,951	42,219	1,624	40,595
2010	413,776		13,477	2,069	15,546	398,230	38,673	1,453	37,220
2011	451,123		14,421	2,256	16,677	434,446	35,136	1,299	33,838
2012	488,470		15,430	2,442	17,872	470,598	31,704	1,160	30,544
2013	522,663		16,510	2,613	19,123	503,540	28,270	1,034	27,235
2014	559,249		17,666	2,796	20,462	538,787	25,207	922	24,285
2015	598,397		18,903	2,992	21,895	576,502	22,476	822	21,654
2016	640,285		20,226	3,201	23,427	616,858	20,041	733	19,308
2017	685,104		21,642	3,426	25,068	660,036	17,870	654	17,216
2018	733,062		23,157	3,665	26,822	706,240	15,934	583	15,351
2019	784,376		24,778	3,922	28,700	755,676	14,208	520	13,688
2020	839,282		26,512	4,196	30,708	808,574	12,669	464	12,205
2021	898,032		28,368	4,490	32,858	865,174	11,296	413	10,883
2022	960,894		30,354	4,804	35,158	925,736	10,073	369	9,704
2023	1,028,157		32,479	5,141	37,620	990,537	8,981	329	8,653
2024	1,100,128		34,752	5,501	40,253	1,059,875	8,008	293	7,715
2025	1,177,137		37,185	5,886	43,071	1,134,066	7,141	261	6,880
2026	1,259,537		39,788	6,298	46,086	1,213,451	6,367	233	6,134
2027	1,347,704		42,573	6,739	49,312	1,298,392	5,677	208	5,470
2028	1,442,043		45,553	7,210	52,763	1,389,280	5,062	185	4,877
2029	1,542,986		48,742	7,715	56,457	1,486,529	4,514	165	4,349
2030	1,650,996		52,153	8,255	60,408	1,590,588	4,025	147	3,878
2031	1,766,565		55,804	8,833	64,637	1,701,928	3,589	131	3,458
							727,732	33,237	694,495

According to the above assessment, the present vale (1997 price) of benefit (toll revenue) shows Rs, $727,732 \times 10^3$ and the present value of costs shows Rs. $33,237 \times 10^3$. The derived net present value (B-C) was Rs. $+694,495 \times 10^3$ in 1997 price, and B/C shows quite high value of 21.9.

It will be concluded that to provide toll collection facilities for the bypass users through interchanges is worthwhile from the viewpoint of bypass operation.

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Chapter 19
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19 Operation and Maintenance System

19.1 General

Any kind of infrastructure, however sophisticatedly designed and built, would eventually deteriorate and lose its function, unless it were properly maintained and operated. A newly built highway, as well, requires deliberate attention and care in this regard. A National Highway bypass built as a toll road must also attain much higher levels of traffic smoothness, safety, and comfort so as to attract more users to it. Thus the concessionaire has to provide its own personnel, facilities, and equipment for operation and maintenance of the National Highway Bypass. O/M stations which accommodate this personnel and equipment should be located in the site of the highway. In the cases of the two Bypasses under the Study, it is recommended that one O/M station be built beside the highway and adjacent to one of the toll plazas.

19.2 Operation and Maintenance Programme

19.2.1 General Plan of an O/M Station

An O/M station in charge of highway maintenance and toll collection generally consists of buildings for management/administration offices and rooms for toll collection, facility control and communication machines, garages for maintenance vehicles, warehouses, parking spaces, etc. The standard spatial requirement for an O/M station whose responsibility covers the entire length of a single medium-sized (about 30 kms) toll highway bypass, though its configurations are diverse, would be assumed as below:

- Building for offices 1,500 sq. m.
- Building for machines 500 sq. m.
- Building for garages 1,000 sq. m.
- Warehouse 500 sq. m.
- Parking spaces 8,000 sq. m.

If a toll road has more than one toll plazas, a substation ,under the O/M station, in charge of toll collection only is needed for each additional toll plaza, which would require about one forth of the above area ,in aggregate, for buildings for offices and machines and parking lot.

19.2.2 Personnel for an O/M Station

Personnel to be staffed for operation and maintenance of a 24-hour open toll road includes such manpower as for management, administration, civil engineering maintenance/repair/reconstruction, equipment (mechanical, electric, architectural, communication, etc.) maintenance, toll collection, security and so on. Each category

generally consists of a combination of different personnel rankings such as managers, clerks, technical specialists, and labourers.

Table 19-1 Personnel Composition of an O/M Station

	Managers	Clerical/ Engineers	Tech. Specialists	Labourers
Management	O	O		
Administration		O		
Civil Eng. Maintenance	O	O	O	O
Equipment Maint.		O	O	O
Toll Collection	O	O		
Security		O	O	
Others				O

19.2.3 Equipment for an O/M Station

The equipment required for such a typical O/M station as mentioned above would be assumed as shown in Table 19-2.

19.3 Operation and Maintenance Activities

19.3.1 Toll Collection

A toll fixed for each of the four vehicle classes is paid by the user who stops at the toll gate and collected manually by the attendant in the corresponding booth, who then hands over the receipt and the change, if any. The toll plazas are operated 24 hours a day and attendants in charge are usually mobilised on a three-shift basis. Tolls collected at opening booths are periodically conveyed and kept in the O/M station/substation. Data on collected tolls and traffic should be systematically and incessantly computed and recorded.

Toll collection management to be undertaken by the O/M station includes routine checking of tolls and traffic data, safekeeping of collected tolls, periodic transfer to the bank account, bookkeeping, assignment of attendants to the booths, supply of materials to the toll plaza, maintenance of toll collection machines, and so on.

Responsibilities for such matters as policy and strategy formulation for and overall management of toll collection, accounting, and auditing will be generally taken by the headquarters of the concessionaire rather than the O/M station.

Table 19-2 Maintenance Equipment for an O/M Station

Item	Quantity
Sedans	3
Vans	4
Light Trucks	1
Heavy Trucks	2
Water Trucks	1
Lift Trucks	1
Sign Trucks	4
Tow Trucks	1
Sweepers	1
Portable Generators	4
Power Mowers	5
Chain Saws	1
Tampers	1
Miscellaneous Hand Tools	Lump sum

19.3.2 Road Maintenance

Road maintenance to be performed by an O/M station comprise two types of activities; one being routine maintenance, and the other periodic one. The former is supposed to be performed by personnel and equipment of the O/M station itself, while the latter by contractors on a respective tender basis. They include the followings.

A. Routine maintenance

(1) Road cleaning: pavement surface cleaning by sweepers and/or sprinklers with manual pick-up of large objects, manual cleaning of roadside facilities such as parking lots and arboriculture, machine/manual cleaning of guard rails, signs, delineators, drainage, expansion joints and lighting

(2) Minor repairs of earthworks: repair of slope structure and drainage, removal of slid soils and rocks

(3) Bridge repairs: repairs of expansion joints, shoes, railings, etc.

(4) Repairs of traffic control devices: repairs of guard rails, repair and/or renewal of signs, repainting of pavement markings

(5) Pavement repairs: pot-hole fitting, crack sealing, damaged portion patching, partial adjustment of longitudinal irregularity of vertical alignment

(6) Vegetation control: weeding of slopes and medians, trimming of over-grown trees

(7) Facility maintenance: maintenance/renewal of lighting, power system, communication, and equipment

(8) Inspection: regular daily inspection by patrol cars of road conditions, less frequent but periodic on-foot visual inspection of structures, extra inspection of the road under unusual conditions for prevention of emergencies

B. Periodic maintenance

(1) Pavement overlay: pavement resurfacing or overlay in the interval depending upon the traffic volume and composition

(2) Bridge repainting: repainting of steel bridges in the interval depending upon climatic and geographical conditions

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20 Cost Estimates

20.1 Unit Cost of Major Work Item

The construction cost of the proposed bypass were estimated on the basis of "MoST Standard Data Book For Analysis of Rates"

20.1.1 Unit cost analysis

In order to establish the unit cost for the Study the following three components of unit costs were analysed.

(1) Labour Cost

Latest information of Labour Costs were obtained from PWD Bareilly, PWD Gwalior and local contractors in Gwalior. "Schedule of Rates of Govt. of Maharashtra", "Schedule of Rates For National Highways Wing, Bihar" and "Delhi Schedule of Rates" were also reviewed for the reference. Table 20-1 shows the summary of labour cost obtained from these sources.

(2) Machinery and Equipment cost

In order to calculate the hire charge cost of Machinery and Equipment, formula in "Hand Book on Road Construction Machinery, MoST 1985" were adopted. Latest cost of Machinery and Equipment were enquired from manufacturer/importers in Delhi. Basic cost of machinery is summarised in Table 20-2 and applied formula of hire charge cost is shown in Table 20-3.

(3) Material Cost

Latest information of Material Costs were obtained form PWD Bareilly, PWD Gwalior and local contractors in Gwalior. "Schedule of Rates In National Highway Zone P.W.D. Madhya Pradesh", "Schedule of Rates of Govt. of Maharashtra", "Schedule of Rates For National Highways Wing, Bihar" and "Delhi Schedule of Rates" were also revised for the reference. Table 20-4 shows the summary of material cost obtained form these sources.

20.2 Construction Cost Estimates

20.2.1 Condition of Construction Cost Estimates

20.2.1.1 General

The construction cost estimates was carried out in accordance with the following basic assumption and conditions.

(1) The project cost was based on the prices in the month of March 1998 (FY 1997)

(2) The exchange rate of currency was:
US$1.0=Rs. 39.15 (Average in February, 1998)

(3) Ratio of local/foreign portion of major construction materials were discussed with and recommended by the Most as shown in Table 20-5.

(4) Cost for preparatory work was assumed as Lump sum amount of 30 million Rupees.

(5) Contractor's profit and overhead charges were assumed as follows:

- 15% of Labour Cost
- 10% of hire charge of Machinery and Equipment
- 10% of Material Cost

Table 20-1 Labour Cost Data

Rs./day

Description	Bareilly	Gwalior		Maharashtra	Bihar	Delhi
	PWD	PWD	Contractor	Schedule of Rate	Schedule of Rate	Schedule of Rate
Diver						500 *
Mechanic	88	150~200	120	84.4		
Operator	50	150~200	150			
Supervisor	52	120	100		65	
Mate	52	120	70		42.9	
Carpenter I	88	150	100	84.4	48.1	110
Mason I	88	125~150	110	84.4	54	110
Welder				78.4	59.2	100
Blacksmith	75	120	90	78.4	48.1	110
Bandhani	45	100	100			75
Carpenter II				78.4		90
Mason II				78.4	48.1	90
Driller				78.4		65
Blaster					67	65
Chiseller						75
Breaker						
Dresser	50	75	80			
Sprayer	45	75	80	78.4		70
Bhisti	50	80	70	76.4		71
Fitter				78.4		
Mazdoor	50	60	55	73.4	39.7	

* MOST Standard Data Bood For Analysis of Rate

Table 20-4 Material Cost Data

	Material	Unit	Bareilly		Gwalior		Maharashtra	Bihar	Delhi	MOST
			PWD	Carriage	Schedule of Rate	Contractor	Schedule of Rate	Schedule of Rate	Schedule of Rate and Contractor	Standard data book for analysis of rates
Steel	Mild steel		16,700	300			15,500		14,350	
	H.Y.S.D	tonne	16,700	300	15,000	15,700~16,500	16,000	14,000	14,500	
	Binding wire	tonne					26	22		
	Structure steel	tonne					20,000			
	Copper plate	tonne							160,000	
	H.T. Strand	tonne							42,000	
	Nuts, bolts	kg							280	
Cement	Cement	tonne	3,000		3,000	2,260	2,600	2,700~3,200	2,525	
Bitumen	Packed	tonne	8,500	500	6,000		5,528	5,838		
	Bulk		8,000	500	6,000		4,768	5,044		
	Emulsion		11,650	350	9,000		7,100		6,500~8,220	
	Premoulded joint filler 20 mm thick	m2							378	
Brick	Brick	1000 nos.	1,500				1,600			
Aggregate	75 mm broken stone	m3	210	150	70	140*		105	220	
Sand	63 mm broken stone	m3	220	150	80	140*	90	115	225	
Stone	45 mm broken stone	m3	230	150	95	160*	95		230	
	45 mm crushed stone	m3	230	150	140	300*	210	140	230	
	26.5 mm crushed stone	m3	240	150	185	400*	240	150	240	
	22.4 mm crushed stone	m3	250	150	185	400*	290	160	265	
	13.2 mm crushed stone	m3	255	150	210	350*		270	270	
	11.2 mm crushed stone	m3	254	150	210	350*	290	206	270	
	6.7 mm crushed stone	m3	230	150	120	300*	200	115	280	
	Crushed stone dust	m3			50	200*		38		
	Coarse sand	m3				190*			315	
	Sand (screen)	m3				190*	80		175	
	Sand	m3	200	150	50	190*	60			
	Moorum	m3			18	100*	18	45	190	
	Gravel	m3			45	130*				
	Boulder	m3	270	150				80		
	Bajri	m3							214	
	Bentonite	m3							3,000	1,500
	Through and bond stone	m3							115	
Wood products	Sal ballies								30	
	Ply wood 25 mm							270		
	Ply wood 20 mm							235		
	Ply wood 12 mm							160		
	Ply wood 6 mm							110		
Others	Sheathin pipe	m							60	
	Safety fuse wire	coil								200
	Neoprene nodules	kg							7	
	Special Gelatine 80%	kg							18	
	Fibre board 20 mm thick	m2							325	
	Admixture	kg								75

* 25km lead included

Table 20-2 Basic cost of Machinery

Machinery and Equipment	Basic cost (Rs.)
Road Roller 8 to 10 ton.	600,000
Vibratory Road Roller 8.5t	2,500,000
Hot Mix Plant 40-60tonne	28,000,000
Paver Finisher with sensor device 700 to 800t/hr.	7,500,000
Tipper/Dumper 5 to 6 Ton.	625,000
Tipper 10 Ton.	690,000
Bitumen Boiler Oil Fed 1500lts.	200,000
Bating Plant(30m³/hour)	5,170,000
Concrete Pump(27m³/hour)	3,000,000
Transit Mixer	1,400,000
Shovel 1.0m³	4,200,000

Table 20-3 Formula of Hire Charge Cost of Machinery and Equipment

Item		
Ownership charge	A)	Total investment at site of work
	B)	Deduct salvage value 15% of A)
	C)	Total investment to be depreciated
	D)	Economic life in hours
	E)	Depreciation per hour
	F)	Strage charge per hour 1% of E)
	G)	Total ownership charge E)+F)
	H)	Contractor's interest and insurance charge
	I)	Total ownership charge for Contractor E)+F)+H)
Operational charge	J)	Repair charge per hour 150% of E)
Overhead charge	K)	5% of ownership and operatinal charge
Running charge	L)	Operater
	M)	Diesel
	N)	Mobil & Grease,others
	O)	Total running charge L)+M)+N)
Total Hire Charge		

Table 20-5 Ratio of Foreign Portion and Local Portion

	Local Portion %	Foreign Portion %
Steel	100	0
Cement	100	0
Bitumen	90	10
Diesel	60	40
Machinery	90	10

20.2.1.2 Conditions for Bareilly Bypass

(1) Labour Cost

Latest information of Labour Costs was obtained from PWD Bareilly. "Schedule of Rates of Govt. of Maharashtra", "Schedule of Rates For National Highways Wing, Bihar" and "Delhi Schedule of Rates" were also reviewed for the reference. Table 20-6 shows the summary of labour cost obtained from these sources.

(2) Machinery and Equipment cost

In order to calculate the hire charge cost of Machinery and Equipment, formula in "Handbook On Road Construction Machinery 1985, MoST" were adopted. Latest cost of Machinery and Equipment were enquired from manufacturer/importer in Delhi. Basic cost of Hire charges of Machinery and Equipment applied for the cost estimates are shown in Table 20-7. The procedures of calculation of hire charge are shown in "Breakdown of Cost Estimates".

(3) Material Cost

Latest information of Material Costs was obtained form PWD Bareilly. "Schedule of Rates In National Highway Zone P.W.D. Madhya Pradesh", "Schedule of Rates of Govt. of Maharashtra", "Schedule of Rates For National Highways Wing, Bihar" and "Delhi Schedule of Rates" were also reviewed for the reference. Carriages of Sand, Aggregate and Gravel, etc. were applied 150 Rupee with the assumption of approximately 90km hauling distance from quarry site. Table 20-8 shows the summary of material cost obtained form these sources.

(4) Analysis of Rates

Analysis of Rates was calculated based on the updated data listed in Table 20-6 to Table 20-8. In order to calculate Analysis of Rates, "Standard Data Book For Analysis of Rates of MoST" was applied. Table 20-9 shows the summary of Analysis of Rates and the procedures of calculation are shown in "Breakdown of Cost Estimates.

(5) Schedule of Rates

Schedule of Rates was calculated on the basis of Analysis of Rates. Table 20-10 shows the Schedule of Rates applied the cost estimates of the project. The procedures of calculation are shown in "Breakdown of Cost Estimates.

Table 20-6 Labour Cost Data for Bareilly Bypass

Description	Unit	Rate		Remarks
		Rs.	US$	
Diver	Each	500	0	Labour1
Mechanic	Each	90	0	Labour2
Operator	Each	90	0	Labour3
Supervisor	Each	90	0	Labour4
Mate	Each	90	0	Labour5
Carpenter	Each	90	0	Labour6
Mason	Each	90	0	Labour7
Welder	Each	80	0	Labour8
Blacksmith	Each	80	0	Labour9
Bandhani	Each	80	0	Labour10
Carpenter2	Each	80	0	Labour11
Mason2	Each	80	0	Labour12
Driller	Each	60	0	Labour13
Blaster	Each	60	0	Labour14
Chiseller	Each	60	0	Labour15
Breaker	Each	60	0	Labour16
Dresser	Each	60	0	Labour17
Sprayer	Each	60	0	Labour18
Bhisti	Each	60	0	Labour19
Fitter	Each	60	0	Labour20
Blacksmith2	Each	60	0	Labour21
Mazdoor	Each	50	0	Labour22

Table 20-7 Hire Charge Cost of Machinery and Equipment for Bareilly Bypass

Item	Unit	Department		Contractor		Remarks
		Rs.	US$	Rs.	US$	
Road roller 8 to 10 ton.	hour	185.9	1.2	212.4	1.1	Machinery1
F.E. loader (1m3)	hour	327.9	3.5	363.3	3.4	Machinery2
Vibratory road roller 8.5t	hour	559.4	2.3	669.9	2.2	Machinery3
Motor grader	hour	1,039.5	4.1	1,304.8	5.0	Machinery4
Motorised scraper	hour	1,097.1	4.5	1,318.2	5.4	Machinery5
Dozer	hour	966.1	4.2	1,156.3	4.7	Machinery6
Hot Mix Plant 40-60tonne	hour	3,967.7	11.5	5,073.3	51.1	Machinery7
Paver finisher 700ton/hr.	hour	1,168.7	4.0	1,478.3	5.5	Machinery8
Paver finisher with sensor device	hour	1,247.4	4.2	1,579.1	6.1	Machinery9
Crawler tractor	hour	138.7	0.9	158.6	0.8	Machinery10
Tipper/Dumper 5 to 6 Ton.	hour	157.4	1.0	185.0	1.0	Machinery11
Tipper 10 Ton.	hour	162.5	1.4	193.0	1.3	Machinery12
Bitumen boiler oil fed 1500lt.	hour	64.9	0.2	73.8	0.1	Machinery13
Concrete mixer	hour	61.6	0.6	63.7	0.6	Machinery14
Needle vibrator	hour	37.1	0.3	38.4	0.2	Machinery15
Pug mill	hour	43.6	0.3	48.0	0.2	Machinery16
Drilling equipment	hour	263.8	0.9	316.9	0.7	Machinery17
Batching plant (30m3/hour)	hour	1,147.1	4.9	1,375.7	5.9	Machinery18
Transit mixer	hour	409.3	2.0	471.2	1.8	Machinery19
Concrete pump (27m3/hour)	hour	945.5	3.3	1,078.2	3.7	Machinery20
Grab dredging crane	hour	489.6	1.8	613.4	1.8	Machinery21
Shovel (1.0m3)	hour	862.6	5.1	1,048.4	5.3	Machinery22
Truck mounted water tanker	hour	210.8	1.0	241.4	0.9	Machinery23

Table 20-8 Material Cost for Bareilly Bypass

Material	Unit	Basic cost		Remark
		Rs.	US$	
Mild steel	tonne	16,700.0	0.00	Material1
H.Y.S.D	tonne	16,700.0	0.00	Material2
Binding wire	kg	26.0	0.00	Material3
Structure steel	tonne	20,000.0	0.00	Material4
Copper plate	tonne	160,000.0	0.00	Material5
H.T.Strand	tonne	42,000.0	0.00	Material6
Nuts,bolts	kg	280.0	0.00	Material7
Cement	tonne	2700.0	0.00	Material8
Admixture	Lt.	75.0	0.00	Material9
Bitumen	tonne	10,485.0	29.76	Material10
Premoulded joint filler 20mm thick	m^2	340.2	0.97	Material11
Diesel	Lt.	6.3	0.11	Material12
Oil	Lt.	13.2	8.80	Material13
Brick	nos.	1.5	0.00	Material14
Aggregate40mm	m^3	230.0	0.00	Material15
Aggregate20mm	m^3	250.0	0.00	Material16
Aggregate15mm	m^3	250.0	0.00	Material17
Aggregate10mm	m^3	250.0	0.00	Material18
Aggregate5mm	m^3	230.0	0.00	Material19
Bajri	m^3	214.0	0.00	Material20
Crushed stone dust	m^3	200.0	0.00	Material21
Coarse sand	m^3	200.0	0.00	Material22
Sand	m^3	200.0	0.00	Material23
Moorum	m^3	130.0	0.00	Material24
Gravel	m^3	130.0	0.00	Material25
Boulder	m^3	270.0	0.00	Material26
Through and bond stone	m^3	270.0	0.00	Material27
Bentonite	m^3	3,000.0	0.00	Material28
Ply wood 25mm	m^2	270.0	0.00	Material29
Ply wood 6mm	m^2	110.0	0.00	Material30
Sal ballies	m	30.0	0.00	Material31
Neoprene nodules	kg	200.0	0.00	Material32
Safty fuse wire	coil	7.0	0.00	Material33
Special gelatine 80%	kg	18.0	0.00	Material34
Fiber board 20mm thick	m^2	325.0	0.00	Material35
Detonator	nos.	10.0	0.00	Material36
Sheathing pipe	m	54.0	0.15	Material37
Polyethene pipe 150mm	m	90.0	0.26	Material38
Carriage of sand	m^3	150.0	0.00	Material39
Carriage of aggregate	m^3	150.0	0.00	Material40
Carriage of stone	m^3	150.0	0.00	Material41
Carriage of cement	tonne	300.0	0.00	Material42
Carriage of bitumen	tonne	350.0	0.00	Material43
Carriage of steel	tonne	300.0	0.00	Material44

Table 20-9 Analysis of Rates for Bareilly Bypass (1/2)

Item	Unit	Rate		Sl.No.	MOST Spec.	Analysis of rates
		Rs.	US$			
Cleaning and grubbing	Ha	1112.0	5.13	3	201	Analysis of rates1
Excavation	m3	31.1	0.16	3	201	Analysis of rates2
Excavation Hard Rock	m3	149.4	0.14	3	201	Analysis of rates3
Earth filling	m3	31.1	0.16	3	201	Analysis of rates4
Median	m	250.5	0.53	0	0	Analysis of rates5
Compaction of original ground	m2	1.3	0.00	6	305.3.4	Analysis of rates6
Laying earth	m3	12.9	0.05	7	305.3.5	Analysis of rates7
Compaction Rolling	m3	10.0	0.03	7	305.3.5	Analysis of rates8
Excavation for structure1 up to 3m	m3	57.5	0.00	1.1	304	Analysis of rates9
Excavation for structure2 3m to 6m	m3	71.0	0.00	1.1	304	Analysis of rates10
Excavation for structure3 above 6m	m3	92.0	0.00	1.1	304	Analysis of rates11
Excavation Hard Rock for structure	m3	191.2	0.14	1.1	304	Analysis of rates12
Sinking of well(sand)	m	6235.4	16.30	2.6	1200(N)	Analysis of rates13
Sinking of well(clay)	m	13130.9	32.59	2.6(b)	1200(N)	Analysis of rates14
Sand filling in well	m3	479.1	0.00	2.7	1207(N)	Analysis of rates15
Excavation in foundation trenches	m3	41.8	0.00	8	304	Analysis of rates16
Back filling behind abutment	m3	522.3	0.00	1.3	305	Analysis of rates17
Earth filling in foundation trench	m3	17.1	0.00	1.2	304	Analysis of rates18
Granular subbase service road	m3	480.2	0.06	1	404.3.2	Analysis of rates19
Granular subbase Grading I ,CBR=30	m3	631.2	0.45	3	401	Analysis of rates20
Water bound macadam(base)	m3	677.3	0.27	1	404	Analysis of rates21
Wet mix macadam(base)	m3	765.1	0.94	2	406	Analysis of rates22
Bituminous macadam(binding course)	m3	2042.9	6.72	6	504	Analysis of rates23
Dense bituminous macadam	m3	2737.1	8.46	8	507	Analysis of rates24
Premix carpet 20mm thick	m2	79.0	0.53	11(ii)	509	Analysis of rates25
Asphalt concrete	m3	2373.4	8.71	15	512	Analysis of rates26
Asphalt concrete bridge	m3	3977.4	11.99	4.6	2201&512	Analysis of rates27
Bitumen mastic	m3	28.7	0.28	4.7	515	Analysis of rates28
Tack coat	m2	9.9	0.03	5	503(B)	Analysis of rates29
Prime coat	m2	15.8	0.05	4	502(B)	Analysis of rates30
Brick masonry	m3	1070.7	0.00	7	1000/1300	Analysis of rates31
Plain cement concrete M15	m3	1412.0	0.46	2	1000/1700	Analysis of rates32
Culvert (Reinforced cement concrete M25)	m3	2362.5	0.46	4	1700	Analysis of rates33
Well curb M35	m3	3079.1	1.23	2.5(i)	1200(N), 1500(N)&1700(N)	Analysis of rates34
Well steining M35	m3	3074.4	1.23	2.5(i)	1200(N), 1500(N)&1700(N)	Analysis of rates35
Bottom plug M25	m3	3160.6	1.28	2.5(i)	1200(N), 1500(N)&1700(N)	Analysis of rates36
Intermediate plug M25	m3	2394.1	1.08	2.5(i)	1200(N), 1500(N)&1700(N)	Analysis of rates37
Well cap M35	m3	2705.6	1.08	2.5(i)	1200(N), 1500(N)&1700(N)	Analysis of rates38
Cast in Situ Pile(D=1000mm)	m	3047.4	6.98	2.11	1100(N), 1600(N)&1700(N)	Analysis of rates39
Substructure Reiforced cement concrete M25	m3	2761.7	1.22	3.3(b)	1500&1700	Analysis of rates40
RC_Slab M25	m3	3172.7	1.41	4.1(ii)(a)	1500&1700	Analysis of rates41
RC_Slab M30	m3	3303.3	1.41	4.1(ii)(b)	1500&1700	Analysis of rates42
RC_Tbeam M30	m3	3542.4	1.52	4.1(ii)	1500&1700	Analysis of rates43
PC_Hollow M40	m3	4499.7	1.52	4.2	1500(N)&1700(N)	Analysis of rates44
RC_Railing	m	637.3	0.15	4.8	1500,1600,1700&2200	Analysis of rates45
Approach slab	L.S.	20467.6	2.43	4.12	1500,1600,1700&2200	Analysis of rates46
HYSD(culvert)	tonne	20859.6	0.00	6	1000/1600	Analysis of rates47
HYSD(foundation)	tonne	20811.5	0.00	2.8	1600(N)	Analysis of rates48
HYSD(substructure)	tonne	20811.5	0.00	3.5	1600(N)	Analysis of rates49
HYSD(superstructure)	tonne	20954.5	0.00	4.3	1600(N)	Analysis of rates50
PC_strand	tonne	63895.7	21.25	4.4	1800(N)	Analysis of rates51
Cutting edge for well foundation	tonne	38503.5	0.00	2.4	1200(N)&1900(N)	Analysis of rates52
Elastomeric bearings	Each	14584.2	0.00	3.9	2000(N)	Analysis of rates53
Providing galvanised mild steel plate	m	468.0	0.00	3.13(a)	2100(N)	Analysis of rates54
Providing and laying expansion joints	m	814.8	0.00	3.13(b)	2100	Analysis of rates55
Providing and fixing fibre board	m	172.4	0.00	3.13(b)	2100	Analysis of rates56
Providing joint filler	m	176.5	0.27	3.13(b)	2100	Analysis of rates57
Providing and filling joint sealing compound	m	3.8	0.00	3.13(b)	2100	Analysis of rates58
Expansion joint	m	1635.5	0.27	3.13	2100	Analysis of rates59
Laying apron(boulder)	m3	668.8	0.00	5.1	2500(N)	Analysis of rates60

Table 20-9 Analysis of Rates for Bareilly Bypass (2/2)

Item	Unit	Rate		Sl.No.	MOST Spec.	Analysis of rates
		Rs.	US$			
Coarsed rubble masonary(foundation for culvert)	m3	1653.8	0.00	10	1000/1400	Analysis of rates61
Precast Cement Concrete Kerb	m	120.7	0.24	1	1000/1700	Analysis of rates62
Berm ditch	m	105.9	0.03	0	0	Analysis of rates63
Side ditch	m	302.7	0.08	0	0	Analysis of rates64
Veritical drain	m	97.8	0.13	0	0	Analysis of rates65
Turfing slopes of new banks	m2	1.8	0.00	14	307	Analysis of rates66
Planting plants and shrubs	m	14.0	0.00	22(i)	307	Analysis of rates67
Roof setting of toll gate	Each	7244.7	0.00	0	Japanese standard	Analysis of rates68
Anchorage setting of toll gate	Each	27761.5	4.16	0	Japanese standard	Analysis of rates69

Table 20-10 Schedule of Rates for Bareilly Bypass

Item	Unit	Rate		STA	Schedule of rates
		Rs.	US$		
RDCBL_cell 1	Each	2,215,110.4	209.7		Schedule of rates1
RDCBM_cell 1	Each	1,711,724.4	160.8		Schedule of rates2
RDCBS_cell 1	Each	1,011,447.4	93.8		Schedule of rates3
WCCBS_cell 2	Each	1,022,117.5	90.5		Schedule of rates4
RDBR1_Superstructure	Each	19,439,036.0	5,807.3	STA 9+040	Schedule of rates5
RDBR1_Substructure	Each	16,381,359.6	3,293.2	STA 9+040	Schedule of rates6
RDBR1_Foundation	Each	4,406,521.4	10,096.2	STA 9+040	Schedule of rates7
RDBR2_Superstructure	Each	1,964,842.4	749.6	STA13+610	Schedule of rates8
RDBR2_Substructure	Each	9,224,479.3	1,826.3	STA13+610	Schedule of rates9
RDBR2_Foundation	Each	2,642,084.4	6,053.4	STA13+610	Schedule of rates10
RDBR3_Superstructure	Each	893,421.3	334.4	STA22+900	Schedule of rates11
RDBR3_Substructure	Each	7,486,934.3	1,400.8	STA22+900	Schedule of rates12
RDBR3_Foundation	Each	2,431,814.6	5,571.6	STA22+900	Schedule of rates13
ICBR1_Superstructure	Each	1,964,842.4	749.6	STA 8+700	Schedule of rates14
ICBR1_Substructure	Each	9,164,365.8	1,826.8	STA 8+700	Schedule of rates15
ICBR1_Foundation	Each	2,797,501.0	6,409.7	STA 8+700	Schedule of rates16
ICBR2_Superstructure	Each	1,964,842.4	749.6	STA 13+300	Schedule of rates17
ICBR2_Substructure	Each	9,164,365.8	1,826.8	STA 13+300	Schedule of rates18
ICBR2_Foundation	Each	2,797,501.0	6,409.7	STA 13+300	Schedule of rates19
WCBR1_Superstructure	Each	3,816,149.1	1,430.3	STA 7+900	Schedule of rates20
WCBR1_Substructure	Each	13,678,397.7	2,573.2	STA 7+900	Schedule of rates21
WCBR1_Foundation	Each	11,302,482.5	8,096.9	STA 7+900	Schedule of rates22
WCBR2_Superstructure	Each	3,816,149.1	1,430.3	STA 14+270	Schedule of rates23
WCBR2_Substructure	Each	13,737,725.9	2,533.9	STA 14+270	Schedule of rates24
WCBR2_Foundation	Each	14,058,616.1	9,545.7	STA 14+270	Schedule of rates25
WCBR3(Slab)_Superstructure	Each	3,303,100.4	950.0		Schedule of rates26
WCBR3(Slab)_Substructure	Each	5,679,201.7	1,271.0		Schedule of rates27
WCBR3(Slab)_Foundation	Each	2,376,961.9	5,446.0		Schedule of rates28
Toll barrier(BP&EP)	Each	775,435.4	1,305.9		Schedule of rates29
Toll barrier(SH33IC)	Each	816,655.6	1,519.8		Schedule of rates30
Toll gate(2booth)	Each	464,261.5	900.3		Schedule of rates31
Toll gate(3booth)	Each	1,167,873.7	2,632.0		Schedule of rates32
Interchange_SH37IC_1lane	Each	11,599,977.5	29,763.7	L=1380m	Schedule of rates33
Interchange_SH37IC_2lane	Each	11,065,235.4	26,705.2	L=750m	Schedule of rates34
Interchange_SH33IC_1lane	Each	11,684,035.4	29,979.4	L=1390m	Schedule of rates35
Interchange_SH33IC_2lane	Each	7,524,360.1	18,159.6	L=510m	Schedule of rates36
Main operation office	Each	10,341,562.6	7,373.2		Schedule of rates37
Sub operation office	Each	1,017,850.7	1,538.1		Schedule of rates38
Removing telepone line	m	1,559.6	1.3		Schedule of rates39
Removing power line	m	1,549.6	1.3		Schedule of rates40
Service road	km	2,078,165.6	3,329.8		Schedule of rates41
Road appurtenances	km	109,167.7	0.0		Schedule of rates42

20.2.1.3 Conditions for Gwalior Bypass

(1) Labour Cost

Latest information of Labour Costs was obtained from PWD Gwalior and local contractors in Gwalior. "Schedule of Rates of Govt. of Maharashtra", "Schedule of Rates For National Highways Wing, Bihar" and "Delhi Schedule of Rates" were also reviewed for the reference. Table 20-11 shows the summary of labour cost obtained from these sources.

(2) Machinery and Equipment cost

In order to calculate the hire charge cost of Machinery and Equipment, formula in "Handbook On Road Construction Machinery, MoST 1985" were adopted. Latest cost of Machinery and Equipment were enquired from manufacturer/importer in Delhi. Basic cost of Hire charges of Machinery and Equipment applied for the cost estimates are shown in Table 20-12. The procedures of calculation of hire charge are shown in "Breakdown of Cost Estimates".

(3) Material Cost

Latest information of Material Costs was obtained form PWD Gwalior and local contractors in Gwalior. "Schedule of Rates In National Highway Zone P.W.D. Madhya Pradesh", "Schedule of Rates of Govt. of Maharashtra", "Schedule of Rates For National Highways Wing, Bihar" and "Delhi Schedule of Rates" were also reviewed for the reference. Carriages of Sand, Aggregate and Gravel, etc. were applied 80 Rupee with the assumption of approximately 20 km hauling distance from quarry site. Table 20-13 shows the summary of material cost obtained from these sources.

(4) Analysis of Rates

Analysis of Rates was calculated based on the updated data listed in Table 20-11 to Table 20-13. In order to calculate Analysis of Rates, " Standard Data Book For Analysis of Rates of MoST" was applied. Table 20-14 and shows summary of Analysis of Rates and the procedures of calculation are shown in "Breakdown of Cost Estimates".

(5) Schedule of Rates

Schedule of Rates was calculated on the basis of Analysis of Rates. Table 20-15 shows the Schedule of Rates applied the cost estimates of the project. The procedures of calculation are shown in "Breakdown of Cost Estimates.

Table 20-11 Labour Cost Data for Gwalior Bypass

Description	Unit	Rate		Remarks
		Rs.	US$	
Diver	Each	500	0	Labour1
Mechanic	Each	150	0	Labour2
Operator	Each	150	0	Labour3
Supervisor	Each	120	0	Labour4
Mate	Each	120	0	Labour5
Carpenter	Each	120	0	Labour6
Mason	Each	120	0	Labour7
Welder	Each	100	0	Labour8
Blacksmith	Each	100	0	Labour9
Bandhani	Each	100	0	Labour10
Carpenter2	Each	100	0	Labour11
Mason2	Each	100	0	Labour12
Driller	Each	80	0	Labour13
Blaster	Each	80	0	Labour14
Chiseller	Each	80	0	Labour15
Breaker	Each	80	0	Labour16
Dresser	Each	80	0	Labour17
Sprayer	Each	80	0	Labour18
Bhisti	Each	80	0	Labour19
Fitter	Each	80	0	Labour20
Blacksmith2	Each	80	0	Labour21
Mazdoor	Each	60	0	Labour22

Table 20-12 Hire Charge Cost of Machinery and Equipment for Gwalior Bypass

Item	Unit	Department		Contractor		Remarks
		Rs.	US$	Rs.	US$	
Road roller 8 to 10 ton.	hour	200.9	1.3	227.4	1.2	Machinery1
F.E. loader (1m3)	hour	355.8	3.8	391.2	3.8	Machinery2
Vibratory road roller 8.5t	hour	574.4	2.4	685.0	2.3	Machinery3
Motor grader	hour	1057.2	4.2	1322.5	5.1	Machinery4
Motorised scraper	hour	1116.6	4.6	1337.7	5.6	Machinery5
Dozer	hour	986.2	4.4	1176.4	4.9	Machinery6
Hot Mix Plant 40-60tonne	hour	3979.7	11.6	5085.3	51.1	Machinery7
Paver finisher 700ton/hr.	hour	1183.8	4.1	1493.4	5.6	Machinery8
Paver finisher with sensor device	hour	1262.4	4.3	1594.1	6.2	Machinery9
Crawler tractor	hour	152.0	0.9	171.9	0.8	Machinery10
Tipper/Dumper 5 to 6 Ton.	hour	171.6	1.1	199.2	1.0	Machinery11
Tipper 10 Ton.	hour	178.8	1.5	209.3	1.4	Machinery12
Bitumen boiler oil fed 1500lt.	hour	75.2	0.2	84.0	0.1	Machinery13
Concrete mixer	hour	74.8	0.7	76.8	0.6	Machinery14
Needle vibrator	hour	48.3	0.3	49.7	0.3	Machinery15
Pug mill	hour	54.8	0.3	59.2	0.3	Machinery16
Drilling equipment	hour	275.1	0.9	328.1	0.7	Machinery17
Batching plant(30m3/hour)	hour	1168.1	5.0	1396.7	6.1	Machinery18
Transit mixer	hour	425.4	2.1	487.3	1.9	Machinery19
Concrete pump(27m3/hour)	hour	959.9	3.4	1092.6	3.8	Machinery20
Grab dredging crane	hour	502.9	1.9	626.7	1.8	Machinery21
Shovel (1.0m3)	hour	890.5	5.4	1076.2	5.6	Machinery22
Truck mounted water tanker	hour	224.0	1.1	254.5	0.9	Machinery23

Table 20-13 Material Cost for Gwalior Bypass

Material	Unit	Basic cost		Remark
		Rs.	US$	
Mild steel	tonne	15000.0	0.00	Material1
H.Y.S.D	tonne	15000.0	0.00	Material2
Binding wire	kg	26.0	0.00	Material3
Structure steel	tonne	20000.0	0.00	Material4
Copper plate	tonne	160000.0	0.00	Material5
H.T.Strand	tonne	42000.0	0.00	Material6
Nuts,bolts	kg	280.0	0.00	Material7
Cement	tonne	2700.0	0.00	Material8
Admixture	Lt.	75.0	0.00	Material9
Bitumen	tonne	8100.0	22.99	Material10
Premoulded joint filler 20mm thick	m2	340.2	0.97	Material11
Diesel	Lt.	6.9	0.12	Material12
Oil	Lt.	15.5	0.26	Material13
Brick	nos.	1.6	0.00	Material14
Aggregate40mm	m3	220.0	0.00	Material15
Aggregate20mm	m3	320.0	0.00	Material16
Aggregate15mm	m3	270.0	0.00	Material17
Aggregate10mm	m3	270.0	0.00	Material18
Aggregate5mm	m3	220.0	0.00	Material19
Bajri	m3	140.0	0.00	Material20
Crushed stone dust	m3	120.0	0.00	Material21
Coarse sand	m3	110.0	0.00	Material22
Sand	m3	110.0	0.00	Material23
Moorum	m3	20.0	0.00	Material24
Gravel	m3	50.0	0.00	Material25
Boulder	m3	250.0	0.00	Material26
Through and bond stone	m3	250.0	0.00	Material27
Bentonite	m3	3000.0	0.00	Material28
Ply wood 25mm	m2	270.0	0.00	Material29
Ply wood 6mm	m2	110.0	0.00	Material30
Sal ballies	m	30.0	0.00	Material31
Neoprene nodules	kg	200.0	0.00	Material32
Safty fuse wire	coil	7.0	0.00	Material33
Special gelatine 80%	kg	18.0	0.00	Material34
Fiber board 20mm thick	m2	325.0	0.00	Material35
Detonator	nos.	10.0	0.00	Material36
Sheathing pipe	m	54.0	0.15	Material37
Polyethene pipe 150mm	m	90.0	0.26	Material38
Carriage of sand	m3	80.0	0.00	Material39
Carriage of aggregate	m3	80.0	0.00	Material40
Carriage of stone	m3	110.0	0.00	Material41
Carriage of cement	tonne	300.0	0.00	Material42
Carriage of bitumen	tonne	350.0	0.00	Material43
Carriage of steel	tonne	300.0	0.00	Material44

Table 20-14 Analysis of Rates for Gwalior Bypass (1/2)

Item	Unit	Rate		Sl.No.	MOST Spec.	Analysis of rates
		Rs.	US$			
Cleaning and grubbing	Ha	1217.4	5.42	3	201	Analysis of rates1
Excavation	m3	41.2	0.21	3	201	Analysis of rates2
Excavation Hard Rock	m3	212.3	0.25	3	201	Analysis of rates3
Earth filling	m3	41.2	0.21	3	201	Analysis of rates4
Median	m	276.6	0.57	0	0	Analysis of rates5
Compaction of original ground	m2	1.5	0.00	6	305.3.4	Analysis of rates6
Laying earth	m3	13.3	0.05	7	305.3.5	Analysis of rates7
Compaction Rolling	m3	10.5	0.03	7	305.3.5	Analysis of rates8
Excavation for structure1 up to 3m	m3	69.0	0.00	1.1	304	Analysis of rates9
Excavation for structure2 3m to 6m	m3	85.2	0.00	1.1	304	Analysis of rates10
Excavation for structure3 above 6m	m3	110.4	0.00	1.1	304	Analysis of rates11
Excavation Hard Rock for structure	m3	215.8	0.14	1.1	304	Analysis of rates12
Sinking of well(sand)	m	6443.7	16.47	2.6	1200(N)	Analysis of rates13
Sinking of well(clay)	m	13547.5	32.93	2.6(b)	1200(N)	Analysis of rates14
Sand filling in well	m3	271.7	0.00	2.7	1207(N)	Analysis of rates15
Excavation in foundation trenches	m3	50.6	0.00	8	304	Analysis of rates16
Back filling behind abutment	m3	323.5	0.00	1.3	305	Analysis of rates17
Earth filling in foundation trench	m3	20.9	0.00	1.2	304	Analysis of rates18
Granular subbase service road	m3	268.4	0.06	1	404.3.2	Analysis of rates19
Granular subbase Grading Ⅰ,CBR=30	m3	525.0	0.46	3	401	Analysis of rates20
Water bound macadam(base)	m3	532.0	0.27	1	404	Analysis of rates21
Wet mix macadam(base)	m3	612.2	0.98	2	406	Analysis of rates22
Bituminous macadam(binding course)	m3	1640.3	5.93	6	504	Analysis of rates23
Dense bituminous macadam	m3	2366.2	7.39	8	507	Analysis of rates24
Premix carpet 20mm thick	m2	72.8	0.50	11(ii)	509	Analysis of rates25
Asphalt concrete	m3	2029.8	7.74	15	512	Analysis of rates26
Asphalt concrete bridge	m3	3483.2	10.57	4.6	2201&512	Analysis of rates27
Bitumen mastic	m3	28.4	0.27	4.7	515	Analysis of rates28
Tack coat	m2	8.1	0.02	5	503(B)	Analysis of rates29
Prime coat	m2	12.5	0.04	4	502(B)	Analysis of rates30
Brick masonry	m3	1149.7	0.00	7	1000/1300	Analysis of rates31
Plain cement concrete M15	m3	1477.0	0.49	2	1000/1700	Analysis of rates32
Culvert (Reinforced cement concrete M25)	m3	2330.2	0.49	4	1700	Analysis of rates33
Well curb M35	m3	3069.9	1.28	2.5(i)	1200(N), 1500(N)&1700(N)	Analysis of rates34
Well steining M35	m3	3065.3	1.28	2.5(i)	1200(N), 1500(N)&1700(N)	Analysis of rates35
Bottom plug M25	m3	3079.8	1.33	2.5(i)	1200(N), 1500(N)&1700(N)	Analysis of rates36
Intermediate plug M25	m3	2313.7	1.12	2.5(i)	1200(N), 1500(N)&1700(N)	Analysis of rates37
Well cap M35	m3	2650.4	1.12	2.5(i)	1200(N), 1500(N)&1700(N)	Analysis of rates38
Cast in Situ Pile(D=1000mm)	m	3098.7	3.35	2.11	1100(N), 1600(N)&1700(N)	Analysis of rates39
Substructure Reinforced cement concrete M25	m3	2705.4	1.27	3.3(b)	1500&1700	Analysis of rates40
RC Slab M25	m3	3111.0	1.46	4.1(ii)(a)	1500&1700	Analysis of rates41
RC Slab M30	m3	3243.6	1.46	4.1(ii)(b)	1500&1700	Analysis of rates42
RC Tbeam M30	m3	3478.7	1.57	4.1(ii)	1500&1700	Analysis of rates43
PC Hollow M40	m3	4563.9	1.57	4.2	1500(N)&1700(N)	Analysis of rates44
RC Railing	m	608.9	0.16	4.8	1500,1600,1700&2200	Analysis of rates45
Approach slab	L.S.	19203.7	2.53	4.12	1500,1600,1700&2200	Analysis of rates46
HYSD(culvert)	tonne	19209.5	0.00	6	1000/1600	Analysis of rates47
HYSD(foundation)	tonne	19193.0	0.00	2.8	1600(N)	Analysis of rates48
HYSD(substructure)	tonne	19193.0	0.00	3.5	1600(N)	Analysis of rates49
HYSD(superstructure)	tonne	19336.0	0.00	4.3	1600(N)	Analysis of rates50
PC strand	tonne	64275.5	20.88	4.4	1800(N)	Analysis of rates51
Cutting edge for well foundation	tonne	40091.5	0.00	2.4	1200(N)&1900(N)	Analysis of rates52
Elastomeric bearings	Each	14280.4	0.00	3.9	2000(N)	Analysis of rates53
Providing galvanised mild steel plate	m	421.3	0.00	3.13(a)	2100(N)	Analysis of rates54
Providing and laying expansion joints	m	816.4	0.00	3.13(b)	2100	Analysis of rates55
Providing and fixing fibre board	m	172.5	0.00	3.13(b)	2100	Analysis of rates56
Providing joint filler	m	176.6	0.27	3.13(b)	2100	Analysis of rates57
Providing and filling joint sealing compound	m	3.9	0.00	3.13(b)	2100	Analysis of rates58
Expansion joint	m	1590.7	0.27	3.13	2100	Analysis of rates59
Laying apron(boulder)	m3	625.0	0.00	5.1	2500(N)	Analysis of rates60

Table 20-14 Analysis of Rates for Gwalior Bypass (2/2)

Item	Unit	Rate		Sl.No.	MOST Spec.	Analysis of rates
		Rs.	US$			
Coarsed rubble masonary(foundation for culvert)	m3	1634.4	0.00	10	1000/1400	Analysis of rates61
Precast Cement Concrete Kerb	m	133.5	0.26	1	1000/1700	Analysis of rates62
Berm ditch	m	110.8	0.04	0	0	Analysis of rates63
Side ditch	m	327.0	0.08	0	0	Analysis of rates64
Veritical drain	m	102.2	0.14	0	0	Analysis of rates65
Turfing slopes of new banks	m2	2.0	0.00	14	307	Analysis of rates66
Planting plants and shrubs	m	14.0	0.00	22(i)	307	Analysis of rates67
Roof setting of toll gate	Each	7373.0	0.00	0	Japanese standard	Analysis of rates68
Anchorage setting of toll gate	Each	27898.9	4.22	0	Japanese standard	Analysis of rates69

Table 20-15 Schedule of Rates for Gwalior Bypass

Item	Unit	Rate		STA	Schedule of rates
		Rs.	US$		
Extra lead 13km	m3	34	0		Schedule of rates1
RDCBL_cell 1	Each	2,126,262	229		Schedule of rates2
RDCBM_cell 1	Each	1,643,422	176		Schedule of rates3
RDCBS_cell 1	Each	971,603	102		Schedule of rates4
WCCBL_cell 3	Each	4,354,941	453		Schedule of rates5
WCCBM_cell 3	Each	2,871,513	296		Schedule of rates6
WCCBM_cell 2	Each	2,019,817	208		Schedule of rates7
WCCBS_cell 1	Each	548,527	55		Schedule of rates8
ROB_Superstructure	Each	3,155,410	1,022	STA26+100	Schedule of rates9
ROB_Substructure	Each	7,903,212	1,863	STA26+100	Schedule of rates10
ROB_Foundation	Each	1,115,525	612	STA26+100	Schedule of rates11
WCBR1_Superstructure	Each	7,220,070	2,214	STA10+340	Schedule of rates12
WCBR1_Substructure	Each	6,418,562	1,442	STA10+340	Schedule of rates13
WCBR1_Foundation	Each	1,115,525	612	STA10+340	Schedule of rates14
WCBR2_Superstructure	Each	3,496,764	1,367	STA 12+720	Schedule of rates15
WCBR2_Substructure	Each	9,771,913	2,102	STA 12+720	Schedule of rates16
WCBR2_Foundation	Each	6,894,745	2,130	STA 12+720	Schedule of rates17
WCBR3(Slab)_Superstructure	Each	3,144,695	960	STA 7+760	Schedule of rates18
WCBR3(Slab)_Substructure	Each	5,300,177	1,344	STA 7+760	Schedule of rates19
WCBR3(Slab)_Foundation	Each	1,227,077	898	STA 7+760	Schedule of rates20
WCBR4(Slab)_Superstructure	Each	4,647,714	1,428	STA25+650	Schedule of rates21
WCBR4(Slab)_Substructure	Each	8,942,789	2,043	STA25+650	Schedule of rates22
WCBR4(Slab)_Foundation	Each	5,518,239	3,008	STA25+650	Schedule of rates23
Toll barrier(BP&EP)	Each	703,787	1,257		Schedule of rates24
Toll barrier(SH33IC)	Each	758,411	1,544		Schedule of rates25
Toll gate(2booth)	Each	414,676	863		Schedule of rates26
Toll gate(3booth)	Each	1,039,405	2,578		Schedule of rates27
Main operation office	Each	9,802,542	7,411		Schedule of rates28
Sub operation office	Each	904,543	1,520		Schedule of rates29
Removing telepone line	M	1,604	1		Schedule of rates30
Removing power line	M	1,594	1		Schedule of rates31
Service road	Km	1,632,915	3,294		Schedule of rates32
Road appurtenances	Km	109,168	0		Schedule of rates33

20.2.2 Estimated Construction Cost

Direct Construction Cost of Bareilly Bypass and Gwalior Bypass were estimated as shown in Tables 20-16 and 20-17, respectively. Details of the direct construction cost of both bypasses were presented in Tables 20-18 and 20-19, respectively.

Table 20-16 Direct Construction Cost of Bareilly Bypass

Item	Rs.	Local Portion Rs.	Foreign Portion US$	Ratio
1 Preparatory work	30,000,000	30,000,000	0	2.8%
2 Earthwork	178,972,500	159,622,700	494,200	16.9%
3 Pavement	351,318,400	330,365,500	535,200	33.1%
4 Culvert	42,603,800	42,492,600	2,800	4.0%
5 Bridge/Viaduct	218,740,600	216,420,000	59,300	20.6%
6 Toll gate	68,484,900	64,548,100	100,600	6.5%
7 Service road	134,938,400	129,205,300	146,400	12.7%
8 Drainage	16,721,700	16,327,500	10,100	1.6%
9 Utility Diversion	13,099,300	12,886,000	5,400	1.2%
10 Road appurtenances	3,482,400	3,482,400	0	0.3%
11 Horticulture	1,766,900	1,736,900	800	0.2%
12 Environmental Mitigation Measures	500,000	500,000	0	0.0%
Total of direct cost	1,060,628,900	1,007,587,000	1,354,800	

Table 20-17 Direct Construction Cost of Gwalior Bypass

Item	Rs.	Local Portion Rs.	Foreign Portion US$	Ratio
1 Preparatory work	30,000,000	30,000,000	0	3.8%
2 Earthwork	286,891,600	255,971,800	789,800	35.9%
3 Pavement	261,282,800	244,125,300	438,300	32.7%
4 Culvert	49,685,900	49,539,600	3,700	6.2%
5 Bridge/Viaduct	73,143,800	72,466,900	17,300	9.2%
6 Toll gate	26,910,200	25,500,400	36,000	3.4%
7 Service road	44,448,100	42,116,500	59,600	5.6%
8 Drainage	15,185,800	14,911,700	7,000	1.9%
9 Utility Diversion	6,751,700	6,596,100	4,000	0.8%
10 Road appurtenances	2,892,600	2,892,600	0	0.4%
11 Horticulture	1,613,300	1,589,200	600	0.2%
12 Environmental Mitigation Measures	500,000	500,000	0	0.1%
Total of direct cost	799,305,600	746,209,900	1,356,200	

Table 20-18 Construction Cost of Bareilly Bypass (1/3)

Item	Sub item	Unit	Qty.	Rate		Amount.		Remark
				Rs.	US$	Rs.	US$	
1 Preparatory work	Lab.Equipment,Accomodation And Vhicle, Etc.	LS				30,000,000		
SUB TOTAL(1)						**30,000,000**		
2 Earthwork	Cleaning and grubbing	Ha	247	1,162.49	3.76	287,136	929	Analysis of rates1
	Excavation	m^3	0	32.70	0.12	0	0	Analysis of rates2
	Excavation Hard Rock	m^3	0	150.59	0.11	0	0	Analysis of rates3
	Earth filling	m^3	2,691,780	32.70	0.12	88,027,801	320,668	Analysis of rates4
	Median include kerb	m	29,510	256.01	0.39	7,554,885	11,509	Analysis of rates5
	Laying earth	m^3	2,691,780	13.37	0.04	35,987,482	97,750	Analysis of rates7
	Compaction Rolling	m^3	2,691,780	10.31	0.02	27,765,421	63,391	Analysis of rates8
SUB TOTAL(2)						**159,622,724**	**494,247**	
3 Pavenent	Asphalt concrete	m^3	12,593	2,408.70	6.35	30,332,753	79,992	Analysis of rates26
	Dense bituminous macadam	m^3	42,285	2,865.03	6.46	121,148,003	272,992	Analysis of rates24
	Wet mix macadam(base)	m^3	112,874	805.05	0.83	90,868,916	93,290	Analysis of rates22
	Granular subbase Grading 1 ,CBR=30	m^3	110,405	669.23	0.52	73,886,039	57,653	Analysis of rates20
	Tack coat	m^2	817,584	10.11	0.02	8,268,107	18,241	Analysis of rates29
	Prime coat	m^2	362,108	16.19	0.04	5,861,643	13,027	Analysis of rates30
SUB TOTAL(3)						**330,365,462**	**535,196**	
4 Culvert	RDCBL_cell 1	Nos.	1	2,217,305.91	149.99	2,217,306	150	Schedule of rates1
	RDCBM_cell 1	Nos.	17	1,713,407.81	115.02	29,127,933	1,955	Schedule of rates2
	RDCBS_cell 1	Nos.	10	1,012,428.92	67.05	10,124,289	671	Schedule of rates3
	WCCBS_cell 2	Nos.	1	1,023,064.97	64.71	1,023,065	65	Schedule of rates4
SUB TOTAL(4)						**42,492,593**	**2,841**	
5 Bridge/Viaduct (Superstructure)	RDBR1_Superstructure STA 9+040	Nos.	1	12,694,857	3,269.86	12,694,857	3,270	Schedule of rates5

Table 20-18 Construction Cost of Bareilly Bypass (2/3)

Item	Sub item		Unit	Qty.	Rate		Amount.		Remark
					Rs.	US$	Rs.	US$	
	RDBR2_Superstructure	STA13+610	Nos.	1	2,594,592	660.54	2,594,592	661	Schedule of rates8
	RDBR3_Superstructure	STA22+900	Nos.	1	1,143,390	291.00	1,143,390	291	Schedule of rates11
	ICBR1_Superstructure	STA 8+700	Nos.	1	2,594,592	660.54	2,594,592	661	Schedule of rates14
	ICBR2_Superstructure	STA 13+300	Nos.	1	2,594,592	660.54	2,594,592	661	Schedule of rates17
	WCBR1_Superstructure	STA 7+900	Nos.	1	5,394,835	1,321.50	5,394,835	1,322	Schedule of rates20
	WCBR2_Superstructure	STA 14+270	Nos.	1	5,394,835	1,321.50	5,394,835	1,322	Schedule of rates23
	WCBR3(Slab)_Superstructure		Nos.	6	3,057,237	657.57	18,343,424	3,945	Schedule of rates26
(Substructure)	RDBR1_Substructure	STA 9+040	Nos.	1	16,056,853	2,380.04	16,056,853	2,380	Schedule of rates6
	RDBR2_Substructure	STA13+610	Nos.	1	8,930,534	1,298.96	8,930,534	1,299	Schedule of rates9
	RDBR3_Substructure	STA22+900	Nos.	1	7,213,431	989.90	7,213,431	990	Schedule of rates12
	ICBR1_Substructure	STA 8+700	Nos.	1	8,870,425	1,299.32	8,870,425	1,299	Schedule of rates15
	ICBR2_Substructure	STA 13+300	Nos.	1	8,870,425	1,299.32	8,870,425	1,299	Schedule of rates18
	WCBR1_Substructure	STA 7+900	Nos.	1	13,283,707	1,834.46	13,283,707	1,834	Schedule of rates21
	WCBR2_Substructure	STA 14+270	Nos.	1	13,245,069	1,749.50	13,245,069	1,750	Schedule of rates24
	WCBR3(Slab)_Substructure		Nos.	6	5,549,159	914.48	33,294,957	5,487	Schedule of rates27
(Foundation)	RDBR1_Foundation	STA 9+040	Nos.	1	4,453,568	3,256.58	4,453,568	3,257	Schedule of rates7
	RDBR2_Foundation	STA13+610	Nos.	1	2,670,297	1,952.47	2,670,297	1,952	Schedule of rates10
	RDBR3_Foundation	STA22+900	Nos.	1	2,457,790	1,797.02	2,457,790	1,797	Schedule of rates13
	ICBR1_Foundation	STA 8+700	Nos.	1	2,827,371	2,067.54	2,827,371	2,068	Schedule of rates16
	ICBR2_Foundation	STA 13+300	Nos.	1	2,827,371	2,067.54	2,827,371	2,068	Schedule of rates19
	WCBR1_Foundation	STA 7+900	Nos.	1	11,740,443	4,043.41	11,740,443	4,043	Schedule of rates22
	WCBR2_Foundation	STA 14+270	Nos.	1	14,508,602	5,082.53	14,508,602	5,083	Schedule of rates25
	WCBR3(Slab)_Foundation		Nos.	6	2,402,338	1,756.56	14,414,029	10,539	Schedule of rates28
SUB TOTAL(5)							216,419,987	59,276	
6 Toll gate	Toll barrier(BP&EP)		Nos.	3	264,771.18	33.06	794,314	99	Schedule of rates29
	Toll barrier(SH33IC)		Nos.	2	264,771.18	33.06	529,542	66	Schedule of rates30
	Toll gate(2booth)		Nos.	1	104,548.15	11.47	104,548	11	Schedule of rates31
	Toll gate(3booth)		Nos.	2	139,301.72	15.62	278,603	31	Schedule of rates32

Table 20-18 Construction Cost of Bareilly Bypass (3/3)

Item	Sub item	Unit	Qty.	Rate		Amount.		Remark
				Rs.	US$	Rs.	US$	
	Interchange_BP&EP_1lane	Nos.	1	6,282,292.11	11,335.01	6,282,292	11,335	Schedule of rates33
	Interchange_BP&EP_2lane	Nos.	1	6,291,615.22	11,288.73	6,291,615	11,289	Schedule of rates34
	Interchange_SH37IC_1lane	Nos.	1	7,407,691.17	13,449.80	7,407,691	13,450	Schedule of rates38
	Interchange_SH37IC_2lane	Nos.	1	10,893,660.74	19,779.15	10,893,661	19,779	Schedule of rates36
	Interchange_SH33IC_1lane	Nos.	1	12,037,805.84	23,438.66	12,037,806	23,439	Schedule of rates37
	Interchange_SH33IC_2lane	Nos.	1	7,407,691.17	13,449.80	7,407,691	13,450	Schedule of rates38
	Main operation office	Nos.	1	10,441,173.14	5,363.69	10,441,173	5,364	Schedule of rates39
	Sub operation office	Nos.	2	1,039,558.08	1,122.62	2,079,116	2,245	Schedule of rates40
SUB TOTAL(6)						**64,548,053**	**100,558**	
7 Service road	Service road	km	60.41	2,138,806.97	2,424.08	129,205,329	146,439	Schedule of rates43
SUB TOTAL(7)						**129,205,329**	**146,439**	
8 Drainage	Precast Cement Concrete Kerb	m	31,500	123.05	0.18	3,876,044	5,670	Analysis of rates62
	Berm ditch	m	3,400	106.29	0.02	361,391	68	Analysis of rates63
	Side ditch	m	31,980	303.50	0.06	9,706,026	1,919	Analysis of rates64
	Veritical drain	m	24,100	98.92	0.10	2,384,080	2,410	Analysis of rates65
SUB TOTAL(8)						**16,327,541**	**10,067**	
9 Utility Diversion	Removing power line	m	3,510.00	1,552.33	1.23	5,448,680	4,317	Schedule of rates42
	Removing telepone line	m	920.00	1,562.33	1.23	1,437,344	1,132	Schedule of rates41
	Removing HTL	L.S	1.00	6,000,000.00	0.00	6,000,000	0	
SUB TOTAL(9)						**12,886,024**	**5,449**	
10 Road appurtenances	Road appurtenances	km	31.90	109,167.65	0.00	3,482,448	0	Schedule of rates44
SUB TOTAL(10)						**3,482,448**	**0**	
11 Horticulture	Turfing slopes of new banks	m2	465,000	1.80	0.00	836,881	766	Analysis of rates66
	Planting plants and shrubs	L.S	1.00	900,000.00	0.00	900,000	0	Analysis of rates67
SUB TOTAL(11)						**1,736,881**	**766**	
12 Environmental Mitigation Measures	Construction of check dams/retaining walls/baffels etc.	L.S	1	500,000.00	0.00	500,000	0	
SUB TOTAL(12)						**500,000**	**0**	
TOTAL OF DIRECT COST						**1,007,587,042**	**1,354,838**	

Table 20-19 Construction Cost of Gwalior Bypass (1/3)

Item	Sub item		Unit	Qty.	Rate		Amount.		Remark
					Rs.	US$	Rs.	US$	
1 Preparatory work	Lab.Equipment,Accomodation And Vhicle, Etc.		LS				30,000,000.00		
SUB TOTAL(1)							**30,000,000**		
2 Earthwork	Cleaning and grubbing		Ha	218	1,271.39	4.04	277,162	881	Analysis of rates1
	Excavation	3km lead	m^3	165,905	43.33	0.16	7,188,470	26,296	Analysis of rates2
	Excavation Hard Rock	3km lead	m^3	165,905	214.21	0.20	35,538,095	33,181	Analysis of rates3
	Earth filling	3km lead	m^3	1,781,713	43.33	0.16	77,199,547	282,402	Analysis of rates4
	Median	include kerb	m	27,260	283.27	0.40	7,721,818	10,904	Analysis of rates5
	Extra lead 13km	4km to 13km	m^3	2,163,295	34.74	0.14	75,162,586	302,861	Schedule of rates1
	Laying earth		m^3	2,163,295	13.70	0.04	29,633,046	80,505	Analysis of rates7
	Compaction Rolling		m^3	2,163,295	10.75	0.02	23,251,037	52,748	Analysis of rates8
SUB TOTAL(2)							**255,971,762**	**789,778**	
3 Pavement	Asphalt concrete		m^3	11,122	2,023.51	5.67	22,505,503	63,104	Analysis of rates28
	Dense bituminous macadam		m^3	37,346	2,446.55	5.69	91,368,719	212,312	Analysis of rates26
	Wet mix macadam(base)		m^3	99,690	653.56	0.87	65,153,354	87,139	Analysis of rates24
	Granular subbase Grading I ,CBR=30		m^3	97,509	564.60	0.55	55,054,056	53,688	Analysis of rates22
	Tack coat		m^2	722,090	8.25	0.02	5,954,925	12,970	Analysis of rates31
	Prime coat		m^2	319,814	12.78	0.03	4,088,735	9,037	Analysis of rates32
SUB TOTAL(3)							**244,125,291**	**438,250**	
4 Culvert	RDCBL_cell 1		Nos.	4	2,128,670.90	163.67	8,514,684	655	Schedule of rates2
	RDCBM_cell 1		Nos.	9	1,645,269.45	125.51	14,807,425	1,130	Schedule of rates3
	RDCBS_cell 1		Nos.	10	972,680.54	73.16	9,726,805	732	Schedule of rates4
	WCCBL_cell 3		Nos.	2	4,359,706.59	323.71	8,719,413	647	Schedule of rates5
	WCCBM_cell 3		Nos.	2	2,874,630.00	211.74	5,749,260	423	Schedule of rates6
	WCCBM_cell 2		Nos.	1	2,022,010.76	149.02	2,022,011	149	Schedule of rates7
	WCCBS_cell 1		Nos.	3	549,104.43	39.24	1,647,313	118	Schedule of rates8
SUB TOTAL(4)							**49,539,598**	**3,736**	

Table 20-19 Construction Cost of Gwalior Bypass (2/3)

Item	Sub item		Unit	Qty.	Rate		Amount.		Remark
					Rs.	US$	Rs.	US$	
5 Bridge/Viaduct (Superstructure)	ROB_Superstructure	STA26+100	Nos.	1	2,125,861	824.33	2,125,861	824	Schedule of rates9
	WCBR1_Superstructure	STA10+340	Nos.	1	4,712,522	1,795.78	4,712,522	1,796	Schedule of rates12
	WCBR2_Superstructure	STA 12+720	Nos.	1	4,959,888	1,007.82	4,959,888	1,008	Schedule of rates15
	WCBR3(Slab)_Superstructure	STA 7+760	Nos.	1	2,908,648	715.92	2,908,648	716	Schedule of rates18
	WCBR4(Slab)_Superstructure	STA25+650	Nos.	1	4,658,571	1,062.55	4,658,571	1,063	Schedule of rates21
(Sub structure)	ROB_Substructure	STA26+100	Nos.	1	7,709,275	1,386.54	7,709,275	1,387	Schedule of rates10
	WCBR1_Substructure	STA10+340	Nos.	1	6,030,906	1,072.81	6,030,906	1,073	Schedule of rates13
	WCBR2_Substructure	STA 12+720	Nos.	1	9,479,683	1,564.54	9,479,683	1,565	Schedule of rates16
	WCBR3(Slab)_Substructure	STA 7+760	Nos.	1	5,181,552	1,000.06	5,181,552	1,000	Schedule of rates19
	WCBR4(Slab)_Substructure	STA25+650	Nos.	1	8,740,459	1,520.36	8,740,459	1,520	Schedule of rates22
(Foundation)	ROB_Foundation	STA26+100	Nos.	1	1,121,846	440.82	1,121,846	441	Schedule of rates11
	WCBR1_Foundation	STA10+340	Nos.	1	1,121,846	440.82	1,121,846	441	Schedule of rates14
	WCBR2_Foundation	STA 12+720	Nos.	1	6,913,893	1,594.20	6,913,893	1,594	Schedule of rates17
	WCBR3(Slab)_Foundation	STA 7+760	Nos.	1	1,236,342	646.56	1,236,342	647	Schedule of rates20
	WCBR4(Slab)_Foundation	STA25+650	Nos.	1	5,565,561	2,217.69	5,565,561	2,218	Schedule of rates23
SUB TOTAL(5)							72,466,852	17,291	
6 Toll gate	Toll barrier(BP&EP)		Nos.	2	723,628.25	980.72	1,447,256	1,961	Schedule of rates24
	Main operation office		Nos.	1	9,903,373.22	5,371.21	9,903,373	5,371	Schedule of rates30
	Sub operation office		Nos.	1	926,244.79	1,104.60	926,245	1,105	Schedule of rates31
	Interchange_BP&EP_1lane		Nos.	1	6,530,915.78	13,539.28	6,530,916	13,539	Schedule of rates28

Table 20-19 Construction Cost of Gwalior Bypass (3/3)

Item	Sub item	Unit	Qty.	Rate		Amount.		Remark
				Rs.	US$	Rs.	US$	
	Interchange_BP&EP_2lane	Nos.	1	6,692,580.33	14,035.71	6,692,580	14,036	Schedule of rates29
SUB TOTAL(6)						**25,500,371**	**36,012**	
7 Service road	Service road	km	24.87	1,693,464.20	2,394.68	42,116,455	59,556	Schedule of rates34
SUB TOTAL(7)						**42,116,455**	**59,556**	
8 Drainage								
	Precast Cement Concrete Kerb	m	19,600	136.59	0.18	2,677,203	3,528	Analysis of rates64
	Berm ditch	m	800	111.17	0.03	88,937	24	Analysis of rates65
	Side ditch	m	32,270	327.77	0.06	10,577,235	1,936	Analysis of rates66
	Veritical drain	m	15,110	103.80	0.10	1,568,358	1,511	Analysis of rates67
SUB TOTAL(8)						**14,911,733**	**6,999**	
9 Utility Diversion	Removing power line	m	1,590.00	1,597.53	1.25	2,540,076	1,988	Schedule of rates33
	Removing telepone line	m	1,590.00	1,607.53	1.25	2,555,976	1,988	Schedule of rates32
	Removing HTL	L.S	1.00	1,500,000.00	0.00	1,500,000	0	
SUB TOTAL(9)						**6,596,052**	**3,975**	
10 Road appurtenances	Road appurtenances	km	26.50	109,167.65	0.00	2,892,615	0	Schedule of rates35
SUB TOTAL(10)						**2,892,615**		
11 Horticulture	Turfing slopes of new banks	m2	361,800	2.07	0.00	749,155	616	Analysis of rates68
	Planting plants and shrubs	L.S	1	840,000.00	0.00	840,000	0	Analysis of rates69
SUB TOTAL(11)						**1,589,155**	**616**	
12 Environmental Mitigation Measures	Construction of check dams/retaining walls/baffels etc.	L.S	1	500,000.00	0.00	500,000	0	
SUB TOTAL(12)						**500,000**	**0**	
TOTAL OF DIRECT COST						**746,209,882**	**1,356,213**	