Chapter 11. PRELIMINARY DESIGN

11.1 General

The scope of the 2nd Kohat Tunnel and Access Roads construction is to provide two additional lanes to the existing road to create a dual carriageway road. NHA already acquired the Right-of-Way (ROW) on the east side (right hand side) for the 2nd Kohat Access Road during the 1st Kohat Tunnel and Access Road construction. As there are no advantageous alternative routes, the preliminary design was carried out based the road and tunnel alignments recommended in Chapters 9 and 10 and in accordance with the design standards established in Chapter 8.

The design results are reflected in Volume II (Preliminary Design Drawings) of the Feasibility Study Report.

11.2 Highway Design

11.2.1 Alignment Design (Plan and Profile)

(1) Position of the 2nd Kohat Tunnel Access Road

The roadway centreline of the 2nd tunnel access roads was set out as the centreline of the 4-lane dual carriageway, except for the tunnel and approach sections as illustrated in Figure 11.2.1.

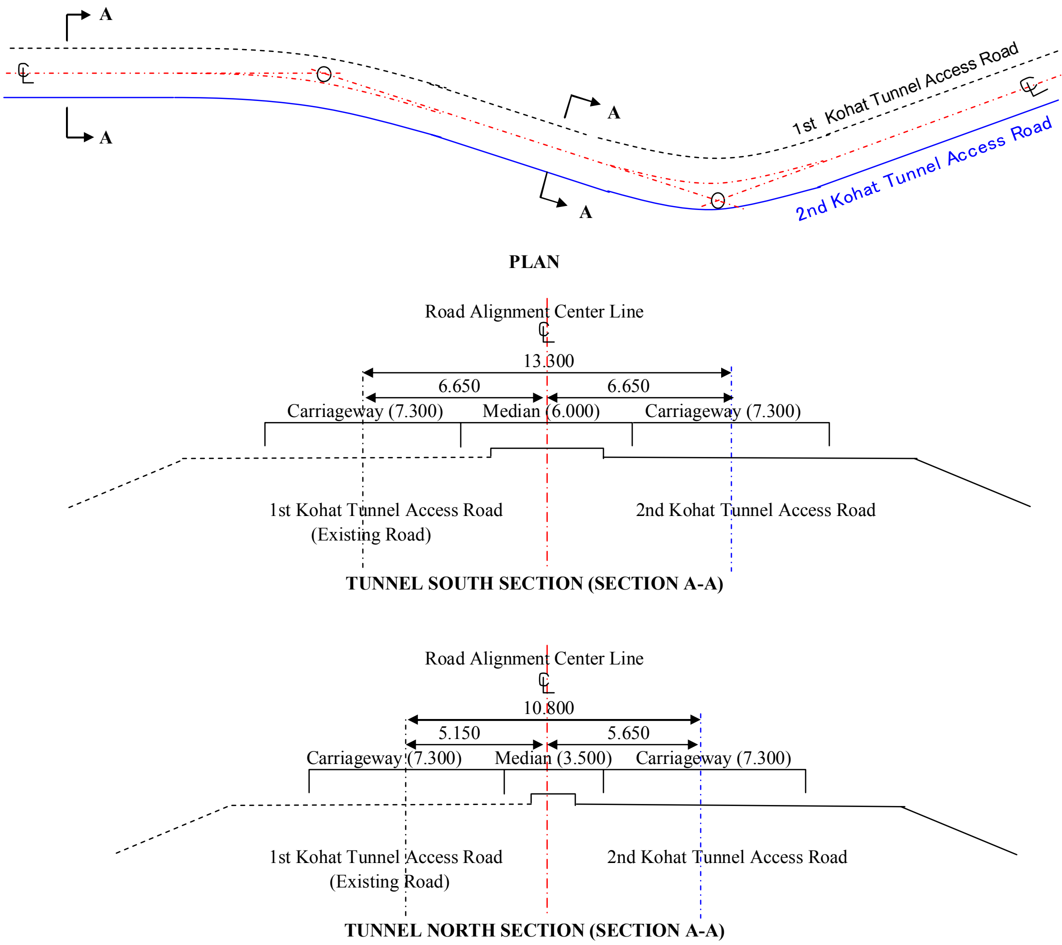


Figure 11.2.1 Position of the 2nd Kohat Tunnel Access Roads

The distance from the 4-lane dual carriageway centreline to the existing road centreline (to the left) and to the centreline of the new 2 lanes (to the right) is 6.65 m for the south section up to Sta.18+700. The section from Sta.18+700 to Sta.19+200 is a transition section to the Bridge No.4 (dual carriageway bridge). Separate centrelines are set out for the tunnel approach section from Sta.19+200 to Sta.20+186.738 (tunnel south portal). The centreline off-set distance between the 1st and 2nd Kohat tunnels is 30m. In the north section, the distance from the 4-lane dual carriageway centreline to the left 2-lane carriageway centreline (1st road) is 5.15 m and that to the right 2-lane carriageway centreline (2nd road) is 5.65 m.

(2) Horizontal Alignment

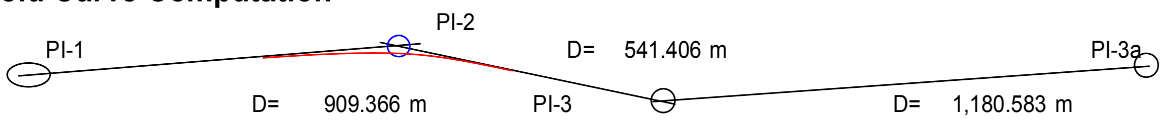
The Study Team designed alternative horizontal alignments for the tunnel south sections; one without transition curves (as same as the 1st Kohat Tunnel and Access Roads) and the other with a transition curve as described in Sub-section 8.3.2(2). The Excel basis Clothoid curve elements computation program (Figure 11.2.2) was used for the alignment design. The maximum deviation of the horizontal alignment with and without transition curves is limited to about 0.50 m to absorb the alignment deviation within the median. However, the introduction of transition curves is difficult for the north section as the existing alignment is a combination of short straight lines and sharp curves. The vertical alignment changes also in a short distance. Moreover, as the median width of the north section is 3.5m and it is difficult to absorb the centreline deviation within this median not like the 6.0m-wide median in the south section, transition curves are not introduced for the north section.

The total Project road length is 30.271 km from Sta.0+000 to Sta.25+906.255. Several breaks were inserted in the carriageway centreline of the 1st Kohat Tunnel Access and Roads. These breaks were retained as they are considering the need to use the same types of cross drainages, bridges, tunnel and other structures of the 1st road in the design of the 2nd road to ensure consistency between the two roads. The beaks are introduced at the same locations, in principle, for the 1st Kohat Tunnel and Access Roads as summarized in Table 11.2.1.

Table 11.2.1 Breaks and Project Road Length

	Break Length (m)	Station	Length (m)
● **South Section:**			
- **Project Start Point Sta.**		0+000.000	
Break	-12.895	6+318.981 (B)	
		6+306.086 (A)	
Break	-407.017	19+607.017 (B)	
		19+200.000 (A)	
Total Break (S)	-419.912 m		
- **South Section Length:**			**20,606.650 m**
Break	-3,939.738	20+186.738 (B)	
(Tunnel South Portal Sta.)		16+247.000 (A)	
● **Tunnel Section Length:**			**1,885.000 m**
(Tunnel North Portal Sta.)		18+132.000	
● **North Section:**			
Break	19.932	18+874.472 (B)	
		18+894.404 (A)	
Break	4.257	21+792.502 (B)	
		21+796.759 (A)	
Break	-29.691	24+908.443 (B)	
		24+878.752 (A)	
Total Break (N)	-5.502 m		
- **North Section Length:**			**7,779.757 m**
- **Project End Point Sta.**		25+906.255	
Total Break	-4,365.153 m		
● **Total Project Length:**			**30,271.408 m**

Clothoid Curve Computation



PI-2

Input (replace red figures)

R=	590	m						
I =	deg.	min.	sec.					
	29	10	5		29.1681	degrees =	0.5091	radian
A1 =	250.000				A2 =	250.000		
Note:	R/3	=< A <=	R		R/3	=< A <=	R	
	197	=< A1 <=	590		197	=< A2 <=	590	
Ls1 =	A^2 / R	=	105.932		Ls2 =	A^2 / R	=	105.932

Note:

Design Speed	Min. Transition Curve Length
90 km/h	50 m
80 km/h	44 m

Straight Section Length			
From / To	PI-1	PI-2	424.062 m
From / To	PI-2	PI-3	181.698 m
(Note: ST to TS Distance)			

CL = Ls1 + Ls2 + Lc = 406.289

Ts1 = Xm1+W2-z1 = 206.666　　Ts2 = Xm2+W2+z2 = 206.666

$\theta_s 1$ =	Ls / 2R	=	0.0898 radian		$\theta_s 2$ =	Ls / 2R	=	0.0898 radian		
	degree	deg.	min.	sec.		degree	deg.	min.	sec.	
=	5.1436	5	8	37	=	5.1436	5	8	37	

X1= Ls (1-Ls^2 / 40 R^2 + Ls^4 / 3456 R^4 - Ls^6 / 599040 R^6)
= 105.847

X2= Ls (1-Ls^2 / 40 R^2 + Ls^4 / 3456 R^4 - Ls^6 / 599040 R^6)
= 105.847

Y1 = Ls^2 / 6R (1-Ls^2/(56*R^2)+Ls^4/(7040*R^4)-Ls^6(1612800*R^6))
= 3.168

Y2 = Ls^2 / 6R (1-Ls^2/(56*R^2)+Ls^4/(7040*R^4)-Ls^6(1612800*R^6)
= 3.168

ΔR1 =	Y1 + Rcos θs1 - R =	0.792		ΔR2 =	Y1 + Rcos θs1 - R =	0.792
Xm1 =	X1 - Rsin θs =	52.952		Xm2 =	X1 - Rsin θs1 =	52.952
W1 =	TAN (I/2) x (R+ΔR1) =	153.714		W2 =	TAN (I/2) x (R+ΔR1) =	153.714
TL1 =	X1 - Y1 cot (θs1) =	70.651		TL2 =	X1 - Y1 cot (θs1) =	70.651
Tk1 =	Y1 / sin θs1 =	35.338		Tk2 =	Y1 / sin θs1 =	35.338
σ1 =	cot (Y1/X1) =	0.030 radian		*σ2* =	cot (Y2/X2)	0.030 radian

	degree	deg.	min.	sec.	degree	deg.	min.	sec.
=	1.7144	1	42	52	1.7144	1	42	52

$\theta_s 1 - \sigma 1$ = 0.0599 (radian)　　$\theta_s 2 - \sigma 2$ = 0.0599 (radian)

	degree	deg.	min.	sec.	degree	deg.	min.	sec.
=	3.4292	3	25	45	3.4292	3	25	45

θc = I-(θs1+θs2)= 0.32953 radian =

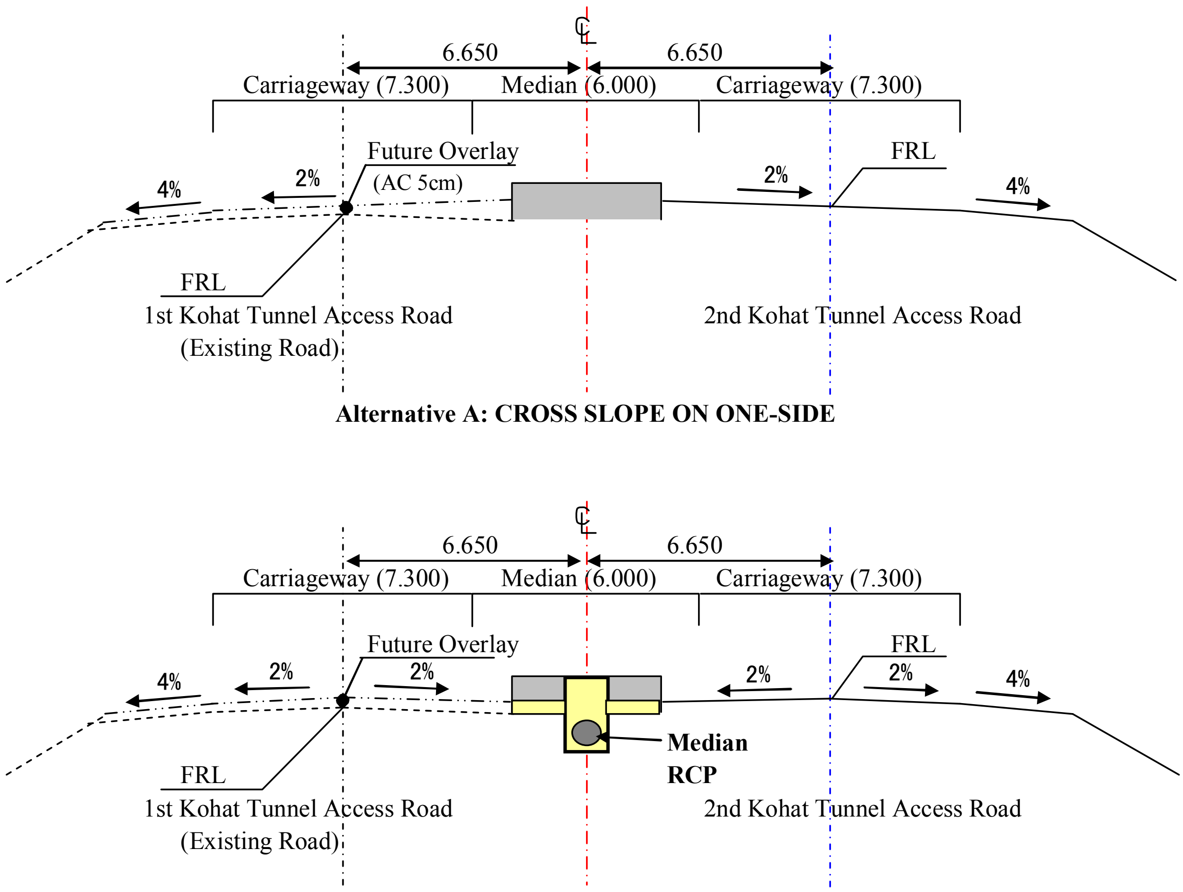
degree	deg.	min.	sec.
18.8808	18	52	51

Lc =	R * θc =	194.424				
LT1 =	$(X1^2 + Y1^2)^{1/2}$ =	105.894		LT2 =	$(X2^2 + Y2^2)^{1/2}$ =	105.894
U1 =	$(Tk1^2 - Y1^2)^{1/2}$ =	35.196		U2 =	$(Tk^2 - Y^2)^{1/2}$ =	35.196
z1 =	(ΔR1 - ΔR2) / tan (I) =	0.000		z2 =	(ΔR1 - ΔR2) / sin(I) =	0.000
Es =	(R+(ΔR1+ΔR2)/2) - R = / cos I/2	20.462				

Figure 11.2.2　Clothoid (Spiral) Curve Elements Computation Program

(3) Vertical Alignment

The vertical alignment follows the existing 1st Kohat Tunnel and Access Roads in principle. As the 1st road was constructed with two lanes (single carriageway), there are two representative methods to provide carriageway cross slopes and the finished road level (FRL) of the 2nd Kohat Tunnel and Access Road as shown in Figure 11.2.2.



Alternative A: CROSS SLOPE ON ONE-SIDE

Alternative B: CROSS SLOPE ON BOTH-SIDES

Figure 11.2.3 Carriageway Cross Slope Alternatives

Alternative A is to provide carriageway cross slopes on one side (outside) and Alternative B is to provide cross slopes at both sides. The Study Team adopted Alternative A considering the fact that Alternative B requires a median drainage system through the Project road.

Asphalt concrete overlay will be required in year 2012-2013 for the 1st Kohat Tunnel Access Roads, as the design period of the existing AC pavement is 10 years. The Finished Road Level (FRL) of the 2nd road is designed to be 5 cm higher than that of the 1st road taking the future AC overlay thickness into consideration.

The average grade is -1.07% (down-grade) for the south section and 1.03% (up-grade) for the north section. The maximum grade is 4.76% for the down-grade section and 4.34% for the up-grade section as listed in Table 11.2.2.

Table 11.2.2 Vertical Grade of the 2nd Kohat Tunnel and Access Roads

South Section

No.	From Sta.	To Sta.	Distance (m)	Grade
S.1	0+000.000	0+200.000	200.000	0.7200%
S.2	0+200.000	0+700.000	500.000	0.6500%
S.3	0+700.000	1+100.000	400.000	0.2500%
S.4	1+100.000	1+500.000	400.000	0.2000%
S.5	1+500.000	1+900.000	400.000	0.8000%
S.6	1+900.000	2+400.000	500.000	-0.6238%
S.7	2+400.000	2+850.000	450.000	0.0000%
S.8	2+850.000	3+000.000	150.000	0.6000%
S.9	3+000.000	3+700.000	700.000	-0.7500%
S.10	3+700.000	3+900.000	200.000	-1.0000%
S.11	3+900.000	4+300.000	400.000	-0.1380%
S.12	4+300.000	4+500.000	200.000	0.9510%
S.13	4+500.000	4+900.000	400.000	-1.4608%
S.14	4+900.000	5+100.000	200.000	-0.7285%
S.15	5+100.000	5+400.000	300.000	1.7667%
S.16	5+400.000	6+200.000	800.000	0.6250%
S.17	6+200.000	6+800.000	612.895	0.6853%
S.18	6+800.000	7+200.000	400.000	0.3250%
S.19	7+200.000	7+500.000	300.000	0.0667%
S.20	7+500.000	7+900.000	400.000	1.2500%
S.21	7+900.000	8+400.000	500.000	-0.1800%
S.22	8+400.000	8+900.000	500.000	-0.5820%
S.23	8+900.000	9+391.212	491.212	2.0633%
S.24	9+391.212	9+767.240	376.028	0.0056%
S.25	9+767.240	9+950.000	182.760	-1.6667%
S.26	9+950.000	10+350.000	400.000	1.2500%
S.27	10+350.000	11+000.000	650.000	0.7692%
S.28	11+000.000	11+300.000	300.000	0.5667%
S.29	11+300.000	11+700.000	400.000	-0.3750%
S.30	11+700.000	12+100.000	400.000	0.9600%
S.31	12+100.000	12+700.000	600.000	0.5000%
S.32	12+700.000	13+000.000	300.000	1.0000%
S.33	13+000.000	13+300.000	300.000	1.9533%
S.34	13+300.000	13+900.000	600.000	0.3833%
S.35	13+900.000	14+200.000	300.000	1.5000%
S.36	14+200.000	14+700.000	500.000	4.7600%
S.37	14+700.000	15+350.000	650.000	1.3138%
S.38	15+350.000	15+700.000	350.000	-0.4400%
S.39	15+700.000	16+100.000	400.000	1.2000%
S.40	16+100.000	16+500.000	400.000	2.8750%
S.41	16+500.000	16+700.000	200.000	0.0000%
S.42	16+700.000	17+100.000	400.000	0.9000%
S.43	17+100.000	17+800.000	700.000	2.4174%
S.44	17+800.000	19+600.000	2,207.017	3.9000%
S.45	19+600.000	20+100.000	500.000	2.6303%
S.46 [a]	20+100.000	20+186.738	86.738	2.4000%
		Average Grade:		1.0686%

Note: a. Tunnel South Portal

Tunnel Section

No.	From Sta.	To Sta.	Distance (m)	Grade
T.1 [b]	20+187.637 ← 16+247.000	18+132.000	1,885.000	2.4000%

Note: b. A break at Sta.20+187.637 / Sta.16+247.000 (3,939.

North Section

No.	From Sta.	To Sta.	Distance (m)	Grade
N.1 [c]	18+132.000	18+250.000	118.000	2.4000%
N.2	18+250.000	18+797.200	547.200	-2.8560%
N.3	18+797.200	19+250.000	432.868	-0.0069%
N.4	19+250.000	19+550.000	300.000	-3.8600%
N.5	19+550.000	20+050.000	500.000	-0.9000%
N.6	20+050.000	20+600.000	550.000	0.3509%
N.7	20+600.000	20+750.000	150.000	-1.6780%
N.7	20+750.000	21+500.000	750.000	-0.3077%
N.8	21+500.000	21+950.000	445.743	-3.0679%
N.9	21+950.000	22+350.000	400.000	-0.7375%
N.10	22+350.000	22+600.000	250.000	0.3800%
N.11	22+600.000	23+025.000	425.000	-1.0965%
N.12	23+025.000	23+250.000	225.000	-1.5769%
N.13	23+250.000	23+500.000	250.000	-1.1768%
N.14	23+500.000	24+076.000	576.000	1.8920%
N.15	24+076.000	24+300.000	224.000	-2.4607%
N.16	24+300.000	24+850.000	550.000	-1.7520%
N.17	24+850.000	25+050.000	229.691	0.0000%
N.18	25+050.000	25+298.400	248.400	-4.3402%
N.19	25+298.400	25+700.000	401.600	-1.1121%
N.20	25+700.000	25+850.000	150.000	-0.9627%
N.21	25+850.000	25+906.255	56.255	-0.9980%
		Average Grade:		-1.0300%

Note: c. Tunnel North Portal

11.2.2 Intersections/Interchanges

(1) Major Intersections/Intersections

Following are the major intersections and interchanges on the Project road:

- Kohat Toi Intersection at the Project road start point
- Kohat Pindi Interchange with N-80 (Off-Ramps and On-Ramps)
- Kohat Link Road Interchange (Off Ramp and On-Ramp)
- Sanda Basta Interchange with N.W.F. Road (Off Ramp and On-Ramp)
- Dara Adam Khel Intersection at the Project road end point.

The Kohat Toi and Dara Adam Khel Intersections were already constructed with a 4-lane carriageway under the 1st Kohat Tunnel and Access Roads Project. However, as the traffic capacity of the right turn traffic from Kohat Town to Bannu will become insufficient in future, one lane should be added for the Kohat Toi Intersection. One additional lane is also required for the Dara Adam Khel Intersection to solve the similar under-capacity problem. No additional ROW acquisition is required as the new lanes can be accommodated within the existing ROW (see following photos).

ROW for An Additional Lane
Provision for Kohat Toi Intersection

ROW for An Additional Lane
Provision for Dara Adam Khel Intersection

Introduction of a traffic control signal system will be a better alternative to increase the capacity of those junctions if a systematic operation and maintenance system is secured.

The traffic capacity of the current N-80 Rawalpindi - Kohat Town Road Intersection is sufficient and no improvement is required.

Approximately 40% of the traffic on the Kohat Tunnel and Access Roads diverts from/to Kohat Town through the Kohat Link Road IC. Besides, the Kohat Link Road IC will work as a bypass/ ring road for Kohat Town in future as illustrated in Figure 11.2.4. Part of the traffic currently passing through the Kohat Town centre will use the Kohat Link Road/N-55 as its passage becomes free after the relocation of the main toll gate at Sta.10+600 to the new site at Sta.17+400.

Therefore, a proper IC traffic flow system is planned, providing an On-Ramp for the traffic from Kohat Town to the south/Rawalpindi (N-80) and an Off-Ramp for the traffic from the south/Rawalpindi (N-80) to Kohat Town through the Kohat Link Road (see Figure 11.2.5).

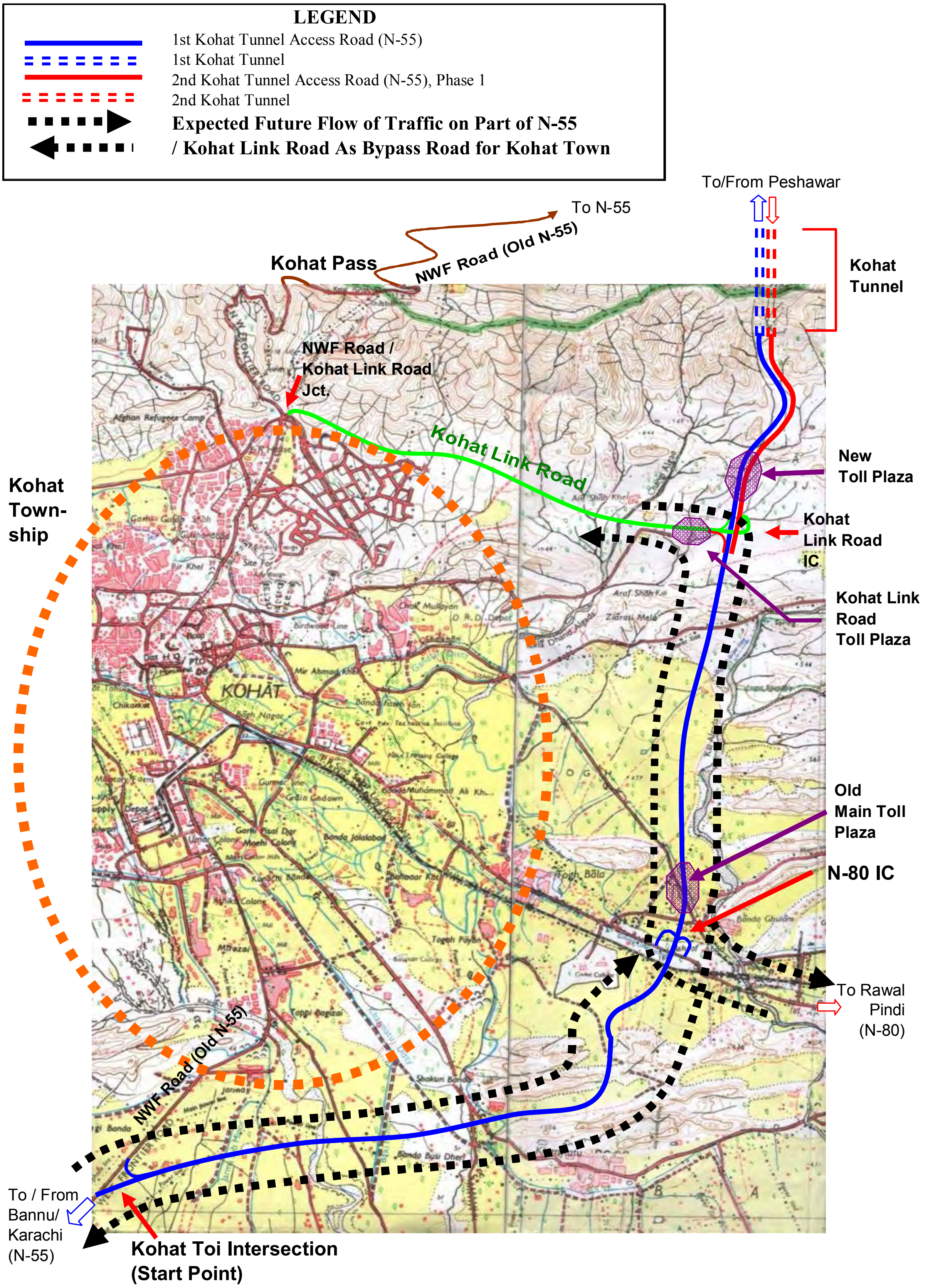


Figure 11.2.4 Future Bypass Road System for Kohat Town

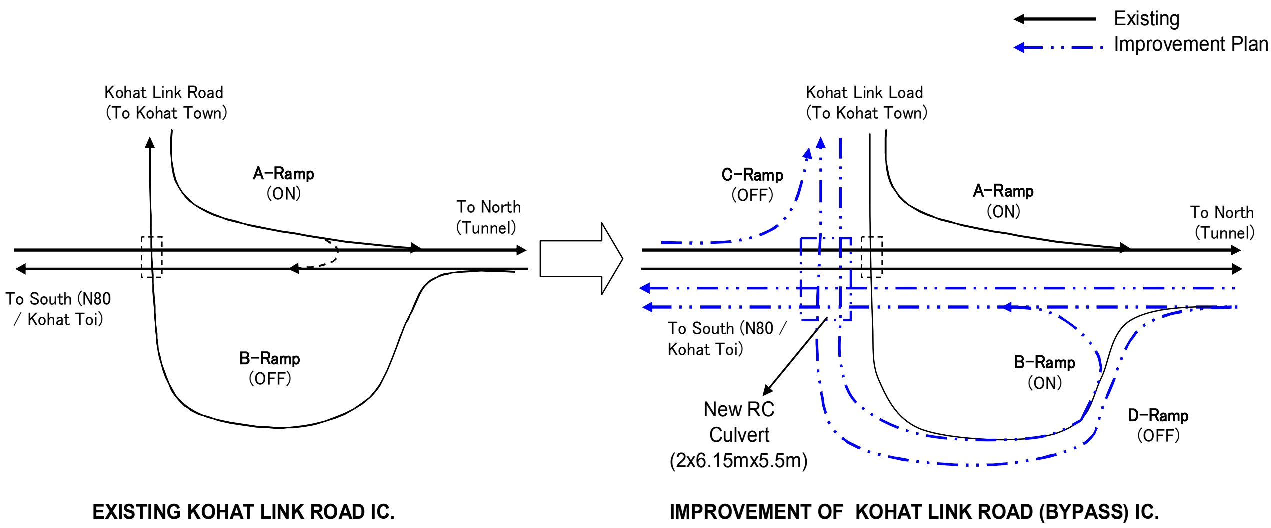


Figure 11.2.5 Kohat Link Road IC Improvement Plan

There is almost no traffic on On/Off Ramps (see the right photo) of the N.W.F. Road IC as the traffic uses the Dara Adam Khel Intersection for tunnel access. However, these On/Off Ramps have an important role after the construction of the 2nd Kohat Tunnel and Access Roads as they will be used by the tunnel maintenance vehicles. The end part of the On-Ramp requires reconstruction to connect to the new 2 lanes.

N.W.F.Road IC (Sta.19+088)

(2) Minor Intersections

There are several minor intersections between Kohat Toi and the N-80 IC at Sta.1+300, Sta.2+200, Sta.2+900, Sta.3+500, Sta.3+900, Sta.4+810, Sta.4+900 and Sta.5+400. To ensure safety of high speed traffic on the through lanes, right and left turn lanes are provided though the traffic on these lanes is not significant.

11.2.3 Slope Protection

No major slope failures have occurred during and after the opening of the 1st Kohat Tunnel and Access Roads. As the slope protection works adopted for the 1st road are effective, the following same slope stabilisation methods are adopted for the 2nd Kohat Tunnel and Access Roads.

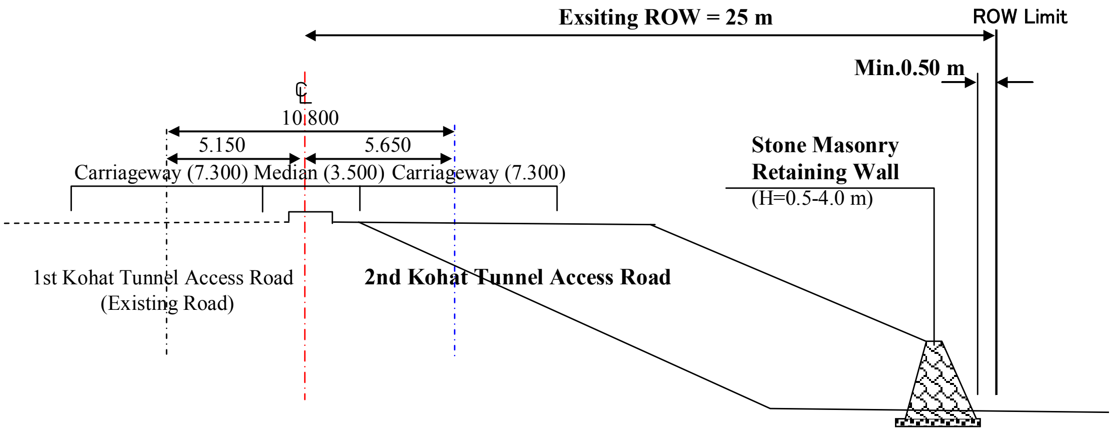
Slope protection works for cut slopes:

- Grouted riprap
- Shotcrete
- Rock net

Slope protection works for fill slopes:

- Grouted riprap
- Rock fill
- Stone masonry retaining walls

There are some locations in the tunnel north section where the acquired ROW is insufficient (approximately 1-5 m wide). It is designed to construct stone masonry retaining walls illustrated in the following figure within the existing ROW to secure the roadway width as land acquisition will not be easy. A minimum width of 0.5 m should be kept between the ROW limit and structures, especially near residential houses to avoid oppression sense.



11.2.4 Drainage Structures

The drainage structures for the Project road consist of roadway cross drainages (box and pipe culverts), median drainages, road side drains and tunnel drainages (refer to Sub-section 11.4 for box culverts and Subsection 11.5 for tunnel drainage). Table 11.2.3 is a list of RCC pipe culverts to be extended from/to the existing RC pipes constructed under the 1st Kohat Tunnel and Access Roads Project.

Median drainages are provided where run-off from the carriageway flows to the roadway centre as illustrated in Figure 11.2.3. Their dimensions and length depend on the road geometry and topography. Roadside drainages (lined ditches) are provided along the roadside for cut sections or part of the embankment sections where run-off from the cut-slopes and the carriageway is to be drained out.

Table 11.2.3 List of RC Pipe Culverts

No.	Pipe	Station	RCCP Dia.910 mm (m)	RCCP Dia.1070 mm (m)
South Section				
1	1	00+423.65	30	
2	3	00+692.20	32	
3	7	01+270.22	11	
4	7A	01+427.28	11	
5	8	01+432.48		12
6	9A	01+450.73	12	
7	9B	01+512.86	12	
8	10	01+575.29	11	
9	11	01+678.68	10	
10	12	01+809.50	11	
11	13A	01+827.02	11	
12	13B	01+856.00	14	
13	16	02+218.25	12	
14	17	02+284.16	11	
15	18	02+302.79	11	
16	20	02+940.89		12
17	21	03+033.00		11
18	21A	03+035.50	12	
19	22	03+120.26		12
20	23	03+170.00	13	
21	24	32+360.30		12
22	26	03+390.31		13
23	28	03+635.00	12	
24	29B	04+034.48	17	
25	30	04+096.45	17	
26	30A	04+178.95	27	
27	32	04+360.93	17	
28	37B	07+532.00	11	
29	46	10+946.60	46	
30	50A	11+038.00	26	
31	59	11+038.00		24
Sub-Total for South Section			**397**	**96**
North Section				
1	74	18 + 558.00		16
2	76	19 +323.00		21
3	78	19 + 600.00		11
4	79	19 + 800.00		10
5	87a	22 + 246.00		15
6	91	23 + 247.00		15
7	95a	25 + 075.00		20
8	96b	24 +792.00		18
Sub-Total for North Section			**0**	**126**
Grand Total			**397**	**222**

11.2.5 Other Incidentals

Other road facilities including bus stops, traffic signs, pavement marking, guardrail, traffic guide posts, median barriers, Km posts, ROW fence and ROW markers are also provided to ensure safety and convenience of road users. PCC curve stones are constructed along the median. Appropriate shrubs, flower trees and grasses are planted in the median.

The existing guardrails on the right shoulders of the existing road will be removed and reinstalled for the 2nd Kohat Tunnel and Access Roads.

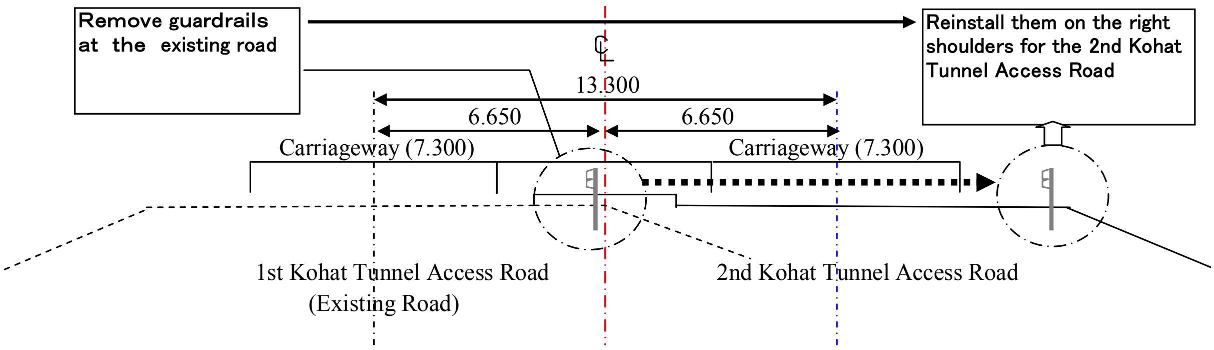


Figure 11.2.6 Removal and Reinstallation of Guardrails

Installation of RC concrete barriers (New Jersey Barrier) will be one of the best alternatives to prevent crush accidents at smaller curves with a radius of less of than 300m in the north section (see Figure 11.2.7).

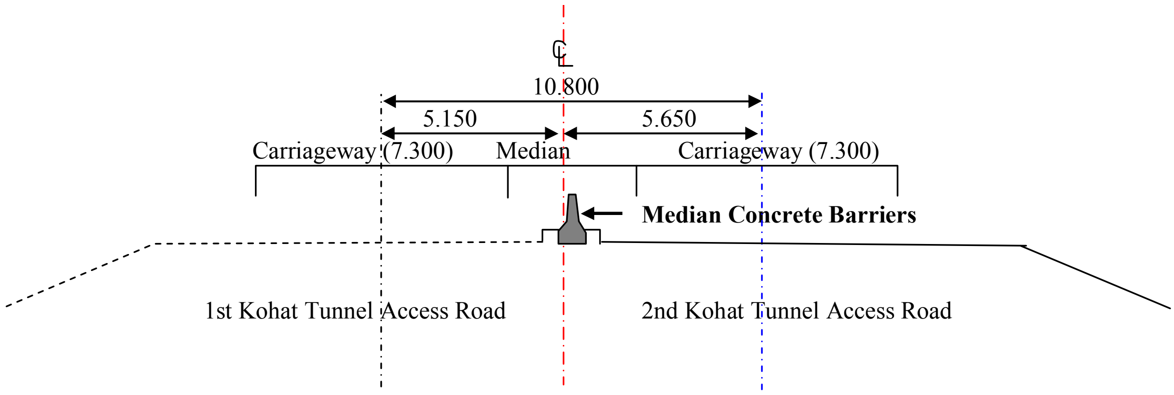


Figure 11.2.7 Median Concrete Barriers for North Section at Small Curves (R < 300 m)

11.3 Pavement Design

11.3.1 Design Conditions

(1) Design Traffic and CESA (Cumulative Equivalent Single Axle Load)

The design traffic, traffic growth rate and directional distribution used for the pavement design are as analyzed in the section on Traffic Analysis in Chapter 7.

NTRC conducted a comprehensive axle load survey on national highways in 1995 and the results of this survey are used for estimating the axle load since there is no comprehensive up-date study since that. There were two survey stations on N-55 near Kohat. One is between Kohat and Peshawar and the other between Bannu and D.I. Khan. The Equivalent Single Axle (ESA) of the latter is higher than that of the former as vehicles are less loaded when running on the steep Kohat Pass. The ESA used for the pavement design (see Table 11.3.1) is based in principle on the axle load study at the Bannu station as it is considered that the current traffic characteristics at this station are similar to those of N-55 near Kohat after the opening of the Kohat Tunnel in 2003. NTRC provided two different axle loads: one is based on AASHTO and the other on the Road Note 31. The former is applied for the Project because the Road Note 31 is not applicable as its Cumulative Equivalent Single Axle Load (CESA) limit is 30 x 10^6.

Table 11.3.1 Average ESA for Pavement Design

Vehicle Type	ESA/Veh.			
	Road Note 31 Method		AASHTO Method	
	Empty	Loaded	Empty	Loaded
Bus	-	0.50	-	0.50
Truck (2-Axles)	0.04	7.33	0.04	5.47
Truck (3-Axles)	0.08	16.26	0.08	8.28
Tractor/ Trailer	0.43	19.14	0.43	11.50

Source: Data processed by the Study Team based on the Axle Load Study (NTRC, July 1996)

CESA was computed from several relevant factors including ESA, AADT, traffic growth rate, loading/empty ratio, directional distribution and lane distribution (see Appendix F). Only buses, trucks and truck trailers are accounted for in determining the pavement design load as effects of lighter vehicles are little. The design period for flexible pavement is 10 years and that for rigid pavement is 20 years. Flexible pavement (asphalt concrete pavement) is used for the access roads. Rigid pavement (cement concrete pavement) is adopted only for the toll plaza and tunnel pavement.

The CESA value estimated for flexible pavement design is 28.3 million for Section 1-1 (Sta.0+000-Sta.10+000), 30.3 million for Section 1-2 (Sta.10+000-Sta.15+000) and 32.3 million for Section 2 (Sta.15+000-Sta.25+906). The CESA applied for rigid pavement design is 87.0 million as summarized in Table 11.3.2.

Table 11.3.2 Cumulative Equivalent Single Axle Load (CESA) for Pavement Design

Unit: 10^6

Section	CESA for Flexible Pavement Design Period (10 years)		CESA for Rigid Pavement Design Period (20 years)		Remarks (CESA for 1st Kohat)	
	AASHTO	RN 31	**AASHTO**	RN 31	Flexible	Rigid
Section 1-1 (Sta.0 - Sta.10+000) Kohat Toi to N-80 IC	**28.3**	46.0	76.2	123.9	17.0 (Sta.0 -Sta.9+000)	40.0
Section 1-2 (Sta.10+000 - Sta.15+000) N-80 IC to Kohat Link Road	**30.3**	49.2	81.4	132.4	17.0 (Sta.0 -Sta.9+000)	40.0
Section 2 (Sta.15+000 - Sta.25+906) Kohat Link Road to Dara Adam Khel	**32.3**	52.0	**87.0**	140.0	40.0 (Sta.9+000 - End Point)	40.0

Note: Rigid Pavement is only for Toll Gate and Tunnel in the case of the 2nd Kohat Access Road

The CESA values used for the 1st Kohat Tunnel and Access Roads are not consistent between flexible and the rigid pavements as shown in the right column of Table 11.3.2.

(2) Design CBR and Resilient Modules (M_R)

The CBR values of soil along the road alignment vary from 5% to 60%. The design CBR for subgrade used for flexible pavement is 15% throughout the Project road as most of the sections are fill sections where the borrow material with CBR of more than 15% is introduced (refer to Material Survey in Section 6.5). Most of the cut sections are composed of soft/hard rock. Subgrade improvement will be made where CBR is less than 15%. The design CBR used for rigid pavement is 30% (a mixture of borrow and crushed aggregates) for subgrade. There are several methods to define Subgrade Resilient Modules (M_R) as shown in Figure 11.3.3 and the Study Team applied the conservative values. The M_R used for flexible pavement is 12,000 psi and that for rigid pavement is 16,500 psi.

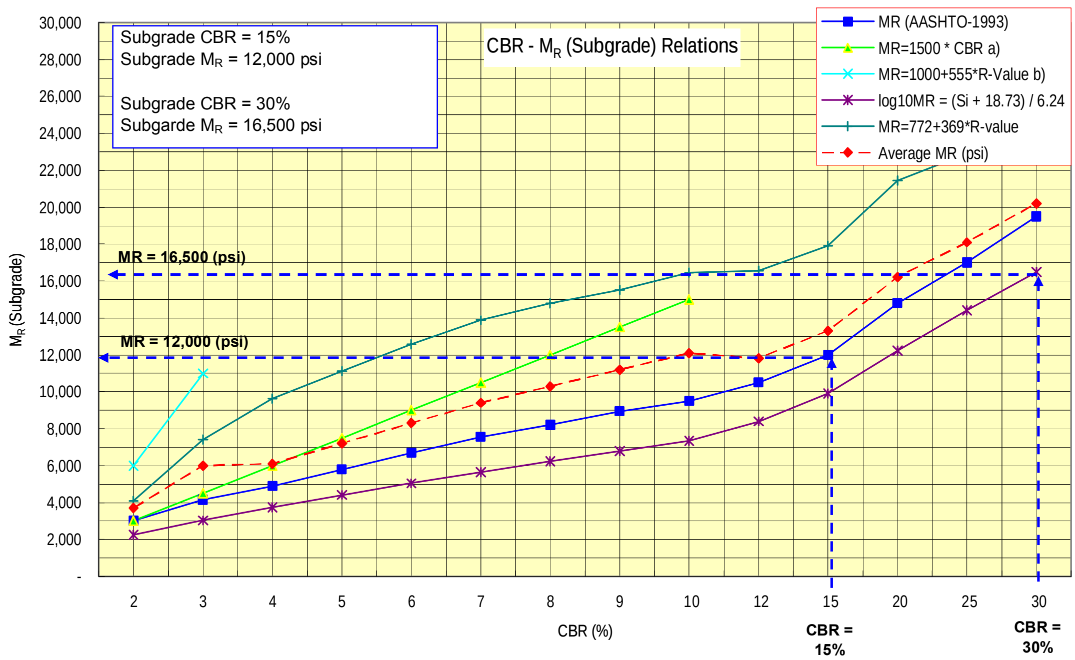


Figure 11.3.3 Subgrade CBR and Modules for Pavement Design

(3) Design Equations and Parameters

The design equations, design parameters, layer coefficients, drainage coefficients, pavement material modules are based on "AASHTO Pavement Design Guide of 1993". The pavement materials are those specified in the NHA's Standard Construction Specifications.

11.3.2 Pavement Thickness Design

The pavement design was carried out using Excel-basis design programs developed by the Study Team for flexible pavement design and for rigid pavement design (See Appendix F). Table 11.3.3 summarises the flexible pavement structures for both the 1st and the 2nd Kohat Tunnel and Access Roads. The AC wearing/base thickness (22 cm-23 cm) of the 2nd Kohat Tunnel and Access Roads is thinner than that of the 1st Kohat Tunnel and Access Roads, while the aggregate base/subbase thickness (30 cm) of the former is thicker than the latter.

Table 11.3.3 Summary of Flexible Pavement Structures

The 1st Kohat Tunnel Access Road

Pavement Structures	From To	Section 1 Kohat Toi Sta.9+000	Section 2 Sta.9+000 Sta.25+450
AC Wearing		5 cm	5 cm
AC Base		18 cm	21 cm
Aggregate Base		20 cm	22 cm
Granular Subbase		-	-
Subgrade (Borrow Material)		30%	15%
Note: Design SN		4.370 (inch)	4.889 (inch)

The 2nd Kohat Tunnel Access Road

Pavement Structures	From To	Section 1-1 Kohat Toi Sta.15+000	Section 1-2 Sta.10+000 Sta.15+000	Section 2 Sta.15+000 Dara Adam Khel
AC Wearing		5 cm	5 cm	5 cm
AC Base (Class B)		8 cm	8 cm	8 cm
AC Base (Class A)		9 cm	10 cm	10 cm
Aggregate Base		15 cm	15 cm	15 cm
Granular Subbase		15 cm	15 cm	15 cm
Subgrade (Borrow Material)		15%	15%	15%
Note: Design SN		5.198 (inch)	5.237 (inch)	5.291 (inch)

As the design period of flexible pavement is 10 years, AC overlay will be required after 10 years to secure performance of the pavement further for the next 10 years. The estimated minimum overlay thickness is 5-10 cm after repair of spot failures and rutting as analyzed in Figure 11.3.4.

FLEXIBLE PAVEMENT DESIGN
(Overlay Requirement after 10 Years)

Design Conditions:
- Design Period: 20 years
- Loading: NHA Standard
- Design CESA: 87.00 x 10^6

Note:

SN Design Equation:

$\log_{10} W_{18} = Z_R{*}So + 9.36{*}\log_{10}(SN+1) - 0.20 + \{\log_{10}[APSI / (4.2 - 1.5)] / [0.40 + 1094/(SN+1)^{5.19}]\} + 2.32{*}\log_{10}M_R - 8.07$

Design Inputs:

R	=	95	%
Z_R	=	-1.645	
So	=	0.45	
W_{18}	=	87.00	x 10^6 *(18KIP ESAL)*
MR	=	12,000	*psi*
DPSI	=	1.70	*(4.2-2.5)*

(For try&error computation)

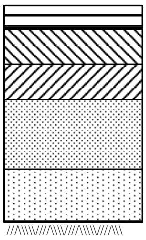
7.940	=	7.939

Output:

SN = 6.049 o.k. !!!

Note: Input approx.SN and repeat as suggested

PAVEMENT STRUCTURE



	Layer Coefficient per cm (Input)	Layer Coefficient per inch	Thickness Product mm (Input)	Thickness Product in inch	Drainage Coefficient
a_1=	0.173	0.44	94	1.63	
a_2=	0.173	0.44	80	1.39	
$a_{2'}$=	0.173	0.44	100	1.73	
$a_{2''}$=	0.053	0.135	150	0.88	1.10
a_3=	0.049	0.124	80 (150)	0.43	1.10
		Total:	504	6.05	
		Total Design SN =		6.053	o.k. !!!
		Required SN =		6.049	

M_R = 1500*CBR(%) if a CBR value < 10% is entered.
Otherwise, M_R = value in from other sources
Input M_R *or* CBR

M_R *psi*	CBR (%)
12,000	

Drainage Coefficients (Input)

m_2	Aggregate Base	1.10
m_3	Granular Subbase	1.10

Module of Pavement Materials

Surface	Wearing Course	440,000	psi, MS =	1,000	kg
	Binder Course	440,000	psi, MS =	1,000	kg
Base	AC Base	440,000	psi, MS =	1,000	kg
	Asphalt Treated Base (ATB)				
	Aggregate Base	28,500	psi, CBR>	80%	
Subbase	Granular Subbase	17,200	psi, CBR>	50%	

Figure 11.3.4 AC Overlay Thickness Estimate after 10 Years

The design concrete pavement slab thickness is 30 cm which is same as the 1st Kohat Tunnel pavement. Concrete slabs are reinforced with φ6 mm steel mesh (120 mm x 120 mm). Transverse contraction joints are dowel bar joints (φ32 mm x 600 mm) provided at 10 m intervals. Tie bars (φ12 mm x 600 mm) are provided at every 50 cm as illustrated in Figure 11.3.5.

11.4 Bridge and Culvert Design

11.4.1 Bridge Design

(1) List of Bridges

Ten new bridges are planned to be constructed for the dual carriageway system of the 2nd Kohat Tunnel and Access Roads as listed in Table 11.4.1.

Table 11.4.1 List of Bridges

No.	Station (at center)	Type	Length (m)	Span	Pile Length (m)	Remarks (Crossing)
1 R	2+736.245	PC Girder	120	4 - 30m Span	16	Over Jerma Minor River
2 R	4+735.415	PC Girder	50	2 - 25m Span	14	Over river
3A R	9+454.363	PC Girder	20	1 - 20m Span	20	Over railways
3B R	9+645.760	PC Girder	30	1-30m Span	21.5	Over N-80
9 R	14+800.000	RC Girder	12	1-12m Span	20	Over Bazi Khel Road
10 R	16+585.000	RC Girder	12	1-12m Span	20	Over a track
Kohat Tunnel *						
5 R	18+935.415	PC Girder	80	25m+30m+25m	20	Over Osti Khel Algad
8 R	19+088.355	PC Girder	20	1 - 20m Span	Spread Fd.	Over NWF Road
6A R	21+260.525	PC Girder	180	6-30m Span	12	Over Osti Khel Algad & Panderi Algada
7 R	25+388.915	PC Girder	40	2-20m Span	20	Over Mullah Khel Algad
Total:			564	m		

Notes: * Break at Sta. 20+186.738 /Sta.16+247.000 (-3,939.738)

The Bridges 1R, 2R, 5R, 6AR and 7R cross over rivers, Bridge 3AR over a railway, Bridge 3BR over the National Highway N-80 IC, and Bridge No.8R over the NWF road. The river crossing bridges satisfy discharge, HFL clearance and scouring depth as analyzed in Sub-section 6.3 of this report.

(2) Cross Section

The typical cross section of bridge is illustrated in Figure 11.4.1. The total width is 10.500m. The width of the carriageway and shoulder is the same as the 1st Kohat Tunnel and Access Roads. The outer distance between the bridges on the 1st and 2nd Kohat Tunnel and Access Roads is 2.80 m in the south section and 0.30 m in the north section.

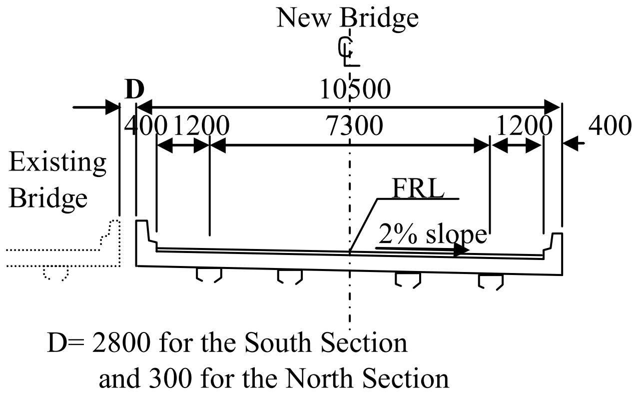


Figure 11.4.1 Typical Section of Bridge Structures

(3) Bridge Structures

The bridge superstructure consists of RC deck on standard PCC girders, except for the Bridges 9R and 10R for which RCC girders are used. The abutments are of the reverse

T-type on pile foundations (dia.900 mm or 750 mm), except for the Bridge No.5R for which spread foundation is used. Piers are of circular column type with larger dimensions than those used in the 1st Kohat and Access Roads to provide sufficient resistance to the new seismic force. The diameter of foundation piles for some bridges is increased from 750 mm to 900 mm to meet the new seismic load.

(4) Wing Walls and Protection Works

Wing walls are provided for embankment protection. Grouted ripraps are provided for protection of abutments.

A part of the wing walls and the grouted ripraps should be demolished for construction of the new bridges for the 2nd Kohat Tunnel and Access Roads Project. These shall be reconstructed later.

(5) Scouring Protection Works

Scouring protection works are provided for the river crossing bridges (Bridges No.1R, No.2R, No.9R, No.5R, No.6A R and No.7R). The protection works are either one of the following types or a combination thereof:

- Gabions
- Rock fill (dia.300 - 600 mm)
- Grouted riprap

(6) ROW for New Bridges

The ROW necessary for construction of the new bridges was already secured together with the Roadway ROW acquisition during the 1st Kohat Tunnel and Access Roads construction. However, there is still a private land (approximately 8 m x 4 m x 1/2= 16 m^2) at the site where the Bridge No.6AR is constructed (see following photos).

A Piece of Private Land located
at No.6AR Bridge Construction Site
(River Bed) at Sta.21+260

A Piece of Private Land located
at No.6AR Bridge Construction Site
(River Bed) at Sta.21+260

11.4.2 Box Culvert Design

Eighty six box culverts are planned for the 2nd Kohat Tunnel and Access Roads as listed in Table 11.4.2. Standard box-culverts of NHA are used. The total length of box culverts is 1,388m. Most of them are for roadways cross drainage and some are underpasses of the 2nd Kohat Tunnel and Access Roads. The box-culverts (2 cells x 6.15 m x 5.5 m) at Sta.15+575 are for the Kohat Link Road underpass.

Table 11.4.2 List of Box Culverts

No.	Culvert No.	Station	Dimension (Cell No.xWxH)	Length m
South Section				
1	2	00 + 532.74	1-1.0x1.0	15.0
2	4	00 + 819.44	1-1.0x1.0	11.4
3	9	01 + 445.19	1-1.0x1.0	11.8
4	13	01 + 819.97	2-1.5x1.5	10.5
5	14	02 + 039.89	1-1.0x1.0	13.1
6	15	02 + 125.58	1-1.0x1.0	12.2
7	27	03 + 627.00	1-2.0x1.5	9.9
8	29	03 + 895.15	1-1.0x1.0	10.7
9	31	04 + 207.85	1-1.0x1.0	11.3
10	33	04 + 459.09	1-1.0x1.0	19.3
11	34	04 + 511.00	1-4.5x4.8	13.4
12	35	04 + 523.08	2-2.5x2.5	25.8
13	36	05 + 041.25	1-1.0x1.0	10.5
14	37A	05 + 296.00	1-1.5x1.0	17.6
15	38	08 + 286.00	1-2.0x2.0	9.8
16	39	08 + 615.00	1-1.0x1.0	12.8
17	40	08 + 866.00	1-1.0x1.0	14.8
18	41	09 + 062.00	1-1.0x1.0	19.2
19	41A	09 + 822.00	1-1.0x1.0	31.9
20	41B	10 + 017.50	1-1.0x1.0	29.0
21	47	10 + 954.00	1-1.5x1.5	38.9
22	48	10 + 962.00	1-4.5x4.8	16.2
23	50	11 + 021.00	1-2.5x2.5	17.6
24	51	11 + 109.00	1-1.0x1.0	24.3
25	52	11 + 260.00	1-4.5x4.8	9.4
26	53	11 + 312.45	2-1.5x1.5	40.0
27	53A	11 + 338.00	1-1.0x1.0	41.1
28	54	11 + 674.00	2-1.5x1.5	11.9
29	55	12 + 040.00	1-1.0x1.0	11.5
30	56	12 + 171.00	1-1.5x1.5	13.5
31	57	12 + 340.00	1-1.0x1.0	13.1
32	58	13 + 366.00	1-3.5x4.0	11.9
33	60	13 + 872.60	1-2.0x2.0	9.5
34	61	14 + 361.00	1-2.0x2.0	15.9
35	62	14 + 734.00	1-2.0x2.0	21.4
36	63	14 + 900.00	1-1.0x1.0	23.5
37	64	15 + 050.00	1-1.0x1.0	16.7
38	65	15 + 244.00	1-2.0x2.0	12.1
39	66	15 + 480.00	2-3.0x3.0	36.7
40	66A	15 + 789.00	1-1.5x1.5	34.6
41	66B	15 + 575.00	2-6.15x5.5	34.9
42	67	18 + 562.60	1-2.0x2.0	70.6
43	68	18 + 636.30	1-2.0x2.0	81.2
44	69	19 + 642.00	1-2.0x2.0	32.4
45	69A	19 + 838.00	1-2.0x2.0	11.6
46	69B	19 + 975.00	3-2.5x2.5	17.5
47	72	20 + 002.46	1-4.0x4.0	11.1
Sub-Total for South Section				**989.1**

No.	Culvert No.	Station	Dimension (Cell No.xWxH)	Length m
North Section				
1	73	18 + 380	3-3.0x3.0	21.2
2	75A	18 + 829	1-1.5x1.5	20.1
3	75b	19 + 290	1-5.0x5.0	16.1
4	77	19 + 491	1-2.5x2.5	15.2
5	80	20 + 123	1-2.0x2.0	16.1
6	80A	20 + 355	3-3.5x3.5	13.7
7	80b	20 + 400	1-2.5x2.5	22.3
8	81	20 + 567	1-4.5x4.8	17.2
9	81A	20 + 753	2-3.0x3.0	14.8
10	82	20 + 818	4-3.0x3.0	18.3
11	88A	22 + 645	1-3.5x3.5	11.1
12	89	22 + 833	1-3.0x3.0	14.4
13	90	23 + 023	1-3.5x3.5	13.4
14	92	23 + 415	1-2.5x2.5	11.1
15	93	23 + 520	1-2.5x2.5	14.4
16	94	23 + 675	1-1.0x1.0	27.5
17	95	23 + 897	1-2.75x2.75	10.3
18	95b	24 + 296	1-2.0x2.0	12.5
19	96	24 + 531	1-3.0x3.0	15.2
20	96a	24 + 703	1-2.5x2.5	10.8
21	96c	24 + 862.800	1-1.5x2.0	16.3
22	97	24 + 900	1-3.0x3.0	15.6
23	97a	24 + 995	1-2.0x2.0	13.2
24	97b	25 + 070	1-2.0x2.5	10.5
25	98	25 + 121	1-2.5x2.5	11.9
26	98A	25 + 317	1-1.5x2.0	9.6
29	SBC-3	00 + 277	1-1.0x1.0	6.1
Sub-Total for North Section				**398.9**
Total				**1,388.1**

Notes: * Break at Sta. 20+186.738 /Sta.16+247.000 (-3,939.738)

11.5 Tunnel

11.5.1 Design Conditions

(1) Design Conditions

The new tunnel is a two-lane road tunnel and will be constructed in parallel to the existing Kohat Tunnel at 30 m away. The design conditions of 2nd Kohat Tunnel are listed in Table 11.5.1. The tunnel length is 1,885 m, and the longitudinal slope is 2.4%. The support method is NATM (New Austrian Tunnelling Method). The tunnel is excavated from both portals. The excavation method is top-heading and bench cut method. Excavated materials are hauled by trucks.

Table 11.5.1 Tunnel Design Conditions

Items		2nd Kohat Tunnel
1. Tunnel Length		1,885m
2. Portal Locations		Sta.16+247 ～ Sta.18+132
3. Tunnel Slope (grade)		i =2.4%（upgrade from south to north）
4. Support and Excavation Method	CI, CII	- NATM
	DI	- Top heading and bench cut method
5. Geological Condition		CI, C-II and DI (almost same as the 1st Kohat Tunnel)
6. Excavation Method		Blasting
7. Mucking Method		Loading by a loader and hauling by trucks
8. Direction of Excavation		From both south and north portals
9. Design Standards		Technical Standards for Road Tunnel in Japan

(2) Geological Conditions

The geological condition is based on Section 6.4 Geological Survey of this Report. 59.7% of rock is classified as CI, 13.5% as CII and 26.8% as DI (Table 11.5.2). The geological profile is shown in Figure 11.5.1.

Table 11.5.2 Classified Rocks in Tunnel

Soil Classification	Section Length (m)	Proportion (%)
CI	1124.5	59.7
CII	255.5	13.5
DI	505.0	26.8
Total	1885.0	100

Note: DI includes the tunnel entrance sections.

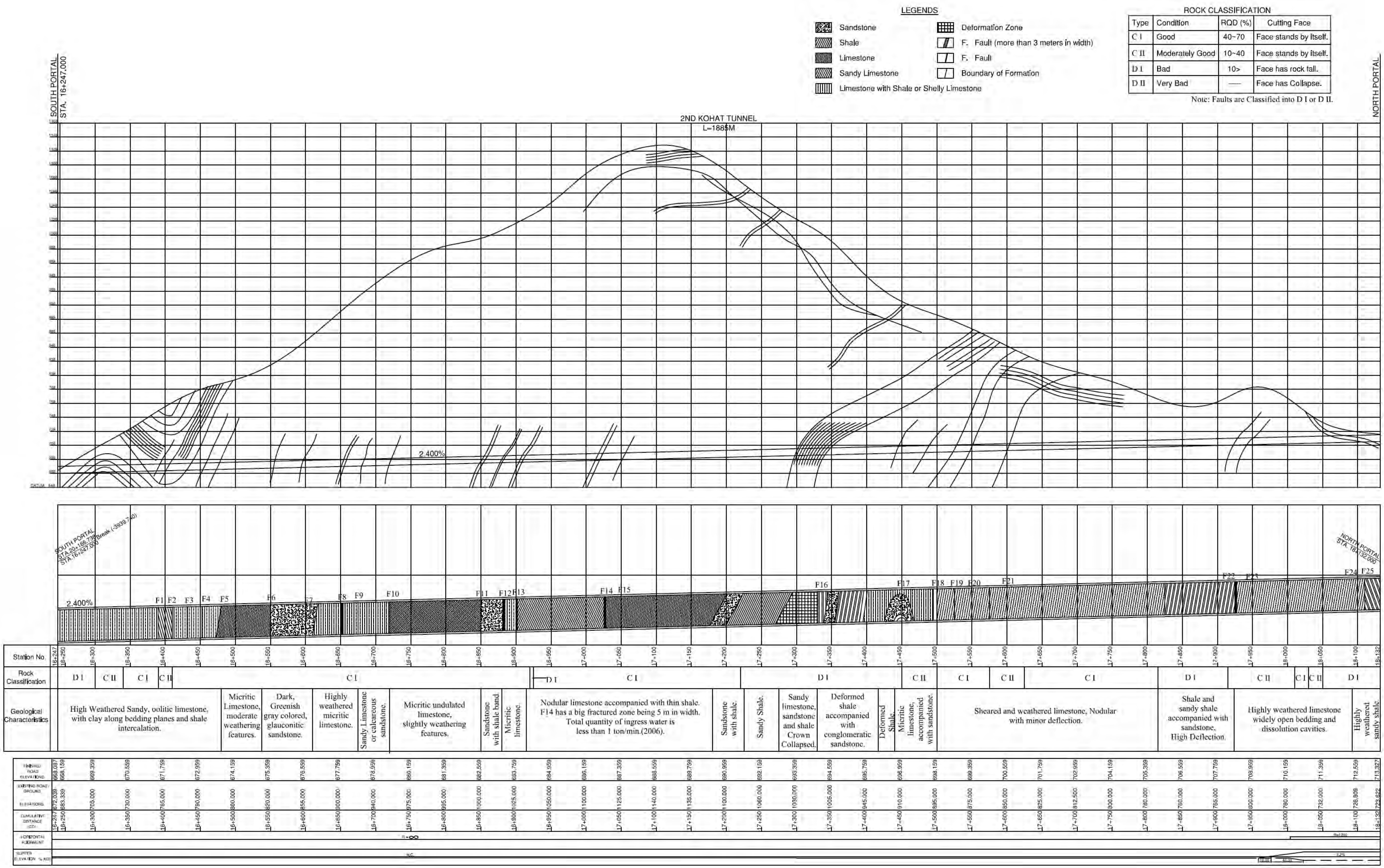
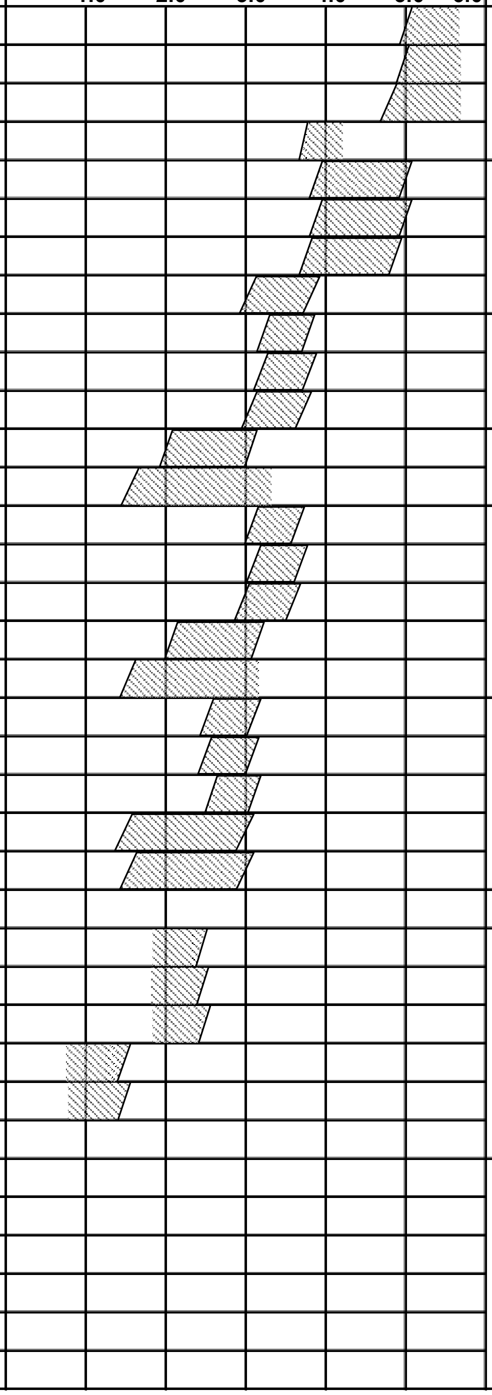


Figure 11.5.1 Geological Profile



GRADE		TYPE OF ROCK	Elastic Wave Velocity (Vp,km/s) 1.0 2.0 3.0 4.0 5.0 6.0	2- Strength - Earth Pressure Rate	(3) Boring Core: State of Core	(3) Boring Core: RQD(%)	(4) Geological Features (result of geological test or the state of the face)	Observation: When Hammered	Observation: Pitch of Opening	(6) State after excavation: Face Stability	(6) State after excavation: Convergence (mm)
A		a, b, c, d1		-	Generally has more than 90% core recovery and shows a perfect columnar shape. Rarely contains fragments.	90 or More	- Very hard and fresh rock forming large mass which is continuous and stable with few cracks. - No deterioration caused by water.	Hammer springs back. Strong hammering barely breaks to expose fresh planes.	100 to 50 Minimum	- In very good self-standing state and no loosening for a long time. - Loosening height is 1.6m.	Slight
B		a, b, c, d1		-	Generally has more than 70% core recovery and shows a shape of rather large fragmental rock, a short columnar shape, or a rod-like shape. Most cores are 10 to 20 cm in length but there are some with lengths of about 5cm.	90 ~ 70	- Fresh and hard relatively few cracks. - Despite considerable hardness, rock appears to have been degenerated by weathering. - Rock is hard but in strata; stratification or schistosity is found and rock easily breakable along the plane. No deterioration caused by water.	Broken when Hammered strongly but break mostly run along cracks, or joints& broken pieces are relatively large.	70 ~ 10	- Face stands by itself. Unsupported excavated face shows local fall of rocks but remains generally stable. - If there are locally loosened portions, the ground seeds partial supporting. - Loosing height is 1.5-3.0 m	Slight
C	I	a, b, c		-	Core recovery rates range from 40 to 70%. A large number of cracks are found. Decreases in size as it is crushed easily. Pieces which are 5 cm or less are recovered in abundance. Difficult to restore to original shape.	70 ~ 40	- Altered by weathering and rock is somewhat softened. - Though rock is relatively hard, fine cracks are formed and clay is sandwiched thinly between them. - Rock shows clear stratification. Very thin and easily broken. - Narrow and small faults are sandwiched.	Easily broken by a hammer into cracked planes. Breaking is rather difficult on planes other than cracks.	About 50 minimum	- Face stands by itself. the ground requires shotcrete on the crown immediately after blasting. - Loosening height is 2.04.0 m.	50 or Less
C	I	d1, d2		4 or More						- Face stands by itself. Unsupported excavated face has fall of rocks near the crown and the ground requires un supporting. - Loosening height is 2.0-4.0m.	
C	II	a, b, c, d1, d2		4 or More	Core recovery rates range from 40% or less Core become small piece or sometimes mixed with breccidated pebbles, or clay.	40~10	- Subjected to severe weathering, rock is partially transformed to soil. Soft and brittle with slightly hard portions remaining inside. - Joints are so numerous that scraping in places other than cracks is possible. - Crush zone which still has time to be changed completely to clay; cohesive soil is mixed with rock fragments, containing some hard portions. - Soil, talus cone, etc. - If face is softened by water, the ground is classified under DII	Rapidly crushed by a hammer. Rock is brittle and easily broken by hand.		- Both face and unsupported excavated face has either large-scale fall of rocks or slight squeezing. The ground needs immediate presupporting and early support. - Plasticity range or loosening height is 3.0-6.0 m.	
D	I	a, b, c, d1, d2		4~2	-	No more than about 10					60 or Less
D	I	e		2 or more							
D	II	a, b, c, d1, d2, e		2~1				Crushed when hit slightly with a hammer. The end of the hammer runs into the ground.		- Face has large -scale fall of rocks. Unsupported excavated face has squeezing pressure. - Plasticity range or loosening heights is 3.0-6 m	200 or Less
E		a, b, c, d1, d2, e		1 or Less	-	-	- Faults conspicuously changed to clay, under high unsymmetrical earth pressure or circumferential earth pressure, and considerably large in width. - Easily deteriorated by water to be softened.			- Squeezing is caused on face. Faces May be thrusted out by earth pressure. - Unsupported excavated face has circumferential squeezing pressure. - Plasticity range >7.0 m	400 or Less

(Notes) 1 . Type of Rocks
a : Metamorphic rock (phyllite, graphite schist, siliceous graphite schist, quartz schist, green schist, gneiss, serpentinite. homfels, etc.), plutonic rock (gabbro, peridotite, etc.)
b: Pataeozoic strata and Mesozoic strata (state, sandstone and conglomerate, hard sandstone, limestone, quartzite, diabasic tuff, etc.)
c: Volcanic rock (quartz trachyte, andesite, basalt, etc.), Dike rock (granite porphyry, quartz porphyry, porphyrite, diabase, etc.), Plutonic rock (granite, diorite)
d: Tertiary Strata and tower diluvium strata (mud stone, shale, siliceous shale, sandstone and conglomerate, tuft, tuff breccia, agglomerate, etc.) However, by using the uniaxial compressive strength (qu) 200 kgf/cm2 of fresh rock samples as a reference, this rock type is subdivided into dl and d2.
d1: qu more than and equal to 200kgf/cm2
d2: qu less than 200kgf/cm2
e: Upper diluvium strata (loam and clay, volcanic pyroclastic matter), alluvial strata (talus, surface soil, etc.)

National Expressway Practice in Japan (Tunnel), Expressway Technology Center (ETC), Japan, in 1995

Table 11.5.3 Rock Classification for Tunnel

a) Study and Analysis of Geological Report of the 1st Kohat Tunnel Construction

The following geological report was prepared for the construction of the 1st Kohat Tunnel and Access Road:

"Kohat Tunnel and Access Road Project, Technical Report of Geological Supervision - Pacific Consultant International J/V Mouchel Consulting Limited in association with Engineering Associates and National Engineering Services Pakistan (PVT) LTD. (September, 2003)"

The main contents of this report are as follows:

1) Tunnel peripheral mapping
2) Geological profile of the tunnel
3) Rock classification for support pattern
4) Measurement of groundwater
5) Laboratory test for rock
6) Analysis of supporting pattern
7) Analysis of rock bolt
8) Analysis of inner space deflection
9) Daily tunnel observation record
10) Suggestion for second tunnel

Table 11.5.4 Result of Rock Test for the 1st Kohat Tunnel

location (Sta.No)		17+178	17+208	17+317		17+357	17+378	17+590	17+870
Rock Type		Lime stone	Sandstone	Lime stone	Shale	Shale	Shaley Limestone	Lime stone	Shaley sand stone
Supporting Pattern		CI	CI	DI	DI	MDI	MDI	CII	DI
Specific Gravity		2.71	2.75	2.77	-	-	2.77	2.73	2.77
Water Absorption (%)		0.30	2.10	0.10	-	-	2.20	0.61	0.53
Compressive Strength (Mpa)		82	-	86	-	-	42	-	-
Statistic Modulus of Elasticity (Mpa)		8.86 E+04	-	2.90 E+04	-	-	-	-	-
Static Poision's Ratio		0.767	-	0.555	-	-	-	-	-
Cohesion	(Mpa)	12.5	-	25.0	-	-	25.0	-	-
	(tf/m²)	12.8	-	25.5	-	-	25.5	-	-
Angle of Internal Friction(◦)		38	-	35	-	-	31	-	-
Slaking Index		-	-	0	1	2	0	-	3

Technical Report of Geological Supervision,
Pacific Consultant International , Tokoyo Japan ,2003
Note : Cohesion Values were corrected by re-calculation

The results of rock test are shown in Table 11.5.3 and the standard of rock classification is shown in Table 11.5.4. The geological condition of tunnel described in this report is as follows:

1) Rock types found in the tunnel:

   Limestone = 70%, Sandstone = 15%, Shale = 15%

2) Ratio of rock classification in the tunnel:

   C Ⅰ = 59.7%, CⅡ = 13.5%, D Ⅰ = 26.8%

3) Main relation between rock type and rock classification:

   Limestone and sandstone : C Ⅰ and CⅡ, Shale and fractured zone : D Ⅰ

4) In the tunnel, there are 25 faults. Their main strikes are E-W and dips are between 70° and 90°. Among these faults, there are 3 main big faults and the width of fractured zones is between 1.5 m and 5.0 m.

5) Main ingress water was found between Sta. 17+000 and Sta. 17+150. A maximum water ingress rate of about 5,000 L/min was recorded at this site.

6) According to the result of rock test, the compressive strength of limestone ranges between 42 MPa (428.3 kgf/cm2) and 86 MPa (876.9 kgf/cm2).

b) Evaluation of Geological Condition

i) Slope Condition at the Portal

North Portal:

As shown in Figure 6.4.2 Geological Cross Section, the 2nd Kohat Tunnel and Access Roads are aligned on a gentle monoclinal slope covered with thin talus deposit with a 3.5 m thickness.

The basement rock consists of weathered shale. The gradient of slope is between 20° and 25° westward, and the dip of shale is also 20° westward. Therefore there is a possibility of slope collapse due to tunnel excavation. Therefore, appropriate measures should be taken to dig the north portal which is composed of talus deposit and weathered shale.

South Portal:

As shown in Figure 6.4.3 Geological Cross Section, the 2nd Kohat Tunnel and Access Roads are aligned at the end of a small ridge between the east valley and the west valley. The bottom of both valleys is buried by debris flow deposits. The basement rock consists of weathered fine limestone. On the slope, there is no talus deposit and limestone on the portal is hard enough. For that reason, therefore, the excavation at this site would cause no problem. But it is possible that debris flow from the east valley directly hits the projected road in the section downstream of the portal. Under this Project, the control office is planned to be relocated from the east valley side to the west valley side. If large scale debris flow happens in the west valley, the new control office may be damaged. Therefore some protection facilities like sabo dam are required to be provided on the east and west valleys.

ii) Geological Condition of the 2nd Kohat Tunnel

The geological profile of the 2nd Kohat Tunnel is shown in Figure 11.5.1. According to the underground geological map of the 1st Kohat Tunnel, there are 25 faults in the tunnel. These faults and formations extend mainly in the E-W direction, and dip southward or vertically. Therefore the geological profile of the 2nd Kohat Tunnel was prepared by extending the strikes and dips from the 1st Kohat Tunnel to 30 m eastward.

According to the rock classification of the 1st Kohat Tunnel, limestone and sandstone are classified into C Ⅰ and CⅡ, and shale, fractured zone and deformation zone are classified into DⅡ. The ratio of CⅠ and CⅡ to the total length is 73.2%. For that reason, therefore, it is considered that there will be few geo-technical problems for excavation of the tunnel, except for faults and groundwater. The locations and widths of main fractured zones are as follows.

- . F4: Sta.No.16+460, w = 1.0m
- . F8: Sta.No.16+650, w = 2.0m
- . F12: Sta.No.16+880, w = 2.0m
- . F14: Sta.No.17+060, w = 5.0m
- . F15: Sta.No.17+090, w = 1.5m
- . F20: Sta.No.17+560, w = 1.0m
- . F21: Sta.No.17+570, w = 1.0m
- . F22: Sta.No.17+933, w = 2.0m
- . F23: Sta.No.17+940, w = 1.0m

At the sections with the above faults, rock fall and collapse happened during construction works. Between Sta. 17+250 and Sta. 17+340, a deformation zone accompanied by complex folded sandstone, shale, conglomerate and limestone was found. Rock fall and collapse also occurred in this zone.

The sections with ingress water in the tunnel are the following:

- Sta. 16+940 ~ Sta. 17+100 Limestone
- Sta. 17+190 ~ Sta. 17+240 Sandstone and Shale
- Sta. 17+290 ~ Sta. 17+400 Sandstone and Shale
- Sta. 17+660 ~ Sta. 17+665 Limestone
- Sta. 17+720 ~ Sta. 17+740 Limestone
- Sta. 17+820 ~ Sta. 17+830 Shale
- Sta. 17+890 ~ Sta. 17+900 Sandstone and Shale

Among these sections, the section between Sta. 17+000 and Sta. 17+100 including F14 and F15 is the most remarkable ingress water zone. The variation of the total volume of water is as follows.

2003 : 5,000 litres/min.

2005 : 2,000 litres/min.

2006 : 500 ~ 1,000 litres/min.

The volume of ingress water varies with annual rainfall. It increases during the monsoon season between July and August, and decreases during the dry season. At present, ingress water from the tunnel runs through a channel and is led into a measure beside the control office at the south portal.

In conclusion, it can be said that the 2nd Kohat Tunnel has no geotechnical problem for excavation. But proper measures are to be taken to cope with the fractured zones, deformation zones, and ingress water in the tunnel.

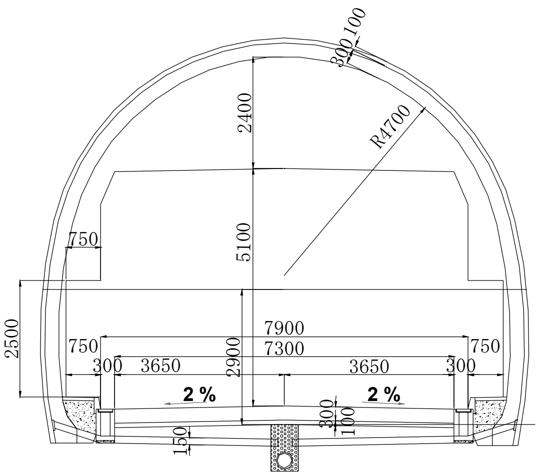
11.5.2 Cross Sections of Tunnel

The tunnel cross sections were designed referring to the design of 1st Kohat Tunnel. The standard road width is 7.9 m: two 3.65 m-wide lanes and 0.3 m-shoulder on each side. Vertical clearance limit is 5.1 m.

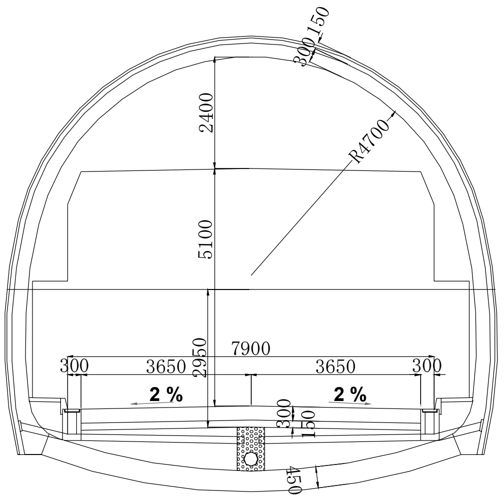
The thickness of shotcrete, support work pattern and lining thickness are determined by rock classification. Five patterns are provided by rock classification: two types for portal sections and emergency parking bays and three patterns for CI, CII and DI.

Figure 11.5.2 shows typical cross sections for CI, C-II and DI. The same cross section is applied for CI and CII. Invert is constructed for DI considering the ground condition. Invert is also constructed at portals since it is difficult to form grand arch.

Figure 11.5.3 shows typical cross sections for portals and emergency parking bays. Invert is necessary for the portals but it is not necessary for the emergency parking bays as they are located at CI and CII rock sections.

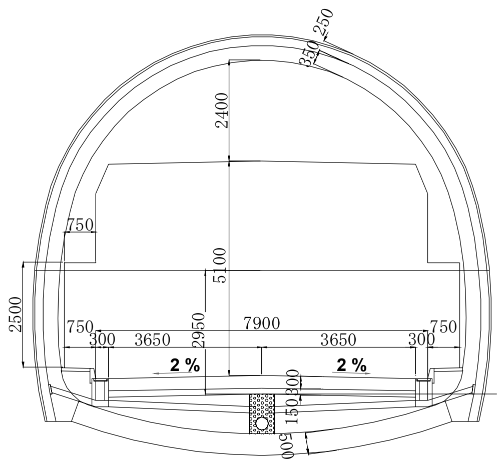


TYPICAL CROSS SECTION PATTERN TYPE - C I

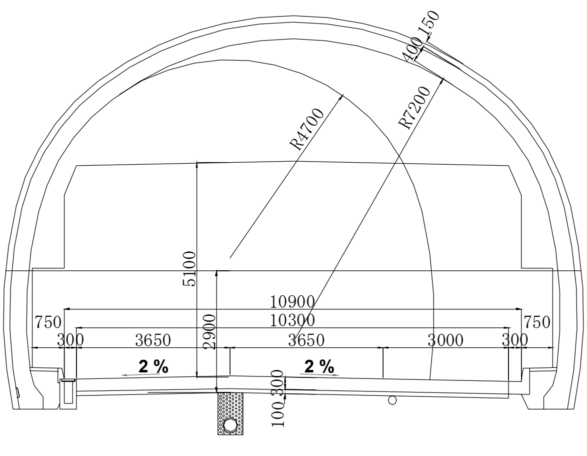


TYPICAL CROSS SECTION PATTERN TYPE - D I

Figure 11.5.2 Typical Cross Sections for CI, CII and DI



TYPICAL CROSS SECTION PATTERN TYPE PORTAL



EMERGENCY AREA TYPICAL CROSS SECTION PATTERN

Figure 11.5.3 Typical Cross Sections of Portals and Emergency Parking Bays

11.5.3 Support System Design

The support system of the tunnel was designed by rock classification.

(1) Type CI

Sixteen (16) rock bolts of 3 m in length are fixed at 1.5m.

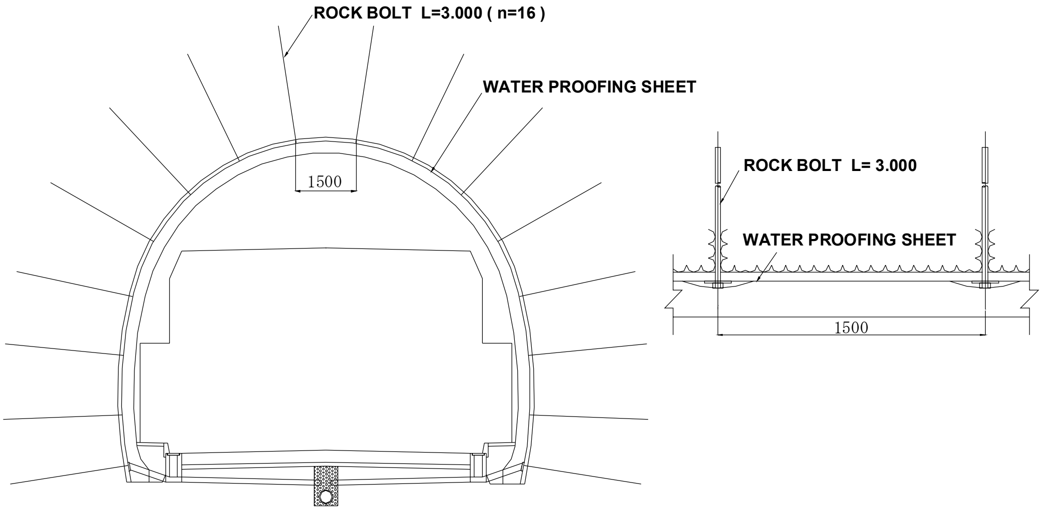


Figure 11.5.4 Support System for Type CI Sections

(2) Type CII

Sixteen rock bolts of 3 m are fixed at 1.5m. H-beams (125x125x6.5x9) are installed around the upper arch section.

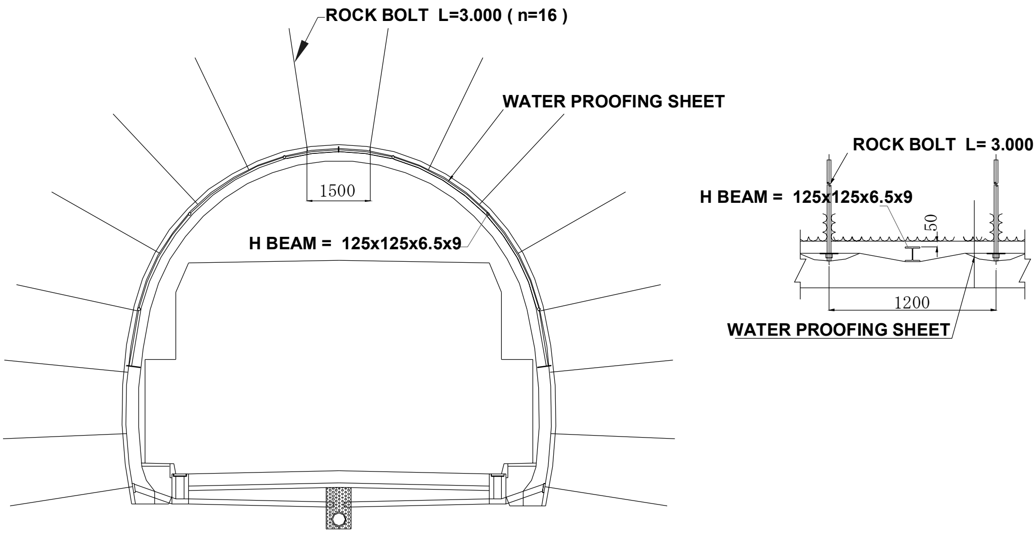


Figure 11.5.5 Support System for Type CII Sections

(3) Type DI

The DI geology of the Kohat Tunnel section is composed of weathered limestone, sandstone and sandy shell. Figure 11.5.5 shows the basic support pattern for DI. Twenty 4 m rock bolts are fixed against the tunnel arch.

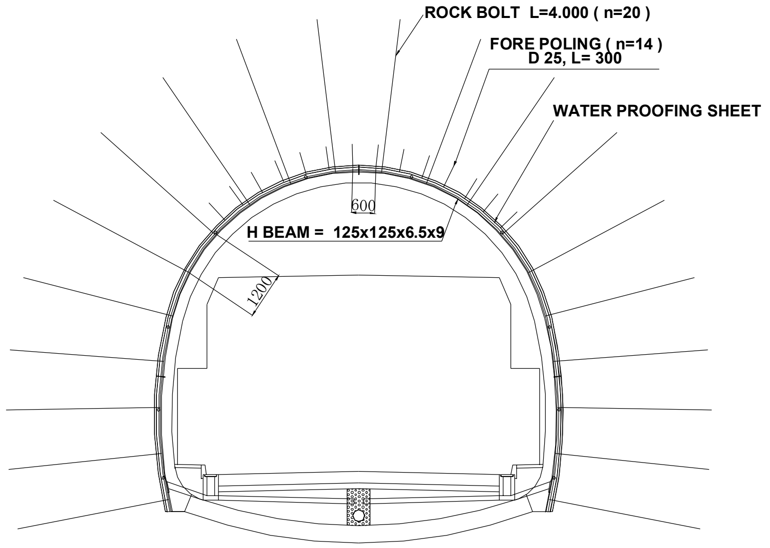


Figure 11.5.6 Support System for DI Sections with Fore-Poling

Fore-poling (pre-support) was used together with rock bolts for DI sections for stabilizing highly weathered rock during the 1st Kohat Tunnel construction as it was the 1st road tunnel in Pakistan. The fore-poling section was approximately 30% of the total tunnel length. As well as in the 1st tunnel, the fore-poling method is applied for the 2nd tunnel design from the safety viewpoint as the tunnel construction experience is still premature in Pakistan.

(4) Portals

Fourteen fore-poles are fixed before excavation and then 10 rock bolts and H-beams are installed along the arch at one meter intervals after the 1st or 2nd shotcrete (Figure 11.5.7).

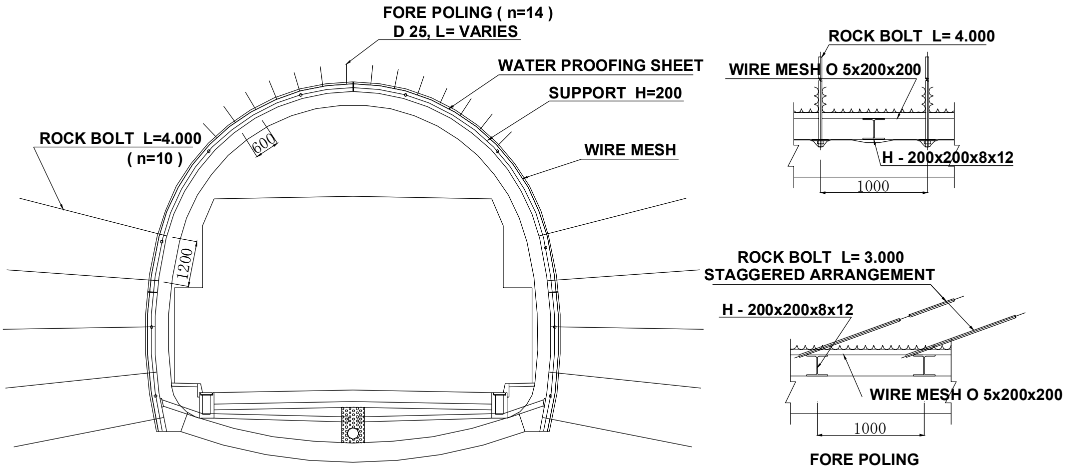


Figure 11.5.7 Support System for Tunnel Portals

(5) Emergency Parking Bays

At emergency parking bays, 22 rock bolts of 4m in length and H-beams are installed at every 1.2 m (Figure 11.5.8).

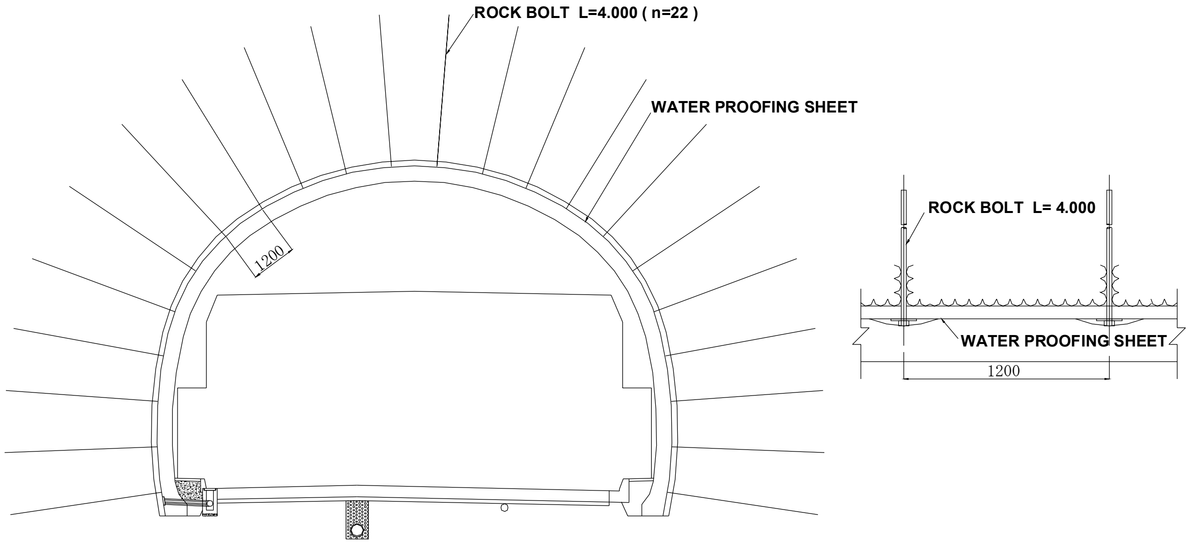


Figure 11.5.8 Cross Section of Emergency Parking Bays

11.5.4 Cross Passage (Evacuation Tunnel)

A part of the two cross passages (evacuation tunnels) was already constructed during the 1st Tunnel construction. These cross passages are required to connect to the 2nd Kohat Tunnel. As there is some elevation difference between the 1st and 2nd tunnels, these two tunnels need to be connected by stairs as shown in Figure 11.5.9.

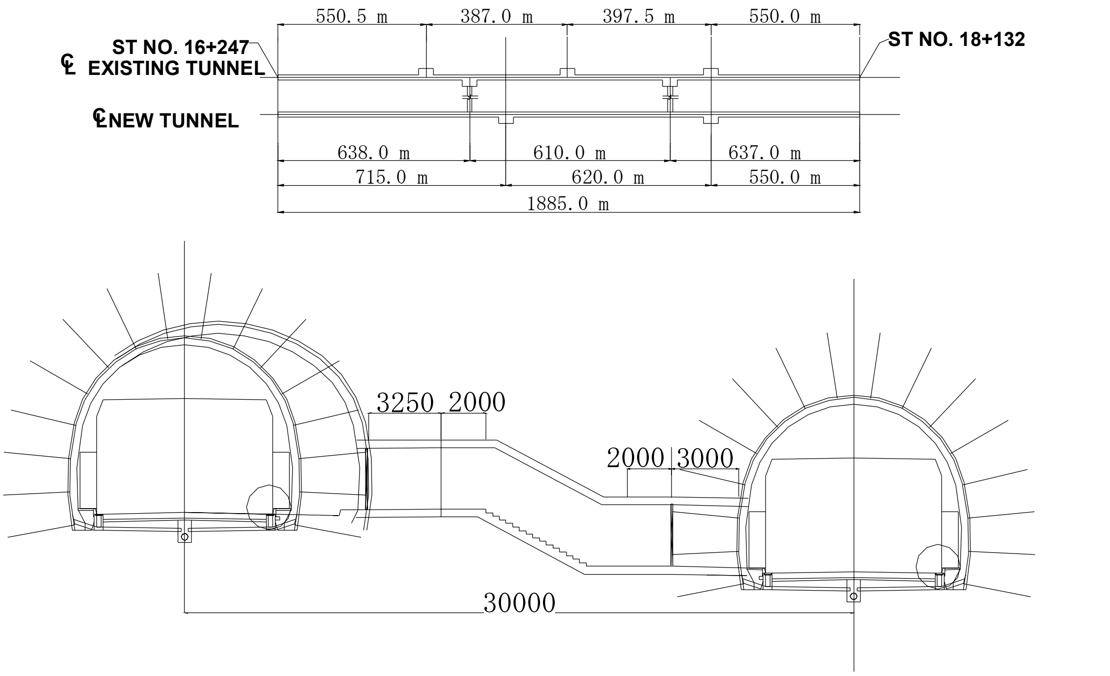


Figure 11.5.9 Cross Passage (Evacuation Tunnel) between the 1st and 2nd Kohat Tunnels

11.5.5 Portal Design

The tunnel portal consists of a portal and tunnel adjacent section (portal section). The starting point of the portal section is determined considering necessary covering (3-4 m) for tunnel construction by NATM. The wing type portal is deigned for both south and north portals.

The portals are designed as follows:

- Portal section is extended up to the point where the covering depth becomes at least 3.0 m.
- Fore-poling is used for the tunnel crown to prevent rock fall.
- Ring cut excavation method is adopted to stabilize the tunnel face.
- Cut slope is protected by shotcrete.
- Temporary supports are installed until completion of the portal construction.

The current tunnel control room located on the right hand side of the south portal is required to be relocated to either the opposite site or the north portal site prior to the tunnel excavation from the south.

11.5.6 Drainage Design

(1) Relief of Seepage

Seepage water shall be drained out from the tunnel as soon as possible. Retention of water causes problems including excess loading on the lining, cracking in the lining, reducing the life of lighting/safety facilities and adverse affects on pavement. In order to protect the tunnel lining from seepage, waterproof sheets (1.5 mm-thick) are placed on the surface of shotcrete. The sheets are also effective for preventing cracks in lining concrete.

(2) Drainage

Seepage water behind the lining collected at the tunnel knee is guided to catch basins at approximately 50m intervals. It is drained out through PVC pipes of φ150mm along the roadside to the tunnel south portal. The road surface water from rainfall and surface cleaning is directly collected by catch basins and drained to the outside of the tunnel through PVC pipes under gutters. Any groundwater to the tunnel underneath is drained by perforated pipes (φ300) installed under the pavement at the centre of the tunnel. Though the capacity of the centre drain is large, it was not used effectively under the existing system.

(3) Capacity of Drainage Facilities of the 1st Kohat Tunnel

The heavy rainfall on 1st March 2005 induced overflow of catch basins in the tunnel. The recorded run-off was 2.1 m^3/min (0.035 m^3/sec). This was over the capacity of catch basins within the discharge capacity of PVC pipes.

Table 11.5.5 shows the discharge capacity computation for the centre and side drains.

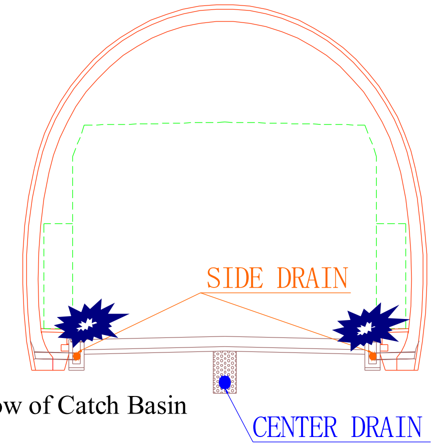
Table 11.5.5 Capacity of Drainage Pipes

Type of Drains	Diameter (mm)	Roughness Coefficient	Discharge (m^3/sec)	
			Slope of Waterway: 2.2%*	Slope of Waterway: 2.4%*
CENTRE DRAIN (Perforated Pipe)	φ 300	0.025	0.064	0.067
SIDE DRAIN (P.V.C)	φ 150**	0.01	0.025×2=0.050	0.026×2=0.052
	φ 200		0.056×2=0.112	0.058×2=0.116
	φ 250		0.10×2=0.20	0.104×2=0.208

Notes: *2.2% for the 1st Kohat Tunnel and 2.4% for the 2nd Kohat Tunnel.

** φ 150 for the 1st Kohat Tunnel.

Drainage Outlet at South Portal



Overflow of Catch Basin

Figure 11.5.10 Tunnel Drainage System

The left figure in Figure 11.5.10 shows a part of the current drainage system. The flow through the road side drain and spring water from mountain meet at small basins (30 cm x 30 cm) and induce overflow.

A recommended improvement plan for the 2nd Kohat Tunnel is shown in the right figure of Figure 11.5.11. The drain for spring water from mountain is connected to the centre drain and separated from the surface drain to avoid overflow in the tunnel. This will also contribute to the improvement of the 1st tunnel drainage.

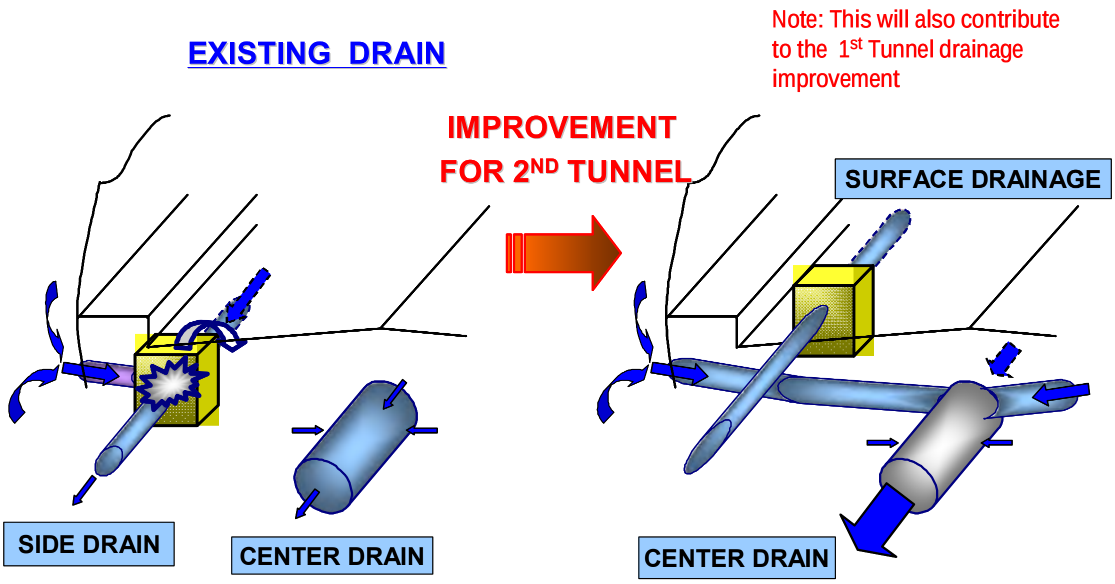


Figure 11.4.11 Drainage Plan for 2nd Kohat Tunnel

11.5.7 Pavement Design

The pavement in the tunnel and the tunnel approach sections (L=150m each) is concrete pavement as it is almost maintenance free compared with the AC pavement. The design thickness of concrete pavement is 30cm (refer to Subsection 11.3.2 of this Report as to the detailed design). The concrete pavement is constructed on the lean concrete base (10-15cm thick). Concrete slabs are reinforced with φ6 mm steel mesh (120mm x 120mm). The transverse contraction joints are dowel bar joints (φ32mm x 600mm) provided at 10m. Tie bars (length= 600mm) are φ12 mm at 50 cm.

11.6 Tunnel Facilities

11.6.1 General

For the safety of driving through tunnel, following systems should be provided in the tunnel:

1) Ventilation system
2) Lighting system
3) Power supply system
4) Emergency facilities
5) Other facilities

According to Section 10.1.1 Location of the South Portal and Approach Road Alignments, the exiting control room yard shall be moved away. So, the relocation of the existing control room yards is also described in the last part of this section.

The image of mechanical and electrical facilities in the tunnel is shown in figure 11.6.1.

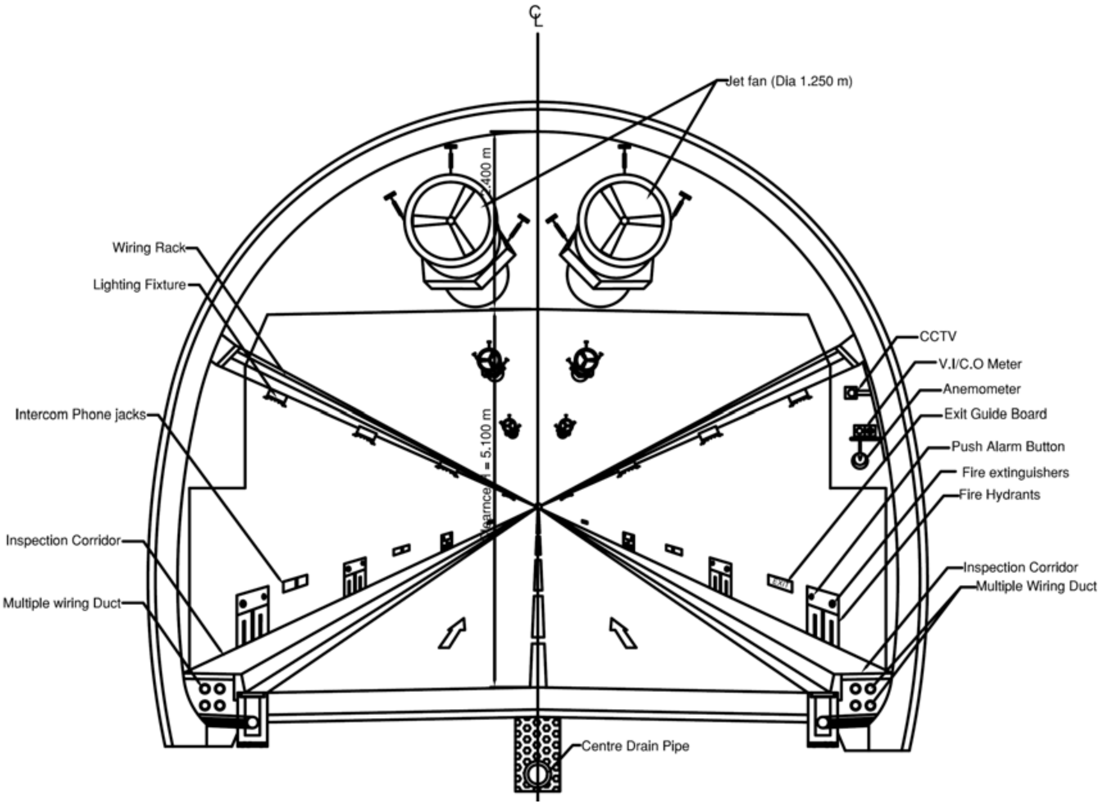


Figure 11.6.1 Image of Mechanical & Electrical Facilities in Tunnel

11.6.2 Design Conditions and Data

Based on the tunnel civil part design, the following design conditions and data are applied for designing tunnel facilities:

1) Tunnel geometric conditions

- Tunnel length: 1885m (same as No.1 Kohat Tunnel)
- Tunnel profile: 2.2% continuous grade, rising from south to north (the existing Kohat Tunnel changes from two-way to one-way for north-bound traffic), and 2.4% continuous grade, descending from north to south (the planned No.2 Kohat Tunnel is used for one-way south-bound traffic)

- Tunnel inner sectional area: 61.8 sq.m (same as No.1 Kohat Tunnel)

2) Traffic direction: two-way traffic with 2 lanes becomes one-way traffic with 2 lanes each after construction.

3) Traffic characteristics:

   - Design traffic volume: 11,685 veh./day (2012) and 33,760 veh./day (2032)
   - Traffic speed: 60km/hour
   - Traffic composition: 40% (with diesel engine), 60% (with gasoline engine)

4) Tunnel finishing:

   Surface of ceiling/wall/road: Concrete (asme as No.1 Kohat Tunnel)

5) Reference Data

   - Kohat Tunnel and Access Roads Project
   - Design Review Report, August 1998

11.6.3 Ventilation System

(1) General

In a tunnel it is necessary to minimize the presence of contaminated air, which is caused by the emission from internal combustion engines of vehicles. The polluted air in a long tunnel with a heavy traffic volume is minimized by a mechanised ventilation system that is a key factor in deciding the tunnel structure plans and cross sections.

Provision for power supply and facilities to be used in emergency cases should be determined together with that of ventilation. Thus the ventilation system is integrated into the whole tunnel system.

(2) Tunnel Ventilation System

Ventilation systems are required for road tunnels because the exhaust gas emitted by vehicles is harmful for people in the vehicles and the smoke and dust produced by vehicles reduce drivers' visual field.

a) Ventilation System

A short tunnel does not need any mechanical ventilation system as long as the natural draft in the specific tunnel is effective enough to blow out the exhaust gas, smoke and dust. In the case of the Kohat Tunnel, as it is too long the natural draft system only is not sufficient, especially for the two-way traffic on 2 lanes (as in the case of the No.1 Kohat Tunnel).

b) Adopted Ventilation System

It is apparently clear that the longitudinal system is most economical for the Kohat Tunnels.

From the economic point of view, the longitudinal ventilation system has the following advantages:

- Less pressure losses.
- No extra ventilation duct required in the tunnel.
- No building required for ventilation fans installation.

Jet fans have been selected for the longitudinal flow system, considering their following advantages:

- Adjustability and possibility to add fans to cope with the increasing volume of traffic.
- Less initial cost.
- Required cross-sectional area of the tunnel is smaller than other systems.

c) Design Criteria

The PIARC (Permanent International Association of Road Congress, XIV-XVII) Report recommends that carbon monoxide (CO) be less than 150 ppm and smoke measured for 100m visibility be 50%. However, the above figures are applicable only if vehicles' engines are well maintained. If the majority of engines are old and poorly maintained the above criteria should be revised and adapted.

Considering the fact that most vehicles are old and poorly maintained and the design speed in the tunnel is 60 km/hr and referring to the Japanese Standards, the parameters for revision are given below:

- Permissible CO: 100ppm
- Smoke transmittance measured for 100m visibility: 40%

d) Design Conditions

Table 11.6.1 presents the design conditions and factors to determine the ventilation system for the Kohat Tunnel.

Table 11.6.1 Tunnel Design Conditions and Factors

Items		Contents
Traffic direction		One-way Two-lane traffic
Traffic characteristics	Design traffic volume	In 2013 : 11,685 veh./day (760 veh./hr) In 2032 : 33,760 veh./day (2,195 veh./hr)
	Design travel speed	60 km/hour
	Traffic composition	With diesel engine : 40% With gasoline engine : 60% Heavy vehicle ratio : 26.5% Other vehicle ratio : 73.5%
Tunnel geometric conditions		Plan- Straight For Kohat #1: Straight 2.2% gradient rising from south to north For Kohat #2: Straight 2.4% gradient descending from north to south
Tunnel inner section area		Ar = 62.2 sq.m Dr = 8.24m

Note:
Ar : Calculated effective tunnel area for ventilation.
Dr: Calculated hydraulic diameter of tunnel.

e) Required Air Volume for Ventilation

CO is mainly generated by petrol-driven vehicles, while smoke is produced by diesel-driven vehicles.

The required air volume is determined by taking the volume calculated for diluting CO or smoke whichever is greater.

In this Project, however, the required air volume is calculated according to the criterion for smoke, which is greater than CO, as almost all the vehicles involved are trucks with diesel engines.

The calculation normally follows the method by which the "basic" air volume is first calculated, followed by the adjustments of the volume according to the altitude and gradient.

The results of calculation based on the criteria to maintain 100m visibility and 40% smoke transmittance are summarized in Table 11.6.2

Table 11.6.2 Required Air Volume in Tunnel

Tunnel	Existing #1 Kohat	#1 Kohat (Northbound One-way)		#2 Kohat (Southbound One- way)	
Tunnel length	1,885m	1,885m		1,885m	
Vertical gradient	2.2%	2.2%		2.4%	
Year	2013	2013	2032	2013	2032
	(before construction)	Initial stage	Final stage	Initial stage	Final stage
Vehicle per hour	760	360	1,039	400	1,156
Unit air volume	0.1054	0.1110	0.1110	0.0674	0.0674
Gradient factor	1.70	1.98	1.98	0.55	0.55
	0.57				
Altitude correct coefficient	1.09	1.09	1.09	1.09	1.09
Required air volume	221 m3/s	161.2 m3/s	469.6 m3/s	30.7 m3/s	88 m3/s

Note: Gradient Factor (G.F)
G.F = Traffic Volume Ratio to Northbound / Traffic Volume Ratio to Southbound
= 0.4734/ 0.5266 = 0.899

f) Number of Jet Fans

The required number of Jet Fans is calculated as shown in Table 11.6.3

Table 11.6.3 Required Number of Jet Fans

Tunnel Name		No.1 Kohat		No.2 Kohat		Remarks
Year	In:	2013	2032	2013	2032	
	stage	Initial	Final	Initial	Final	
Tunnel length		1885	1885	1885	1885	
	Vt=	60	60	60	60	
Traffic Direction		Northbound		Southbound		
Traffic Volume		360	1039	400	1156	
Air Requi.	Qm3/s	161.2	469.6	30.7	88.0	
						Ar=61.8m2
Air Speed		2.61	7.60	0.50	1.42	Dr=8.24m
Pressure Losses in Tunnel	ΔPr (mmAg)	29.88	253.56	1.08	8.90	
	Δpmte	27.45	27.45	27.45	27.45	
	ΔPt	65.90	70.53	101.26	254.95	
	ΔP Total	-8.58	210.48	-72.73	-218.59	
	ΔPj	19.626	16.051	21.139	20.475	
Number of Jet Fans		-0.4	13.1	-3.4	-10.7	Ptoal/PJ
		(2)	14	(2)	(2)	

ΔPr	: Frictional losses at the Inlet and exit portals
ΔPmte	: Atmospheric back-pressure
ΔPt	: Piston effect force
ΔP total	: Total of the ΔPr + ΔPmte + ΔPt
ΔPj	: Jet fan ascend-pressures

The timing for increasing the number of jet fan at the No.1 Kohat Tunnel is as shown below, according to the estimated northbound traffic volume.

Year	Estimated traffic Volume		Nos. of Jet Fan	Remarks
	(Veh./day)	(Veh./hour)	(for No.1 Kohat Tunnel)	
2013	5,540	360	2	Incl. smoke discharge
2020	8,500	550	4	
2025	10,800	700	8	
2030	13,800	900	14	

g) Location of Jet Fans

Two sets of jet fan will be fitted on the tunnel ceiling by supporting devices at each centre of lane, in the upper part of tunnel vertical clearance.

h) Detector for Air Control

The following detectors will be installed in the tunnel for air control:

- Carbon monoxide (CO) meter 2 sets
- Visibility (VI) meter 2 sets
- Air speed meter (anemometer) 1 set

i) Calculation Sheets

The design calculation sheets for jet fan number determination are attached in Appendix B.

11.6.4 Lighting System

(1) General

The objective of tunnel lighting is to secure safe and smooth passage of traffic in the tunnel.

The tunnel lighting system is designed mainly based on the Japanese Standards and referring to PIARC recommendations.

(2) Lighting Inside the Tunnel (Interior Zone)

The following road luminance and illuminance for the interior zone lighting were adopted:

- Luminance: 3 cd/m2 (based on PIARC recommendation)
- Illuminance: 40 lux (based on PIARC recommendation)

(3) Tunnel Entrance Lighting

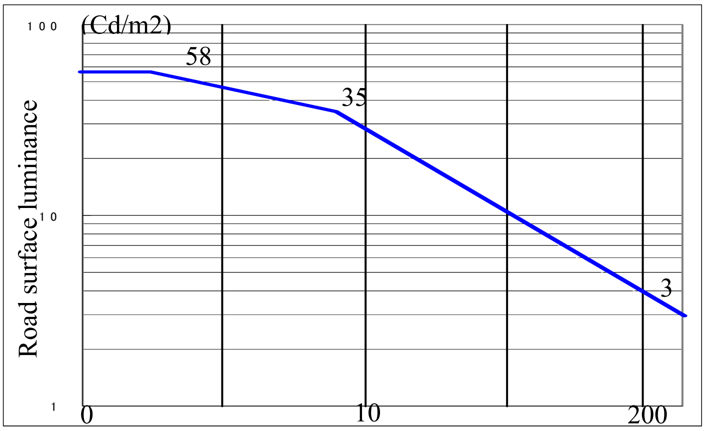
In the design of the tunnel entrance lighting, the following factors were adopted:

- Outside luminance (portal): 4,000 cd/m2
- Entrance luminance curve corresponding to the adopted design speed.

The adopted tunnel entrance luminance curve selected for the lighting design based on the adopted travel speed is as shown in Table 11.6.4.

Table 11.6.4 Adopted Entrance Luminance

Travel Speed	Threshold Zone			Threshold Zone			Adaptation Zone			Interior Zone	
Km/hr	Lumin-ance	Illumi-nance	Required distance	Lumin -ance	Illumi-nance	Required distance	Lumin -ance	Illumi-nance	Required distance	Lumin -ance	Illumi-nance
	cd/m2	lux	m	cd/m2	lux	m	cd/m2	lux	m	cd/m2	lux
60	58	760	25	58 to 35	760 to 460	65	35 to 3	460 to 40	125	3	40



Note: 1 cd/m2 = 13 lux (Concrete Pavement)

Figure 11.6.2 Adopted Entrance Luminance Curve

(4) Design Conditions

The following design conditions and data were used for the lighting design.

- Outdoor luminance: 4000 cd/m2
- Travel speed: 60km/hr
- Tunnel geometric conditions: See Item 11.4.1
- Reflection factor: 0.25 (value for concrete of ceiling, wall surface and road surface)
- Maintenance factor: 0.45 (typical value of the MOC-J Design Standard, recognized by PIARC)

(5) Tunnel Lighting Requirements

The tunnel lighting requirements are based on the following factors:

a) Installation of lighting luminaries

The tunnel lighting luminaries are to be installed at 5.2 m or more above the road level, outside the carriageway limits. The higher is the better for luminance distribution to the road surface, but on the contrary this will result in poorer maintenance of fittings.

From the design point of view, the mounting height of lighting luminaries of 5.5m was adopted.

b) Fittings arrangement

There are three types of fittings arrangement: Centre lined, opposite, and staggered arrangements.

The centre lined arrangement has big disadvantage for maintenance because of its height. The opposite fitting arrangement is adopted, considering its following advantages compared with the staggered one.

- Better luminance distribution,
- Less glare of fittings' and
- Less flickering

c) Spacing of lighting luminaries

Proper spacing between light luminaries should be provided to satisfy the following conditions:

i) Space between luminaries (S) in relation to the installation height (H):

$S \leqq 2.5H$

ii) Spacing (S) shall be limited as shown by the following formula to avoid the flickering phenomenon, in relation to travel speed:

$S \geqq V/18$ and $S \leqq V/36$

V= travel speed (km/hr)

d) Formula for spacing of Lighting Luminaries

Spacing of luminaries is determined by the following lumen method formula generally in use:

$$S = F \times U \times M \times N / E \times W$$

Where,

S : Spacing between lighting luminaries. (m)
F : Luminous flux of light source: (1m)
U : Utilization factor
M : Maintenance factor
N : Number of light source: (Opposite = 2)
E : Average horizontal-plane illuminance of the road surface: (lux)
W : Width of road surface (m): Carriageway

e) Emergency lighting during power failure

i) Emergency lighting by battery power

- Emergency lamps should be lit inside the tunnel by a non-failure type battery power source during power failure.
- The lamps should be turned on automatically and should be capable of providing light for more than 3 minutes continuously, immediately after the power failure.
- Every tenth luminaire inside the tunnel should be battery powered for safety sake.

ii) Emergency lighting by stand-by power source

Fifty percent of total illuminance inside the tunnel (Interior Zone), should be provided with stand-by power source within 2 minutes after the main line power failure.

Stand-by power source will be provided by diesel-engine generator.

(6) Tunnel Lighting System

a) Interior Tunnel Lighting

70-Watt high-pressure sodium lamps (HPS) installed at a height of 5.5 m on both side-walls will light the interior length of the tunnel carriageway with a lux level maintained at 40.

The lighting fittings on each sidewall will be fed by 2 main circuits, connected alternately, so that one circuit can be kept off at night to provide only 20 lux throughout the tunnel.

Table 11.6.5 Circuit Control Schedule

		Day Time	Night Time	Stand-by Power
One Side	Circuit A	○	○	○
	Circuit C	○	×	×
Opposite Side	Circuit D	○	×	×
	Circuit B	○	○	○

Notes:
○ Denotes circuit "On:" Position
× Denotes circuit "OFF" Position
Daytime: 7am to 6 pm
Night time: 6pm to 7 am
Emergency : Ditto
Any time setting is adjustable by hand

During the main line power failure time, illuminance in the tunnel will be kept at 20 lux throughout with the power fed by the standby diesel generating set.

Automatic switch devices will control the circuits.

b) Tunnel Entrance Lighting

250-Watt HPS lamps and 70-Watt HPS lamps will light the tunnel entrance zone inlet, the threshold, the transition and the adaptation in addition to the lights mentioned for the Interior Zone. Sets of fittings with HPS-250 lamps and HPS-70 lamps will be used to light each entrance.

The lighting luminaries on one sidewall will be fed by 2 main circuits.

The circuit control schedule is as shown in Table 11.6.6

Table 11.6.6 Circuit Control Schedule for Entrance

		8 am - 2 pm		**2 pm - 6 pm**	
	Cd/Sq.m	Over 1000	Over 3000	Under 3000	Under 1000
One Side	Circuit E	○	○	○	×
	Circuit G	×	○	×	×
Opposite Side	Circuit H	×	○	×	×
	Circuit F	○	○	○	×

Notes:
i) ○ denotes circuit "On:" Position
× denotes circuit "OFF" Position
ii) Based on the outside luminance level, a set of automatic switch device will control the circuits shown in the table for the economical utilization of lighting.

c) Lighting outside of tunnel entrance

A 150-W HPS lamp and highway type fitting mounted on 9 m tapered pole will be installed for adjusting the drivers' eyes to outside darkness from higher illuminance inside the tunnel at night time.

(7) Selection of Light Sources

High pressure sodium lamps were chosen for the interior and entrance zones of the tunnel rather than low pressure sodium lamps for the following reasons:

- High luminous efficiency,
- Large capacity of lumen,
- Good colour rendering, and

- Common light source for road lighting in Pakistan

The following light sources were considered and selected:

- For the interior zone: HPS-70W 6,500 lm
- For the entrance zone: HPS-250W 30,000 lm

Selection of a single type of lamp results in less initial cost and easier maintenance compared with the adoption of several types.

(8) Calculation Data

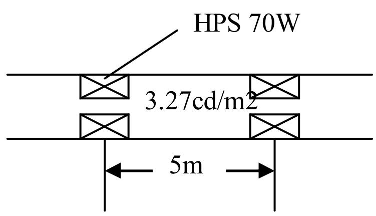
a) Determination of lantern spacing in the Interior Zone

i) Calculation based on the Required Average Intensity of Illuminance/Luminance.

S = F x U x M x N/E x B

Where;

S = Required spacing of lanterns in metre, S = 5.0 m
F = 6500 lm
U = 0.266
M = 0.45
N = 2
E = 40 lx (approx 3 cd/sq.m x 13 lx/cd/sq.m)
W = 7.3 m
Luminance
= F x U x M x N/S x W x 13 cd/sq.m
= 3.27 cd/sq.m



ii) Spacing selection based on the Favourable Distribution of Brightness.

S< 2.5H = 2.5x 5.5	= 13.75m	S <13.75m
S> V/18 = 60/18	= 3.3m	S > 3.3m
S< V/36 = 60/36	= 1.6m	S < 1.6m

iii) Adopted lantern spacing

5.0m lantern spacing is adopted in the design.

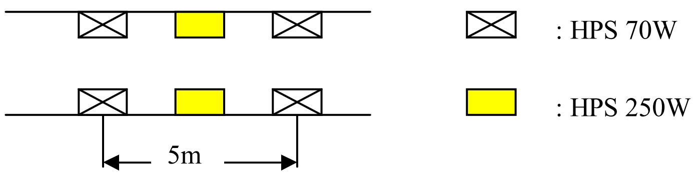
b) Determination of lantern spacing in Entrance and Transition Zones

Luminance = F x U x M x N/S x W x 13 cd/sq.m

Where;

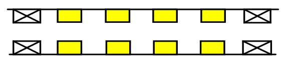
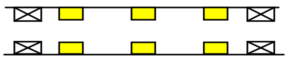
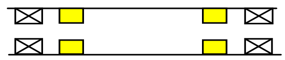
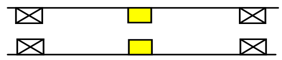
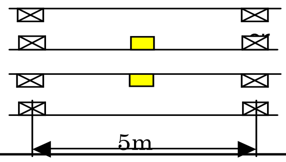
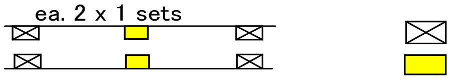
F = 30,000 lm
U = 0.266
M = 0.45
N = 2
Luminance = 15.13 cd./m2

W = 7.3 m
S = 5.0 m
Luminance = E/13 (cd/m2)



The selected lanterns layout and the numbers of lamps are shown in Table 11.6.7

Table 11.6.7 Arrangement of Lanterns

Discription / Block (Length)	Required Average Intensity of Luminance (cd/m2)	Luminance in Interior Zone (cd/m2)	Additional Luminance in Entrance Zone		Total Luminance in Entrance Zone (cd/m2)	Arrangement of Lanternes
			Nos. of HPS 250 Lanterns	Caluculated Luminance (cd/m2)		
A (40m)	58	3.27	2 x 4sets	60.52	63.79	
B (45m)	46	3.27	2 x 3sets	45.39	48.66	
C (35m)	28	3.27	2 x 2sets	30.26	33.53	
D (60m)	16	3.27	2 x 1sets	15.13	18.40	
E (35m)	5.3	3.27	2 x 0.5 sets	7.57	10.84	 or
Note	ea. 2 x 1 sets  HPS 70 HPS 250					

11.6.5 Power Supply System

(1) General

The power supply system will feed electrical power to the Kohat Tunnel facilities as well as the facilities in the Substation and the Control Room, at the South Portal.

The power supply system consists of:

- Main power supply system
- Stand-by generators

(2) Design Codes and Standards

The following design codes and standards were applied for the design of the power supply system:

- Regulations on Installation of Electrical Equipment in Buildings 15th Edition issued by the Institute of Electrical Engineers, London, England.
- Publications issued by the International Electro-Technical Commission (I.E.C).
- Service requirements and climatic conditions.
- Local rules and requirements for electrical installations.

(3) Design Conditions

a) Incoming Power from WAPDA

- Power supply system: 3-Phase 3-wire 50 Hz 11KV
- Applied tariff for the Project: Tariff B-3 (for Industrial Supply at 11KV and 33KV)

b) Facilities to be supplied:

- Tunnel ventilation fans

- Tunnel lighting
- Tunnel measurement devices [Carbon monoxide meter (CO), Visibility meter (VI), and Air speed meter (AS)]
- Traffic signals
- Facilities in the Substation and Control Room at the portal
- Facilities in the tunnel substations
- Lighting (inside and outside of buildings)
- Motor power
- Communication devices (telephone, radio equipment)

c) Wiring System for Facilities

	Tunnel Facility	Wiring System
i)	Tunnel ventilation fan	3 ϕ 3w 400V
ii)	Tunnel safety	3 ϕ 4w 400V
iii)	Tunnel lighting	3 ϕ 3w 400V
		1 ϕ 2w 230V
iv)	Tunnel measurement devices	3 ϕ 4w 400V
v)	Facilities in the Control Room	3 ϕ 4w 400V

d) Maximum Permissible Volt Drop

The total voltage drop between the consumer's terminals and any other point in the installation must not exceed 2.5 percent of the normal voltage.

(4) Requirements of Power Supply System

- A substation (S/S) for the Kohat Tunnel will be installed at the entrance of the South portal. An incoming 3-phase 3-wire 11KV 50Hz line will be connected from WAPDA to the S/S. Tunnel substations (TN S/S) will be provided at two emergency areas located inside the tunnel
- The tunnel facilities will be fed from the tunnel substations. Substations with an area of approx. 30 sq.m will be provided in the tunnel.
- The S/S, including WAPDA room, high-tension room, generator room, generator panel room, transformer room, and UPS room will occupy approx. 270 sq.m and the generator room approx. 100 sq.m.

An Uninterruptable Power Supply (UPS) system room will be planned and installed. The UPS capacity is approx. 10 KV, of which 8 KVA is for the control room and 2 KVA for the tunnel substation, roughly estimated.

A approx. 100sq.mm 3-core main cable will be laid between the UPS and the power terminal set in the Central Processing Unit Panel. From the terminal set, power supply cables to the relevant SVC system will be laid.

The UPS will feed the following systems and panels:

In Control Room: SVC System, Processing Computer Panel, Ventilation Control Panel, and Safety Panel.

In Tunnel Substation: SVC System

(5) Summary of Power Supply System

Table 11.6.8 summarises power consumption values, and Table 11.6.9 shows the required load for the diesel engine generators.

Selected transformers and generator sets are also shown in the same tables.

Table 11.6.8 Summary of Power Consumption

Item	Control Room	Substation S/S	1st TN TN S/S	2nd TN S/S	Total	Description
1st TN Ventilation	-	-	310.6 KW (6 sets) (264KVA)		310.6 KW (264 KVA)	Pf=0.85
1st TN Safety	25	-			25	
1st TN Lights	-	-	93	93	186	Includes TN Outside Lights
1st TN Facilities	25	50	3.5	3.5	82	
1st TN Total Load (KVA)	50	50	360.5	96.5	557	
1st TN Selected Transformers	100 KVA*		630 KVA*	100 KVA**		*Existing **New one
2nd TN Ventilation	-	-		310.6KW (6 sets) (264KVA)	310.6KW (264 KVA)	Pf=0.85
2nd TN Safety	25	-				
2nd TN Lights	-	-	93	93	186	Includes TN Outside Lights
2nd TN Facilities	25	50	3.5	3.5	82	
2nd TN Total Load (KVA)	50	50	96.5	360.5	557	
2nd TN Selected Transformers	100 KVA**		100 KVA**	630 KVA*		*Move from #1 ** New ones

Table 11.6.9 Required Load for Diesel Generators

Item	Max. Power Demand (KVA)	Max. Demand For D.G (%)	Required Loads For D.G (KVA)	Description
TN Ventilation	528	37.9 (6 No.)	198	First stage 4 sets 259KW pf=0,85 Final stage 12 sets 333 KW
TN. Safety	25 x 2	100	50	
TN. Lights	186 x 2	50	186	
Facilities	82 x 2	100	164	
Total (KVA)	1,114	-	598	<300KVA x 3 sets* * 2 sets are existing 1 set is new

Note: D.G: Diesel Engine Generator
3 sets work: 598/900 x 100% = 66%

11.6.6 Emergency Facilities and Safety Systems

(1) General

Tunnel emergency facilities are designed for mitigating damage in the event of fire or any other accident occurring in the tunnel.

Emergency facilities are categorized into information and alarm equipment, fire extinguishing equipment, escape and guidance equipment, and others.

(2) Design Standards for Emergency Facilities

Emergency facilities requirements within the tunnel are shown in Table 11.6.10 and Figure 11.6.3. Figure 11.6.3 presents a classification of tunnel into five groups with respect to the tunnel traffic volume and its length, and Table 11.6.10 shows a list of facilities which should be installed in accordance with the tunnel classification. These were recommended in PIARC XVII World Congress (October 1983).

The same design conditions were used for the safety system study as described in the section concerning the ventilation system.

Table 11.6.10 Standards for Installation of Emergency Facilities by Tunnel Classification

Emergency Facilities	Tunnel Classification	AA	A	B	C	D
Communication and Alarm Equipment	Emergency Telephone	O	O	O	O	
	Alarm Button	O	O	O	O	
	Fire Detector	O	∆			
	Signal and Alarm	O	O	O	O	
Fire Fighting Equipment	Extinguisher	O	O	O		
	Fire Hydrant	O	O			
Escape and Guidance Equipment	Exit Guide Board	O	O	O		
	Smoke Discharge Equipment Or Refuge Passage	O	∆			
Other Equipment	Hydrant (Water Supply)	O	∆			
	Radio Communication Ancillary	O	∆			
	Radio Rebroadcast Equipment Or Loudspeaker	O	∆			
	Sprinkler	O	∆			
	Television	O	∆			

Notes: O Denotes "Should be Installed as the Rule"
∆ Denotes "To be installed as Required "

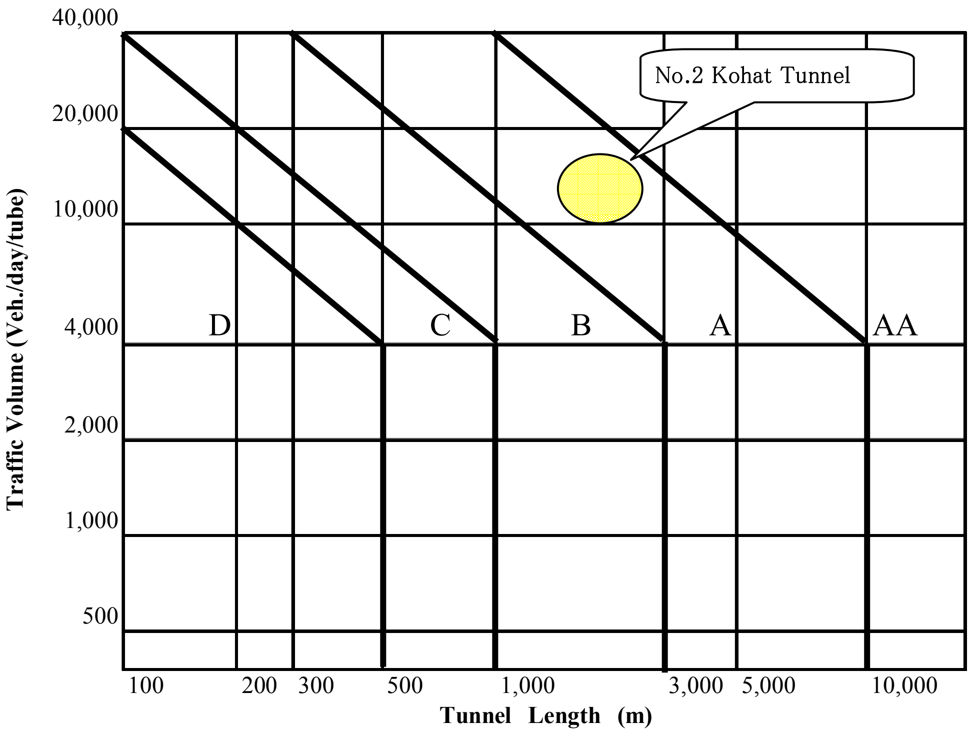


Figure 11.6.3 Classification of Tunnels

(3) Tunnel Emergency Areas and Escape corridor

After the completion of the No.2 Kohat Tunnel, the existing No.1 Tunnel will become a one-way 2-lane carriageway for the north-bound traffic and the No.2 Tunnel will have also two lanes for the traffic in the opposite direction. In an emergency case, any disabled car in the tunnel should be moved to a safe and suitable area in the tunnel so as not to disturb the traffic flow.

Therefore, in the 2nd Kohat Tunnel with a length of 1885m, emergency areas or rescue yards will be provided at two places on the left side of the tunnel along the vehicle flow.

An emergency area location plan is shown in Figure 11.6.4. The length of the area will be enough to accommodate a trailer truck.

Escape corridors connecting the No.1 Kohat Tunnel (northbound) and the parallel No.2 Kohat Tunnel (southbound) will be provided for evacuation of road users in case of accident in the tunnel to a safety place. The locations of these passages were decided at the existing tunnel's construction and were excavated beforehand. Both ends of these corridors will be closed by fire resistant doors, which should be opened by hand at an emergency occurrence.

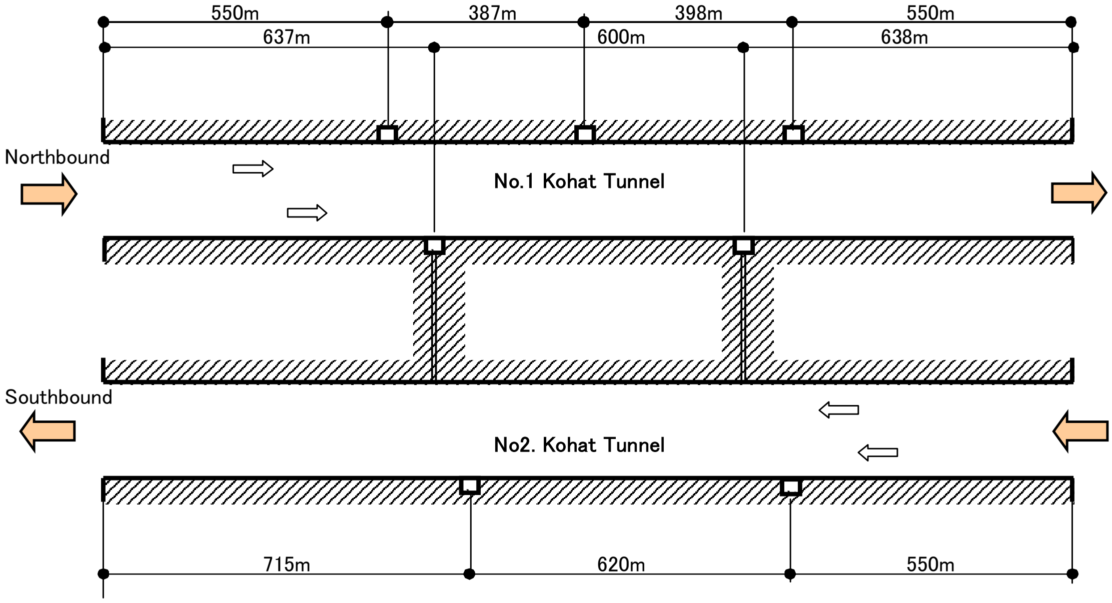


Figure 11.6.4 Location Plan of Emergency Area

(4) Safety System

The Kohat Tunnel belongs to the "A" class as shown in Figure 11.6.3 based on its tunnel length and traffic volume. The "A" class should have a safety system composed of the following devices:

- Emergency telephone
- Alarm buttons
- Signals (red and amber) and alarm devices
- Fire extinguishers
- Fire extinguishers in place of fire hydrants
- Exit guide boards

The facilities of the tunnel safety system and their locations are as shown in Table 11.6.11.

Table 11.6.11 Tunnel Safety System

Items	Location	Description
Emergency Telephone	Every emergency area (2) and escape corridor (2)	Public telephone type
Alarm Buttons	Every 50m. eastside wall mounted	Pushbutton - type
Traffic Signals	North side tunnel entrance, Mounted on the guard bars	Red and amber, automatic type
Extinguishers	Every 50m east side wall mounted	of chemical type
Big Extinguishers	Every emergency area (2 areas)	of chemical type
Exit Guide Boards	Every 100m	of plate type
Guard Bars	North side tunnel entrance	Continuous-type over-height protector

11.6.7 Supervision and Control System

(1) Introduction

Introduction of tunnel supervision and control systems is planned to systematize various facilities for safety of drivers running through the tunnel.

(2) Location of Substation and Control Room Bldg. Yard

The condition and capacity of the existing Toll Plaza and Administration Building will still be enough after the 2nd Tunnel opening. Since the planned tunnel entrance is just behind the existing Control Room yard, it is necessary to relocate the existing control room and substation to another place.

Two potential sites for the yard relocation were considered, one near the south portal and the other near the north portal. Through comparison of both sites, the location at the south portal was selected. Table 11.6.12 presents a comparison of the locations of the Control Room and Substation Building Yards.

(3) Tunnel Facilities to be Supervised and Controlled

a) Facilities to be supervised and controlled:

- Facilities in Tunnel
- Facilities in Substation
- Facilities in Control Room

Other building facilities provided in the Toll Plaza and Administration Building are managed separately.

The Control Room will be provided at the south tunnel portal. Control Room supervisors will be available in the centre in shifts for 24 hours to ensure continuous of control and supervision of the various facilities in the tunnel, such as ventilation, safety, lighting and power supply sytems.

Tunnel facilities will be supervised and controlled as follows:

b) Ventilation

As described in the section on ventilation system, there will be 2 sets of CO meter, 2 sets of visibility meter, and 1 set of air-speed meter to guide and control the operation of jet fans in the tunnel.

The limiting factors of CO content, smoke transmittance and air-speed which will determine the actual number of jet fans to be run at any one time are as follows:

- CO content: 100ppm.
- Smoke transmittance: 40%

- Maximum air-speed: 12m/sec

Supervisors in the control room will monitor the meters and operate the jet fans accordingly.

Major facilities of the ventilation system for each tunnel include:

- 2 sets of axial type dia 1250 x 37 kW jet fans (initial stage)
- 2 sets of CO meter
- 2 sets of visibility meter
- 1 sets of air-speed meter

After the completion of the 2nd Kohat Tunnel, both tunnels will handle one-way traffic, therefore the load for ventilation will be improved very much compared to the existing one.

c) Safety

To ensure safety against any accident or fire hazard in the tunnel, safety facilities including emergency telephones, extinguishers with alarm buttons and traffic signals will be provided. These will be interlinked with the control centre and monitored by the control room supervisor. In the case of any accident or fire in the tunnel, the emergency telephone can be used or the alarm button can be pressed by tunnel users, informing the control room supervisor about the accident. The control room supervisor will in turn alert the rescuer staff or fire-fighting personnel who are stationed at the portal for 24 hours, for taking necessary action immediately by dispatching a relief van and an ambulance in case of accident, and by sending fire-fighters in case of fire. At the same time the traffic signals on both tunnel entrances will turn red to warn vehicles not to enter the tunnel.

Major facilities of the safety system are:

- Emergency telephone at every emergency area and entrance of escape corridor: 4 nos. (box type)
- Alarm button: every 100m (press type)
- Red and green traffic signals: both tunnel entrances (automatic type)
- Extinguishers: every 100m (chemical type)
- Big extinguishers at every emergency area: 2 nos. (chemical type)
- Exit guide board: every 100m (continuous type)
- Guard bar: both tunnel entrances (for checking over-height vehicles)
- Telephone jack at every emergency area: 2 nos. in the tunnel and at both entrances Lighting

One basic circuit for lighting will provide illuminance throughout the tunnel at 20 lux which is the requirement at night time, and also the requirement when the power is being fed by stand-by diesel generating set. The other circuit, meant to provide another 20 lux making a total of 40 lux, which is the requirement for interior zone during day time, will come into operation during the day.

The illuminance in the entrance zone inside the tunnel will be determined by the luminance at the portal outside the tunnel. The light in the entrance zone would be automatically adjusted according to the external luminance by means of photoelectric sensors.

The light system consists of:

- interior tunnel lighting of $3cd/m^2$
- tunnel entrance lighting of $58\text{-}5.3\ cd/m^2$
- approach lighting outside the tunnel (pole mounted)

d) Power Supply

The main power supply source will be provided by WAPDA. In case of failure of power supply from WAPDA, power will be fed by stand-by diesel engine generators installed in the substation building at the portal. Generator operators will be available in shifts for 24 hours in the generator room for operation of the generators whenever required.

The power supply system will have the following features:

- 1 WAPDA incoming line, 3-phase 3-wire 50Hz 11KV
- 2 outgoing lines, 11KV
- wiring system, 3-phase 3-wire 50Hz 400V
- wiring system, 3-phase 4-wire 50Hz 400V
- wiring system, single phase 2-wire 50Hz 230V
- 3sets of 300KV sand-by generator (including existing ones)

e) Substation Building and Facilities

i) Substation Building Location

The substation building is located at approx. 40m from the tunnel south portal on the west side of the No.1 Kohat Tunnel.

For minimizing voltage drop, the location of the substation building is selected near the tunnel entrance.

ii) Substation Building

The substation building (approx. 15m x 18m) will contain the following rooms:

- Stand-by operator room
- Generator panel room
- Generator room
- High tension room
- Transformer room
- UPS room
- WAPDA room

iii) Facilities

The facilities for the building are:

- Lighting with switches in every room
- Interphone in every room
- Exterior lighting

The building facilities design is included in the architectural design.

f) Control Room and Facilities

i) Control Room Location

The building of the control room is located beside the substation, approx. 10m apart, its east side facing the roadway.

ii) Control Room Building

The building (approx. 12m x 11m) will contain the following rooms:

- Control room
- Staff room and corridor
- Maintenance room
- Store
- Toilet

g) Tunnel Substations and Facilities

i) Tunnel Substation Location

Two tunnel substations will be provided in the tunnel emergency area, for the same functions as the outside substation of the tunnel.

ii) Tunnel Substation

A minimum inner space of 2.8m wide by 8m long, will be provided at right angle to the tunnel wall in the centre of the east side emergency areas, with a 2.8m wide entrance.

The substation will be used for the installation of HV and transformer panel, and LV panels for jet fans and tunnel lighting, tunnel safety, polluted air detectors for the ventilation system.

h) Water Reservoir

A water tank with a capacity of approx. 200m^3 will be provided as required from the safety point of view.

The water reservoir will be located beside the Control Room Building.

(4) Tunnel Supervision and Control

a) General

The tunnel supervision and control activities are planned to systemize various facilities to ensure safety for drivers running through the tunnel.

The activities will be conducted under the following two conditions:

i) Normal condition

ii) Accident condition

Supervision and control activities are manned by the control room supervisors and are available by shifts for 24 hours.

b) Location of Control Room

The control room will be located near the substation for the following reasons:

i) easy and quick response to any accident or fire hazard in the tunnel

ii) reduction in length and cost of control cables

c) Tunnel Supervision and Control

The tunnel operation and control activities will be conducted under the following two conditions:

1) Normal condition

In the normal condition, the control room supervisor will monitor the meters and watch the conditions of the facilities to be controlled. All such facilities will be supervised and controlled automatically.

2) Accident condition

In the accident condition, the supervisor will take the following actions:

i) In case of traffic accident in the tunnel:

- Receive information on the accident from the Tunnel Patrol team or tunnel users by wireless radio or emergency telephones or alarm buttons.

- Alert the rescue staff, patrol staff for taking necessary action immediately by dispatching appropriate vehicles.
- Ensure that traffic signals on both tunnel entrances turn red, warning vehicles not to enter the tunnel.
- Provide first aid to rescued patient(s), or request assistance from local government hospital(s) for the patient(s) if more medical action is judged necessary by the rescuer officer.

The supervisor will also select the full levels of tunnel lighting and the full-notch of ventilation.

ii) In case of fire in the tunnel

- Receive information on the fire, in the same way as in the case of traffic accident.
- Alert the fire fighting personnel, rescuer staff and patrol staff for taking necessary action by dispatching appropriate vehicles.
- Use available means such as powder type extinguisher and cart type extinguisher to fight the fire in its initial stage.
- Ascertain the need of requesting local government agencies, police, fire fighting and medical agencies, for help in the case of fire or accident.
- Turn signals to “Red Warning”, same as in the case of traffic accident.
- Take necessary action to put out fire with tunnel users, using powder type extinguisher or fire fighting personnel with cart type extinguisher, as initial arrangement until the local agencies arrive.
- Rescue the victim(s).

The supervisor should select the full levels of tunnel lighting and “OFF” notch of ventilation until receiving the authorized personnel’s further instructions.

d) Tunnel Supervision and Control System

The system of Tunnel Supervision and Control (TN. SVC) is outlined in Figure 11.6.5.

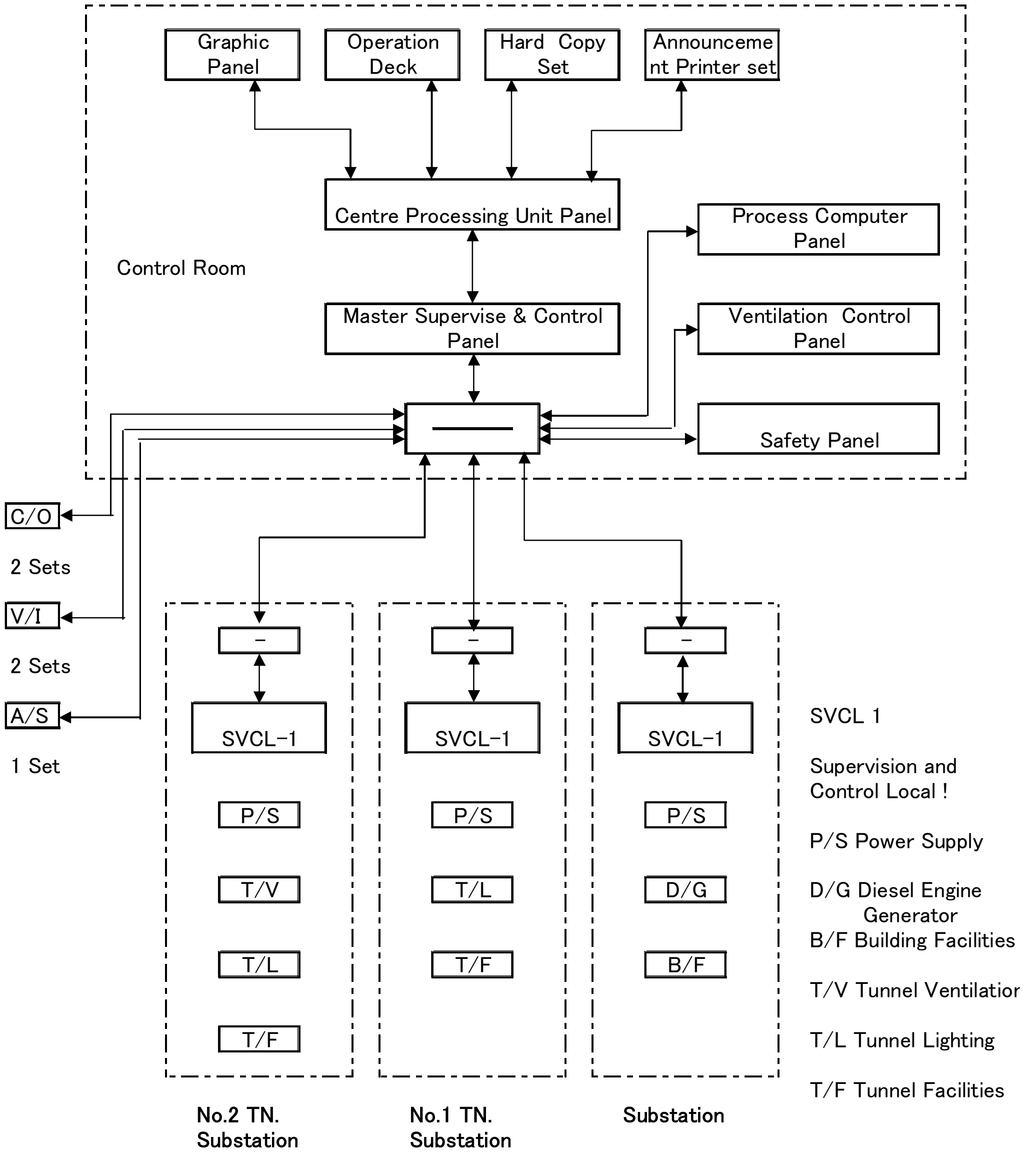


Figure 11.6.5 Outline of Tunnel Supervision and Control System

e) Telephone System

In order to maintain a smooth and effective operational system for the No.2 Kohat Tunnel, same as the No.1 Kohat Tunnel, a telephone exchange with multiple-line capacity will be provided for the tunnel, substation, control room and administrative areas.

The tunnel controller will be connected to the emergency telephones and patrolmen's telephone jacks directly within the tunnel system. The controller can contact the rescue service directly as it is standing by in the same building, and the police, fire brigade, administration building, toll office or other points connected to the T&T system by outside lines.

A system with the potential for 8 external and 40 internal connections has been included in the design.

11.6.8 Relocation of the Existing Control Room and Substation Building

As mentioned in Section 10.1.1 Location of the South Portal and Approach Road Alignments, the existing Control Building and Substation building yard should be relocated to another place, since it will be just in front of the new tunnel portal.

An area of about 1,200m^2 is required for the relocation and it should preferably be near the existing control building, that means near the south portal. Two alternative relocation areas, one in front of the south portal and the other in front of the north portal, were compared as shown in Table 11.6.12.

The site in the west of the south portal is recommended, considering the merit of its proximity to the existing control yard, although it is necessary to deal with the existing valley.

Table 11.6.12 Comparison of the Location of Control & Substation Building Yard

	Location	In front of South Portal West side	In front of North Portal West side
	Explanation of the location	Before the South portal of the Tunnel West side Elevation of the yard will be same as the elevation of the tunnel Entrance	Before the North Portal of the Tunnel West side. Elevation of the yard will be same as the elevation of the tunnel Entrance
	Photo of the location		
Characteristic of the location and evaluation for that point	* Distance from the existing Yard	Nearest to the existing Yard O	Opposite side of the tunnel entrance and far from the existing Yard X
	* Necessity of special consider for water flow and others	Need to reclaim an existing valley, so need to prepare not only water flow but also for debris flow. Δ	No special consideration is necessary O
	* Construction Procedure	Relocation of cable in side the existing tunnel is few and mostly out side of it. Δ	Relocation of cable in side the existing tunnel is essential and very difficult without long stoppage of traffic. X
	* Rough estimated Cost	Yard Preparation 49Mill Rp. Cable & Remova 12Mill Rp. Total 61Mill Rp. O	Yard Preparation 5Mill Rp. Cable & Removal 85Mill Rp. Total 90Mill Rp. X
	Total Evaluation	(Recommended) O	X

Note: **O** Good, **Δ** Fair, **X** Bad

11.7 Other Facilities and Buildings

11.7.1 Administration Offices and Control Room

The following buildings and associated facilities will be provided for administration, operation and maintenance of the tunnel and access roads:

- South Administration Building at Sta.13+700 (L)
- Tunnel Control Room at South Portal (R)
- North Emergency Building at Sta.18+650 (L)
- Toll Plazas and Custom Office Buildings

The existing South Administration Office and the North Emergency Building have sufficient area and facilities, therefore no extension is required for the 2nd Kohat Tunnel and Access Roads. The existing Tunnel Control Room and associated facilities shall be relocated in a new area either on the left side of the south portal or at the north portal.

The Main Toll Plaza was constructed at Sta.10+600 for collection of toll fees for both the south-bound and north-bound traffics. Subsequently the Kohat Link Road Toll Plaza was constructed at the Off/On Ramp at Sta.15+575 for collection of toll fees and control of vehicles entering the main road. A New Toll Plaza was constructed at Sta.17+400 and started operation in July 2006. This New Toll Plaza will absorb the other two toll plazas, therefore additional toll booths are to be constructed for the 2nd Kohat Tunnel and Access Roads.

11.7.2 U-turn Facility for Tunnel Maintenance Vehicles

At present the tunnel maintenance vehicles can make a u-turn outside the tunnel as the existing lanes are not separated. However, as a median will be constructed on the whole Project road, a u-turn facility (median opening) is to be constructed near the south portal at around Sta.19+700 for movement of the tunnel maintenance vehicles from the south-bound lane to the north-bound lane as illustrated in Figure 11.7.1.

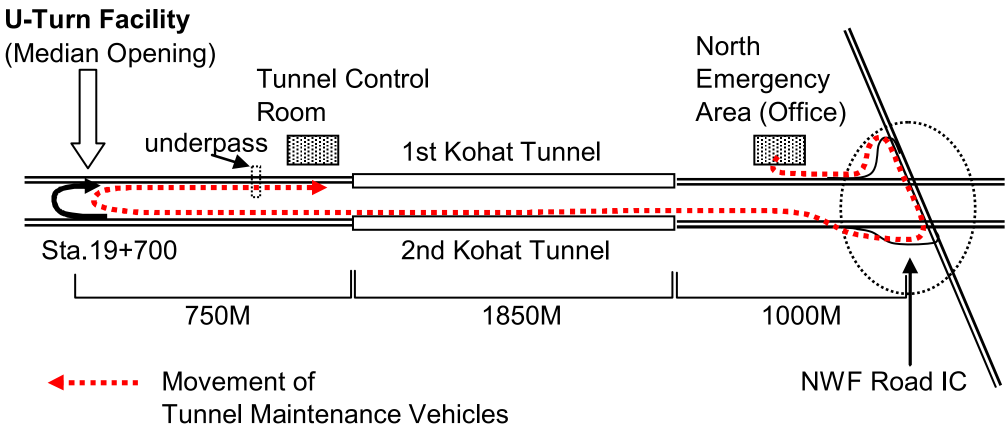


Figure 11.7.1 U-turn Facility (Median Opening) for Tunnel Maintenance Vehicles

Chapter 12. OPERATION AND MAINTENANCE

12.1 General

NHA is responsible for the management of valuable road assets (national highways and motorways) under its administration. NHA should provide maintenance funding in a way that returns maximum benefits to road users, communities and the government. Maintenance is one of the important elements in the highway system management, aiming at preserving and repairing the road facilities in their designed or accepted configuration.

Maintenance programs include road surfaces, shoulders, drainage facilities, slopes, bridges, tunnels, traffic markings and signs, lighting fixtures, etc. Maintenance operations involve monitoring and assessment of the conditions of road facilities, diagnosis of the problems and adopting the most appropriate measures. Annual and periodical maintenance programs should be established based on the maintenance techniques, personnel, materials and equipment available in economical and effective ways. They include defining activities (maintenance criteria and standards), planning works and schedule, allocating resources, organising personnel or contractors, controlling fiscal aspects, monitoring and evaluating performance, and feeding back results to seek further improvement.

12.2 Maintenance of Road Facilities

Physical maintenance of the road facilities under the responsibility of NHA includes pavement, bridges, slopes and other road facilities. The budget of these maintenance works is allocated by the NHA head office.

Maintenance for the Project road is defined as a process to optimize the overall performance of the roadway over time. The process comprises a number of activities (or measures) that will have impacts on the road facilities. Classification of the maintenance activities to be applied for the Project road is as summarized in Table 12.2.1.

Table 12.2.1 Maintenance Activities for the Project Road Facilities

Category	Classification	Routine	Periodic	Emergency
Roadway	Road surface	Crack sealing Patching	Rutting Repair Overlay	
	Shoulders and approaches	Vegetation control		Damage by heavy vehicles
		Spot failure repair		
Drainage	Culverts	Cleaning		Cleaning debris
	Roadside Drains	Cleaning		Cleaning debris
Roadside	Embankments			Slope failure
	Cut slopes	Removal of fallen rock/boulders		Slope failure repair (grouted riprap, rock net)
Bridges	Superstructure	Drainage		
	Foundation			Scouring protection / repair
	Others	Approach road settlement		
Traffic control device	Information and regulation signs, markings, etc.		Repainting of markings	Replacement of crushed signs, etc.
Safety devise	Guard rails, barriers, etc.			Replacement of crushed guard rails, signs, barriers, etc.

Routine maintenance is the activity that needs to be undertaken each year. It consists of cyclic works whose needs depend on environmental effects rather than traffic, like vegetation control, clearing of side drains and culverts, and necessary works to remedy minor defects caused by a combination of traffic and environmental effects such as crack sealing, patching and depression repair.

Periodical maintenance is the activity to be undertaken at the interval of several years. As the design period of asphalt pavement for the 2nd Kohat Tunnel and Access Roads is 10 years, an overlay of 5-10cm thick is required in future.

Special (or emergency) maintenance is the activity that cannot be foreseen with certainty. The relevant works undertaken by the Kohat Administration Office so far include repair of shoulders damaged by passage and parking of heavy traffic on them, repair of bridge foundations scoured by floods, slopes damaged by rain water runoff, guardrails crushed by vehicles, and removal of crushed or broken vehicles. The daily patrols currently practised are very effective for identifying the emergency works necessary to address safety issues and this should be continued.

The maintenance policies and procedures for roadways should be well established and a yearly budget be allocated based on the maintenance plan.

Maintenance of the safety devices includes maintenance and repair of guardrails, guide posts, barriers, curbs, etc. Maintenance of traffic control devices includes traffic signs, pavement markings and other information and regulation system. Traffic markings should be periodically repainted for safe traffic operations.

The damage of shoulders by passage of heavy vehicles on them for overtaking was one of the major problems in terms of traffic safety and maintenance costs for the 1st Kohat Tunnel and Access Roads. This kind of incident will be reduced substantially after the construction of the additional two lanes. However, education of drivers to respect the yellow lines at the boundary of the carriageway and shoulder is also important to eliminate this bad practice even after the improvement of the road to the dual carriageway system.

Periodical inspection should be carried out for approximately 120 numbers of RC box and RC pipe culverts crossing the Project road. As roadway cross drainages account for 90% of these structures, their emergency inspection is necessary during and after heavy rains. It is recommended to establish a data base for these culverts and keep inspection records so that it is possible to identify the culverts for which intensive care or improvement is necessary.

The major problems of the existing cut slopes are erosion, rock fall and blockage of roadside drains by debris. The current daily patrol should include slopes inspection in order to take appropriate actions for maintaining safety of the traffic and the road facilities. As weathering of cut surface will continue, periodic inspection should be conducted to plan the permanent measures of slope stability works, wherever necessary, like rock net installation or construction of grouted riprap.

12.3 Overload Control of Heavy Vehicles

Overload control is one of the important operations to ensure safety of the tunnel and minimise pavement failure. The Kohat Operation and Maintenance Office started overload control operation utilizing weigh bridges at the Main Toll Plaza (Sta.10+600) in July 2006 in compliance with the National Highways Safety Ordinance 2000. This operation should be continued.

When heavy vehicles pass on a weigh bridge, their gross weight is transmitted to a computer and the magnitude of overloading and corresponding imposed fines are identified and indicated on an electrical board automatically. This system is expected to contribute to substantial reduction of overloaded vehicles as many drivers and transport operators are using this route customarily.

Another weigh bridge exists at the on-ramp of the Kohat Link Road. This facility should be also utilized for overload control.

However, it may be better to combine the overload control stations at the New Toll Plaza (Sta.17+400) in future so that all heavy vehicles are subjected to inspection and measurement in an efficient way.

Another important measure for minimizing overloading is education of transport operators and drivers by providing information on the overload control and fine system periodically. The data of overload control practice should also be distributed to these operators as a part of public information system.

12.4 Maintenance of Bridges

Routine inspection and minor maintenance such as cleaning of drainages should be carried out as a part of the road inspection and maintenance operation. Periodical inspection should be carried out using a standard inspection form. Special inspections should be carried out after floods to check the condition of the foundations.

The current problem of bridge maintenance is scouring of foundations (Bridge No.1) by floods and settlement of the bridge approaches as no approach slabs were provided. Inspection and repair are necessary for bridge approaches against depression for the traffic safety and minimizing adverse effects on the bridge structures. As approach slabs are designed for all new bridges of the 2nd Kohat Tunnel and Access Roads, bridge approach settlement will be reduced.

12.5 Operation and Maintenances of Tunnel

12.5.1 Tunnel Operation

NHA contracted the operation and maintenance of the 1st Kohat Tunnel to a private company named AXS Pakistan (Pvt) Ltd. who works as Management Contractor & Operator (MC&O). Under the control and supervision of the Chief Operating Officer of NHA, who stays in the Administration Building, MC&O is providing tunnel operation and maintenance services.

The scope of works of MC&O includes:

- Tunnel operation including operation of supervisory and control (SV&C) system, ventilation system, lighting system, radio communication system, electronic toll and traffic management (ETTM) system, etc.;
- Toll collection; and
- Maintenance and cleaning of buildings, tunnel maintenance vehicles, facilities of various system facilities, cleaning of tunnel floor and walls, approach roads, toll plaza and weigh bridges.

About facility maintenance, MC&O is responsible for routine inspection and preventive maintenance, and preparation of preventive maintenance plans. Repair and maintenance of civil works of the tunnel and approach roads are out of scope of MC&O, which is managed directly by NHA.

The document Standard Operating Procedures (SOP) for management and organization, tunnel operation, audit and accounting, facility maintenance and SV&C system operation was firstly prepared with assistance of the Japanese Tunnel O&M Experts who carried out training of the MC&O. The SOP is to be revised and updated from time to time, and Revision No.3 is currently used.

There are four main operational sites and at weigh bridges and sizing barriers for tunnel operation and maintenance:

- Control Room and South Emergency Response Building at the south tunnel portal (Sta. 20+190);
- North Emergency Building at the north tunnel portal (Sta. 18+650);
- Main Toll Plaza (Sta. 10+600); and

- Kohat Link Road Toll Plaza.

NHA is installing a single toll plaza at Sta. 17+350 while cancelling the Main Toll Plaza and the Kohat Link Toll Plaza.

There will be no substantial modification of the tunnel operation and maintenance system, even after completion of the 2nd Kohat Tunnel.

12.5.2 Maintenance of Tunnel Civil Structures

(1) Inspection

The inspection of tunnels is broadly divided into two categories. One is the inspection of civil structures such as lining, portals and drainage facilities and the other is checking and maintenance of facilities including ventilation system, machines and equipment, and the communication system.

The inspection for the civil structures is categorized into daily inspection, routine inspection and periodical inspection. The daily inspection covers inspection of concrete soundness, exfoliation and detachment of concrete and water leakage, visually from car or by foot.

Periodical inspection is a more detailed inspection conducted to check cracks, tunnel lining, etc. in an inspection gallery.

Special inspection is conducted when unusual phenomena occur as a supplementary to the daily and periodical inspections.

(2) Maintenance and Improvement

Since tunnels are closed structures, maintenance is necessary particularly in view of disaster or accidents prevention. The maintenance includes cleaning surface, remarking, cleaning drainage facilities and repair and replacement of traffic signs. Annual programs should be provided and required budget should be secured.

Database for maintenance should be established such as inspection results, repair and improvement records.

12.6 Organization for Operation and Maintenance

NHA has a well-established organization for operation and maintenance of the tunnel (refer to Subsection 5.3 of this Report). The Standard Operating Procedures Manual (SOP) for operation and maintenance of the 1st Kohat Tunnel is introduced in Subsection 5.3 of this Report. NHA has contracted the operation and management of the 1st Kohat Tunnel and Access Roads to a private company (AXS Pakistan Ltd.) since its opening in May 2003 under overall supervision of the Chief Operating Officer of NHA at the Kohat Administration Office. NHA has sufficient fund for the operation and maintenance (O&M Cost) of the tunnel. NHA collects approximately Rs. 130 million of toll fees per year from the Kohat Tunnel and spends approximately 70% of the toll revenues for that outsourcing. As the current operation and maintenance system has worked well, the same methodology will be applicable for the 2nd Kohat Tunnel and Access Roads. However, NHA should make efforts to reduce the tunnel O&M costs while keeping the current safety and service level. Introduction of competition and collaboration with local authorities will be one of the future issues.

NHA has carried out physical road maintenance and repair of road facilities by contract to private firms. This is a common practice and an effective way. However, NHA should establish a system for timely emergency repair of safety facilities, like guardrails, damaged by vehicles. A National Highway Safety Ordinance has been enacted to provide the legal basis for establishing the Highway and Motorway Police (NH&MP) Force under the federal Ministry of Communications. This measure expands the role of the motorway police to the

National Highway System, in a phased manner.

The Motorway Police and NHA are under the same ministry and work together for the safety and efficiency of motorway traffics.

For example through overload control of trucks mentioned in 12.3, the fines collected at weigh bridges are transferred to the Road Maintenance Fund of NHA. At this moment, the Ministry of Communications is expanding the checking system and the Motorway Police is collecting fines from vehicle exceeding the limit weight so that road users will realize the importance of the overload control.

Chapter 13. ENVIRONMENTAL STUDY

13.1 Environmental Legislations and EIA Procedure in Pakistan

13.1.1 EIA Regulations

In 1997, the National Assembly passed the 1997 Pakistan Environmental Protection Act (PEPA), which subsumed the 1983 Ordinance. This Act requires IEE (Initial Environmental Examination) and EIA (Environmental Impact Assessment) for all development projects.

Environmental impact assessment of all development projects, whether public or private, is a legal requirement under section 12 of PEPA of 1997, which became effective in 2001. Project categories requiring an IEE are listed in Schedule A (see Figure 13.1.1). Projects for which an EIA is required are shown in Schedule B.

The Pakistan Environmental Protection Agency (EPA) Review of IEE and EIA Regulations 2000 ("The 2000 Regulations") prepared under PEPA 1997 defines the procedures for IEEs and EIAs, and gives legal status to the Pakistan Environmental Assessment Procedures prepared by the Federal EPA in 1997.

The number of EIA reports submitted to EPAs has increased from 6 in 2000 to 29 in 2004, and the number of IEEs has passed from 31 in 2000 to 189 in 2004.

A list of mandatory EIA or IEE for the projects in the transportation sector is provided in Table 13.1.1:

According to the following table, the project proponent of the 2nd Kohat Tunnel and Access Roads Project is required to submit an EIA and discuss on it with NWFP EPA.

Table 13.1.1 List of Mandatory EIA / IEE

List of Projects Requiring an EIA (Schedule 2)	List of Projects Requiring an IEE (Schedule 1)
■ Mining & Mineral Processing · Major mineral development activities including those related to mining and processing of coal, gold, copper, iron, and precious stones · Major smelting plants · Major non-ferrous metals, iron and steel rolling	■ Mining & Mineral Processing · Commercial extraction of sand, gravel, limestone, clay and other minerals not included in Schedule A. · Crushing, grinding and separating processes · Minor smelting plants
■ Transport · Major ports and harbors development · Major airports · Federal or provincial highways or major roads with a value superior to 5 crore rupees, and their required maintenance works (rebuilding or reconstruction of existing roads is excluded from EIA implementation). · Major railway works	■ Transport · Port and harbor development projects for ships of less than 500 gross tons · Federal or provincial highways (except maintenance, rebuilding or reconstruction of existing metalled roads) with a value inferior to 5 crore rupees.
■ Environmentally Sensitive Areas · Any project located in an environmentally sensitive or critical area should be carefully analyzed. Results of the said study shall be communicated to the authority in charge for its decision on whether an EIA is to be carried out (See "Guidelines for Sensitive and Critical Areas.")	
■ Any other project that EPA may require	■ Any other project that EPA may require.

13.1.2 EIA Procedure

No proponent of a project can proceed with the project implementation unless having filed an Initial Environmental Examination (IEE) with the Federal EPA, and received the corresponding approval. No particular project may be proceeded if it is likely to cause adverse environmental effects, unless the pertinent EIA has been approved by the Federal Agency.

After the filing of the IEE, the Federal EPA must respond within 10 working days and state if the submission is acceptable or not, or if an EIA is required. If acceptable, the Federal EPA is required to review the IEE and approve it within 45 days. If an EIA is required, the EPA must review the EIA, after which, the agency has three possible courses of action: (1) The EPA can give its approval subject to certain conditions within 90 days; (2) Require that the EIA be re-submitted after any stipulated modifications, or (3) Reject the project itself.

Every review of an EIA must be carried out with public participation. No commercially confidential information shall be disclosed during the said public participation though, unless such disclosure is in the public interest. The Federal Agency must communicate its approval, or any other conclusion, within four months from the date the IEE or EIA is first filed. If the submission is complete and complies with the required procedure, but no response is given, then the IEE or EIA shall be deemed approved. The Federal Government can, at its discretion, extend the four months period, if justified by the nature of the project.

The Federal Agency must maintain separate registers for IEE and EIA projects containing brief particulars of each project, as well as a summary of decisions taken. These registers are to be open to the public. The procedure pertaining to IEE and EIA submissions and approvals is shown in Figure 13.1.1.

13.1.3 Environmental Management Plan

The project proponent will be responsible for ensuring implementation of those environmental mitigation measures recommended in the IEE or EIA. The corresponding Environmental Management Plan (EMP) should be prepared during the planning phase of the respective IEE/EIA. The said EMP should include specific mitigation measures, environmental monitoring requirements, institutional arrangements and its corresponding budget.

The EMP is a crucial document that should be prepared during the IEE / EIA planning phase. Aftr its approval by the EPA, the EMP is to be taken into consideration when defining the contractual obligations to be imposed on the contractor.

Implementation of the EMP while performing the corresponding construction works is the responsibility of the contractor. The contractor is responsible for environmental monitoring and reporting activities. The project proponent must ensure that the performance of the contractor is in accordance with EMP. The contractor should submit annually a report on EMP implementation. The monitoring and approval procedure is shown in Figure 13.1.2. The Federal EPA has delegated power to approve IEEs / EIAs to the provincial level EPAs.

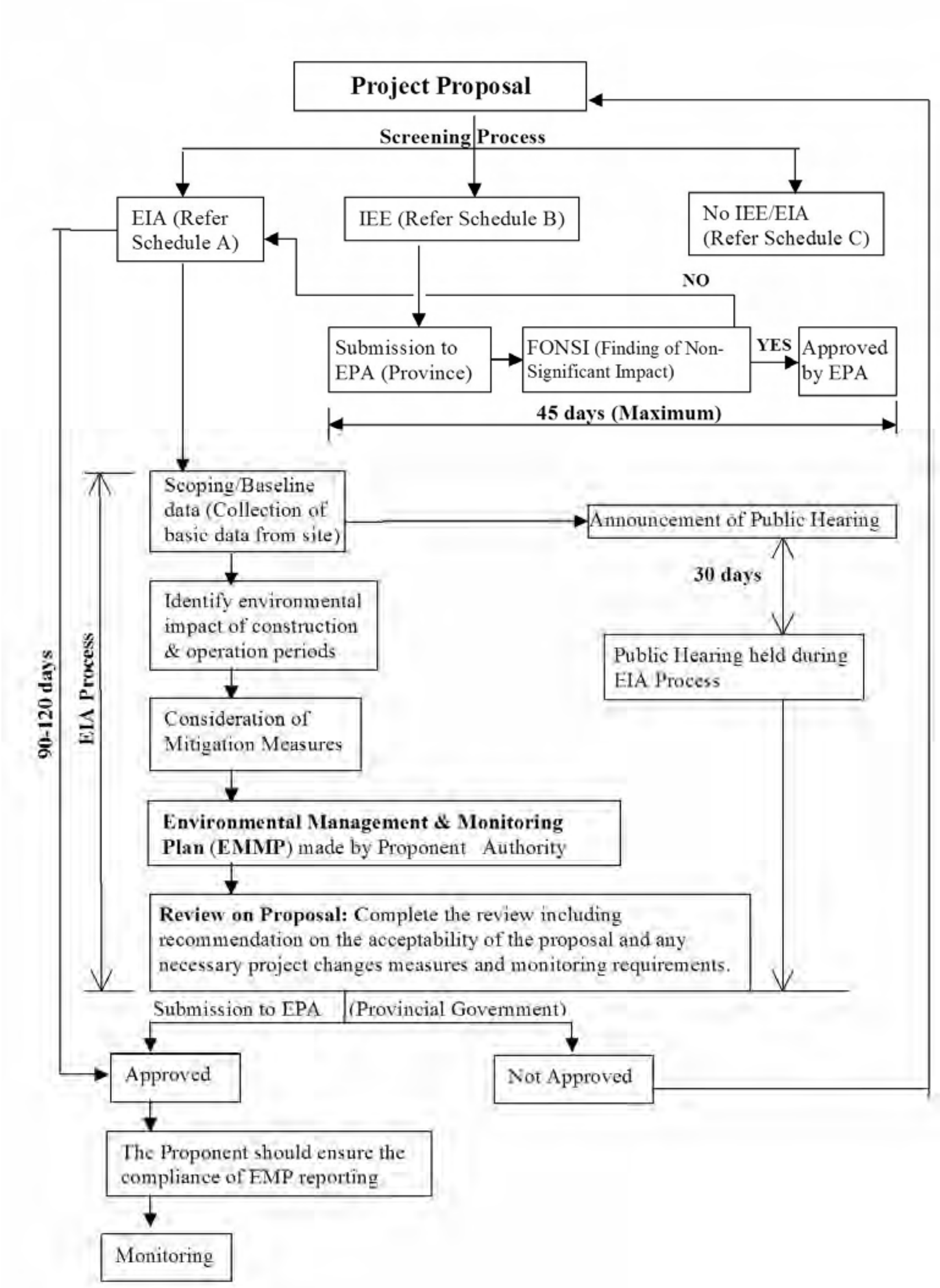


Figure 13.1.1 EIA Approval Procedure

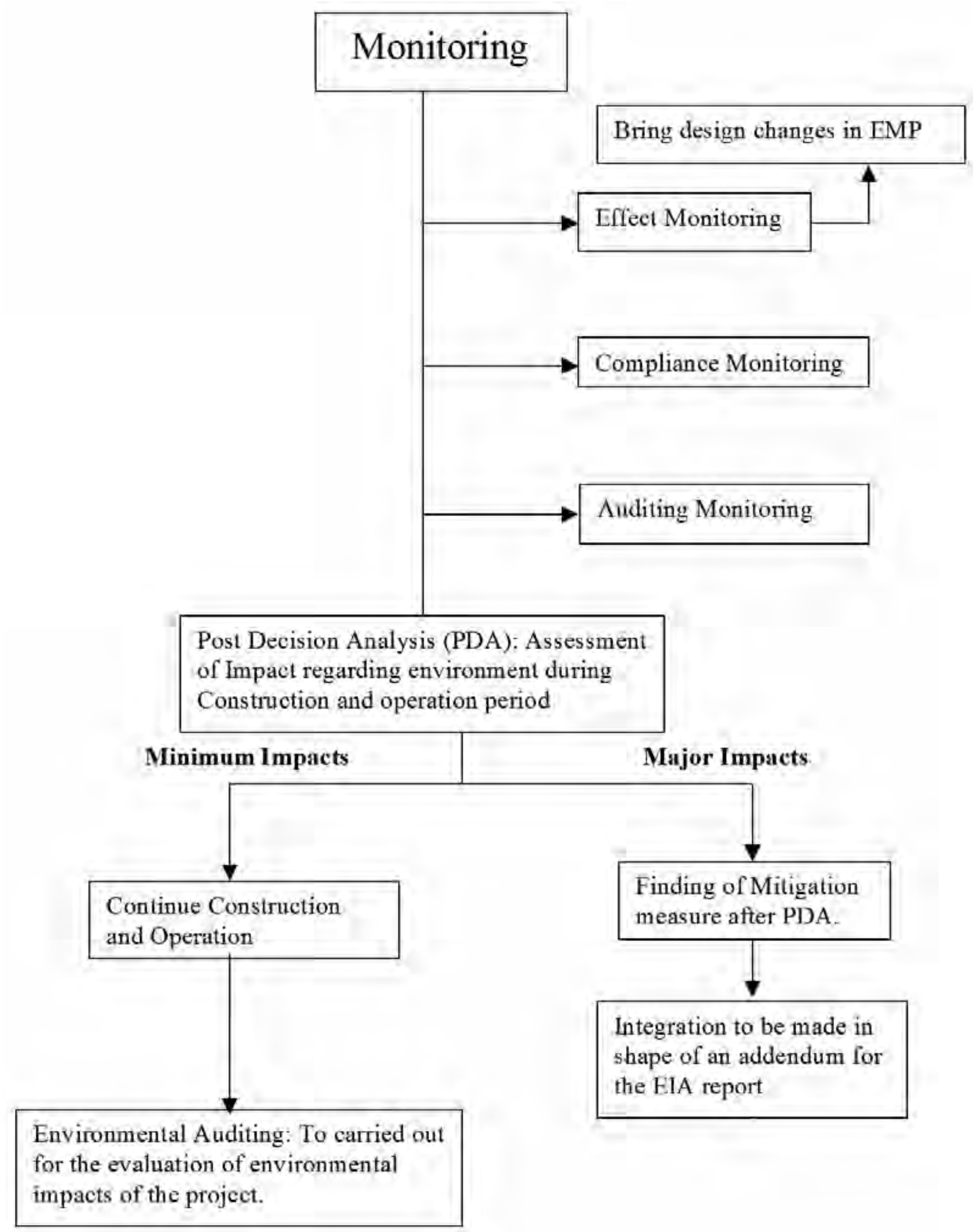


Figure 13.1.2 Post-EIA Monitoring Procedure

13.1.4 JICA and Pakistan EPA Guidelines

Upon comparing JICA guidelines and the requirements of the Federal EPA, no significant differences have been found.

JICA guidelines make reference to a Strategic Environmental Assessment (SEA), which the Pak-EPA does not mention. However, MOE would like to see this included at a policy level. Resettlement is taken into consideration in both guidelines. Nevertheless, MOE admits having not enough capacity to assess such an issue.

With regard to technical considerations, no relevant differences have been found. A comparison is provided in Table 13.1.2 below.

Table 13.1.2 JICA and Pak-EPA Environmental Guidelines:

A Comparison of Requirements

Scope of Impacts for Evaluation in Environmental Assessments	
JICA	**Pak – EPA**
Direct and immediate impact of projects	Site selection
Derivative, secondary and cumulative impacts	Indirect impact on natural resources
Environmental impact of a trans-boundary or global scale, e.g. global warming	Project-related impact
Impacts on natural environment:	Impacts on natural environment:
Air	Air quality
Water and water usage	Water quality, water supply, storm water management, ground water and flooding
Soils, ground subsidence, sedimentation and geographical features	Soil stability, soil erosion and sedimentation
Waste	Safe storage of materials on construction site
Accidents	Construction hazards, traffic accidents and disaster response plan
Ecosystems and biota	Flora and fauna (biota), destruction of habitats (ecosystems) and loss of species
Noise and vibration	Noise and vibration
Social considerations:	Social considerations:
Migration of people, social institutions and infrastructure, local decision-making institutions, and existing social infrastructures and services	Displacement of existing uses, breakdown of community cohesion, and provision of replacement community facilities
Involuntary resettlement	Adequate resettlement and compensation to allow viable lifestyle to continue
Local economy, employment and livelihood, distribution of benefits and losses, and equality in the development process	Economic issues and loss of livelihood
Land use and utilization of local resources	Landscape, visual amenity and induced land change
Cultural heritage	Cultural heritage
Infectious diseases such as HIV/AIDS.	Health and spread of diseases
Local conflict of interests among vulnerable social groups: poor and indigenous people, and gender and children's right issues	

13.2 Evaluation of Environmental Impacts by the 1st Kohat Tunnel and Access Roads Construction

13.2.1 Environmental Aspects of the 1st Kohat Tunnel and Access Roads

(1) Background

The National Highway 55, called the "Indus Highway," connects Karachi with Peshawar, and passes through the North-West Frontier Province near the Afghanistan border. This is mountainous area that has long been considered dangerous because of narrow roads, sharp curves and steep slopes. The 9.2-km long mountainous Kohat Pass must be crossed to reach Peshawar. This represented a hot spot where frequent traffic accidents occurred, resulting in nearly 30 deaths every year, as large vehicles could not drive over this pass, and were required to make major detours. In order to ease traffic congestion and improve safety, the "Kohat Tunnel and Access Roads Construction Project" was initiated to provide an alternative route. The construction of a 1,885m long 2-lane tunnel began in 1999, and once it was completed, it enabled an easier passage for large vehicles, alleviated traffic congestion, improved traffic safety, and reduced mileage and travel time. The tunnel was inaugurated and opened to the public in June 2003. The tunnel increased the role of the

Indus Highway (N-55) as a trunk road, stimulating social and economic development of the region, particularly in the North-West Frontier Province.

(2) Operations

The tunnel has an operational centre at its southern portal, as well as an emergency response centre at its northern portal. The operational centre maintains a close circuit television (CCTV) monitoring of the tunnel interior and access roads. It also controls the ventilation system and lighting. The longitudinal ventilation system is employed. There are five paired fans with provision for installation of three more pairs. The fans are capable of reverse flow, and this is determined by the wind direction at the north and south portals. The fans are designed to give a maximum ventilation speed of 8.0 m/second. In case of power failure, the fans may also run with an 11kv WAPDA (Water and Power Development Authority) supply including an UPS and a backup diesel generator.

The access roads connected to the tunnel have a design speed of 80-90 km/hr. The tunnel itself has a design speed of 60 km/hr. In fact, the speed limit in the tunnel is 40 km/hr, which means that the design transit time is around two or three minutes.

The tunnel ventilation system is designed to control two main elements: Carbon monoxide (CO) and visibility. The tunnel sensor system has two carbon monoxide sensors, two visibility meters and a wind velocity meter installed near the portals. The design standard for CO requires concentrations to be maintained at less than 100 ppm, based on international practice. The design standard for visibility requires it to be kept below 40% obscuration at 100 metres. The ventilation system is operated by a computer-controlled threshold activation system. A fan pair starts operating if the CO level rises above 30 ppm. If the said level persists, extra fans are switched on. In case the visibility falls below 85%, the fans commence operation. The threshold system can also be controlled by manual override.

(3) Emergency Response and Safety

The emergency response centre provides facilities for on-site safety. It has a relief van for towing disabled vehicles, an ambulance, a fire engine, and a water tanker truck. The fire fighting water tank installed next to the control room holds 200m^3 of water, of which 250 gallons per minute can be supplied for two hours continuously. Emergency stopping lay-bys are provided in the tunnel. Fire extinguishers are provided at every 100 metres, and five big extinguishers are located in the emergency areas. Traffic lights at both portals can be turned red in order to prevent traffic entering into the tunnel during an emergency. All staff working in the tunnel wear masks and carry personal CO exposure meters. There is a "Committee for Safety Action for Kohat Tunnel" called COMSAK.

(4) Environmental Impact Assessment and Issuance of NOC

In 2001, NHA requested NWFP EPA to issue a "Certificate of No Objection" for the tunnel construction and its subsequent operation. EPA pointed out that 36% of the tunnel had already been completed, and the application should have been made at the PC-1 planning stage. However, EPA stated that there were no overriding environmental reasons why the project should not proceed. Some conditions relating to construction drainage, ventilation, and safety reporting during construction were imposed, and NHA was requested to give an undertaking in order to comply with such conditions.

13.2.2 Current and Future Environmental Issues

(1) Vehicle Speed

Commercial vehicles in Pakistan are generally old and overloaded beyond their design load. They move slowly on gradients, and when climbing up even modest gradients of 2.2% in the tunnel, they usually limit their maximum speed to 10-20 km/hour. This reduces drastically the overall traffic speed, and vehicles require around 6-12 minutes to traverse the tunnel. For the Heavy Goods Vehicles (HGVs), this still compares favourably with the two to three hours previously needed to climb over the Kohat pass. As the Kohat tunnel is a single carriageway with dual lanes, private cars' drivers feel frustrated at having to follow those slow moving vehicles with no chance of overtaking them.

(2) Fire Hazard

The access roads to the tunnel are steep, and vehicles can overheat before they reach the tunnel. Despite this there has never been so far a major fire in the tunnel. Nevertheless, three fires in vehicles outside the tunnel, and a minor fire inside a bus in the tunnel have been reported. Apparently, this was caused by a relief driver who dropped a cigarette in his sleeping area. The bus exited the tunnel north portal, and the fire response team put out the fire after being alerted by the CCTV monitors.

Some vehicles are not permitted in the tunnel. Vehicles classed as HAZCHEM (carrying hazardous materials) are sent over the pass. Buses are not allowed to enter if passengers are sitting on the roof or have their arms outside the windows. Pedestrians are not allowed to pass through the tunnel either.

(3) Control of Overheating and Slow Vehicles

The tunnel operators have implemented a "convoy" system for slow smoking vehicles. Vehicles reaching the entrance to the south portal are ordered to stop and rest their engines. This gives their brakes and engines time to cool down. They are given free water for their radiators. Without having to wait more than ten minutes, they are then sent through in a group. Drivers accept this system and do not object as it allows their vehicles to cool off. This cooling is needed only in summer.

(4) Fuel Quality

A major concern is the use of low-quality fuel in poorly maintained engines. Although certain allowances have been made in the design of the ventilation system for Pakistani vehicles, it is still suspected that petrol engines emit excessive CO, while diesel engines produce excessive smoke. In addition to this, the fuel used is high in sulphur, which can lead to considerable SOx emissions, and badly tuned diesel engines can emit high NOx emissions. These issues are not currently monitored. Although vehicle emissions are excessive, the tunnel has removed traffic from the Kohat town centre, thus relieving urban congestion.

(5) Fiscal Control Measures

The tunnel management considered offering cheaper fares for slow and heavy vehicles to use the tunnel at night, and not during the day, in order to allow faster traffic speed for passenger cars. A proposal was submitted to NHA from the Kohat chief operating officer, based on differing toll rates at different times. At present, HGVs pay an Rs150 toll. It was suggested to increase this up to Rs200 during the day, and reduce it to Rs100 at night. This proposal has not met with general support, as it may encourage falsifying timings. Further, transporters complained that it would cause adverse effects on the timing of departures from certain points of origin such as Karachi. At the present, this initiative seems unlikely to be adopted.

(6) Interior Lighting

It has been indicated by NWFP EPA that the interior roof of the tunnel is dark. It was originally dark grey, this being the colour of cement. It has become darker due to soot from vehicles. The internal wall tiles and roof light panels are cleaned regularly, but the roof is not. This is because the electrical wiring is not waterproof, and the use of high-pressure hoses would cause damage to the circuitry. In order to compensate for this, more lights are switched on, particularly in the transition zone from daylight to darkness at the portal entrances.

13.2.3 Issues Regarding the Second Kohat Tunnel

(1) Spoil Disposal

The construction of the aperture will be by rock tunnelling, with the rock spoil being removed in both north and south directions. The access roads will require cutting of existing rock faces for widening. Each access road will also require fill material for new embankments. The mass balance is shown in Table 13.2.1 below. The extracted tunnel rock will be used as fill with 60% for the north approach road, and 40% for the south approach road. There will be a shortfall of approximately 594,000 m^3 of material that will be needed for embankment formation (refer to sub-section 14.2.2 as to details). This will probably be taken from borrow areas to the south and east of the existing south access road.

Table 13.2.1 Cut and Fill Balance

	Cut Material	Fill Material
Tunnel	152,005 m^3	None
North access road	84,503 m^3	260,168 m^3
South access road	226,700 m^3	846,181 m^3
Total	463,278 m^3	1,106,349 m^3
Balance	None	- 594,159 m^3
N.B. The tunnel rock spoil will be used as fill: 60% for north road, and 40% for south road.	All figures estimated and accurate to $\pm$ 20%	Extra fill material will be prepared from existing borrow pit

(2) Air Quality Monitoring

It is not normal to monitor NOx and SOx in tunnels as they are pollutants which have long-term chronic effects. Conversely, CO has a direct short-term toxic effect, can be lethal at high concentrations, and is normally measured in real time. However, due to the large amount of adulterated fuel leading to high NOx and SOX emissions, it may be useful to install NOx and SOx monitors in the second tunnel.

(3) Positive Benefits of Second Tunnel

The second tunnel will create several positive benefits:

- The operation of a second tunnel will provide two lanes of traffic per tunnel. This will allow overtaking in each tunnel so HGVs can use a slow lane and passenger cars can use a fast lane. The transit time through the tunnel should be restored to the design value of 3-4 minutes for cars.
- The ventilation system will be improved as all vehicles will be moving in the same direction. This will create a piston effect. Also the longitudinal fans will be more effective.
- The second tunnel will be close to the first tunnel, as their centrelines will be 30 m apart. Two cross passages to connect two tunnels will be constructed and this is an added safety feature as it provides evacuations routes in the event of an emergency in either tunnel.

13.3 Initial Environmental Examination Based on JICA's Environmental and Social Consideration Guidelines

13.3.1 Objectives and Methodology for IEE

(1) Objectives

Initial Environmental Examination (IEE) means a study including analysis of alternative plans, prediction and assessment of environmental impacts, and preparation of mitigation measures and monitoring plans on the basis of secondary data and simple field surveys.

Objectives of the IEE are as follows:

- Before conducting environmental and social consideration activities based on the Pakistan's EIA law, the proponent should grasp the current status of the project site, possible impacts, required approval procedures and other relevant issues.
- The proponent will illustrate required mitigation measures based on IEE results, or adopt alternatives including such as "without the project."
- The proponent will conduct an environmental and social baseline survey through a scoping report based on the IEE.

(2) Target Items for the IEE

IEE has been carried out by exploratory and literature surveys. Items for the IEE are as presented in Figure 13.3.below1, and are all inclusive, which are described also in the JICA's and Pakistan's EIA Guidelines.

Table 13.3.1 IEE Items

Items	
1) Social Environment	a. Involuntary resettlement b. Local economy, employment and livelihood c. Land use and local resources utilization d. Existing social infrastructures and services e. Local communities f. Benefit and damage misdistribution g. Gender h. Children's rights i. Cultural heritage j. Local conflicts of interests k. Public sanitation l. Infectious diseases such as HIV/AIDS m. Water usage and rights n. Traffic accidents
2) Natural Environment	o. Global warming p. Biota and ecosystems q. Geographical features r. Soil erosion s. Underground water t. Hydrological situation u. Coastal zone (mangroves, coral reefs, tidal flats, etc.) v. Climate w. Landscape
3) Pollution	x. Air pollution y. Water pollution z. Soil contamination aa. Waste ab. Noise and vibration ac. Ground subsidence ad. Offensive odors ae. Bottom sediment in sea and rivers

13.3.2 IEE Results

(1) Outline of IEE

The IEE has been carried out by the PTPS JICA Study Team, Environmental Specialists in the NHA and the NTRC. It included the following activities.

Table 13.3.2 IEE Outline

	Items
Data and Time Table	[31st May, 2006] ・0900-1030) Site survey from existing road (from Darra Village to NHA Kohat Office) ・1030-1200) Interview with NHA Kohat Office ・1200-1300) Site survey in operation room ・1300-1600) Site survey from existing road (1st Kohat Tunnel - Kohat junction – Kohat Town – Starting point for the project [south part of Kohat Town]) [7th June, 2006] ・1000-1200) Interview with Wildlife Dept. NWFP ・1300-1400) Interview with Wildlife Dept. Kohat ・1400-1500) Site survey

(2) Current Status

The current status of the IEE may be explained as follows:

a) Social Environment

i) Involuntary Resettlement

The planned access road will pass through Darra Village. However, there are no inhabitants in the right of way (see Figure 13.3.1).

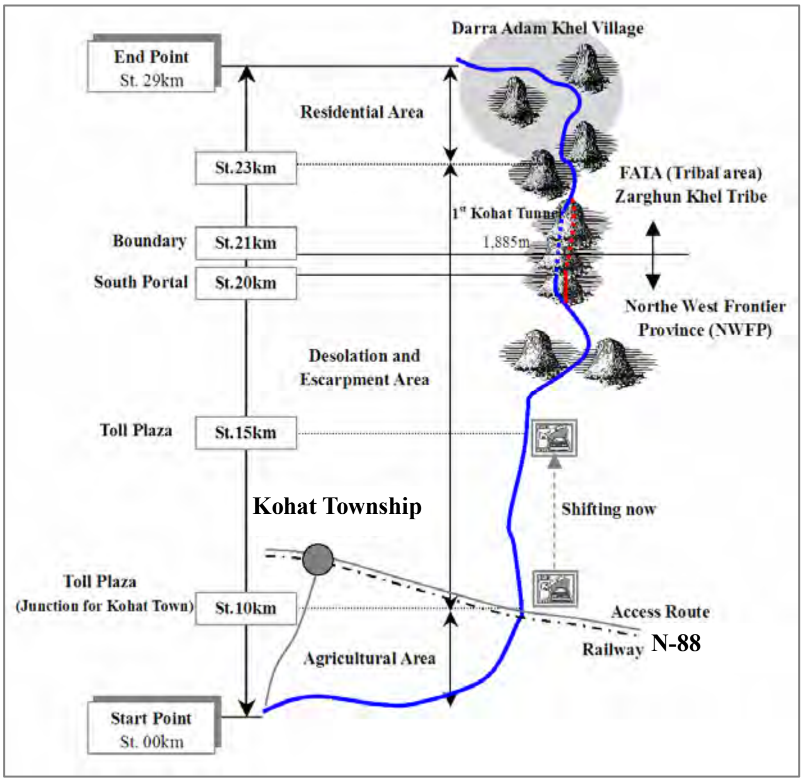


Figure 13.3.1 Project Image Map

ii) Local Economy, Employment and Livelihood

Darra Adam Khel village is one of the major residential areas through which the existing road passes. Darra Adam Khel is the nearest village to the project area that is located on the southwest side of Peshawar. The local economy in Darra Adam Khel is based largely on the gun-making cottage industry. Except agriculture, no other industries exist in the concession area. Scarcity of water does not support commercial agricultural activity. A large proportion of the population's livelihood is based on service industries such as the armed forces, police, militia and other services. The ratio of people having agriculture as means of livelihood is very small. The remainder of the population is engaged in various types of business either in Peshawar, Karachi, Rawalpindi and other cities of Pakistan.

iii) Land Use and Local Resources Utilization

Due to limited water supplies for irrigation, the level and management of agricultural practices in the project area is low. As a result, subsistence agriculture does not produce enough to meet the food and financial requirement of the farming population. Rainfall uncertainty is also one of the major reasons for low agricultural production. Major crops in the project area are rain fed, such as groundnuts and pulses in Kharif, and wheat, barley and oil seeds.

Roughly 50% of the total project area is not available for cultivation because of the existence of hills, mountains and houses. Due to the inaccessibility, between 25% and 30% of the total cultivable land is not cultivated at all. The cropped area in any season amounts to only about 20% of the total cultivable area. In the project area, the agricultural area is from the start point (the Kohat Toi junction) to about 10 km, the escarpment area from 10 km to 22 km, and the residential / settlement area from 22 km to the end point.

iv) Social Infrastructure and Local Decision-making Institutions

The project area is located in the tribal area called Frontier Region (FR) Kohat, which is about 23 to 25 km away from the provincial capital of Peshawar. The jurisdiction of FR Kohat starts from the check post of Spina Thana and culminates towards Kohat Tunnel in its south. Thereafter, the jurisdiction of the provincial government starts (both ends of the tunnel). Thus, here in the project area two government administrations are involved.

In the southern part of the project area, a small mosque, some shops and a restaurant are situated on the existing access road. No other relevant infrastructure is available.

v) Local Communities

In Darra Adam Khel, there are five tribes: the Zarghun Khel, the Akhurwal, the Shareki, the Tur Chapper and the Bazti Khel Tribes.

vi) Benefits and Reduction of Damage

The construction of the Kohat Tunnel will not only reduce the traveling time between Peshawar and Kohat, but also reduce environmental pollution due to vehicular emissions in the tunnel. There will also be a great saving in fuel consumption.

vii) Gender

The implementation of this Project will not affect the movement of women due to local customs.

viii) Children's Rights

No findings in the site survey were available.

ix) Cultural Heritage

The culture and traditions of this area are deeply motivated by, and related to Pushtuns customs. During the survey, neither sites of archaeological importance likely to be considered as a world cultural heritage or national heritage, nor historical cultural heritage findings have been identified in the project area. However, each village has a graveyard on its outskirts. It is usually located on common property, which is called Shamilaat.

x) Local Conflicts of Interests

There is no conflict among local people and the government during the 1st Kohat Tunnel

Project because the public authorities have already provided and distributed displacement reimbursement fees to local village leaders.

However, certain disputes among local people and the village leaders still occur occasionally due to non-transparent distribution of government money.

xi) Public Sanitation

In the Darra Adam Khel area, no proper drainage or sanitation system exists. The people are mostly illiterate, and they are still using primitive types of toilet.

xii) Infectious Diseases such as HIV/AIDS

In the Darra Adam Khel tribal area, there are no reported signs of any infectious diseases like HIV, AIDS, etc.

xiii) Water Usage and Rights

In the Darra Adam Khel area, no river or canal exists. Tube wells are available, but piped water distribution systems are very limited. Groundwater is available only after rains. Water wells and hand pumps are operational only sporadically, not throughout the year. A majority of residents in the project area rely on the water accumulated from rainwater, which they consider to be fit for human consumption.

b) Natural Environment

i) Traffic Accidents

In the project area, only minor traffic accidents occurred due to reckless and rough driving.

ii) Global Warming

No findings in the site survey have been observed.

iii) Biota and Ecosystems

The native vegetation of the project area is limited to shrubs and dry sub-tropical temperate vegetation. There is no major forest cover in the project area, and no exotic species or medicinal plants were found. Hence, there is quite limited fauna and flora in the escarpment area, with the exception of some birds of prey. It is confirmed by interview survey and visual inspection by site reconnaissance. The Protection Wildlife (Peshawar and Kohat) and IUCN in Peshawar concluded that there were no considerable species in the site.

The DFO Wild Life Department NWFP Kohat City considers that the project site has few sensitive areas, forest reserves, product reserves, or endangered species, hence, have “no objection” regarding this Project.

iv) Geographical Features

The region extending from the start point to 15 km is a plain area; the one from 15 km to 19 km is hilly; and from 19 km to 29 km (end point) the site is an escarpment area. The escarpment area has a very steep rocky slope in which truck accidents occur due to landslide.

v) Soil Erosion

As it is explained in the “Geographical Features” section, landslide and soil erosion are confirmed in the escarpment and hilly areas. Annual rainfall is around 400 mm, but its hourly intensity is very high, which removes soil from the agricultural field to the seasonal river “wadi”.

vi) Underground Water

According to local people, the underground water is fresh water, found at about 300 to 400 ft depth. The water is located underneath rocks with low permeability and infiltration rates. During the site visit, ground water extraction was not observed. Because of its location at a considerable topographic depth, it is considered that no exploitable underground water resources exist in the project area.

vii) Hydrological Situation

Underground water may come out through excavation activities for tunnel construction. However such volume will be limited and will not impact the existing hydrological situation.

viii) Coastal Zone (mangroves, coral reefs, tidal flats, etc.)

There is no coastal zone or sensitive habitat in the river.

ix) Climate

As the project area is mountainous, variations in local temperature are obvious. The climate is marked by seasonal fluctuations in temperature and rainfall. The climatic conditions of the project area vary from extreme cold in the snow-clad mountains, to hot and sultry in the plains. The rainfall is scanty, varying from 150 mm in the hills, to 40 mm or less in the plains, per year.

x) Landscape

The landscape is categorized into two types: One is the desert plain and hilly area, and the other is the skyline of the escarpment area. The most representative elements of these areas are a few acacia trees and rocks.

c) Pollution

i) Air Pollution

Ambient Air Quality Standards (AAQS) have not yet been introduced in any part of Pakistan, and there is no data available on the measured values of SPM (Suspended Particulate Matter), SOx, NOx, Lead, CO, and other traffic-related pollutants.

According to the data obtained in the operation room in the 1st Kohat Tunnel, the CO values are very low at around 1-5 ppm at both portals, much less than the allowable maximum of 100ppm.

In the dry weather, especially in sand storms, high dust levels may cause visibility problems for transportation. Visibility problems can also arise in cold or foggy winter seasons as well.

ii) Water Pollution

There are five rivers, Kohat Toi (Jerma Minor), Chargai Algada, Osti Khel Algad, Osti Khel Algad/Panderi Algada and Mullah Khel Alga crossing the Project road (refer to Section 6.3). Bridges were constructed on these rivers under the 1st Kohat Tunnel and Access Roads Project. Several irrigation canals also exit and box-culverts were constructed crossing over them. Bridges and box culverts for the 2nd Kohat Tunnel and Access Roads were designed to minimize negative affects on these rivers and canales. Appropriate measures should be taken during the construction to avoid water pollution.

iii) Soil Contamination

No findings in the site survey are available.

iv) Waste Solid

No findings in the site survey are available.

v) Noise and Vibration

The residential area in Darra Village is set back by at least 50 meters from the existing road. So far, there are no complains regarding noise or vibration.

vi) Ground Subsidence

No findings in the site survey are available.

vii) Offensive Odors

No findings in the site survey are available.

13.4 Scoping for Environmental and Social Considerations through IEE

13.4.1 General Information on the Project Site

(1) Natural Conditions

Much of Pakistan is a dry, sun-scorched region. To the west of the Indus are the rugged dry mountains of the Sulaiman Range, including the project area, and merging with the treeless Kirthar Range in the south. Farther west are the arid regions of the Baluchistan Plateau and the Kharan Basin. A series of mostly barren low mountains and hills predominate in the western border areas. Furthermore, there are no wetlands, major rivers with continuous flow or sensitive forests.

(2) Climate

The climate of Pakistan varies widely with sharp differences between the high mountains and low plains. The country experiences four seasons. In the mountainous regions of the north and west, including the project area, temperatures fall below freezing during the winter and are mild during summer. Average temperature through the year in Peshawar is around 22 degrees Celsius. The minimum temperature is 11 degrees Celsius in January, while the maximum temperature is 33 degrees Celsius in June.

In relation to rainfall, most precipitations come with the summer monsoons during February, March, April, July and August. The summer monsoons are seasonal winds that bring torrential rainfall, breaking the hot, dry spell and providing much-needed relief.

The annual rainfall level is approximately 400 – 500 mm. The minimum rainfall level is 10 mm in June, while the maximum is around 70 mm in March or August.

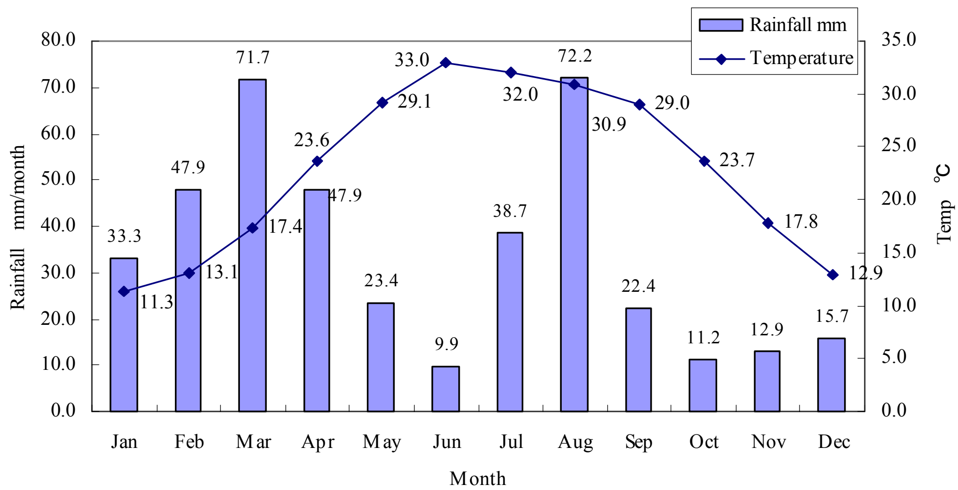


Figure 13.4.1 Annual Rainfalls and Temperature in Peshawar

(3) Public Administration

The ethnic groups of Pakistan are distributed according to their historical settlement in the region. The current political regions of Pakistan roughly correspond to the settlement patterns established long before the partition of British India in 1947, when Pakistan was created as a homeland for Indian Muslims. The four provinces are: Punjab, the Muslim portion of the historic Punjab region; Sind, the traditional homeland of the Sindhis; the North-West Frontier Province (NWFP), a small portion of the Pashtun tribal lands; and Baluchistan, a portion of the Baluchi tribal lands. The traditional homelands of the Pashtuns and Baluchis extend beyond the political borders, both provincial and national.

The NWFP has a population of 17.7 million (2002), among which the Pashtuns occupy the majority. The province is a part of the historic Pashtun tribal lands, which extend throughout southern and southeastern Afghanistan well into western Pakistan, including the Federally Administered Tribal Areas and northern Baluchistan. The NWFP is Pakistan's smallest province in terms of size. In the 1980s, refugees from war-torn Afghanistan began to settle in the province. Refugee camps and rudimentary villages were set up in the border areas. A large number of refugees also established communities in cities such as Peshawar. Many became semi-permanent residents of Pakistan because Afghanistan remained in a state of war through the mid-1990s. The majority of refugees were Pashtuns, facilitating their assimilation into the province's population, in many cases through marriage.

In relation to the project area, from the start point near Kohat Town to Kohat Tunnel (21 km from the start point) is located in NWFP, while from 21 km to the end point is in the Federally-Administered Tribal Areas (FATA), Zarghun Khel Tribe, and Orakuzai Agency.

(4) Industry

The major industry in the project area is agriculture, with wheat as the main produce. In Pakistan, about 28 % of the total land area is cultivated. Agriculture and related activities, including fishing, engage 48 % of the workforce and account for 23 % of the GDP. Major cash crops are cotton (textile yarn and fabrics produce more than one-half of export earnings) and rice. Principal crops in 2004 (with output in metric tons) included the following: Sugarcane, 52 million; wheat, 19.8 million; rice, 7.6 million; cotton lint, 6 million; and corn, 1.8 million. Livestock included cattle, water buffalo, sheep, goats, and poultry.

However, it is said that firearms manufacture is the major industry in the Darra Adam Khel village, north of the Kohat Tunnel. Kohat Town is famous for being a military town with its own armaments industry located on the border. It also counts on restaurants and workshops.

13.4.2 Planned Project Design and Activities by Stages

(1) Project Outline

The project in question is represented by a series of construction works pertaining to the 2nd Kohat Tunnel and the expansion of the access road from one to two carriageways (see Figure 13.4.2).

As described in the design, most of the additional part of the access road will be in the right of way, totaling 50 metres, except for the section from the bridge to the south portal of the 2nd Kohat Tunnel.

Both Kohat Tunnels are to permit one-way traffic, with the first one being for traffic towards Peshawar City, and the second being for traffic towards Kohat Town.

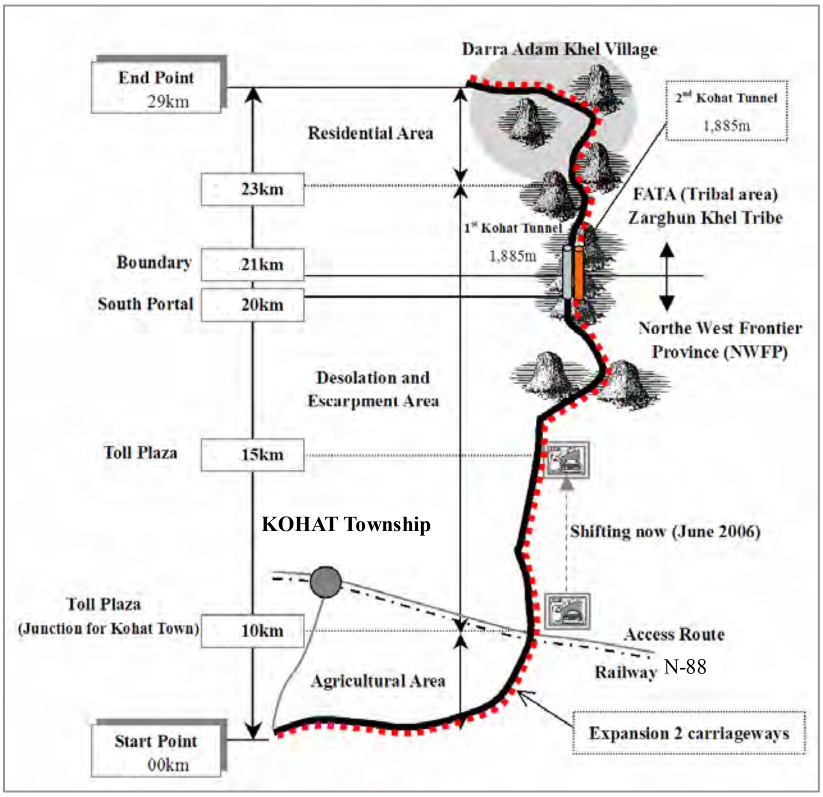


Figure 13.4.2 Project Image Map

(2) Project Activities by Stage

The project activities that may result in adverse impacts are those that, during construction, imply the drilling for the tunnel, cutting of the escarpment area and construction of embankments along the existing access road.

On the other hand, major activities or changes to be obtained after implementation of construction works are vehicle transportation and existence of the tunnel and embankment.

Table 13.4.1 Project Activities (by Stage)

ACTIVITIES		DEGREE OF PREDICTED IMPACTS
During Construction	1. Clearance (Right of way, yard and base camp)	D
	2. Cutting and drilling of the escarpment area	D
	3. Construction of embankment	D
	4. Operation of heavy vehicle	D
	5. Labor’s occupation in the base camp and around villages	B
	6. Operation in borrow pit and quarry	D
Post Construction	1. Existence of the road, embankment and tunnel	D
	2. Traveling of vehicles	E
	3. Management of the tunnel (Monitoring for traffic safety and air quality)	D

A: Expected serious impact
B: Expected certain impact
C: Not clear, further detailed information required
D: Expected minor impact
E: Expected positive impact

13.4.3 Predicted Environmental and Social Impacts by Stages

An outline of the expected positive and negative impacts by stages and works is presented as follows.

With regard to resettlement and land acquisition, no resettlement is required as the required ROW for the 2nd Kohat Tunnel was already secured during the 1st Kohat Tunnel and Access Roads construction. However, as there is still a private land (approximately 8 m x 4 m x 1/2= 16 m^2) at the site where the Bridge No.6AR is constructed, it needs to negotiate on this issue with the concerned tribe chiefs of Darra FATA. Relevant laws and guidelines for resettlement and land acquisition given in the Appendix are only for reference.

Table 13.4.2 Predicted Impacts Outline

Items		Comprehensive Rating	Predicted Impacts			
			Rating	During Construction	Rating	Post Construction
Social Environment	1. Involuntary resettlement	D	D	Resettlement will not be required due to non existence of inhabitants in the right of way. However the road alignment may touch a part of house wall in the Darra Village.	D	Few activities that may provoke adverse impact are predicted.
Social Environment	2. Local economy, employment and livelihood	E	E	Most of workers for the Project will be hired from nearest residential areas, such as the Darra Village or Kohat Town. Further, related consumption shall take place in the same residential area, with which this Project is likely to have a positive impact in the zone.	D	In the Darra Village, the main industry is agriculture. Military industry is prevalent in Kohat Town. Therefore, this Project is likely to provoke no more than a minor adverse impact.
Social Environment	3. Land use and local resources utilization	D	C	Drilling of the tunnel may cut connections for drinking water to residents in the Darra Village.	D	Few activities that may provoke adverse impact are predicted.
Social Environment	4. Existing social infrastructures and services	D	D	There is no social infrastructure on the designed route. A mosque is located at St. 19.5 km from the start point, but it is out of the right of way.	D	Few activities that may provoke adverse impact are predicted.
Social Environment	5. Local communities	D	D	Few activities that may provoke adverse impact are predicted.	D	As described in “Site Description,” the project area is managed by two public administrations: One is FATA (Orakzai Agency), and the other is Kohat district NWFP. No conflict between them regarding this Project has been found. No adverse impact is predicted so far. In the next stage, the proponent should collect stakeholders’ feedbacks through meetings.
Social Environment	6. Benefit and damage misdistribution	E	E	Most of workers for the project will be hired from nearest residential areas, such as the Darra Village or Kohat Town. Further, related consumption shall take place in the same residential area, with which this project is likely to have a positive impact in the zone.	E	Traveling cost and time will be reduced, and such benefit will be distributed fairly.
Social Environment	7. Gender	D	D	Few activities that may provoke adverse impact are predicted.	D	Few activities that may provoke adverse impact are predicted.
Social Environment	8. Children’s rights	D	D	Few activities that may provoke adverse impact are predicted.	D	No activities likely to give adverse impact are predicted.

	Items	Comprehensive Rating	Predicted Impacts			
			Rating	During Construction	Rating	Post Construction
	9. Cultural heritage	D	D	No world heritage, national monument or provincial monument may be found in the nearby.	D	No activities likely to give adverse impact are predicted.
	10. Local conflicts of interests	D	D	Few activities that may provoke adverse impact are predicted.	D	As described in "Site Description," the project area is managed by two public administrations: One, FATA (Orakzai Agency); the other, Kohat district NWFP. No conflict between them has been observed regarding this Project. No adverse impact so far has been predicted. In the next stage, the proponent should collect stakeholders' feedback from meetings.
	11. Public sanitation	E	E	Most of workers are likely to stay in the Darra Village or Kohat Town. Public sanitation systems including toilets or water supply conditions may improve as a result of the increase in their earnings.	E	Traveling cost and time will be reduced through implementation of this Project, resulting in a considerable economic benefit to the project area. This Project will also improve public sanitation systems.
	12. Infectious diseases such as HIV/AIDS	B	B	Some of workers or technicians are from foreign countries. In some cases, such labors may have relation with prostitution. Possibilities of spreading sexually transmitted disease (STD) and infectious diseases among workers and residents are real.	D	No activities likely to give adverse impact are predicted.
	13. Water usage and rights	C	C	Drilling or cutting works may cut connections for drinking water in Darra Village.	D	No activities likely to give adverse impact are predicted.
	14. Traffic accidents	E	D	Construction activities will be carried out separately for the present access road and the tunnel. Hence, few activities that may provoke adverse impact are predicted.	E	Present congestion in the first Kohat tunnel is to be solved
Natural Environment	15. Global warming	D	D	No activities likely to give adverse impact are predicted.	E	Reduction of traveling cost and time will save greenhouse gases.
	16. Biota and ecosystems	D	D	Limited fauna and flora in the project area are found. Few rare and endangered species such as listed IUCN and CITES have been found in the area.	D	Limited fauna and flora in the project area are found. Few rare and endangered species such as listed IUCN and CITES have been found in the area.
	17. Geographical features	D	C	Project route is lying in valleys with steep escarpment with frequent landslide. Project works may also trigger landslide.	D	Landslide will be minimized by implementation of disaster protection under this Project
	18. Soil erosion	C	C	Cutting steep slope without countermeasure design may provoke soil erosion.	C	Cutting steep slope and creation of embankment without countermeasure design may provoke soil erosion.
	19.Underground water	C	C	Drilling or cutting works may cut connections for drinking water in Darra Village.	D	No activities likely to give adverse impact are predicted.
	20. Hydrological situation	D	D	Few activities that may provoke adverse impact are predicted.	D	No activities likely to give adverse impact are predicted.
	21. Coastal zone (mangroves, coral reefs, tidal flats, etc.)	D	D	There is no ecozone such as mangrove and swamp area	D	There is no ecozone such as mangrove and swamp area

	Items	Comprehensive Rating	Predicted Impacts			
			Rating	During Construction	Rating	Post Construction
	22. Climate	D	D	Few activities that may provoke adverse impact are predicted.	D	No activities likely to give adverse impact are predicted.
	23. Landscape	D	D	Few activities that may provoke adverse impact are predicted.	D	No activities likely to give adverse impact are predicted.
Pollution	24. Air pollution	E	D	Cutting escarpment and transportation of materials for creation of embankment will provoke dust pollution.	E	Ambient air quality is expected to be the same as present condition due to maintenance of similar traffic volume. Improvement inside the tunnel is expected as a result of increase of lanes.
Pollution	25. Water pollution	D	D	Although water and mud discharge from drilling of tunnel is to be pumped out to the nearest river, no toxic substances are included.	D	No activities likely to give adverse impact are predicted.
Pollution	26. Soil contamination	D	D	Although soil discharge from drilling of tunnel is to be discharged outside, such soil will be used as material for embankment	D	No activities likely to give adverse impact are predicted.
Pollution	27. Waste	D	B	Labor's occupation may result in creating waste solid and nightsoil in work base camp and surrounding areas.	D	No activities likely to give adverse impact are predicted.
Pollution	28. Noise and vibration	D	D	Construction vehicles will drive through the old current road in the Darra village. Although traffic noise is not likely to exceed 75 dB (A) for 12 hours, the proponent may receive complains from residents living along the old road in Darra FATA.	D	Complaints from residents on current traffic noise and vibration have not been observed so far. Furthermore, the calculated traffic noise after construction is likely to be less than 85 dB (A), without exceeding WHO Guidelines.
Pollution	29. Ground subsidence	D	D	No activities likely to give adverse impact are predicted.	D	No activities likely to give adverse impact are predicted.
Pollution	30. Offensive odors	D	D	No activities likely to give adverse impact are predicted.	D	No activities likely to give adverse impact are predicted.
Pollution	31. Bottom sediment in sea and rivers	D	D	Although water and mud discharge from drilling of tunnel is to be pumped out to the nearest river, no toxic substances are included.	D	No activities likely to give adverse impact are predicted.

13.4.4 Proposed Mitigation Measures and Alternatives by Stages

(1) Alternatives

Some options for alignment of the access road and tunnel location have been considered. However, as such options are less attractive for economic reasons, it was decided that the present route and location represent a more practical alternative.

In the scenario that this Project is not implemented, the present 1st Kohat Tunnel is to become a bottleneck to the Indus Highway that is time wasteful and fuel costly for vehicles passing the Kohat Pass.

(2) Mitigation Measures

Proposed mitigation measures are shown in Table 13.4.3 below:

Table13.4.3 Proposed Mitigation Measures

Items		Comprehensive Rating	Proposed Mitigation Measures			
			Rating	During Construction	Rating	Post Construction
Social Environment	1. Involuntary resettlement	D	D	a) Construction of access road in the right of way b) Holding of stakeholders meeting in the Darra Adam Khel village FATA and Kohat Town c) Set up by relevant bodies of a service to handle complaints	D	Not required
	2. Local economy, employment and livelihood	E	E	Not required	D	a) Discount of toll charge for residents in the Darra village and Kohat district
	3. Land use and local resources utilization	D	C	In the case of cutting drinking water connections, the proponent should set up new wells.	D	Not required
	4. Existing social infrastructures and services	D	D	a) Construction of access road in the right of way b) Holding of stakeholders meeting in the Darra Adam Khel village FATA and Kohat Town c) Reconstruction of such social infrastructure	D	Not required
	5. Local communities	D	D	Not required	D	Not required
	6. Benefit and damage misdistribution	E	E	Proponent should hire labors from nearest village	C	Discount toll charge for residents in the project area
	7. Gender	D	D	Not required	D	Not required
	8. Children's rights	D	D	Not required	D	Not required
	9. Cultural heritage	D	D	Not required	D	Not required
	10. Local conflicts of interests	D	D	Holding of stakeholders meeting in the Darra Adam Khel village FATA and Kohat Town	D	Not required
	11. Public sanitation	E	E	Not required	E	Not required
Social Environment	12. Infectious diseases such as HIV/AIDS	B	B	Healthcare education of workers	D	Not required
	13. Water usage and rights	C	C	In the case of cutting drinking water connections, the proponent should set up new wells.	D	Underground water from tunnel should be lead to the Darra village by piping it.
	14. Traffic accidents	E	D	a) Education on traffic rules to workers b) Staffing of traffic control c) Creation of diversion ways and no use of certain existing road by inhabitants	E	Not required
Natural Environment	15. Global warming	D	D	Not required	E	Not required
	16. Biota and ecosystems	D	D	Not required	D	Not required
	17. Geographical features	D	C	Setting up of slope protection	D	Periodical monitoring and maintenance
	18. Soil erosion	C	C	Setting up of slope protection	C	Periodical monitoring and maintenance
	19. Underground water	C	C	In the case of cutting drinking water connections, the proponent should set up new wells.	D	Underground water from tunnel should be lead to the Darra village by piping it.
	20. Hydrological situation	D	D	Not required	D	Not required

	Items	Comprehensive Rating	Proposed Mitigation Measures			
			Rating	During Construction	Rating	Post Construction
	21. Coastal zone (mangroves, coral reefs, tidal flats, etc.)	D	D	Not required	D	Not required
	22. Climate	D	D	Not required	D	Not required
	23. Landscape	D	D	Not required	D	Not required
Pollution	24. Air pollution	E	B	Sprinkling water near residential area to reduce suspended particles	E	Monitoring of air quality such as CO in the tunnel
	25. Water pollution	D	D	Not required	D	Not required
	26. Soil contamination	D	D	Not required	D	Not required
	27. Waste solid	D	B	Education on waste separation and appropriate disposal	D	Setting up signboards for prohibition of littering
	28. Noise and vibration	D	D	a) Fixing of work time (limited work time in the daytime) b) Consideration of praying time	D	Not required
	29. Ground subsidence	D	D	Not required	D	Not required
	30. Offensive odors	D	D	Not required	D	Not required
	31. Bottom sediment in sea and rivers	D	D	Not required	D	Not required

13.5 Terms of References for Baseline Surveys

13.5.1 Items to be Surveyed and Monitored by Stages

As mentioned earlier, the proponent of the 2nd Kohat Tunnel and Access Road Project is required to submit an EIA to discuss on it with NWFP EPA.

The project proponent should carry out the following baseline survey in the case of full scale EIA.

The proposed baseline survey for the EIA and monitoring items are shown in the following table:

Table 13.5.1 Baseline Survey and Monitoring Items

Items		Baseline Survey	Monitoring Survey	
			During Construction	Post Construction
Social Environment	1. Involuntary resettlement	a) Counting all houses on the right of way and planned route b) Holding a stakeholders meeting in the Darra village and Kohat town	Interview of village leader	Interview of village leader
Social Environment	2. Local economy, employment and livelihood	Social survey through interviews of inhabitants	Not required	Not required
Social Environment	3. Land use and local resources utilization	Preparation of land use maps from aerial photographs	Not required	Not required
Social Environment	4. Existing social infrastructures and services	a) Counting social infrastructures such as schools, religious facilities, graveyards, water supply pipes and meeting places on the right of way and planned route b) Holding a stakeholders meeting in the Darra village and Kohat town	Not required	Not required
Social Environment	5. Local communities	Social survey through interviews of inhabitants	Not required	Interview of village leader
Social Environment	6. Benefit and damage misdistribution	Social survey through interviews of inhabitants	Not required	Interview of village leader
Social Environment	7. Gender	Not required	Not required	Not required
Social Environment	8. Children's rights	Not required	Not required	Not required
Social Environment	9. Cultural heritage	a) Social survey through interviews of inhabitants (Local cultural heritage, graveyard and sanctuary) b) Confirmation by relevant departments of NWFP	Not required	Not required
Social Environment	10. Local conflicts of interests	Social survey through interviews of inhabitants	Not required	Not required
Social Environment	11. Public sanitation	Social survey through interviews of inhabitants	Not required	Not required
Social Environment	12. Infectious diseases such as HIV/AIDS	Social survey through interviews of inhabitants and medical doctors	Social survey through interviews with inhabitants and medical doctor	Social survey through interviews with inhabitants and medical doctor
Social Environment	13.Water usage and rights	Social survey through interviews of village leader (location of well, pump displacement and water quality)	Not required	Social survey through interviews with village leader
Social Environment	14. Traffic accidents	Collection of statistical data from NHA and police department	Collection of statistical data from NHA and police department	Collection of statistical data from NHA and police department

Items		Baseline Survey	Monitoring Survey	
			During Construction	Post Construction
Natural Environment	15. Global warming	Not required	Not required	Not required
	16. Biota and ecosystems	a) Interview of Wildlife Dept. and Forest Dept. in Kohat Town b) Fauna and flora survey by specialists on the right of way and planned route	Interview with Wildlife Dept. and Forest Dept. in Kohat Town	Interview with Wildlife Dept. and Forest Dept. in Kohat Town
	17. Geographical features	Geological survey by drilling	Not required	Not required
	18. Soil erosion	Natural environment survey through interview of village leader	Not required	Not required
	19.Underground water	a) Natural environment survey through interview of village leader b) Measurement of underground water in well in the Darra Village	Measurement of underground water quality (every month / pH, COD, F)	Measurement of underground water quality (every month / pH, COD, F)
	20. Hydrological situation	a) Natural environment survey through interview of village leader b) Check of river condition in rains	Not required	Not required
	21. Coastal zone (mangroves, coral reefs, tidal flats, etc.)	Not required	Not required	Not required
	22. Climate	Collection of statistical data from Kohat Town and NHA Kohat operation center	Not required	Not required
	23. Landscape	Taking pictures on present condition from major residential area	Not required	Not required
Pollution	24. Air pollution	a) Measurement of ambient air quality in the Darra and Kohat Town (NO+NO2, SO2, CO and TPM) b) Collection of data on air quality inside tunnel from NHA Kohat operation room	Measurement of TPM (Total Particulate Material) in the Darra and Kohat town	a) Measurement of ambient air quality in the Darra and Kohat Town (NO+NO2, SO2, CO and TPM) b) Collection of data on air quality inside two tunnels from NHA Kohat operation room
	25. Water pollution	Not required	Not required	Not required
	26. Soil contamination	Pollution survey through interview of village leader (history of land use and factory)	Not required	Not required
	27. Waste Solid	Pollution survey through interview of village leader	a) Confirmation of disposal system through constructor b) Site inspection	Not required
	28. Noise and vibration	Measurement of ambient noise and traffic noise in the Darra and Kohat Town (Equivalent noise for 12 hours)	Measurement of construction noise on the boundary	Measurement of traffic noise
	29. Ground subsidence	Confirmation of consolidation settlement from road planner	Not required	Measurement of consolidation settlement once a year
	30. Offensive odors	Not required	Not required	Not required
	31. Bottom sediment in sea and rivers	Not required	Not required	Not required

13.5.2 Proposed Methodologies for Project Evaluation in the Future

(1) Objectives

It is anticipated that the 2nd Kohat Tunnel and Access Roads Project will bring significant benefits in many diverse areas, such as boosting the economy, improving social environment and so on.

It is important to carry out an impact assessment of this Project from the view of project evaluation. Hence the project proponent should conduct a survey for project evaluation before implementation of the Project and post project completion. This survey must collect quantitative data, and these data will be used as an indicator for evaluation of the Project.

(2) Approach & Methodology

a) Approach

It is important to know how road users feel about the change in road situation and what extra benefits will occur before and after construction of the 2nd Kohat Tunnel. The following indicators should show the differences, especially saving time and fuel consumption as these indicators are directly convertible from quantitative data.

Questions on the following key subjects should be included in the survey:

- Problems faced before the tunnel
- Any problems faced now
- Benefits of tunnel (see note: Travel Cost Method)
  Time saving:
    - i) Normal journey time
    - ii) Time saving as a result of fewer breakdowns (involving oneself)
    - iii) Time saving as a result of less traffic jams (accident provoked by others)

  Economic savings:
    - i) Increase in number of trips
    - ii) More load carried
    - iii) Fuel saving
- Safety element as perceived by users
- Environmental issues (smoke, etc.) as perceived by users

b) Methodology

A survey will be conducted on travelers picked at random from the following three key categories of traffic in the tunnel: goods carrying vehicles, public transportation vehicles, and private vehicles.

Table 13.5.2 Numbers of Interviewees by Vehicle Type

Categories	Type of Vehicle	Number of Persons to be Interviewed			Total
		Drivers	Passengers	Owners	
Goods Carrying Vehicle	Heavy Truck	10	--	5	15
	Light Truck	10	--	5	15
	Very Light Vehicle	10	--	5	15
Public Passenger Transport Vehicle	Bus	10	10	5	25
	Van	10	10	5	25
	Taxi	10	10	5	25
Private Vehicles	Car	--	--	15	15
	Motorcycle	--	--	15	15
Total		60	30	60	150

These target groups cover most of the tunnel users. Regular, long-time users of both the Kohat Pass and Tunnel, will be targeted for the survey. This is because they would be able to provide a comparative analysis of certain issues pertaining to the tunnel before and after implementation of the Project.

Note: Travel Cost Method (TCM)

TCM is a means of determining the values of the things which are generally not bought or sold, and therefore fall outside the market's pricing system. These are non-market assets that most often apply to "recreational resources which necessitate significant expenditure for their enjoyment." For this reason, TCM is often used to assess the value of parks, lakes, and other similar public areas hosting recreational activities which are far enough that access thereto should be by car or airplane.

The basic premise of TCM is that, although the actual value of the recreational experience does not have a price tag, the costs incurred by individuals in travelling to the site can be used as surrogate prices. The weak level of compensation for the goods required for travel to the site makes it possible to estimate a demand curve for the site, and from it, a measure of the site's consumer surplus can be found. It is important to note that the consumer surplus figure is a measure of the user value of the site only, and does not necessarily represent the site's environmental or intrinsic value.

13.6 Action Plans and Schedule

EIA is required as the project is a national highway and its value is more than 5 crore rupees (Rs. 50,000,000) though no resettlement is required and only minor impacts are expected.

Regards to EIA activities, NHA should contact with NWFP EPA and submit the project outline and screening sheet for starting EIA procedures. The recommended survey items and methodology are indicated in Table 13.5.1-Base Line Survey and Monitoring Items. It is predicted that EIA procedures take approximately one year. NHA is also required to discuss with Darra FATA (tribal area) for land use and it will also take approximately one year. Figure 13.6.1 shows an EIA action plan and schedule required for the project implementation.

In addition to the above, it is recommended that NHA should hold stakeholder meetings on transparency and accountability aspects. NHA should prepare the project outline and explain it to stakeholders (residents and local communities) including expected negative impacts and planned mitigation measures prior to the project implementation. Proposals or requests raised in stakeholders meetings should be reflected to the project design or construction in appropriate ways. There are 3-4 communities between the project start point (Kohat Toi) and the Main Toll Plaza (10 km). No residential houses and communities exist between the Main Toll Plaza (10 km) and the tunnel south portal. As the Project road passes through near Darra Adam Khel and Darra FATA (tribal area) after the tunnel north portal, explanation to the residents and communities should also be made through the concerned tribal chiefs.

Activity	Period (month)	2006	2007	2008	2009	2010	2011	2012	2013
Feasibility Study	-								
Screening among the Pakistan Government	2								
Application for Foreign Financial Assistance	-								
EIA Procedures									
- EIA procedures (with NWFP	12								
- Discussion with FATA for land	12								
- Explanation to Stakeholders									
Conclusion for Foreign Financial Assistance	12								
Procurement of the Consultant	6								
Detailed Design and Tender Documents	9								
Procurement of the Contractor	10								
- Pre-qualification	3								
- Tender	7								
Construction	36								
Opening to the Public	-								

Figure 13.6.1 EIA Action Plans and Schedule