Chapter 14. CONSTRUCTION PLAN

14.1 General

The objectives of construction planning are:

- Establishing the most appropriate construction plan and construction period for implementation of the Project on economical and technical aspects.
- Providing a basis for cost estimate and construction schedule establishment.
- Addressing specific issues including construction methods to minimize disturbance to the public traffic on the project road during construction, and environmental considerations.
- Addressing ROW problems, especially for the north section where the project road passes through a tribal area.

The major elements to be considered for construction planning are:

- Site conditions (access roads, geology, climate, traffic, workable days, law and regulations, ROW, etc.).
- Work experience of the 1st Kohat Tunnel and Access Road Project.
- Major work quantities.
- Contract conditions and construction specifications.
- Availability of contractors, equipment and skilled workers.
- Materials sources.

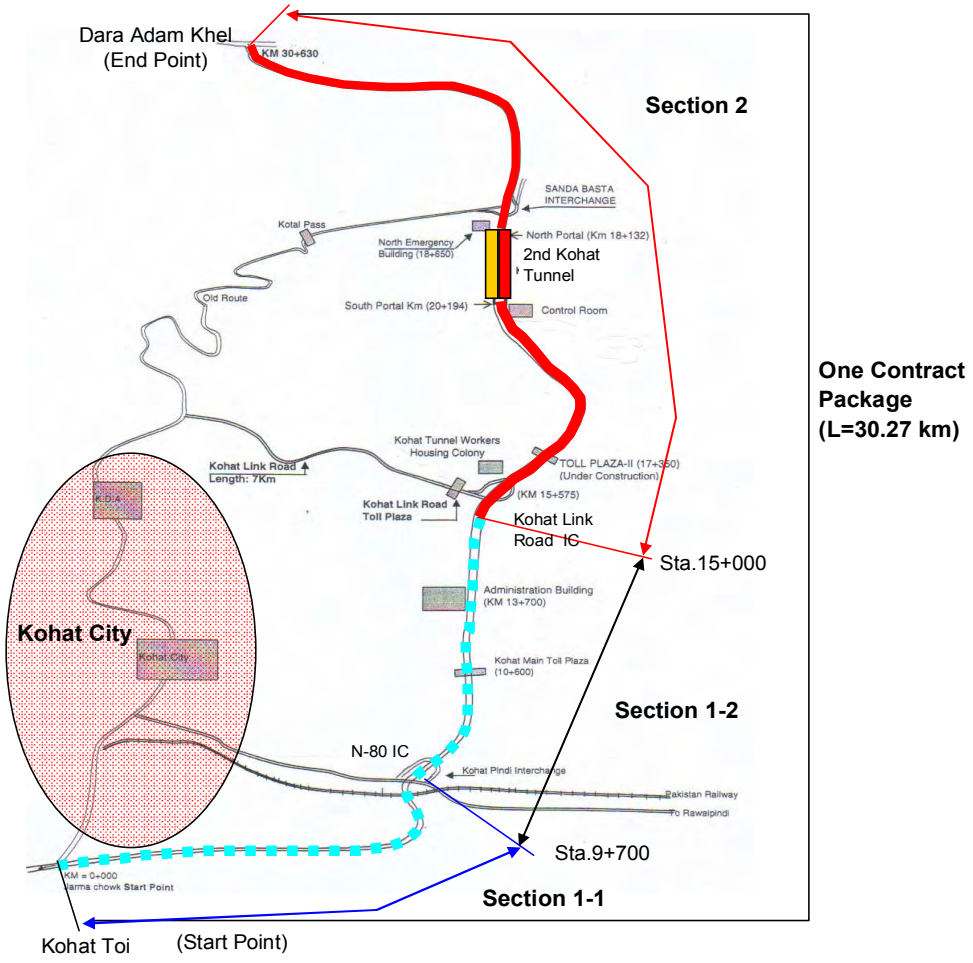


Figure 14.1.1 Contract Packaging for Project Implementation

The project road is divided into two sections (see Figure 14.1.1) according to the traffic capacity analysis in Chapter 7 and the economic evaluation in Chapter 17. Section 1 is from Kohat Toi (Sta.0+000) to the Kohat Link Road (Sta.15+000) and Section 2 from the Kohat Link Road (Sta.15+000) to Dara Adam Khel (the end of project road). However, since simultaneous implementation is recommended for both sections in Chapter 17, construction planning was made for one contract package.

Construction works are assumed to be conducted by qualified international contractors who have sufficient capability to perform the work as no well-qualified local contractors are available for tunnel construction. Besides, locally available construction methods and materials should be used as much as possible to save the construction cost and to create job opportunity in and around the Project area.

14.2 Specific Issues to be addressed

14.2.1 Hard Rock Excavation along the Existing Road

Several high cut sections (4 locations in the tunnel south section and 5 locations in the tunnel north section) are required for the construction of the 2nd Kohat Tunnel and Access Roads (see Table 14.2.1). About 66% of the materials are hard rock and 34% are soil and semi-rock (soft rock). The cut slopes are 1 (V): 0.5 (H) for rock, 1 : 0.8 for semi-rock and 1 : 1.2 for soil. Hard rock excavation is also required for the north and south portals construction.

Table 14.2.1 List of High-cuts for Sections 1 and 2

No.	Station		Estimated Quantity (m^3)	Classification of Materials				Max. Cut Height
				Common		Rock		
	From	To		%	(m^3)	%	(m^3)	(m)
South: KohatLink Road - Kohat Tunnel (South Portal)								
S-1	7+325.000	7+475.000	23,800	5	1,190	95	22,610	28
S-2	14+425.000	14+625.000	4,200	60	2,520	40	1,680	10
S-3	15+250.000	15+425.000	32,100	5	1,610	95	30,490	32
S-4	18+000.000	18+700.000	165,600	60	99,360	40	66,240	30
Sub-Total:			225,700	46	104,680	54	121,020	
North: Kohat Tunnel (North Portal) - Dara Adam Khel (End Point)								
N-1	18+132.000	18+825.000	33,000	5	1,650	95	31,350	15
N-2	21+575.000	21+725.000	26,600	0	0	100	26,600	32
N-3	22+300.000	22+400.000	2,000	0	0	100	2,000	6
N-4	23+850.000	23+975.000	15,500	0	0	100	15,500	24
N-5	24+300.000	24+400.000	7,200	0	0	100	7,200	14
Sub-Total:			84,300	2	1,650	98	82,650	
Total:			310,000	34	106,330	66	203,670	

Source: JICA Study Team

As the current ADT is approximately 7,500 vehicles, it is difficult to apply normal blasting operation. Construction methods that do not disturb or endanger the traffic should be used. The rock excavation for N-3, N-4 and N-5 in the north section is near houses/ buildings, therefore blasting operation should also be limited.

Following alternative excavation methods have been planned and compared.

- Soil and semi-rock: Excavation of soil by hydraulic excavator and semi-rock by 45-ton class bulldozer with ripper.
- Rock (refer to Figure 14.2.1):

- Common blasting. This is a conventional method for rock blasting. ANFO (explosive) is filled in drilled holes and ignited by a high explosive agent like dynamite. Blasted rock will fly over approximately 100-200 m away.
- Excavation in association with controlled blasting (pre-blasting) and by hydraulic breaker. This is a method using 1/3 to 1/4 amount of explosive in drilled holes to induce cracks in rock. Then, hydraulic breaker crushes rock into appropriate piece for removal. By controlling amount of explosive and appropriate cover, flying distance of rock can be reduced to 0-20 m.
- Excavation in association with non-explosive demolition agent and a hydraulic breaker. This is a new method filling non-explosive agent in drilled holes. The agent expands and induces cracks in rock. Then, hydraulic breaker crushes rock into appropriate piece for removal. Flying distance of rock can be none (zero).
- Excavation with special rock breaking equipment. Some equipment can cut or crush hard rock by drill bits or hydraulic breakers without explosive.

A comparison of rock excavation methods is summarized in Table 14.2.2.

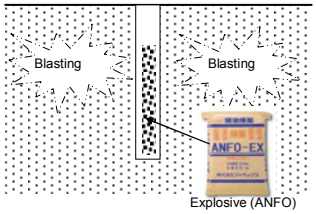
Table 14.2.2 Comparison of Rock Excavation Methods

Excavation Method		Influence to Public Traffic	Productivity (cu.m./hour)	Cost	Requirement of Special Equipment	Evaluation
A	Common blasting	Large	Good	Low	No	× Not recommended as its influence to public traffic is high
B	Excavation in association with controlled blasting (pre-blasting using 1/3 to 1/4 of explosive) and a hydraulic breaker	Medium	Fair	Fair	No	○ Recommended
C	Excavation in association with non-explosive demolition agent and a hydraulic breaker.	Small	Fair	High	No	△ Recommended for tunnel portals and upper part of hill
D	Excavation with special rock breaking equipment	Small	Good	High *	Yes	× Not enough quantity for economical excavation

Note: * If quantity increases, the unit cost per cu.m. will be reduced.

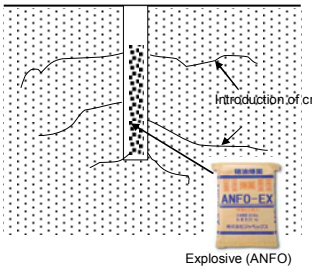
- **A. Common Blasting by Explosive (ANFO)**

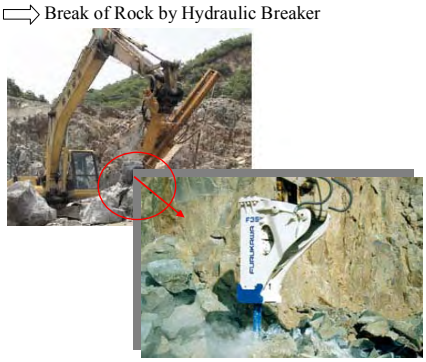
Drilling holes for filling explosives ⇨ Fill explosive (ANFO) ⇨ Blasting



- **B. Excavation in association with controlled blasting (pre-blasting) and hydraulic breaker**

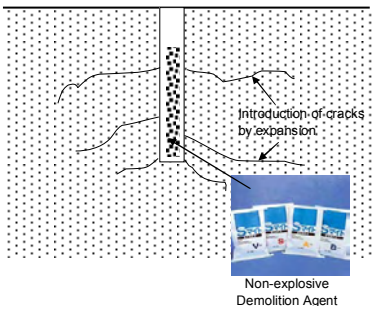
Drilling holes for filling explosives ⇨ Fill 1/3 - 1/4 of explosive for controlled blasting ⇨ Break of Rock by Hydraulic Breaker





- **C. Excavation in association with non-explosive demolition agent and hydraulic excavator**

Drilling holes for filling non-explosive agent ⇨ **Fill non-explosive demolition agent** ⇨ **Break of Rock by Hydraulic Breaker**



- **D. Excavation with special rock breaking equipment**

D.1 Suffice Minor

(Excavation of rock with cutting bits attached to special equipment)

D.2 Impact Breaker

(Combination of ripping and hydraulic breaker)

Figure 14.2.1 Representative Rock Excavation Method

Method A requires shut-down of traffic during blasting and clearing, therefore it is not recommended due to its substantial disturbance to the public traffic. Method D is not cost-advantageous as the volume of rock excavation is approximately 200,000 m^3 for the Project and it is less than the economical volume necessary to introduce special equipment. The recommended method is a combination of Methods B and C. The cost of non-explosive demolition agent is very expensive compared with common explosives (ANFO), therefore, it should be used only for some selected sections and parts, like tunnel portals, upper part of the hill and near houses/buildings. Pre-split blasting method is also used together with the above rock excavation methods.

Excavation will be executed to minimize materials falling down to the existing roadway. Installation of temporary concrete barriers will be required along the roadway to prevent falling rocks from hitting the traffic (Figure 14.2.2). The 3m-wide left shoulder will be strengthened to divert the traffic on that during rock excavation and provide space for temporary barriers.

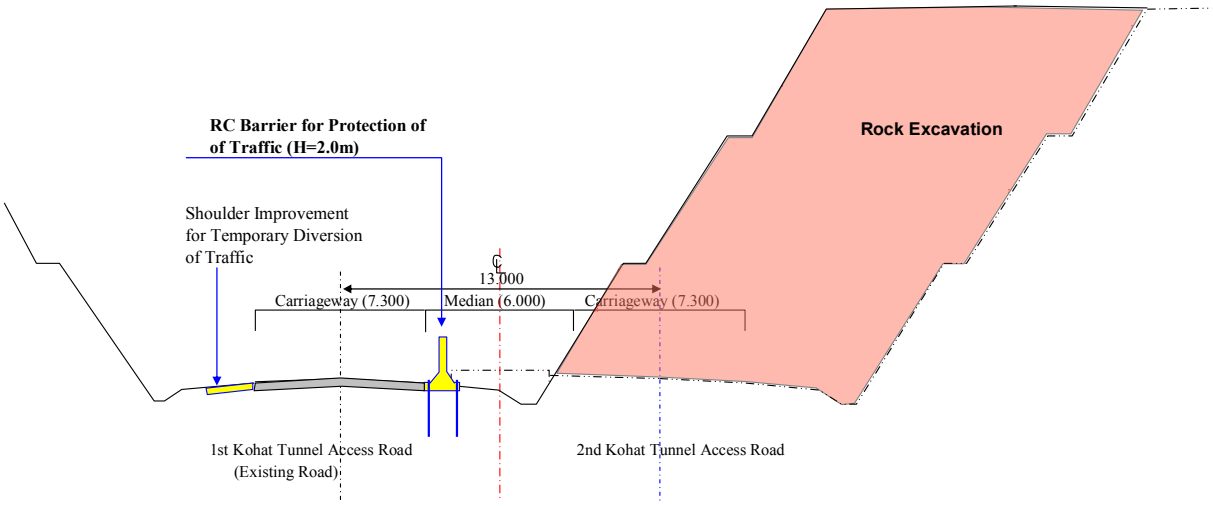


Figure 14.2.2 Temporary RC Barrier for Protection of Public Traffic

14.2.2 Distribution Plan for Cut and Fill Volumes

(1) Excavation

The estimated total quantity of roadway excavation in common materials is 310,000 m^3. It is assumed that 5% of these materials (5,000 m^3) are not appropriate for embankment and to be wasted. The remaining quantities (101,000 m^3 of soil and 205,000 m^3 of rock) are to be used for the roadway embankment formation as broken down in Table 14.2.3.

Table 14.2.3 Quantities of Roadway Excavation

Unit: m^3

Location		Excavation Quantity	Classification					
From Sta	To Sta	m^3	Soil				Rock	
			Total		Disposal	For Fill	For Fill	
South Section 1: Start Point (Sta.0+000) - Sta.15+000								
7+000	8+000	23,794	5%	1,190	59	1,130	95%	22,604
14+000	15+000	4,227	60%	2,536	127	2,409	40%	1,691
Sub-Total		28,021		3,726	186	3,540		24,295
South Section 2: Sta.15+000 - Sta.20+186.738 (South Portal)								
15+000	16+000	32,110	5%	1,606	80	1,525	95%	30,505
18+000	19+000	165,639	60%	99,383	4,969	94,414	40%	66,255
19+000	20+000	1,000	5%	50	3	48	95%	950
Sub-Total		198,749		101,039	5,052	95,987		97,710
North Section : Sta.18+132 (N.Portal) - End Point (Sta.25+906.255)								
18 +150	19+000	33,050	5%	1,652	83	1,570	95%	31,397
19+000	20+000	85	0%	-			100%	85
21+000	22+000	26,583	0%	-			100%	26,583
22+000	23+000	2,080	0%	-			100%	2,080
23+000	24+000	15,510	0%	-			100%	15,510
24+000	25+000	7,196	0%	-			100%	7,196
Sub-Total		84,503		1,652	83	1,570		82,850
Total		311,272		106,417	5,321	101,096		204,855

The estimated total quantity of tunnel excavation is 152,000 m^3 including the tunnel portals. It is assumed that 40% (61,000 m^3) are excavated from the south portal and 60% (91,000 m^3) from the north portal in accordance with the tunnel construction planning. Those materials will be used for the roadway embankment.

(2) Embankment

The total embankment quantity for roadway formation is estimated at 1,106,000 m^3. The materials are from the roadway excavation, tunnel excavation and borrow along the roadway as detailed in Table 14.2.4. The wasted rock materials (58,800 m^3) during the 1st Kohat Tunnel and Access Roads construction within the ROW in the north section were deducted from the embankment quantity.

Table 14.2.4 Quantities of Roadway Embankment

Section	Location		Quantity m^3
	From Sta.	To Sta.	
South Section 1	0+000	15+000	425,007
South Section 2	15+000	20+187 (South Portal)	421,174
North Section	18+132 (North Portal)	25+906	260,168
Total			1,106,349

(3) Earthworks Distribution Plan

The earthworks distribution plan was made based on the above estimated excavation, waste and embankment quantities and earthworks cut/fill volume conversion factors (see Table 14.2.5).

Table 14.2.5 Earthworks Cut/Fill Volume Conversion Factors

Type of Material	Compression Factor	Standard Factor *	2nd Kohat Tunnel & Access Road	
			Roadway	Tunnel
Soil				
Sand / Gravel	0.85 - 0.95	0.90		
Silt / Clay	0.85 - 0.95	0.90	0.90	
Silt / Clay with Gravel	0.90 - 1.00	0.90		
Silt / Clay with Rock	0.90 - 0.95	0.90		
Soft Rock				
Semi-rock	1.00 - 1.30	1.05		
Weathered Rock	0.95 - 1.05	1.00	1.00	1.00
Rock				
Hard	1.05 - 1.35	1.15	1.15	1.20
Very Hard	1.15 - 1.40	1.20		

Note: Based on Japanese Standards

Table 14.2.6 shows the earthworks distribution plan and Figure 14.2.3 indicates the balance of excavation and embankment by section.

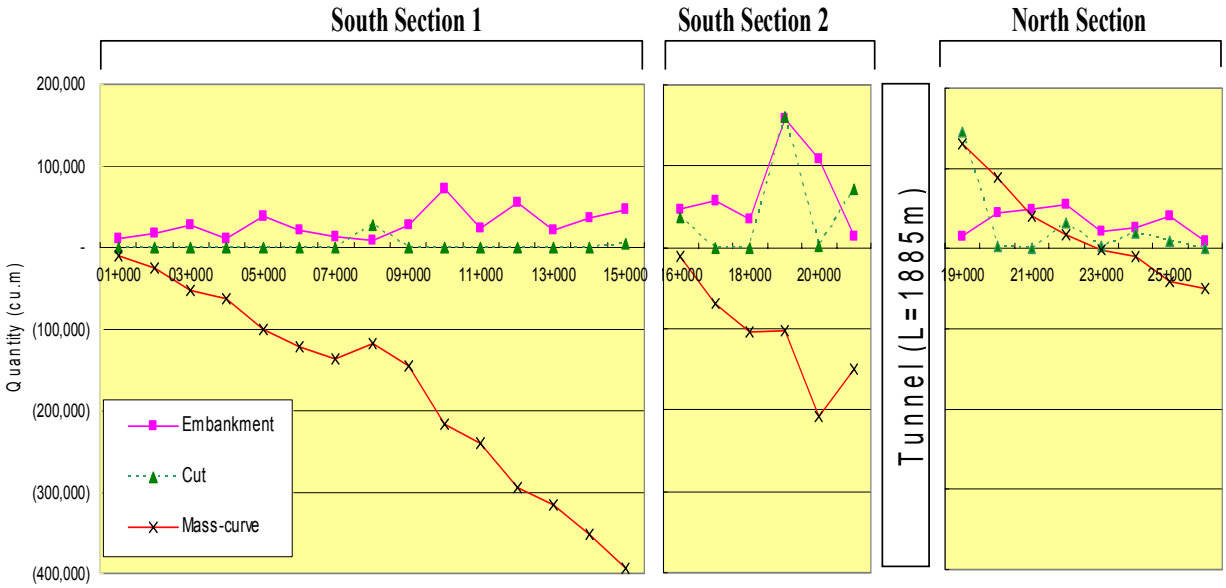
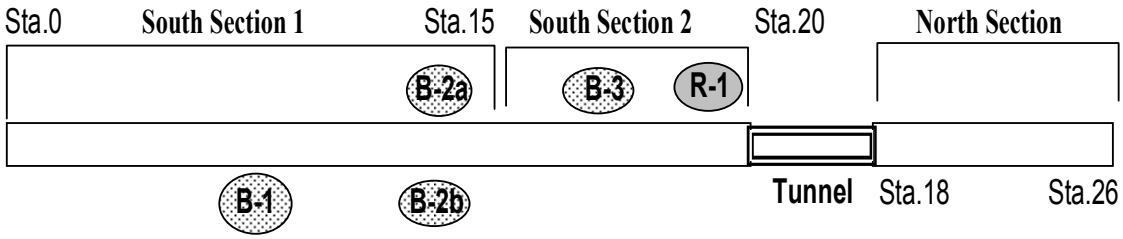


Figure14.2.3 Balance of Excavation and Embankment

Approximately 54% of the embankment materials are from borrow areas and the remainder are from the roadway and tunnel excavation. The borrow materials are available from the borrow areas developed under the 1st Kohat Tunnel and Access Roads Project along the project road in the case of the tunnel south section (see Figure 14.2.4).



Note: Refer to Subsection 6.5 in Chapter 6 as to Borrow Areas)

Figure 14.2.4 Location of Borrow Areas

The excavation quantity for the tunnel is estimated at 152,000 m^3 including tunnel portals. It is planed that approximately 40% of the tunnel length is excavated from the south portal and 60% from the north portal and the excavated materials are used for the embankments, especially at the lower part of embankment on riverbed. However, there is still a shortage of 50,000 m^3 of materials for the north section. As there are no appropriate borrow areas in the north section, embankment materials should be hauled from the tunnel south section. The overburden soil for the planned rock quarry at Sta.19+500 (L) could be used as borrow material for the north section.

As the design CBR of subgrade (1.0 m depth from the subgrade formation level) is 15%, theses materials are obtained from the designated borrow areas in principle.

Table 14.2.6 Summary of Earthworks Volume Distribution Plan

(Formation of Embankment from Roadway Excavation, Tunnel Excavation and Borrow)

South Section 1: Start Point (Sta.0+000) - Sta.15+000

Location		Embankment	Item 108a: In Common Material from Roadway Excavation			Item 108b: in Rock Material from Roadway Excavation			Item PS-14: Embankment from Tunnel Excavation			Item 108c: From borrow
From	To	Quantity	Q'ty in Orig.Ground	C.Factor	Q'ty after Compaction	Q'ty in Orig.Ground	C.Factor	Q'ty after Compaction	Q'ty in Orig.Ground	C.Factor	Q'ty after Compaction	at Sta.7+200 (R) / 14+300 (R/L)
Sta	Sta	m^3	m^3		m^3	m^3		m^3	m^3		m^3	m^3
0 + 000	1 + 000	10,128										
1 + 000	2 + 000	15,953										
2 + 000	3 + 000	26,539										
3 + 000	4 + 000	11,442										
4 + 000	5 + 000	36,925										
5 + 000	6 + 000	21,279										
6 + 000	7 + 000	13,548										
7 + 000	8 + 000	8,912	1,130	0.90	1,017	22,604	1.15	25,995				
8 + 000	9 + 000	26,788										
9 + 000	9 + 700	72,254										
10 + 700	11 + 000	23,638										
11 + 000	12 + 000	54,009										
12 + 000	13 + 000	20,892										
13 + 000	14 + 000	35,543										
14 + 000	15 + 000	47,159	2,409	0.90	2,169	1,691	1.15	1,945				
Total		425,007	3,540		3,186	24,295		27,939	-	1.15	-	393,882
Remarks: % to the total embankment quantity					0.7%			6.6%			0.0%	92.7%

South Section 2: Sta.15+000 - Sta.20+186.738 (South Portal)

Location		Embankment	Item 108a: In Common Material from Roadway Excavation			Item 108b: in Rock Material from Roadway Excavation			Item PS-14: Embankment from Tunnel Excavation*			Item 108c: From borrow
From	To	Quantity **	Q'ty in Orig.Ground	C.Factor	Q'ty after Compaction	Q'ty in Orig.Ground	C.Factor	Q'ty after Compaction	Q'ty in Orig.Ground	C.Factor	Q'ty after Compaction	at Sta.14+300 (R/L) / Sta.17+300 (L)
Sta	Sta	m^3	m^3		m^3	m^3		m^3	m^3		m^3	m^3
15 + 000	16 + 000	47,417	1,525	0.90	1,373	30,505	1.15	35,080				
16 + 000	17 + 000	57,700										
17 + 000	18 + 000	35,390										
1 8+ 000	19 + 000	158,456	94,414	0.90	84,973	66,255	1.15	76,194				
19 + 000	20 + 000	108,259							1,860	1.00	1,860	
20 + 000	20 + 100	13,953	48	0.90	43	950	1.15	1,093	58,943	1.20	70,731	
Total		421,174	95,987		86,388	97,710		112,367	60,802		72,591	149,829
Remarks: % to the total embankment quantity					20.5%			26.7%			0.0%	35.6%

Note: * 40% of the tunnel excavation from the south portal. 35.6%

North Section : Sta.18+132 (N.Portal) - End Point (Sta.25+906.255)

Location		Embankment	Item 108a: In Common Material from Roadway Excavation			Item 108b: in Rock Material from Roadway Excavation			Item PS-14: Embankment from Tunnel Excavation *			Item 108c: From borrow
From	To	Quantity	Q'ty in Orig.Ground	C.Factor	Q'ty after Compaction	Q'ty in Orig.Ground	C.Factor	Q'ty after Compaction	Q'ty in Orig.Ground	C.Factor	Q'ty after Compaction	at the tunnel south Sta.19+500 (L)
Sta	Sta	m^3	m^3		m^3	m^3		m^3	m^3		m^3	m^3
18+350	19+000	15,202	1,570	0.90	1,413	31,397	1.20	37,677	88,414	1.20	106,097	
19+000	20+000	44,328				85	1.20	101	2,789	1.00	2,789	
20+000	21+000	47,952										
21+000	22+000	55,217				26,583	1.20	31,899				
22+000	23+000	21,377				2,080	1.20	2,495				
23+000	24+000	26,057				15,510	1.20	18,612				
24+000	25+000	41,235				7,196	1.20	8,635				
25+000	25+350	8,800										
Total		260,168	1,570		1,413	82,850		99,420	91,203		108,886	50,448
Remarks: % to the total embankment quantity					0.5%			38.2%			0.0%	19.4%

Notes: 1. * 60% of the tunnel excavation form the north portal and 40% from the south portal.

2.**Deducted the quantity of 58,800 m3 for the waste of rock materials from Sta.22+000 to Sta.25+000 during the 1st Kohat Tunnel Access Road Construction

Source: JICA Study Team

14.2.3 Tunnel Construction

(1) Construction Methods

New Austrian Tunnelling Method (NATM) is one of the popular construction methods for mountainous tunnel constructions. The 1st Kohat Tunnel used NATM. It is planned that the same method will be applied also for the 2nd Tunnel. The standard work flow of tunnel construction by NATM is shown in Figures 14.2.5 and 14.2.6.

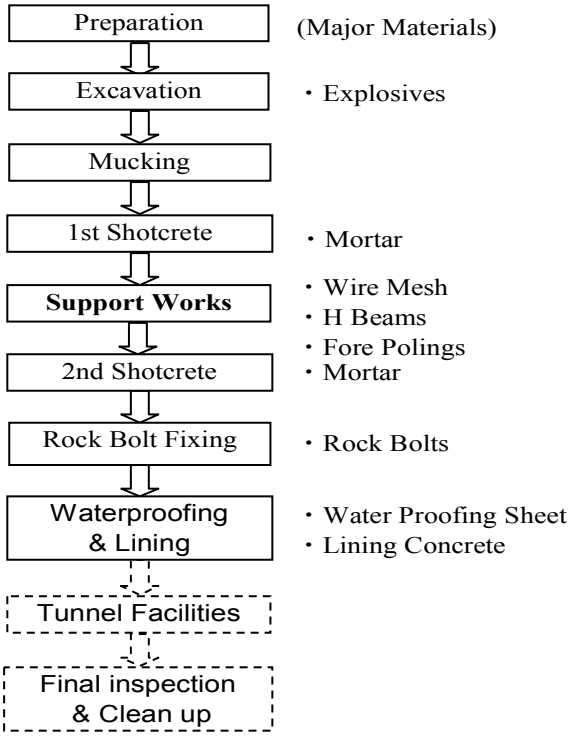


Figure 14.2.5 Standard Work Flow of NATM

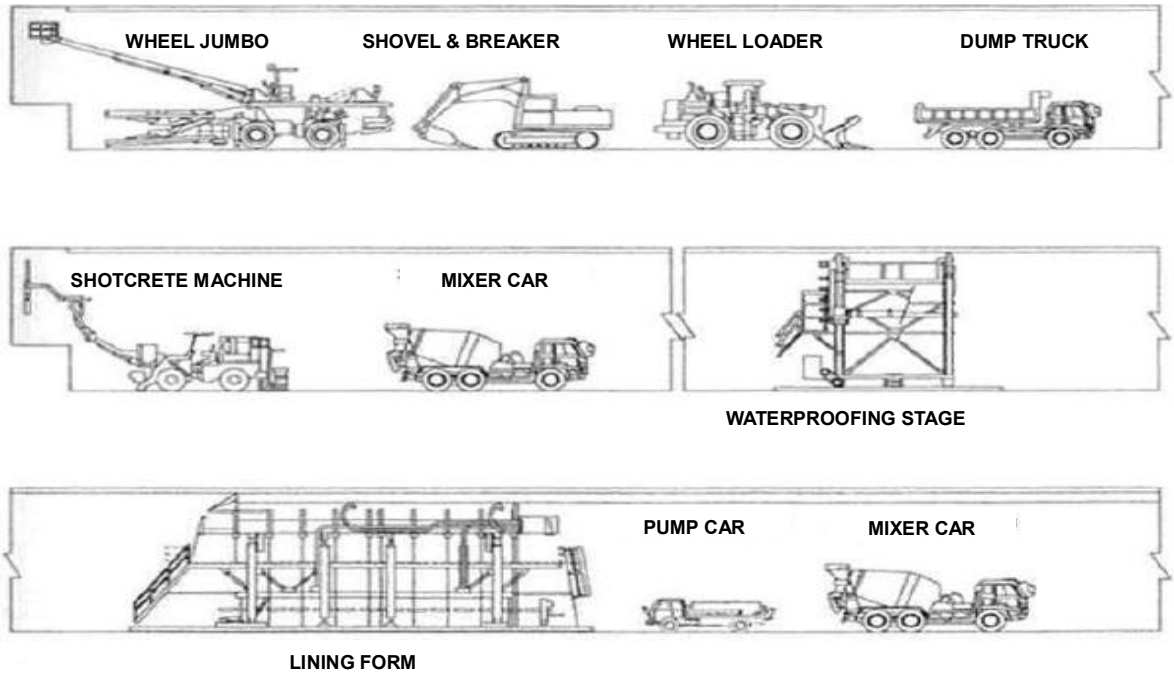


Figure 14.2.6 Construction Procedures

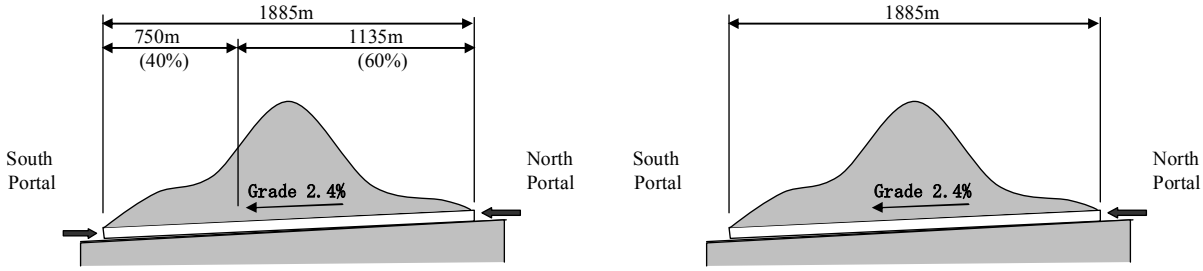
Note: Excavation using Tunnel Boring Machine (TBM) has a wide range of application from rock mass to soft ground. However, it still has various technical problems including workability in fractured zones and poor ground, and high machine costs. Therefore, the Study Team does not recommend using this method for the 2nd Kohat Tunnel construction.

(2) Tunnel Construction Plans

Two alternative construction plans were studied: Alternative-A envisages tunnel excavation from both portals and Alternative-B envisages one side excavation from the north portal (see Figure 14.2.7), as described below:

- Alternative-A: 1,135m (60%) from the north portal and 750 m (40%) from the south portal
- Alternative-B: 1,885m (100%) from the north portal

Note: As it takes about 9-10 months for movement of the tunnel control room and associated facilities, it is necessary to start the excavation from the north portal.



Alternative-A Excavation from Both Portals **Alternative-B Excavation from One-side**

Figure 14.2.7 Alternative Tunnel Excavation Plans

(3) Major Equipment an Machines

The major equipment and machines to be used for the tunnel construction by work category are as listed up in Table 14.2.7

Table 14.2.7 Major Equipment and Machines for Tunnel Works

No	Works	Name of Machine	Type	Number of Equipment*	
				South Portal	North Portal
1	Excavation & Blasting	Drilling Machine Drain Pump	2 booms	2 -	2 2
2	Mucking	Wheel Loader Excavator Hydraulic Breaker Dump Tracks	2.3 m^3 0.7 m^3 20 t	1 1 1 3	1 1 1 3
3	First Shotcrete	Shotcrete Machine Tractor Head Track Mixer	6 m^3 30 t 6 m^3	2 1 Same Track Mixer with Item 7	2 1
4	Support	Drilling Machine	2 booms	2	2
5	Second Shotcrete	Shotcrete Machine Tractor Head Track Mixer	6 m^3 30 t 6 m^3	Same machines with 1st Shotcrete	
6	Rock Bolt Installation	Drilling Machine Grout Pump	2 booms	1 1	1 1
7	Waterproof Sheet & Concrete Lining	Steel centre Concrete Pump Track Mixer	 30m^3/hr 6 m^3	1 1 3	1 1 3

Note: * One set of equipment for one-side excavation (Alternative-B)

Two sets of equipment are required for the construction plan Alternative A, excavation from both portals, and one set of equipment for Alternative B, excavation from one side.

A concrete spread machine and a finisher are required for concrete pavement. Equipment required for preparation works including cranes and cargo trucks are common items for the roadway works.

(4) Ventilation during Construction

Either exhaust air duct or fresh air duct method (see Figure 14.2.8) can be used for ventilation during construction. Although the exhaust air duct method is better in view of the environment inside the tunnel, the fresh air duct method is commonly applied because the former method produces big noise, and it is not easy to install most of ventilators inside the tunnel.

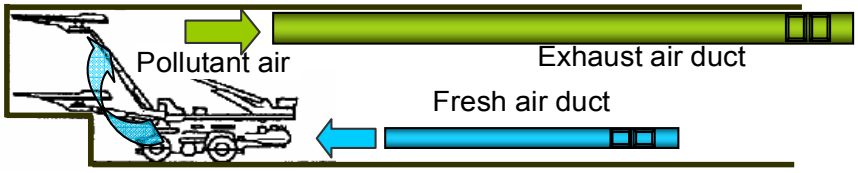


Figure 14.2.8 Ventilation Systems during Construction

The temperature at the project site rises to 40 degrees Celsius in summer. When the fresh air duct installed outside the tunnel is heated, the air from outside could reach over 50 degrees Celsius in the tunnel. For that reason, the exhaust air duct method is planned for the 2nd Kohat Tunnel, which is the same method used for the 1st Kohat Tunnel. Local ventilators are installed on the back of face in order to supply fresh air and prevent polluted air from diffusing to the face.

(5) Temporary Facilities

The following temporary facilities will be required for supporting the tunnel works.

- Electric facility
- Ventilation facility
- Air supplier
- Water supply
- Drain work
- Mud-water treatment
- Concrete plant
- Parking yard for machines and stock yard for materials
- Refuelling facility
- Lighting and communication facilities, etc.

As water necessary for construction is available from the spring water (estimated to be 100 lit. to 200 lit./min) at the tunnel south portal, no special facility is required except a storage tank.

(6) Construction Schedule

Table 14.2.8 shows the monthly construction speeds for the 2nd Kohat Tunnel, estimated based on the experience in the 1st Kohat Tunnel construction. Two-shift work is applied for the tunnel construction.

Table 14.2.8 Construction Speeds of Tunnel Works

Section	Upper Half	Lower Half	Average
Portal	23 m	25 m	24 m
CI	79 m	111 m	95 m
CII	95 m	133 m	114 m
DI	42 m	45 m	44 m
Emergency Parking Area	60 m	95 m	78 m
Lining	87 m		
Drainage	400 m		
Pavement	600 m		

Note: Average construction speed per month

Figure 14.2.9 shows the construction schedule of tunnel civil works for Alternative-A by work category, estimated based on the construction speeds shown in Table 14.3.2. Preparation and cleaning up require about one month each at the start and end of the construction. The tunnel excavation starts from the north portal. The construction from the south portal can start after 9-12 months as the movement of tunnel control room is needed prior to the start of the tunnel excavation. It needs 24.5 months for completion of the civil works. Tunnel facilities installation will require 9-12 months after the completion of tunnel civil works.

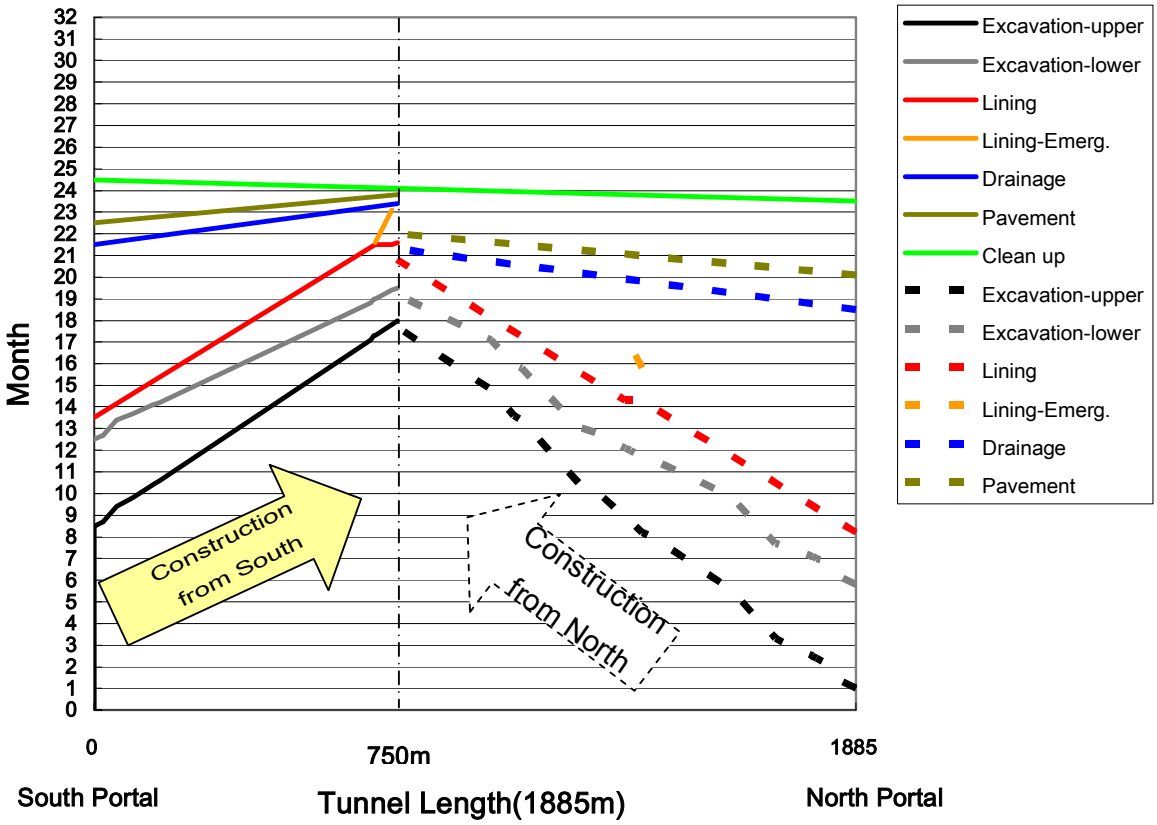


Figure 14.2.9 Construction Schedule for Alternative-A (Both Sides Excavation)

Figure 14.2.10 shows a construction schedule of the tunnel civil works for Alternative-B by work category, estimated based on the construction speeds shown in Table 14.3.2. Preparation and cleaning up require about one month each at the start and end of the construction. The tunnel excavation starts from the north portal and proceeds to the south in one way. It needs 32 months, 7 months more than Alternative-A, for completion of the civil works. Tunnel facilities installation will require 9-12 months after the completion of tunnel civil works.

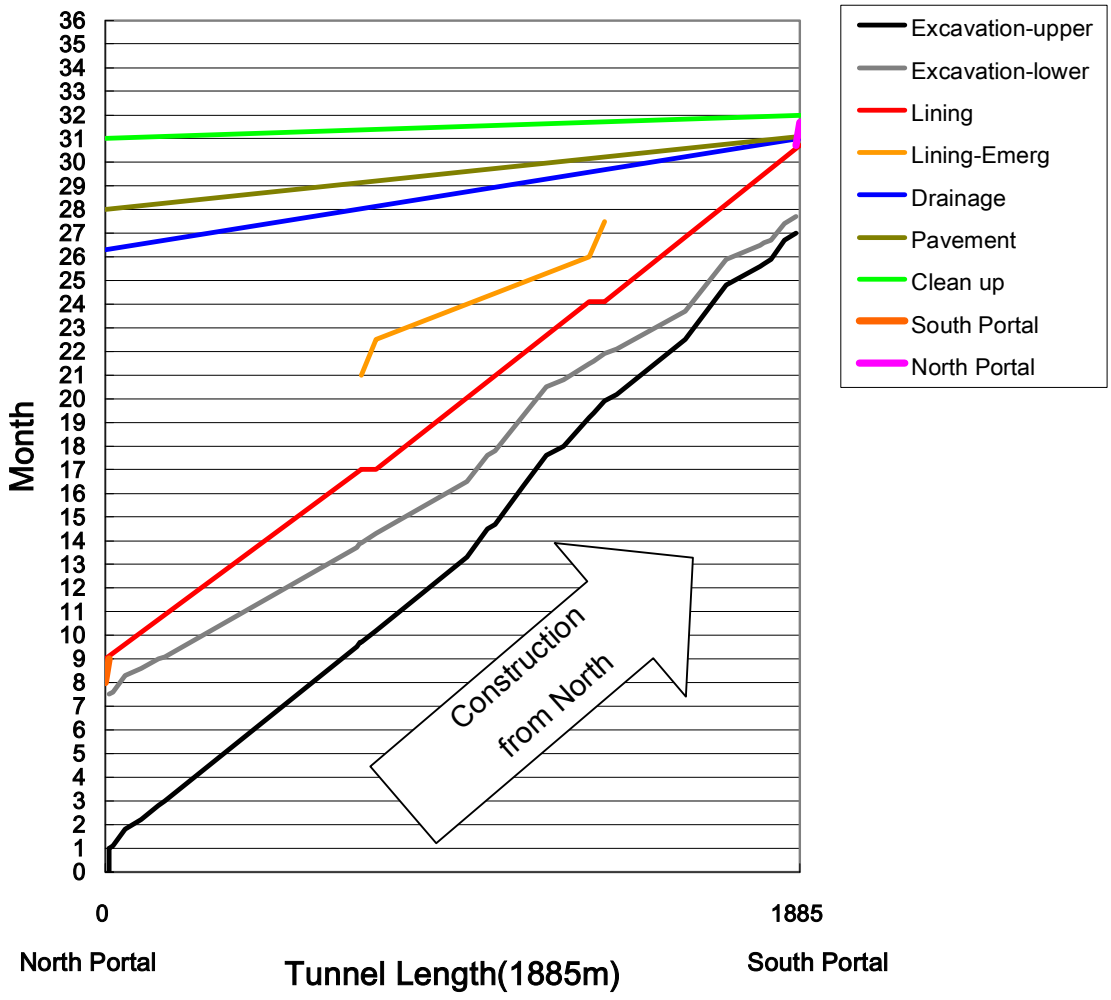


Figure 14.2.10 Construction Schedule for Alternative-B (One Side Excavation)

(7) Evaluation of Alternative Construction Plans

Evaluation of alternative construction plans is summarized in Table 14.2.9. The tunnel construction works are on the Critical Path in the construction schedule, therefore Alternative-A is recommended. The construction cost between Alternatives A and B is not much different. Though the former requires more machines but it can save the overhead expenses because of its shorter construction period.

The estimated embankment quantify for the tunnel north section is 260,000 m^3 and the excavation quantity is 84,500 m^3. The shortage of embankment materials should be obtained from borrow areas. However, as the tunnel north section is located in a tribal area, no appropriate borrow areas exist. The excavated materials from the north portal (91,000m^3) are planned to be used for the embankments in the north section.

Table 14.2.9 Summary of Evaluation of Alternative Construction Plans

Item	Alternative A		Alternative B	
Construction Period	○	24.5months	×	32 months
Equipment / Machines	×	2 sets	○	1 set
Drainage Pump	○	2 pumps (23 months)	×	2 pumps (30 months)
Construction Cost	Not much difference			
Use of excavated materials for the north section embankment	○	Easy	×	Difficult
Overall Evaluation	○	**Recommended**	×	Not recommended

Note: "○"; better than the other, "×": worse than the other

14.2.4 Relocation of the Tunnel Control Center

Since the existing Control Center yard occupies the south portal of the planned 2nd Kohat Tunnel, relocation of existing yard is required and it is on the Critical Path of the whole construction schedule.

The area located in front and on the west side of the south portal of the No.1 Kohat Tunnel is the only available site for the relocation. To reclaim that area it is necessary to construct a drainage for discharging the flow water from the valley. The procedure and time required for the relocation of the Control Center are shown in Figure14.2.11

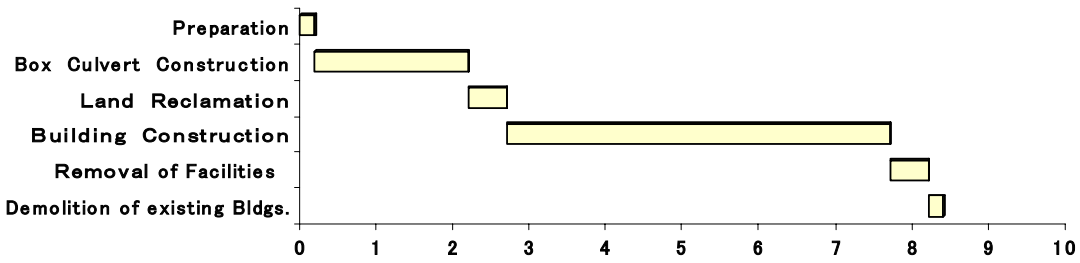


Figure 14.2.11 Construction Schedule before Start of the Tunnel South Portal

From this rough schedule, we can see that a period of 9 months is required before the start of the tunnel excavation from the south portal.

14.2.5 Bridge Construction

Nine bridges will be constructed for the 2nd Kohat Tunnel Access Roads (see Table 14.2.10). As the bridge No.3BR crosses over railways, No.3A R over N-80 (ADT about 4,300) and No.8R over the NWF road (ADT about 3,400), special care is required for public traffic control and maintaining safety during the construction. There is little traffic on the track under the Bridge No.10R.

The superstructure type composed of RC girders was designed for the Bridge No.9R and PC girders for other bridges. PC girders are cast either near the bridge site or at a casting yard. Cranes will be the most appropriate equipment for erection of PC girders. The erection method (see the right photo) commonly used in Pakistan is not appropriate when considering safety of the construction and adverse effects on PC girders.

Photo: PC Beam Erection Method Common in Pakistan

Table 14.2.10 Bridges for the 2nd Kohat Tunnel and Access Roads Project

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 railway
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)

Foundation piles are cast-in-place piles with a 750mm or 900mm diameter. Piles for river bridges should be constructed in the dry season to avoid the risk of damage by floods. Foundation materials are sand, gravel, cobbles, boulders and clay. Earth-drilling equipment mounted on a crawler crane will be appropriate.

Those bridges are constructed beside the existing bridges and embankment. Part of the slope protection works and wing walls of the existing bridges is to be demolished. Temporary structure sustaining measures like a combination of steel sheet piles and steel anchors are required for the new bridges construction (see Figure 14.2.12).

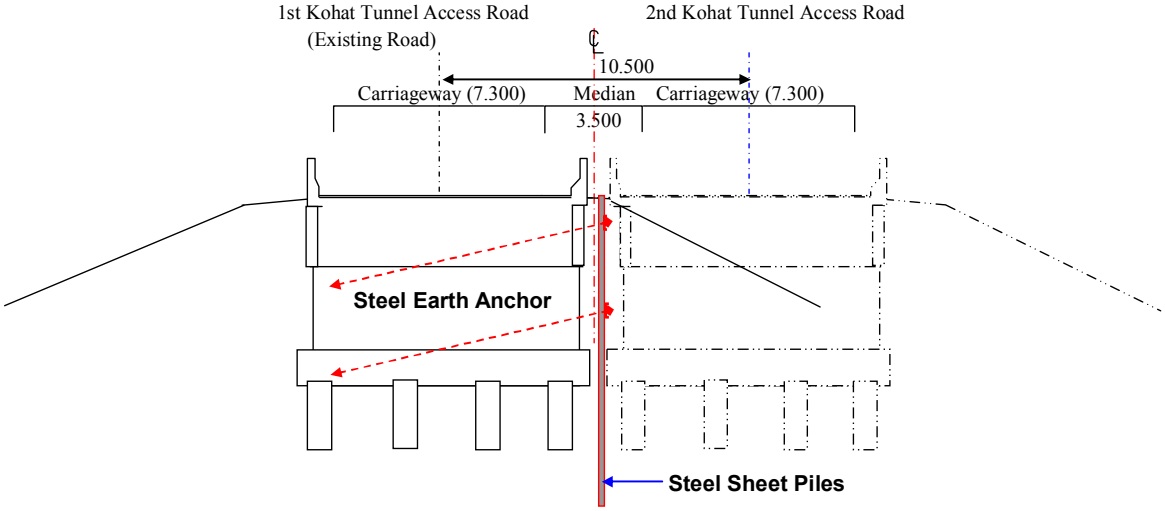


Figure 14.2.12 Temporary Structure Sustaining Measures for New Bridges Construction

14.2.6 Underpass Box Construction at Kohat Link Road IC

The construction of an underpass (box culvert) for the new On/Off Ramps was planned for the Kohat Link Road IC. As the ADT on the main road is approximately 4,100 vehicles and that on the Off-Ramp to Kohat Town is 1,800, a safe construction plan for both traffics should be worked out.

The 1st construction step will be box culvert construction for the new two lanes. After its completion, the traffic on the existing main road will be diverted to the new lanes for construction of the underpass for the existing main road.

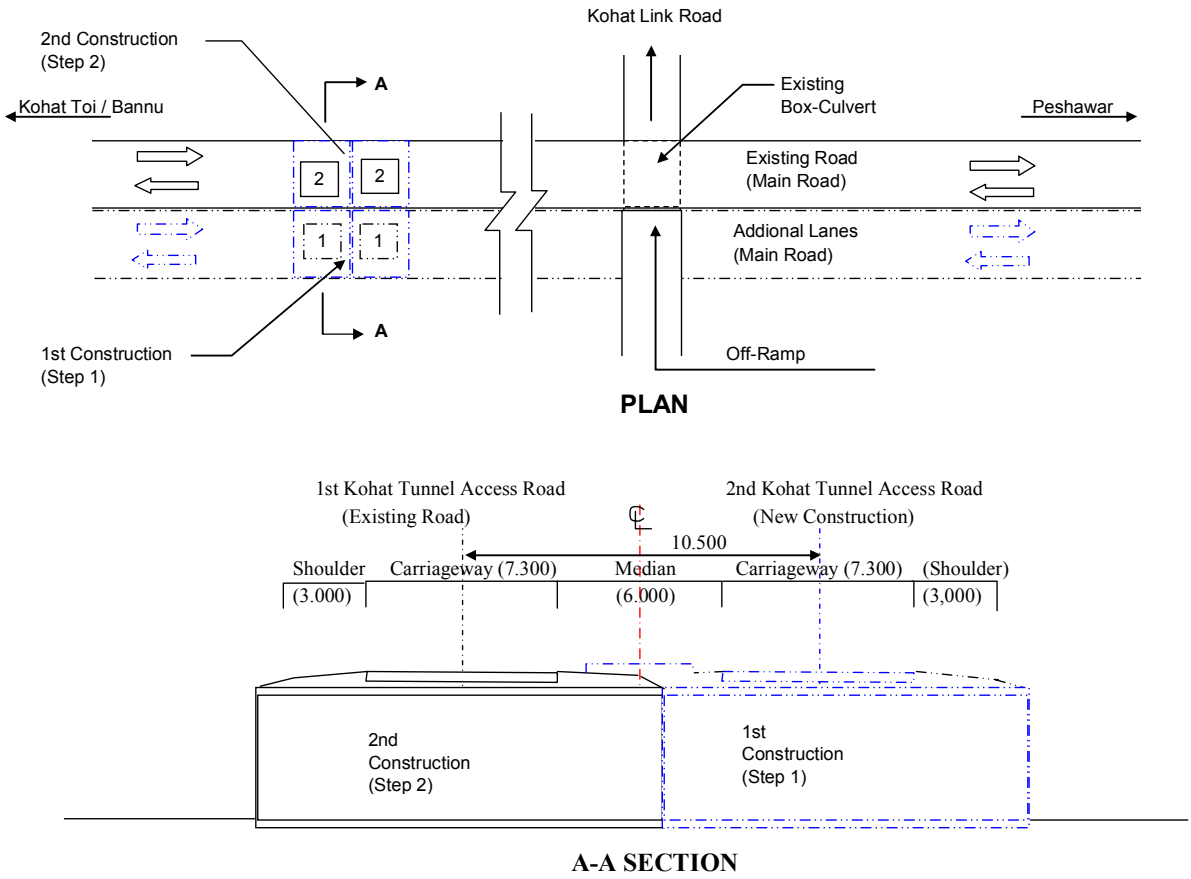


Figure 14.2.13 Construction Steps of Underpass (Box culvert) for Kohat Link IC

14.2.7 Pavement Construction

The pavement construction shall follow the General Specifications of NHA. Job-mix design should be carried out with utmost care. Trial construction should be made prior to the pavement construction to minimize common problems affecting the pavement life and earlier development of rutting and cracks experienced in Pakistan.

The AC base course was designed to have two layers (8-10 cm thick each). As the maximum particle size of the asphalt concrete base is very large, 38 mm for Class B and 50mm for Class A and it is more than 1/2.5 of a pavement construction layer, special care is required for application of the Marshal Stability design in laboratory.

As the AC base is thick, special care and equipment are required to attain the specified density at the lower part. Combination of a heavy duty asphalt finisher and a vibration roller would be one of the appropriate compaction equipment.

Concrete pavement was designed for the tunnel section, its approaches and the toll plaza. The thickness of pavement is 30cm on lean concrete/aggregate base. Strict quality control is required during construction as the maintenance and repair works in the tunnel without influence on traffic are not easy.

14.3 Proposed Contract Packaging

One contract package is recommended for implementation of the 2nd Kohat Tunnel and Access Roads Project (length 30.27km) including tunnel construction taking the estimated cost, length, construction period, work efficiency, excavated material distribution for

embankment, etc. into consideration. International contractor(s) will be employed for the tunnel and access roads construction.

The major scope of civil works is as summarised in Table 14.3.1.

Table 14.3.1 Scope of Civil Works for Implementation of the Project

Item	Roadway Construction	Tunnel Construction
Scope of Construction		
- Roadway Section	- Sta.0+000 - Sta.20+186.738 - Sta.18+132.000 - Sta.25+906.255	- Sta.16+247.000 - Sta.18+132.000
- Length	- 28.38 km	- 1885 m
- Carriageway Width	- 7.30 m (2-lanes)	- 7.30 m (2-lanes)
- Shoulder Width	- 1.00 m for inner shoulder and 3.00 m for outside shoulder	- 0.30 m (both sides) Gradient
- Median Width	- 6.0 m for tunnel south section 3.5 m for tunnel north section	
- Pavement	- AC Pavement (t=22-23 cm including AC Base)	- Cement Concrete pavement (t=30 cm)
- Bridges	9 Nos. (564 m in total)	
- Grade	- 4.8% (maximum)	- 2.4% (descending from the north to the south)
Allied Facilities	- Intersections / Interchanges Kohat Toi Intersection (An additional turn-lane) Kohat Link Road IC (New On-Ramp, Off-Ramp and underpass) NWF (Sanda Basta) Road IC. (New bridge) Dara Adam Khel Intersection (An additional turn-lane) - Main Toll Plaza (extension)	- Emergency Areas 2 nos. including cross passages - Tunnel Control Room (move) - Ventilation (Installation of Jet Fans) - Lighting and other safety facilities

Note: A break at Tunnel South Portal, Sta.20+186.738/Sta.16+247.000 (-3,939.738)

14.4 Sources of Major Materials

Possible procurement sources of materials for the construction were studied through the market investigation in Pakistan. According to the investigation results, common materials to be used for the construction of roads and RC structures can be procured in the domestic market.

On the other hand, certain material, equipment, and manpower related to the construction works of tunnel and tunnel mechanical and electrical facilities must be procured abroad.

14.4.1 Natural Material

Some borrow pits were surveyed. Filing materials suitable for embankment are available along the project site. Coarse aggregate is available from a quarry located to the west of the tunnel south portal. Fine aggregate for structural concrete is obtainable near Attock 70 km east of Peshawar. Details are descried in Section 6.6 Material Survey.

14.4.2 Concrete and Structural Material

Locally produced cement satisfies the quality and quantity requirement.

Steel reinforcement bars are procured in Pakistan. However, their cost is rather expensive at this moment because of the recent construction boom.

14.4.3 Asphalt and Fuels

Asphalt, emulsified asphalt and petrol, diesel fuel and kerosene are obtainable in the domestic market.

14.4.4 Tunnel Special Materials

Tunnel special materials such as water protection sheet, special rock bolts are not available in the domestic market. So they should be procured from international market.

14.4.5 Tunnel Mechanical and Electrical Facilities

Most of tunnel mechanical and electrical facilities such as ventilation equipment, lighting equipment, monitoring equipment, generators, telecommunication system, control system, etc. should be procured from international market.

14.5 Construction Schedule

Figure 14.5.1 shows the construction schedule in the form of bar chart for the 2nd Kohat Tunnel and Access Roads. The required period for the roadway construction by work item was estimated based on the quantity, daily productivity, number of work-units and working days per month as set out in Table 14.5.1.

Table 14.5.1 Estimate of Construction Period for Roadway by Work Item

Work Item	Unit	Estimated Quantity	Daily Production	Number of Work Unit	Working-Day/Month	Required Period (month)
		a	b	c	d	e=/(b*c*d)
Clearing & Grubbing	m^2	516,000	20,000	1	22	1.2
Embankment from Roadway	m^3	570,000	600	2	22	21.6
Embankment from Borrow	m^3	584,000	1,000	2	22	13.3
Embankment from Tunnel Excavation*	m^3	181,000	253	2	22	16.3
Aggregate Subbase	m^3	49,000	300	1	22	7.4
Aggregate Base Course	m^3	51,000	300	1	22	7.7
Bituminous Base Course Plant Mix	m^3	37,000	200	1	15	12.3
Double Surface Treatment	m^2	105,000	1,200	1	22	4.0
Bituminous Wearing Course	m^3	11,000	200	1	15	3.7
Foundation Pile (Dia.750 mm/900 mm)	LM	5,300	10	2	22	12.0

Note: Productivity of embankment construction with the materials from tunnel excavation depends on the tunnel construction progress.

A completion period of approximately 24 months is required for the tunnel civil works and 9 months for the tunnel facilities installation as detailed in Subsection 14.2.3. Together with the mobilization (2-3 months) and demobilization (1 month) periods, the total required construction period was estimated to be 36 months.

The tunnel construction is on the critical path. There are two critical paths as shown in Figure 14.5.1: One is the relocation of the tunnel control room at the south portal, followed immediately by tunnel excavation; and the other is the tunnel construction from the north portal. The roadway works including earthworks, pavement construction, bridge construction, etc. do not constitute critical paths.

As the tunnel geology is known well from the construction record and the geological report on the 1st Kohat Tunnel and Access Roads Project, the construction will not be delayed by geological uncertainty. It is also not much influenced by rains.

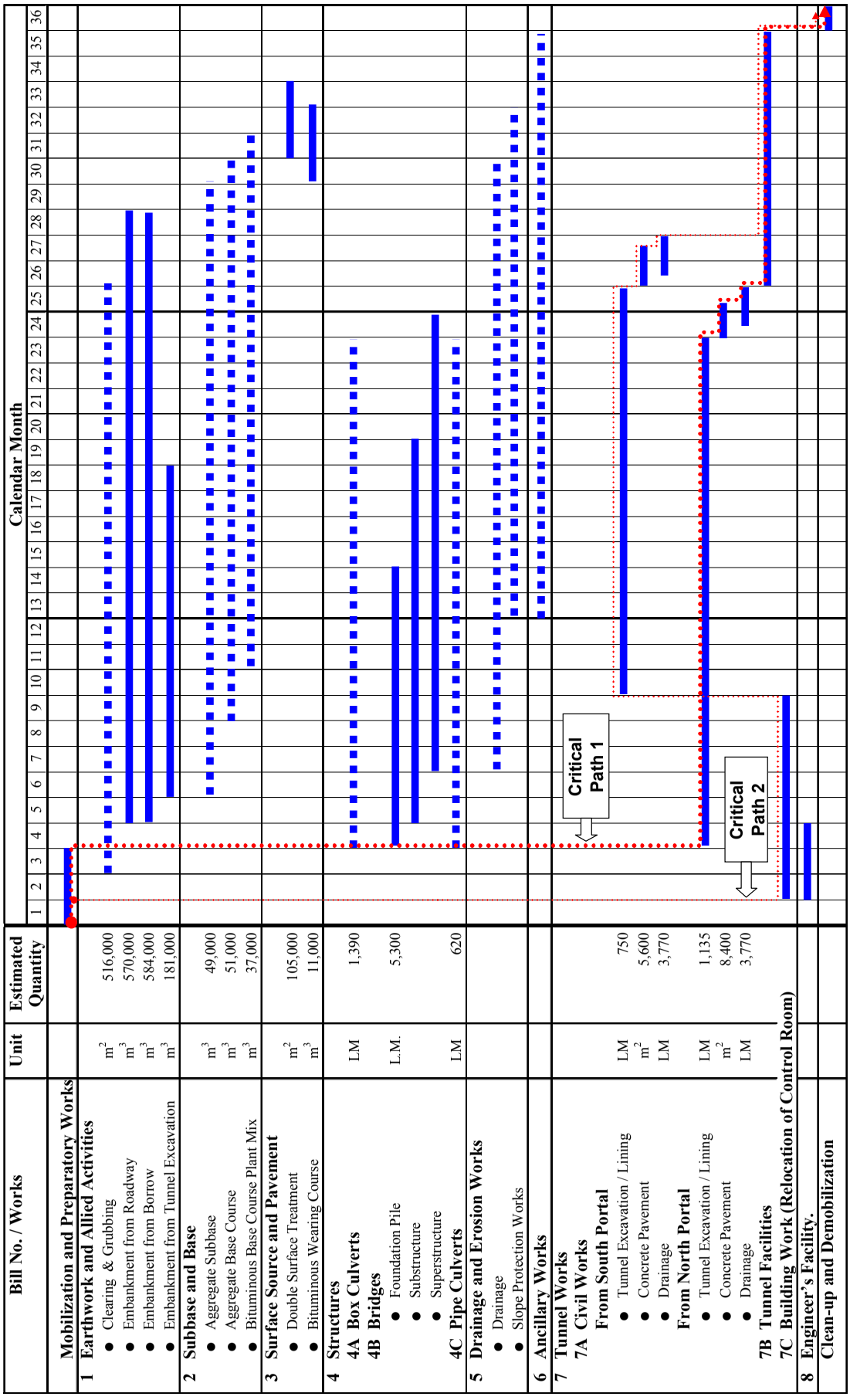


Figure 14.5.1 Construction Schedule for the 2nd Kohat Tunnel and Access Roads

Chapter 15 COST ESTIMATE

15.1 General

The general composition of the project cost is shown in Figure15.1.1. The project cost consists of construction cost, physical contingency, engineering cost for design and construction supervision, land acquisition and compensation cost, and administration cos. The construction cost consists of direct construction cost and indirect construction cost including the Contractor's overhead and profit, and taxes and duties. The cost composition is illustrated in Figure 15.1.1. below.

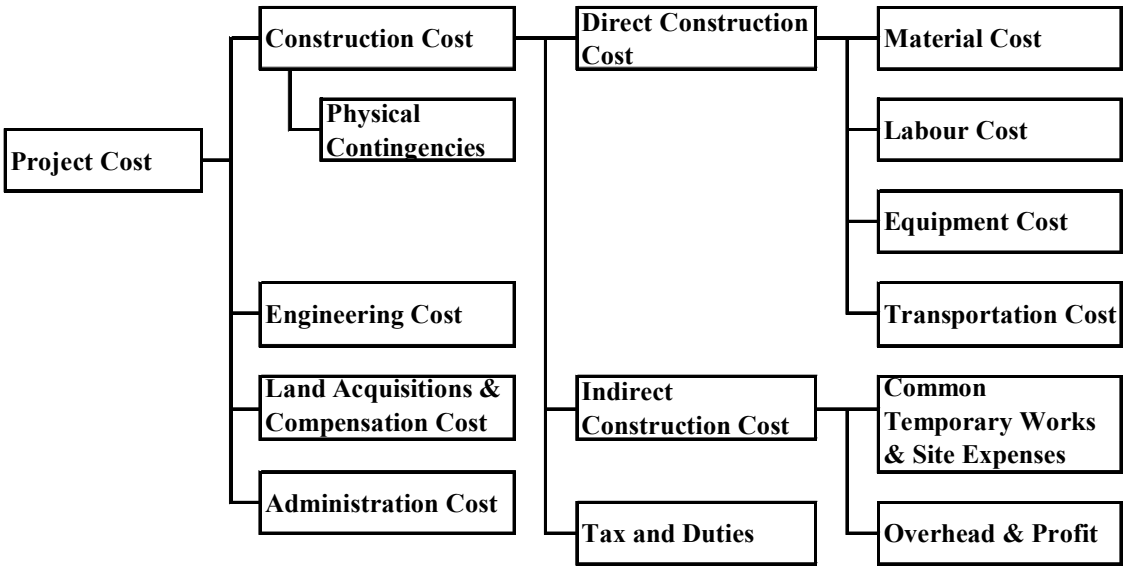


Figure 15.1.1 Composition of the Project Cost

As explained earlier, no additional land acquisition and compensation are required for the construction of the 2nd Kohat Tunnel and Access Roads, since the land required for 4-lane widening was already acquired.

The project cost was estimated in Pakistan Rupees at mid. 2006 price level, without taking price contingency into account. The cost of import materials and equipment was converted at the exchange rate of US$1.00 = Rs.60.0 = Japanese Yen 115.67, based on the average rates applicable during the period from 1st February to 31st July 2006 as shown below.

		Average	High:	Low:	
USD1.00	= Rs.	59.975	60.360	58.950	(Pakistan Rupee)
USD1.00	= JYen	115.670	119.384	108.980	(Japanese Yen)
Rs.1.00	= JYen	1.930	1.990	1.835	(Japanese Yen)

In estimating the construction cost, it was assumed that the construction will be executed by an international contractor. Pakistani contractors have experience in construction of highways and bridges, but no experience in tunnel construction. It was assumed that Pakistani contractors will work as subcontractors to a qualified international contractor.

The NHA's Engineering Estimates were referred to in analysing the unit prices. The respective unit prices of the direct construction cost items are inclusive of all taxes and duties and overhead and profit. The adopted overhead and profit was on average 25% of the direct and indirect construction costs.

The project cost was estimated dividing the Project into the north and south sections, since stage-wise construction is possible due to different traffic volume, and thus the different timing to reach the capacity.

15.2 Procurement Sources and Unit Rates

15.2.1 Procurement Sources

Possible procurement sources of materials, equipment and manpower for the construction were studied through market investigation in Pakistan. The investigation revealed that common materials, equipment, and manpower used for the construction of road and bridge structures can be procured in the domestic market, while those related to the tunnel construction have to be procured from outside Pakistan, in the same situation as the 1st Kohat Tunnel and Access Roads Construction Project.

15.2.2 Unit Rates of Construction Materials

Except for the materials related to tunnel construction, most materials can be procured locally as shown in Table 15.2.1.

Unit rates of construction materials which can be locally procured were studied based on the information obtained from contractors and suppliers in Pakistan. The unit rates of the major materials used in the construction cost estimate are shown in Table 15.2.2.

Table 15.2.1 Procurement Sources of Major Items

Items	Procurement Sources	
	Domestic	International
Cement	○	
Asphalt	○	
Emulsified asphalt	○	
Crusher run	○	
Sand	○	
Reinforcement bars	○	
Prestressing wire and anchorage	○	
Petrol	○	
Diesel fuel	○	
Kerosene	○	
Wood	○	
Tunnel steel H-support	○	
Tunnel-related materials		○

Remarks:

1) Cement: Domestic cement satisfies the quality and quantity requirement.

2) Reinforcement: Though they are rather expensive and not easy to obtain, considering the cost performance, steel re-bars will be procured in Pakistan.

3) Tunnel Materials: Necessary to procure from international market. Procurement from Japan is recommended considering the country's many experiences of tunnel construction.

Table 15.2.2 Unit Rates of Materials

S.No	Item and Description	Condition	Unit	Rate (Rs.)	Remarks
1	Cement: Ordinary Portland Cement	Ex factory	ton	5,640	
2	Asphalt: Gr-60-70	Ex factory	ton	27,925	(Bulk)
	Asphalt: Gr-60-70	Ex factory	ton	33,955	(Packet)
3	Sand : Fine - Course	At Site	m3	2,070	
4	Aggregate : 2"-1.5", 3/4"-3/8"	At Site	m3	2,070	
5	Reinforcement bar: Gr-60	Ex factory	ton	45,000	ASTM-615
6	Pre-stressing wire strand: 3/8"-1/2"	At Site	ton	112,000	
7	H.S Diesel	Ex Pump	Litre	38.82	
8	Petrol	Ex Pump	Litre	58.80	
9	Keroseen Oil	Local Market	Litre	45	
10	Electric Charge	Commercial	KWh	10	
11	H- Shaped Steel	Ex factory	ton	(45,000-55,000)	(varies by shape)
12	Concrete Pipe Dia 300mm	Ex factory	Nos	1,750	8 ft long
13	Concrete Pipe Dia 900mm	Ex factory	Nos	10,781	8 ft long
14	Concrete Pipe Dia 1200mm	Ex factory	Nos	18,530	8 ft long
15	Rock Bolt L-3m	Local Market	Nos	1,450	25mm dia

The unit rates of import materials, mainly for tunnel construction, were referred to the Japanese market prices.

15.2.3 Unit Rates of Labour

Unit rates of labour were estimated based on the information from local contractors. Table 15.2.3 shows the unit rates of Pakistani labour.

Table 15.2.3 Unit Rates of Labour

Item and description	Unit	Wages (Rs.)
Site Engineer	hr	450
General Forman	hr	250
Foreman earth work	hr	250
Foreman Concrete	hr	200
Foreman asphalt	hr	210
Foreman	hr	210
Supervisor	hr	200
Surveyor	hr	200
Assistant Surveyor	hr	130
Mason	hr	110
Carpenter	hr	110
Steel Binder / Cutting	hr	110
Highly Skilled Labour	hr	100
Helper	hr	100
Labour	hr	85

15.2.4 Unit Rates of Construction Equipment and Plants

Most of common construction equipment and plants can be procured in Pakistan. For these equipment and plants, operation costs were estimated based on the leasing prices, which include such costs as depreciation, operator, fuel and maintenance. The unit rates of locally available equipment and plants are shown in Table 15.2.4.

For the special equipment, mainly those required for tunnel construction, operation costs were estimated based on a depreciation basis.

The rate of depreciation of equipment was assumed to be 60% - 90% per project, depending on the characteristics of equipment and their working conditions.

Table 15.2.4 Unit Rates of Equipment and Plants Operation

Item	Specification	Unit	Rate (Rs.)
Bulldozer	120HP(19ton)	hr	3,100
Bulldozer	90HP (15ton)	hr	2400
Front end (FE) loader	3.0 m3	hr	3,000
Front end (FE) loader	2.5 m3	hr	2,600
Excavator	Crawler type 0.9m^3	hr	2,100
Excavator	Crawler type 0.6m^3	hr	950
Dump truck	18t	hr	1,150
Dump truck	108t	hr	950
Motor grader	165HP	hr	2,450
Motor grader	140HP	hr	1,600
Tandem vibration roller	10-12 ton	hr	1,430
Tire roller	18-21 ton	hr	1,115
Concrete batching plant	20 m3/hr	hr	1779
Concrete transit mixer	6 m^3	hr	721
Truck crane	50 ton	hr	12,500
Asphalt finisher	4m wide	hr	3,400

15.2.5 Transportation Cost

For the imported materials and equipment, their transportation routes were assumed as below, and the transportation cost was estimated and included in the direct construction cost.

1) India - Project Site (if any)
2) International - Karachi - Project Site (eg. Tunnel facilities, etc.)

15.3 Cost Estimate

15.3.1 Construction Quantity Estimate

The construction quantities of the 2nd Kohat Tunnel and Access Roads Project were estimated based on the preliminary design described in Chapter 11, the Preliminary Design Drawings (Volume II of the Feasibility Study Report) and the General Specifications of NHA.

The quantities were categorised into the following Bill numbers as specified in the General Specifications of NHA, except Bill No.7: Tunnel Works.

- Bill No.1: Earthwork and Allied Activities
- Bill No.2: Subbase and Base
- Bill No.3: Surface Cource and Pavement
- Bill No.4: Structures
  - Bill No.4A: Box Culverts
  - Bill No.4B: Bridges
  - Bill Bo.4C: Pipe Culverts
- Bill No.5: Drainage and Erosion Works
- Bill No.6: Ancillary Works
- Bill No.7: Tunnel Works
  - Bill No.7A: Civil Works
  - Bill No.7B: Tunnel Facilities
  - Bill Bo.7C: Building Work
- Bill No.8: Engineer's Facilities.

The work items for the tunnel works, which consist of civil works, tunnel facilities and buildings, followed those used in the 1st Kohat and Access Roads Project.

The quantities were estimated by road section: Section 1 from the start point of the Project (Kohat Toi Intersection) to Sta.15+000 (Kohat Link Road IC) and Section 2 from Sta.15+000 (Kohat Link Road) to the end point of the Project (Dara Adam Khel Intersection). The tunnel construction is a part of the Section 2. Table 15.3.1 shows the major quantities for Bill No.1 to Bill No.6 (roadway construction). Table 15.3.2 shows the major quantities for Bill No.7 (tunnel works).

Table 15.3.1 Quantities of Major Work Items for Bill No.1 to Bill No.6

(Roadway Construction)

Item	Description	Unit	Section 1* Start to Sta.15+000	Section 2** Sta.15+000 to End	Total
BILL NO.1: EARTHWORK AND ALLIED ACTIVITIES					
101	Clearing and Grubbing	m^2	233,580	282,333	515,913
106a	Disposal of unsuitable common Material	m^3	186	5,135	5,321
108a	Formation of Embankment from Roadway Excavation in common material	m^3	3,186	87,801	90,987
108b	Formation of Embankment from Roadway Excavation in Rock material	m^3	27,939	211,787	239,726
PS-14	Excavated Material from Tunnel to be used in Roadway Embankment including spreading, compacting Rolling, Watering and Testing	m^3	-	181,477	181,477
108c	Formation of Embankment from Borrow Excavation in Common Material with all leads	m^3	393,882	200,277	594,159
BILL NO.2: SUBBASE & BASE					
201	Granular Sub Base	m^3	25,245	23,513	48,758
202	Aggregate Base Course	m^3	27,257	23,959	51,216
203c	Bituminous Base Course Plant Mix (Class-A)	m^3	9,991	10,106	20,097
203d	Bituminous Base Course Plant Mix (Class-B)	m^3	9,064	7,828	16,892
BILL NO.3: SURFACE COURSE AND PAVEMENT					
304b	Double Surface Treatment	m^2	52,688	52,786	105,473
305a	Bituminous Wearing Course Class - A	m^3	5,465	5,041	10,506
310b	Reinforced Concrete Pavement (30cm thick)	m^2	-	4,205	4,205
BILL NO.4A: STRUCTURE, BOX CULVERTS					
107a	Structural Excavation in common Material	m^3	3,306	11,611	14,917
401a	Concrete Class A	m^3	2,233	5,733	7,966
404b	Reinforcement as per AASHTO M31 Grade-60	Tonne	226	617	843
BILL NO.4B: STRUCTURE, BRIDGES					
107a	Structural Excavation in Common Material	m^3	2,740	2,039	4,779
401a	Concrete Class A	m^3	1,082	1,391	2,473
401c	Concrete Class C	m^3	2,887	3,346	6,233
401d	Concrete Class D	m^3			
404b	Reinforcement as per AASHTO M31 Grade 60	Tonne	565	720	1,285
PS6-a	Prestressed Girders (20m - 30m span)		32	48	80
SS-44_414	RCC Girders: Concrete Class D (12m span)		4	4	4
407d	Cast in place Concrete Piles type				
	750 mm dia	L.M	1,680	2,265	3,465
	900 mm dia	L.M	1,272	585	1,857
BILL NO.4C: STRUCTURE, PIPE CULVERTS					
107a	Structural Excavation in common Material	m^3	244	55	299
401a	Concrete Class A	m^3	157	49	206
501i	Standard Strength Reinforced Concrete Pipe Culverts AASHTO M170 dia 910mm	L.M.	397	-	397
501j	Standard Strength Reinforced Concrete Pipe Culverts AASHTO M170 dia 1070mm	L.M.	-	96	96
BILL NO.5: DRAINAGE AND EROSION WORKS					
107a	Structural Excavation in Common Material	m^3	-	11,254	11,254
411b	Stone Masonry Random with mortar	m^3	-	7,663	7,663
509c	Riprap Class " C" (80mm thick)	m^2	161	1,991	2,152
509e	Grouted Riprap CLASS - A (300mm thick)	m^2	1,848	6,576	8,424
509f	Grouted Riprap Class B (500mm thick)	m^2	5,826	19,089	24,915
PS9-e	Concrete Class C to invert and slope of drainage ditch	m^3	729	474	1,204
BILL NO.6: ANCILLARY WORKS					
601d	Precast Concrete Curbstone	L.M	29,840	26,360	56,200
601g	Median Concrete Barrier	L.M	-	2,830	2,830
604a	Metal Guardrail	Each	4,608	6,080	10,687
PS16	Steel Wire mesh for safety netting	m^2	1,200	18,402	19,601

Notes: * Section 1 is from the Start Point to Sta.15+000 (Kohat Link Road)

** Section 2 is from Sta.15+000 (Kohat Link Road) to the End Point (Dara Adam Khel Intersection)

Table 15.3.2 Quantities of Major Work Items for Bill No.7 (Tunnel Works)

Item	Description	Unit	Quantity
BILL NO.7A : CIVIL WORK.S			
	EXCAVATION (ROCK)		
T.1-T.2	Excavation of CI class Rock CI	m^3	86,406
T.3-T.4	Excavation of CI class Rock CII	m^3	19,852
T.5-T.7	Excavation of CI class Rock DI	m^3	38,599
T.8-T.9	Excavation of Portal	m^3	7,148
	SHOTCRETE		
T.11-T.17	Shotcrete in CI, CII , DI and Portal Patterns	m^3	4,999
	ROCK REINFORCEMENT		
T.19-T.20	Rock Bolts 3m in length in CI and CII Rock	No	13,678
T.21-T.23	Rock Bolts 4m in length in DI Rock	No	9,670
T.24-T.28	Rock Bolts 2-4m in length in Portal, Substation	No	6,029
T.29-T.32	STEEL RIBS	Ton	382
	WATER PROOFING SYSTEM		
T.33	Water Proofing system in Tunnel lining	m^2	42,696
	TUNNEL LINING		
T.34-T.40	Concrete Class B to Tunnel Lining	m^3	15,818
	BACKFILL & ROADWORK'S		
T.47	Concrete Road Slab (t-300)	m^2	13,969
	DRAINAGE		
T.61	310mm (nominal) diameter	m	1,997
T.62	150mm (nominal) diameter side Drain	m	3,776
BILL NO.7B : TUNNEL FACILITIES			
	LIGHTING SYSTEM TUNNEL		
L.2-L4	Lighting Luminaire SON -T 70W - 250W	No	1,106
L.7-L.9	Cable PVC 10 mm^2 -4C - 35mm^2-4C	L.M	24,213
L.10-L.14	Cable BC 6 mm^2 - 16 mm^2	L.M	27,099
L.23	Lighting Luminaire SON -T 150W	No	4
L.25-L.27	Cable PVC 16 mm^2 -2Core - 16 mm2-3Core	L.M	3,779
L.29-L.37	TOLL PLAZA (For Extension)		
	VENTILATION		
V.1	Jet Fan dia 1250 37 KW	No	
V.1a	Providing Jet Fan dia 1250 37Kw	No	6
V.1b	Mountaning of Jet Fan dia 1250	No	8
V.5	CO Meter	No	2
V.6	VI Meter (Projector & Receiver)	No	2
V.7	Air Speed Meter (Anemometer)	No	1
V.17-V.21	Cable for control 1.0 mm^2 10 C - 1.0 mm^2 20C	L.M	10,034
	SAFETY SYSTEM		
S.4	Big Type Extinguisher	No	5
S.9	Emergency Telephone & its Box	No	4
	POWER SUPPLY SYSTEM		
P.18	Diesel Engine Generator 300 KVA	No	1
	SUPERVISION & CONTROL SYSTEM		
C.1-C.12	Various Control Panels	No	9
C.13	Software	Item	1
BILL NO.7C : BUILDING WORK			
PBS.0	Yard preparation	L.S	1
PBS.0a	Removal of Existing Control rooms Facilities	L.S	1
PBS.3	Control Room and Substation	L.S	1

15.3.2 Construction Cost

The unit price of each work item was analyzed. For estimating unit prices of individual work items, input requirements for materials, manpower and equipment were established. The official Pakistan cost estimate guideline "Rate Analysis Formula for NHA CSR 2000 Road Works" was referred to in analysing the unit prices of common highway and bridge construction works.

For the tunnel works, which are not included in the above guideline, unit price analysis was made referring to the cost estimate manuals issued by the Ministry of Construction of Japan.

The unit prices were established by adding indirect construction cost including temporary works and site expenses, and overhead and profit.

The direct construction cost was then estimated by multiplying the respective unit price by the work quantity estimated in the preliminary design.

15.3.3 Physical Contingency

Physical contingency was estimated at 10% of the total construction cost.

15.3.4 Engineering Cost

The engineering cost for preparation of detailed design, assistance in tendering and construction supervision was estimated at 10% of the total construction cost.

15.3.5 Administration Cost

The administration cost to be spent by NHA was estimated at 1% of the sum of the construction cost and the engineering cost.

15.3.6 Project Cost

The total project cost was estimated at Rs.6.322 billion (equivalent to US$ 105.5 million), as shown in Table 15.3.3.

Table 15.3.3 Summary of Project Cost

Description	Amount (Unit: x1,000 Rs.)			
	South Section*	North Section**	Total	
I. CONSTRUCTION COST				
1 Earthwork	194,044	402,898	596,942	(11.4%)
2 Subbase and Base Courses	173,042	166,053	339,095	(6.5%)
3 Surfacing	86,281	97,408	183,689	(3.5%)
4A Structure: Box Culvert	68,106	179,653	247,759	(4.7%)
4B Structure: Bridge	261,259	291,194	552,453	(10.6%)
4C Structure: Pipe Culvert	17,432	13,003	30,435	(0.6%)
5 Drainage and Erosion Protection Works	26,072	70,991	97,063	(1.9%)
6 Ancillary Works	99,091	149,326	248,417	(4.8%)
7A Tunnel Civil Works		1,794,185	1,794,185	(34.3%)
7B Tunnel Facilities		868,412	868,412	(16.6%)
7C Building Works		118,011	118,011	(2.3%)
8 Engineer's Facility	27,760	124,534	152,294	(2.9%)
TOTAL CONSTRUCTION COST	953,087	4,275,668	5,228,755	(100.0%)
II. PHYSICAL CONTINGENCY (10%)	95,309	427,567	522,876	
III. ENGINEERING COST(10%)	95,309	427,567	522,876	
IV. ADMINISTRATION COST(1%)	10,484	47,032	57,516	
TOTAL PROJECT COST	1,154,189	5,177,834	6,332,023	

Notes: * South Section: Construction of Access Road from Start Point to Sta.15+000 (Kohat Link Road IC)
**North Section: Construction of the 2nd Kohat Tunnel and Access Road from Sta.15+000 to End Point

15.4 Operation and Maintenance Costs

15.4.1 Operation and Maintenance Costs for Tunnel Facilities

(1) Routine Maintenance

From the record of the 1st Kohat Tunnel, the annual operation and maintenance cost incurred by the Maintenance Contractor and Operator (MC&O) was estimated at Rs.88,432,000, as an average of five years, which includes staff salaries, tunnel vehicles and operation and

maintenance of tunnel facilities.

Table 15.4.1 Operation and Maintenance Expenditure of 1st Kohat Tunnel

Items	For 5 years (Rs.)	Rs./Year	Ratio
Staff Salaries	335,883,660	67,177,000	76.0%
Tunnel Vehilces	35,353,000	7,071,000	8.0%
Operation & maintenance Cost	70,921,281	14,184,000	16.0%
Total	442,157,941	88,432,000	100.0%

After opening of the 2nd Kohat Tunnel to public traffic, its operation and maintenance scope will be expanded but no big additional expenditure will be required, since it is considered that the present staff can work for the two tunnels. With an extra expenditure estimated at 5% the annual cost for routine maintenance amounts to Rs.92,953,000.

(2) Electricity

The following table shows the actual electricity cost of the 1st Kohat Tunnel in May 2006.

Table 15.4.2 Electricity Cost of 1st Kohat Tunnel

Items	For a month (Rs.)	Rs./Year	Ratio
Tunnel	843,532	10,122,000	82.5%
Toll Plaza	49,375	593,000	4.8%
Administration Building	74,695	896,000	7.3%
Staff Resident Camp	32,240	387,000	3.2%
North Emergency Building	22,013	264,000	2.2%
Total	1,021,855	12,262,000	100.0%

After opening of the 2nd Kohat Tunnel to public traffic, the ventilation load will be reduced significantly. Thus, the electricity cost for tunnel operation was estimated to be 50% of that of the 1st tunnel, i.e. Rs. 10,122,000 x 50% = Rs. 5,061,000. This cost is an addition to the routine expenditure.

(3) Periodical Expenditure

Ten units of jet fans are used for the 1st Kohat Tunnel, which started their operation in 2003. Since their useful life is about 20 years, it is necessary to replace them with new ones in around 2023. Their procurement cost was calculated as the periodical expenditure.

In the same way, some parts of the facilities in the control system, such as electric panels, need to be replaced after 10 years of operation. The periodical expenditure was estimated to be equivalent to 50% of the cost for control system facilities.

The estimated amounts for renewal of fans and control system facilities are as follows:

Renewal of 10 jet fans (every 20 years): Rs.133, 443,000

Renewal of control system facilities (every 10 years): Rs.90, 971,000

15.4.2 Physical Maintenance of Road Facilities

Road maintenance is to preserve and repair the road facilities in its designed or accepted configuration. Maintenance programs for the project road include road surfaces, shoulders, drainage facilities (culverts and roadside drains), slopes, bridges, tunnel, traffic markings, signs, etc. The budget for these maintenance works is allocated by the NHA head office.

The maintenance programs are categorised into routine maintenance and periodical maintenance. The routine maintenance works should be undertaken each year. The periodical maintenance works are to be undertaken at intervals of several years. These maintenance costs were estimated on the following assumptions (see Table 15.4.3).

Table 15.4.3 Maintenance Cost for the Project Road

Category	Works	Cost	Program
Routine Maintenance	Pavement & Shoulders (Patching, partial reconstruction, etc)	2% of Pavement Construction Cost*	Every Year
	Bridge/Culvert (Cleaning, joint repair, etc.)	0.5% of Pavement Bridge & Culvert Construction Cost*	
	Drainage, Slope & Ancillary Items (Guardrails, vegetation control, etc.)	2% of Drainage, Slope & Ancillary Items Construction Cost*	
Periodic Maintenance	AC Overlay on AC pavement (including leveling thickness)	5cm thick AC Overlay 7.5cm thick AC Overlay Construction Cost	At 11th year At 21st year
	AC Overlay on PCC Pavement for Tunnel Section	10cm thick AC Overlay Construction Cost	At 21st year

Note: * average % by year

Table 15.4.4 in the next page shows a breakdown of the maintenance costs by category, program, road section, and year.

An amount of Rs.22 million (Rs.7.3 million/year) has been spent for maintenance and repair of 1.8km of shoulders since the opening of the 1st Kohat Tunnel and Access Roads. Most of the shoulder damage was caused by the passage of heavy vehicles on the shoulders for overtaking and parking, and this situation will continue in future. This situation will be improved substantially after construction of the 2nd Kohat Tunnel and Access Roads to a dual carriageway. The pavement maintenance cost for the existing road will also be reduced by about 20% - 30% per year as the traffic will be distributed from 2 lanes to 4 lanes.

Table 15.4.4 Physical Maintenance Cost Estimate

Unit: Rs 1000

Stage of Project	Year	Section 1 (South), Start Point - Kohat Link Road: Routine Maintenance: Pavement /Shoulder	Section 1: Routine Maintenance: Bridge/ Culvert	Section 1: Routine Maintenance: Drainage, Slope & Ancillary	Section 1: Periodic Maintenance (AC Overlay on ACP)	Section 1: **Total**	Section 2 (North), Kohat Link Road - End Point: Routine Maintenance: Pavement /Shoulder	Section 2: Routine Maintenance: Bridge/ Culvert	Section 2: Routine Maintenance: Drainage, Slope & Ancillary	Section 2: Periodic Maintenance (AC Overlay on ACP)	Section 2: Sub-Total	Section 2: Tunnel Section Periodic Maintenance (AC Overlay)	Section 2: **Total**	**Grand Total (Sections 1+ 2)**	Remarks (% to Civil Cost except tunnel construction)	Cost Saving for Maintenance of 1st Kohat Tunnel Access Roads: Shoulder * Repair with PCCP/ACP	Cost Saving: Pavement * Maintenance	Cost Saving: Total
FS	2006															7,300		
FA	2007															7,300		
DD	2008															7,300		
Tender	2009															7,300		
C1	2010															7,300		
C2	2011															7,300		
C3	2012															7,300		
OM1	2013	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM2	2014	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM3	2015	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM4	2016	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM5	2017	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM6	2018	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM7	2019	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM8	2020	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM9	2021	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM10	2022	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM11	2023	3,034	1,733	1,252	90,052	**96,071**	2,961	2,399	2,203	84,121	91,684		**91,684**	**187,755**	7.48%	7,300	1,200	8,500
OM12	2024	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM13	2025	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM14	2026	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM15	2027	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%	7,300	1,200	8,500
OM16	2028	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM17	2029	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM18	2030	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM19	2031	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM20	2032	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM21	2033	3,034	1,733	1,252	135,078	**141,097**	2,961	2,399	2,203	126,182	133,745	16,075	**149,820**	**290,917**	11.60%		1,200	1,200
OM22	2034	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM23	2035	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM24	2036	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM25	2037	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM26	2038	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM27	2039	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM28	2040	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM29	2041	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
OM30	2042	3,034	1,733	1,252		**6,019**	2,961	2,399	2,203		7,563		**7,563**	**13,582**	0.54%		1,200	1,200
Total		91,027	51,983	37,549	225,131	**405,690**	88,827	71,966	66,095	210,303	437,191	16,075	**453,266**	**858,955**	34.24%	109,500	18,205	145,500

Notes: The shoulder repair with PCC pavement or AC pavement is 1.8 km (0.6km/year) since the opening. This activity will continue up to approximately 25% of the shoulders are replaced with PCC Pavement.

Chapter 16. PROJECT EVALUATION

16.1 General

The existing Kohat Tunnel has been contributing to realizing smooth traffic flows on the National Highway No.55 (N-55) and will continue to enhance the balanced development in the region and in the whole country.

However, as explained in Chapter 5, the traffic speed particularly in the section of the existing 2-lane tunnel is frequently slowed down when one lane is occupied by heavy vehicles running ahead. If such situation continues, the tunnel service level will decrease to an unacceptable level in near future. In order to maintain the functions of N-55 and to raise the service level, construction of the 2nd Kohat Tunnel is proposed. The purpose of this Chapter is to investigate and/or justify the implementation of the Project from the point of view of national economy. In addition, a financial analysis was also carried out for the project road as a Toll Road (Toll Tunnel) comparing project costs with toll revenues.

The scope of the entire Project to be evaluated is defined below:

1) Section 1: Widening of the existing 2-lane road to 4-lane dual carriageway for the South Access Road (from starting point to the Kohat Link Road IC: 15.0 km).

2) Section 2: Construction of the 2nd Kohat Tunnel and widening of the existing 2-lane North Access Road to 4-lane dual carriageway (from the Kohat Link Road IC to the ending point: 15.3 km).

16.2 Economic Evaluation

16.2.1 Economic Costs

All the costs, and benefits as well, estimated at the market prices are to be converted into economic terms in the economic evaluation by excluding such transfer items as taxes and duties. In this Study, the Standard Conversion Factor (SCF = 0.88*) which is generally used in Pakistan was applied to obtain the economic costs. The results of cost estimates at market prices (financial costs) are presented in Chapter 15 and compared with the economic costs as shown below:

(Note:*:"Islamabad-Muzaffarabad Road Project (N-75) PC-1 Proforma, Sep.2005, NHA")

Table 16.2.1 Economic Project Costs (Rs 1000, 2006 Prices)

Road Section	Items	Financial Cost	Economic Costs
Section 1 (South)	Construction	953,087	838,717
	Engineering	95,309	95,309
	Administration	10,484	10,484
	Physical Contingency	95,309	83,872
	Sub Total	**1,154,189**	**1,028,382**
Section 2 (North)	Construction	4,275,668	3,762,588
	Engineering	427,567	427,567
	Administration	47,032	47,032
	Physical Contingency	427,567	376,259
	Sub Total	**5,177,834**	**4,613,446**
Section 1 + 2	Construction	5,228,755	4,601,304
	Engineering	522,876	522,876
	Administration	57,516	57,516
	Physical Contingency	522,876	460,131
	GRAND TOTAL	**6,332,023**	**5,641,827**

Source: Study Team

The operation and maintenance (O&M) costs after opening of the 4-lane roads are estimated as shown in Chapter 15 and converted into the economic costs as well.

16.2.2 Economic Benefits

(1) Quantification of Benefits

Benefits estimated quantitatively are user's benefits which are enjoyed by the expanded tunnel/access road users and classified into the following two types:

- Savings in Vehicle Operating Costs (VOC Savings)
- Savings in Travel Time Costs (TTC Savings)

The savings in traffic accident costs are also expected after opening of the 2nd Tunnel. However, no accidents in the existing tunnel were reported since its opening in 2003 and accident data on the existing old route via N-55 is not available. Therefore, the saving benefits of traffic accidents were not estimated.

(2) "With" and "Without (W/O)" Project Comparison

The above benefits were estimated based on the "With and Without Project comparison method". The "With Project" case means the situation that the Project is implemented and the 4-lane access roads and 2nd Kohat Tunnel are constructed. On the other hand, the "Without Project" case means the present situation with 2-lane access roads and 2-lane Kohat Tunnel.

(3) Traffic Demand

The traffic demand under the Project is one of the main factors for the project evaluation. The results of traffic demand forecast are shown in Chapter 7 and applied to the project evaluation. It should be noted, however, that the traffic demand under the Project was forecast for the "With Project" case and it was assumed that the traffic demand in the "Without Project" case is the same as that in the "With Project" case, whether the 4-lane tunnel and 4-lane access roads are constructed or not. Under this circumstance, the forecast traffic demands are commonly applied to both the "With" and "Without" Project cases not taking into consideration the condition of diverted traffic from other routes which would use the worse/more congested and time consuming routes in the "Without Project" case. Therefore, the benefits from the Project were estimated based on the only differences of vehicle speed between the case of 2-lane tunnel/ 2-lane access roads and the case of 2nd tunnel with widened 4-lane access roads, applying the same traffic demands.

(4) Calculation of Future Vehicle Speed under "With" and "Without" Project Situations

Speed surveys in the existing Kohat Tunnel were carried out by the Study Team in June 2006. The results revealed that the average speed in the Tunnel was 16.7 km/hour to the north direction and 30.9 km/hour to the south direction. The speed in the tunnel, and partly on the 2-lane access roads as well, is affected by the slow movement of heavy vehicles such as 3-4 axle trucks. The relationship between the surveyed speed and the traffic volume at that time (every 15-minute counting carried out by the Study Team in May 2006) is shown in Figures 16.2.1 and 16.2.2.

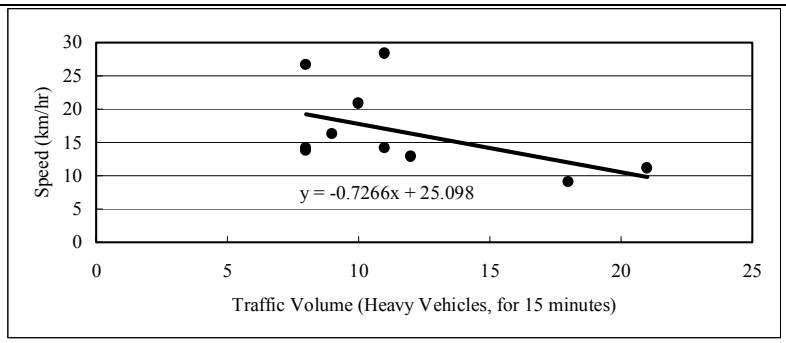
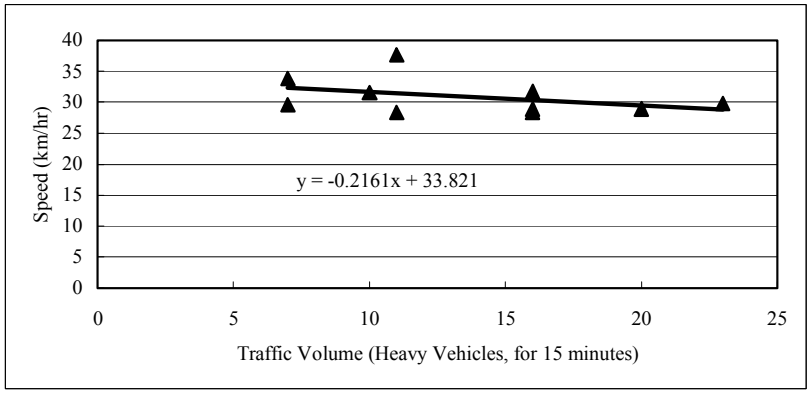


Figure 16.2.1 Speed and Traffic Volume (Heavy Vehicles in Tunnel): North Direction

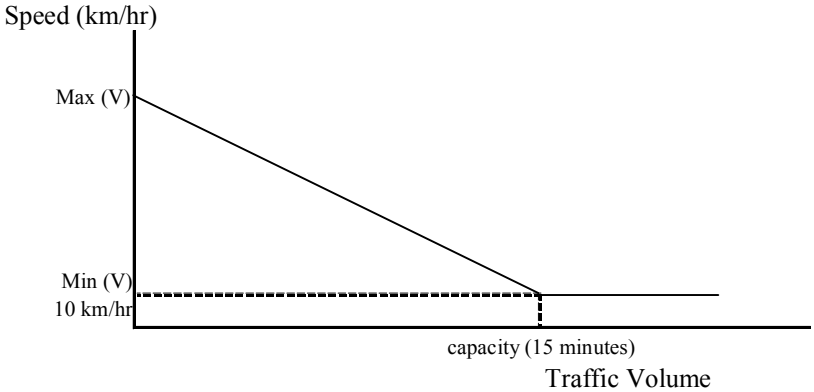


Source: Study Team

Figure 16.2.2 Speed and Traffic Volume (Heavy Vehicles in Tunnel): South Direction

The vehicle speed to the north direction (up-grade) in the tunnel goes down to 10 km/hour when the traffic volume of heavy vehicles is around 20 vehicles per 15 minutes. On the other hand, the vehicle speed to the south direction (down-grade) is almost flat with 30 km/hour on average although a negative relationship between speed and traffic volume (when traffic volume increases, travel speed decreases) is observed.

Based on the above results (parameters in Figures 16.2.1 and 16.2.2) and taking into consideration traffic characteristics/road conditions (speed of heavy vehicles and light vehicles, up-grade, down-grade, inside and outside the tunnel, etc.), the following formula was established showing the relationship between traffic volume and travel speed (Q-V Formula):



Source: Study Team

Figure 16.2.3 Q-V Formula

The above Q-V formula was established based on the following conditions:

1) Road section: 3 sections (Tunnel section, South Access, and North Access roads)
2) Direction: 2 directions (from south to north, from north to south)
3) Vehicle type: 2 types (heavy vehicles and light vehicles)
4) Number of lanes: 2 cases (existing 2-lane case and 4-lane case in future)

Therefore, a total of 24 formulas (3 x 2 x 2 x 2) were prepared as shown below:

Table 16.2.2 Q-V Formulas

Road Section	Vehicle Type	With or Without	Direction (S-N) Q-V Formula	Direction (N-S) Q-V Formula
Northern Access	Heavy (H)	W/O (2-lane)	V=-0.72657QH+30.0	V=-0.21615QH+35.0
		With (4-lane)	V=-0.72657QH+35.0	V=-0.21615QH+37.0
	Light (L)	W/O (2-lane)	V=-0.72657QH+40.0	V=-0.21615QH+40.0
		With (4-lane)	V=-0.22184QL+75.0	V=-0.23891QL+80.0
Tunnel Section	Heavy (H)	W/O (2-lane)	V=-0.72657QH+25.09821	V=-0.21615QH+30.0
		With (4-lane)	V=-0.72657QH+30.0	V=-0.21615QH+35.0
	Light (L)	W/O (2-lane)	V=-0.72657QH+25.09821	V=-0.21615QH+30.0
		With (4-lane)	V=-0.15358HL+55.0	V=-0.18771QL+65.0
Southern Access	Heavy (H)	W/O (2-lane)	V=-0.72657QH+30.0	V=-0.21615QH+35.0
		With (4-lane)	V=-0.72657QH+35.0	V=-0.21615QH+42.0
	Light (L)	W/O (2-lane)	V=-0.72657QH+80.0	V=-0.21615QH+80.0
		With (4-lane)	V=-0.25597QL+85.0	V=-0.27304QL+90.0

Source: Study Team
Note: V: Daily average speed, QH: Traffic of heavy vehicles (for every 15 minutes), QL: Traffic of light vehicles (for every 15 minutes)

The following points were also taken into account in establishing the Q-V formulas:

1) The speed of light vehicles in the existing tunnel (W/O case) is dominated by the speed of heavy vehicles.
2) Light vehicles can overtake heavy vehicles when running outside the tunnel (on the access road sections).
3) Alignment of the south access road is better than the north access road and the grade is almost flat (0.53 % in average), and higher speed than the north access road is possible.
4) Controlled speed in the tunnel section is 40km/hr at present and 60km/hr in the case of the 2nd Tunnel.
5) Controlled speed on the north and south access roads is 80km/hr and 90km/hr respectively.
6) In the Q-V formula, the minimum speed is set at 10km/hr.
7) The road capacity per 15 minutes is determined based on the capacity analysis explained in Chapter 7.

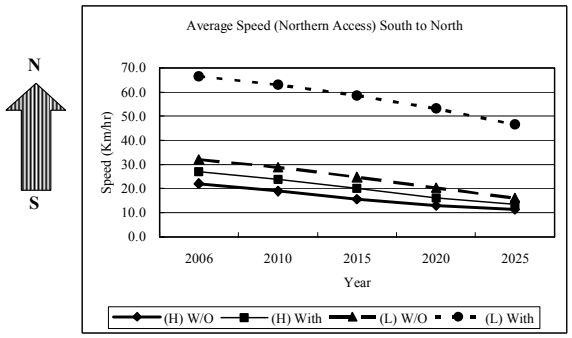
Applying the future traffic volumes to the Q-V formulas, the future vehicle speed was calculated as shown in Figure 16.2.4 for both the “With” and “Without” Project cases.

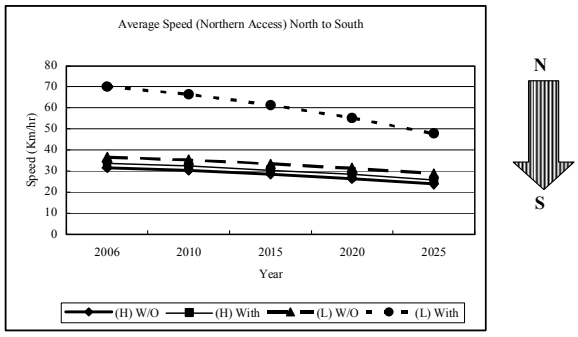
Daily Average Speed (Km/hr)
Northern Access Road
S ----> N

Vehicle Type	Condition	2006	2010	2015	2020	2025
Heavy Vehicle	(H) W/O	22.0	18.9	15.5	12.9	11.4
	(H) With	27.0	23.8	20.0	16.0	13.3
Light Vehicle	(L) W/O	32.0	28.8	24.7	20.3	16.1
	(L) With	66.4	63	58.5	53.1	46.5

Daily Average Speed (Km/hr)
Northern Access Road
N ----> S

Vehicle Type	Condition	2006	2010	2015	2020	2025
Heavy Vehicle	(H) W/O	31.6	30.3	28.5	26.4	23.8
	(H) With	33.6	32.3	30.5	28.4	25.8
Light Vehicle	(L) W/O	36.6	35.3	33.5	31.4	28.8
	(L) With	70.2	66.4	61.4	55.2	47.8



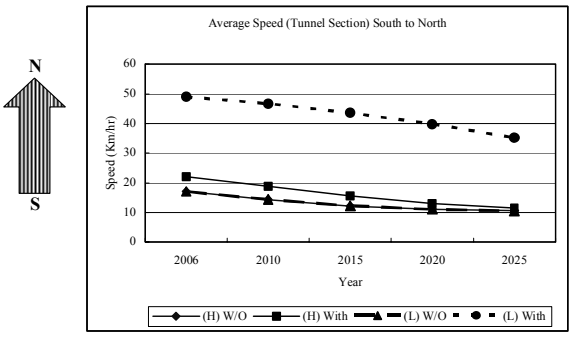


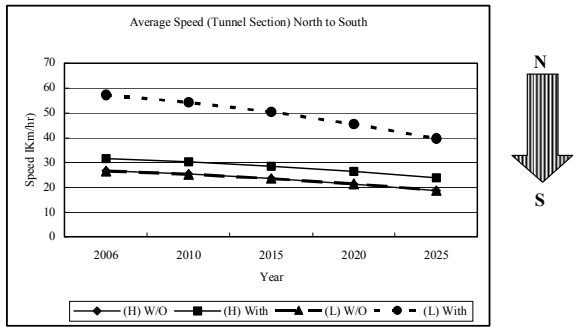
Daily Average Speed (Km/hr)
Tunnel Section
S ----> N

Vehicle Type	Condition	2006	2010	2015	2020	2025
Heavy Vehicle	(H) W/O	17.1	14.4	12.2	11.0	10.5
	(H) With	22.0	18.9	15.5	12.9	11.4
Light Vehicle	(L) W/O	17.1	14.4	12.2	11.0	10.5
	(L) With	49.0	46.7	43.6	39.8	35.2

Daily Average Speed (Km/hr)
Tunnel Section
N ----> S

Vehicle Type	Condition	2006	2010	2015	2020	2025
Heavy Vehicle	(H) W/O	26.6	25.3	23.5	21.4	18.8
	(H) With	31.6	30.3	28.5	26.4	23.8
Light Vehicle	(L) W/O	26.6	25.3	23.5	21.4	18.8
	(L) With	57.3	54.3	50.4	45.5	39.7



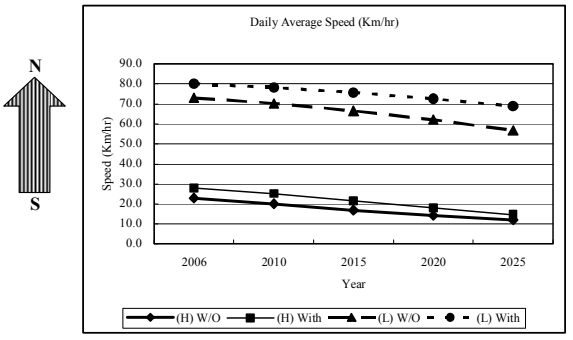


Daily Average Speed (Km/hr)
Southern Access Road
S ----> N

Vehicle Type	Condition	2006	2010	2015	2020	2025
Heavy Vehicle	(H) W/O	23.0	20.1	16.9	14.1	12.1
	(H) With	28.0	25.2	21.6	17.9	14.7
Light Vehicle	(L) W/O	73.0	70.2	66.6	62.1	56.8
	(L) With	80.1	78.2	75.7	72.6	68.9

Daily Average Speed (Km/hr)
Southern Access Road
N ----> S

Vehicle Type	Condition	2006	2010	2015	2020	2025
Heavy Vehicle	(H) W/O	32.2	31.2	29.9	28.2	26.1
	(H) With	39.2	38.2	36.9	35.2	33.1
Light Vehicle	(L) W/O	77.2	76.2	74.9	73.2	71.1
	(L) With	85.1	83.4	80.9	77.9	74.2



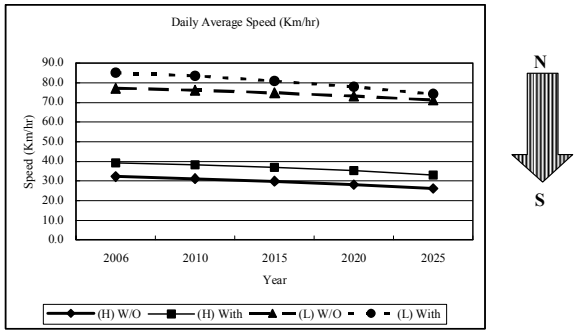


Figure 16.2.4 Calculation of Future Vehicle Speed by Road Section

(5) Vehicle Operating Costs (VOC)

The basic data of Vehicle Operating Costs is presented in PTPS Phase-I Study. As this basic data was calculated at the November 2005 price level, some revisions were made in order to update to the present price level reflecting the recent sharp increase of petrol prices. The latest prices of fuel and engine oil are shown in Table 16.2.3.

Table 16.2.3 Updating Fuel Prices (Rs./litre)

Item		November 2005	August 2006	Increase %
Gasoline Super		56.37	57.78	2.5%
Diesel (HSD)		37.26	38.81	4.2%
Lubricant Oil	for Gasoline	187.10	211.8	13.2%
	for Diesel	193.30	218.30	12.9%

Source: CALTEX, PSO, Sitara-E-Hilly Co.ltd, Shell Pakistan, and Interviewed gas stands.

In addition to the above adjustments, the degree of grade of each road section of the Project was taken into account because the prepared VOC is applicable only for a level tangent road section. As the project tunnel and access roads are located in the mountainous area, fuel consumption of vehicles will depend on up-grade or down-grade running. The necessary data for this adjustment is shown in Table 16.2.4.

Table 16.2.4 Adjustment of Fuel Consumption Rate for Rise and Fall

Rate of Rise (add Litre/1000km to level tangent road case)			
(meter/km)	Car, Jeep	Wagon, Minibus	Bus & Truck
	(+litre/1000km)	(+litre/1000km)	(+litr/1000km)
+10 (grade+1.0%)	17.22	31.39	49.29
+20 (2.0%)	34.43	62.77	98.58
+30 (3.0%)	51.65	94.15	147.87
+40 (4.0%)	68.86	125.54	197.16
+50 (5.0%)	86.08	156.92	246.45
Rate of Fall (subtract Litre/1000km from level tangent road case)			
	(-litre/1000km)	(-litre/1000km)	(-litre/1000km)
-10 (grade -1.0%)	9.22	13.49	20.72
-20 (2.0%)	18.45	27.58	41.45
-30 (3.0%)	27.67	41.38	62.17
-40 (4.0%)	36.89	55.17	82.90
-50 (5.0%)	46.12	68.96	103.62

Source: "Vehicle Operating Costs" NTRC-79, January 1985

The grade conditions of the Project Tunnel and the access roads are summarized below:

Table 16.2.5 Grade Conditions of the Project Tunnel and Access Roads

(From South to North)

Section		Grade (%)
North Access	From North Portal to north end point (7.8 km)	-1.03%
Kohat Tunnel	Tunnel Section (1.885 km)	+2.40%
North Access	From Kohat Link Road to South Portal (5.6 km)	+2.52%
South Access	From start point to Kohat Link Road (15.0 km)	+0.53%

Source: Study Team

Based on the information in Tables 16.2.4 and 16.2.5, the VOC values on each road section of the Project were computed applying the following equations:

Table 16.2.6 Equations for VOC Calculation

Road Section	Average Grade (%) S--→N	Vehicle Type	Direction (S --→ N)	Direction (N --→ S)
North Access (after North Portal) 7.8 km	-1.03%	Car	$C=0.0023V^2-0.2858V+13.127$	$C=0.0023V^2-0.2858V+13.698$
		M.bus	$C=0.0049V^2-0.6468V+32.230$	$C=0.0049V^2-0.6468V+32.750$
		Bus	$C=0.0081V^2-1.0359V+50.592$	$C=0.0081V^2-1.0359V+52.141$
		2-axle	$C=0.0071V^2-0.8548V+37.155$	$C=0.0071V^2-0.8548V+38.173$
		3-axle	$C=0.0085V^2-1.0205V+44.479$	$C=0.0085V^2-1.0205V+45.303$
		Articulate	$C=0.0106V^2-1.2190V+53.850$	$C=0.0106V^2-1.2190V+55.192$
Tunnel & North Access (up to South Portal)	+2.40% & +2.54%	Car	$C=0.0023V^2-0.2858V+14.255$	$C=0.0023V^2-0.2858V+12.828$
		M.bus	$C=0.0049V^2-0.6468V+33.292$	$C=0.0049V^2-0.6468V+31.992$
		Bus	$C=0.0081V^2-1.0359V+53.777$	$C=0.0081V^2-1.0359V+49.904$
		2-axle	$C=0.0071V^2-0.8548V+39.247$	$C=0.0071V^2-0.8548V+36.703$
		3-axle	$C=0.0085V^2-1.0205V+46.174$	$C=0.0085V^2-1.0205V+44.120$
		Articulate	$C=0.0106V^2-1.2190V+56.609$	$C=0.0106V^2-1.2190V+53.267$
South Access (up to Kohat Link Road	+0.53%	Car	$C=0.0023V^2-0.2837V+13.217$	
		M.bus	$C=0.0049V^2-0.6420V+32.137$	
		Bus	$C=0.0080V^2-1.0269V+50.581$	
		2-axle	$C=0.0069V^2-0.8372V+36.769$	
		3-axle	$C=0.0084V^2-1.0053V+44.117$	
		Articulate	$C=0.0104V^2-1.1943V+53.263$	

Source: Study Team
Note: C=VOC, V=Average vehicle speed

(6) Travel Time Cost (TTC)

The saving in travel time cost is another important component of road/tunnel users' benefit. PTPS Phase-I estimated the unit value of travel time (Rs./hour/vehicle) at the 2005 price level. The revised/updated unit TTC was calculated applying the most recent data of per Capita GDP in FY2005/06 as shown below:

Table 16.2.7 Passenger Travel Time Cost (Rs./hour/vehicle:2006 prices)

Vehicle Type	Calculation Process	Time Cost /hour/person	Time Cost /hour/vehicle
Car	Previous JICA Study(*) in 1993: Time Value = Rs.21.02/hour/person Growth rate of Per Capita GDP in current prices: 2006/1993=(Rs 46,954/Rs11,913)=3.94 Time Value of a main driver in 2006=Rs.21.02 x 3.94=**Rs.83.0/hour/person**	Rs.83.0 /hour/person	**Rs.166 /hour/vehicle** (No. of occupants = 2 persons
Mini Bus & Bus	Per Capita GDP (2005/06)=Rs.46,954/year Working hours=25 days/month, 8 hour/day Rs.46,954/12months/25days/8hours=Rs19.6/hour 20% for work weighted at 1.00, 80% of non-work weighted at 0.5 Rs.19.6 x (0.2x1.0 + 0.8x0.5)=**Rs.12.0/hour/person**	Rs.12.0 /hour/person	Mini bus **Rs.204** /hour/vehicle (Occupants=17)
			Bus **Rs.540** /hour/vehicle (Occupants=45)

Source: (*) "The Study on National Transport Plan in the Islamic Republic of Pakistan", Final report, Feb.1995, JICA

In order to confirm the validity of the above estimated time value, a comparison with a different study was made as shown below.

Table 16.2.8 Comparison of Time Values

Study Description	Islamabad-Muzaffarabad Road Project (N-75) Section, Sep.2005, NHA			This Study		
Vehicle Type	Car	Wagon /Minibus	Bus	Car	Wagon /Minibus	Bus
1) Passenger Time Value/hour/person	**Rs.82.15**	**Rs.32.86**	**Rs.32.86**	**Rs.83.0**	**Rs.12.0**	**Rs.12.0**
2) No. of occupants	2.6	14.0	40.0	2.0	17.0	45.0
3) Time Value/vehicle	**Rs.213.6**	**Rs.460.0**	**Rs.1,314.4**	**Rs.166**	**Rs.204**	**Rs.540**
Discounted to 25% (to reflect work and non-work time)	75%reduced Rs.53.4	75%reduced Rs.115.0	75%reduced Rs.328.6			
If the same rates of this JICA Study are applied:	0.466 x 3) = Rs.100	0.6 x 3) = Rs.276	0.6 x 3) = Rs.789			

Source: Study Team

As the value of travel time varies depending on the methodology/assumptions adopted and changeable year by year, it is necessary to check the effects of changed time values on the results of economic evaluation. Therefore, in this Study, sensitivity analyses were carried out assuming different values of travel time.

(7) Total Benefits Estimated

The results of benefit estimate are summarized in Table 16.2.9. As already explained, the benefits which will accrue from the implementation of the Project will be generated by the expansion of 2-lane tunnel/access roads to 4-lane and the resulting increased speed. The road surface is almost the same in "good condition" for both the "With" and "Without" Project cases under the existing well maintained tunnel/access roads. This is one of the reasons that the VOC saving benefit is lower than that of Time Cost saving in this Study, particularly in the north section of the Project.

Table 16.2.9 Estimated Benefits

(in Rs.million, 2006 prices)

	North Section (from Kohat Link Road to north end point (including the Tunnel)			South Section (from south start point up to Kohat Link Road)			Total of Project		
Year	Time Savings	VOC Savings	Sub total	Time Savings	VOC Savings	Sub total	Time Savings	VOC Savings	Total
2010	177.13	197.37	374.50	12.64	32.96	45.60	189.77	230.33	420.10
2015	358.31	303.87	662.18	25.27	51.89	77.16	383.27	355.76	739.03
2020	700.67	432.75	1,133.42	48.52	75.31	123.83	749.19	508.06	1,257.25
2025	1,301.35	575.57	1,876.93	84.21	104.47	188.68	1,385.56	680.04	2,065.60

Source: Study Team

16.2.3 Economic Evaluation

(1) Premises of the Evaluation

For the purpose of economic evaluation, the following preconditions were established:

1) Evaluation Cases:

Scenario 1: The North and South sections of the Project will be opened together with the 2nd Kohat Tunnel and 4-lane access roads at the beginning of 2013 in accordance with the Implementation Schedule.

Scenario 2: (Stage-wise construction) The North section including the 2nd Kohat Tunnel and 4-lane North Access Road will be opened at the beginning of 2013 and the South Access Road will be opened in 2020 (after 7 years) reflecting the results of traffic analysis which suggests that the traffic in the South Section will reach the LOS of E in 2020.

2) Evaluation period was set for 35 years (30 years after opening in the case of Scenario 1)

3) Opportunity Cost of Capital (Discount Rate) = 12%

4) No residual values were counted.

(2) Economic Cash Flows and Evaluation Indicators

The cost and benefit cash flows for both scenarios are shown in Tables 16.2.10 and 16.2.11. The following three (3) kinds of evaluation indicators were calculated

- Economic Internal Rate of Return (EIRR)
- Net Present Value (NPV)
- Benefit/Cost Ratio (B/C)

The results of evaluations are summarized below:

Scenario	Indicator	
Scenario 1	EIRR	16.6%
	NPV (Rs.million)	2,342
	B/C	1.57
Scenario 2	EIRR	17.3%
	NPV (Rs.million)	2,476
	B/C	1.66

Source: Study Team

The results show that the implementation of the Project is economically feasible for both scenarios. However, no big differences are observed between both cases.

Table 16.2.10 Cost Benefit Cash Flow (Scenario 1)

(North & South Sections 4-Lane Open in the same year 2013)

(Rs.Million)

Year	ECONOMIC COST					ECONOMIC BENEFIT	B-C	
	Construction	Engineering	Administration	O & M	COST			
2006								
2007								
2008	0.00	64.14	9.41		73.54	0.00	-73.54	1
2009	0.00	78.43	12.03		90.46	0.00	-90.46	2
2010	1379.62	114.06	12.03		1505.70	0.00	-1505.70	3
2011	1840.91	133.12	12.03		1986.06	0.00	-1986.06	4
2012	1840.91	133.12	12.03		1986.06	0.00	-1986.06	5
2013				98.12	98.12	620.15	522.03	6
2014				98.12	98.12	684.00	585.88	7
2015				98.12	98.12	747.85	649.74	8
2016				98.12	98.12	851.43	753.32	9
2017				98.12	98.12	955.01	856.89	10
2018				98.12	98.12	1058.59	960.47	11
2019				98.12	98.12	1162.17	1064.05	12
2020				98.12	98.12	1265.75	1167.63	13
2021				98.12	98.12	1427.42	1329.30	14
2022				98.12	98.12	1589.09	1490.97	15
2023				448.87	448.87	1750.76	1301.88	16
2024				98.12	98.12	1912.43	1814.31	17
2025				98.12	98.12	2074.10	1975.98	18
2026				98.12	98.12	2177.38	2079.26	19
2027				98.12	98.12	2285.82	2187.70	20
2028				98.12	98.12	2392.39	2294.27	21
2029				98.12	98.12	2511.95	2413.83	22
2030				98.12	98.12	2624.93	2526.81	23
2031				98.12	98.12	2743.00	2644.88	24
2032				98.12	98.12	2866.38	2768.26	25
2033				342.17	342.17	2995.31	2653.14	26
2034				98.12	98.12	3130.05	3031.93	27
2035				98.12	98.12	3255.20	3157.08	28
2036				98.12	98.12	3385.36	3287.24	29
2037				98.12	98.12	3520.73	3422.61	30
2038				98.12	98.12	3661.51	3563.39	31
2039				98.12	98.12	3807.92	3709.80	32
2040				98.12	98.12	3960.19	3862.07	33
2041				98.12	98.12	3960.19	3862.07	34
2042				98.12	98.12	3960.19	3862.07	35
Total	5061.43	522.88	57.52	3538.27	9180.09	69337.19	60157.09	

N+S 4-Lane Open in the same year 2013
(Evaluation Period: 2008-2042)

EIRR (%)	**16.6%**	
NPV	**2,342**	Rs.million
B/C	**1.57**	

Opportunity Cost of Capital = 12%

Source: Study Team

Table 16.2.11 Cost Benefit Cash Flow (Scenario 2)

Stage-wise Construction
North Section: 4 Lanes Open in 2013
South Section: 4 Lanes Open in 2020 (Rs.Million)

Year	ECONOMIC COST					ECONOMIC BENEFIT	B-C	
	Construction	Engineering	Administration	O & M	COST			
2006								
2007								
2008		64.14	9.41		73.54	0.00	-73.54	1
2009		64.14	9.41		73.54	0.00	-73.54	2
2010	1379.62	99.77	9.41		1488.79	0.00	-1488.79	3
2011	1379.62	99.77	9.41		1488.79	0.00	-1488.79	4
2012	1379.62	99.77	9.41		1488.79	0.00	-1488.79	5
2013				92.82	92.82	550.85	458.03	6
2014				92.82	92.82	608.38	515.56	7
2015				92.82	92.82	665.92	573.10	8
2016		14.30	2.62	92.82	109.74	760.17	650.43	9
2017		14.30	2.62	92.82	109.74	854.41	744.68	10
2018	461.29	33.36	2.62	92.82	590.09	948.66	358.57	11
2019	461.29	33.36	2.62	92.82	590.09	1042.91	452.82	12
2020				98.12	98.12	1264.73	1166.61	13
2021				98.12	98.12	1426.40	1328.28	14
2022				98.12	98.12	1588.07	1489.95	15
2023				369.63	369.63	1749.74	1380.11	16
2024				98.12	98.12	1911.41	1813.29	17
2025				98.12	98.12	2073.08	1974.96	18
2026				98.12	98.12	2176.36	2078.24	19
2027				98.12	98.12	2284.80	2186.68	20
2028				98.12	98.12	2392.24	2294.13	21
2029				98.12	98.12	2511.80	2413.69	22
2030				177.36	177.36	2624.78	2447.42	23
2031				98.12	98.12	2742.85	2644.74	24
2032				98.12	98.12	2866.23	2768.12	25
2033				223.30	223.30	2995.17	2771.87	26
2034				98.12	98.12	3129.90	3031.79	27
2035				98.12	98.12	3255.06	3156.94	28
2036				98.12	98.12	3385.22	3287.10	29
2037				98.12	98.12	3520.58	3422.47	30
2038				98.12	98.12	3661.36	3563.25	31
2039				98.12	98.12	3807.78	3709.66	32
2040				216.98	216.98	3960.04	3743.06	33
2041				98.12	98.12	3960.04	3861.93	34
2042				98.12	98.12	3960.04	3861.93	35
Total	5061.43	522.88	57.52	3501.19	9143.02	68678.98	59535.96	

Stage Construction
N: 4 Lane Open 2013
S: 4 Lane Open 2020

EIRR (%)	**17.3%**	
NPV	**2,476**	Rs.million
B/C	**1.66**	

Opportunity Cost of Capital = 12%

Source: Study Team

16.2.4 Sensitivity Analysis

(1) Prepared Cases for Sensitivity Tests

The robustness of feasibility of the Project was tested by changing related factors within a probable range. The test cases prepared in this sensitivity analysis are as follows:

●Sensitivity Analysis 1 (Variations of Cost and Benefit)

Test 1: Project Cost: 10% up, Project Benefit: 10% down

Test 2: Project Cost: 20% up, Project Benefit: 20% down

●Sensitivity Analysis 2 (Variation of Evaluation Period)

Test 3: Evaluation Period: 20 years after first opening

●Sensitivity Analysis 3 (Variations of Unit Time Values)

Test 4: Unit Time Value: reduced by 20% from the original values

Test 5: Unit Time Value: reduced by 50% from the original values

(2) Results of Sensitivity Analysis

The results of the five tests are summarized in Table 16.2.12.

Table 16.2.12 Results of Sensitivity Analysis

Scenario	Tested Cases	EIRR (%)	NPV (Rs.million)	B/C
Scenario 1	Base Case	16.6	2,342	1.57
	Test 1: Cost: 10% up, Benefit: 10% down	14.4	1,284	1.28
	Test 2: Cost: 20% up, Benefit: 20% down	12.4	227	1.05
	Test 3: Evaluation Period: 20 years after first opening	15.2	1,239	1.30
	Test 4: Unit Time Value: reduced by 20%	15.2	1,546	1.38
	Test 5: Unit Time Value: reduced by 50%	12.8	352	1.09
Scenario 2	Base Case	17.3	2,476	1.66
	Test 1: Cost: 10% up, Benefit: 10% down	15.1	1,478	1.36
	Test 2: Cost: 20% up, Benefit: 20% down	13.0	480	1.11
	Test 3: Evaluation Period: 20 years after first opening	16.0	1,370	1.37
	Test 4: Unit Time Value: reduced by 20%	15.8	1,695	1.45
	Test 5: Unit Time Value: reduced by 50%	13.3	524	1.14

The above results indicate the robustness of the economical feasibility of the Project showing that the values of EIRR are higher than 12%, positive figures of NPV (NPV>0), and higher B/C than unity (B/C>1.0) in any of the cases prepared for the sensitivity analysis.

16.3 Financial Analysis

16.3.1 General

Financial analysis is, in general, carried out for the projects which generate revenues/income. Unlike the economic analysis, the purpose of financial analysis is to investigate the financial viability of a project comparing the revenues with costs in terms of market prices (financial costs). It is noted that the financial analysis of the Kohat Tunnel Project was carried out only

for the Scenario 1 (north and south sections open together in 2013). The toll revenues are generated from the north section (including the 2nd Tunnel) and the same amount of toll revenues are generated in both Scenarios 1 and 2.

16.3.2 Calculation of Toll Revenues

The toll structure of the existing Kohat Tunnel is presented in Table 16.3.1.

Table 16.3.1 Toll Structure of Existing Kohat Tunnel

Vehicle Type	Toll Level/vehicle
1) Car/Jeep	Rs.20
2) Hiace, F/Coach	Rs.80
3) Bus, 2-axle,3-axle truck	Rs.100
4) Articulated truck	Rs.150

Source: NHA

Toll revenues which will be generated by the future traffic demand are shown in Table 16.3.2.

Table 16.3.2 Forecast Toll Revenue

Year	Toll Revenue (Rs. Million)
2005 (Actual)	131.3
Forecast	
2006	165.9
2013	280.3
2015	316.5
2020	421.5
2025	548.3

Source: Study Team

16.3.3 Financial Evaluation

The financial cash flows are shown in Table 16.3.3. All cost items are expressed in terms of market prices (financial costs) and compared with future toll revenues. The Financial Internal Rate of Return (FIRR) is computed at 4.7%, very low return to cover the total costs including investment cost unless some subsidies are given.

However, Table 16.3.3 shows that the annual Operation and Maintenance (O&M) costs will be sufficiently covered by the annual toll revenues (O&M costs will be about 30-40% of the toll revenues). In addition, the accumulated net surplus (revenue - O&M costs) after five years will reach more than Rs.1.0 billion under the constant price. If the inflation rate goes up more than 11% every year, the net surplus will be lost.

Table 16.3.3 Financial Cash Flow

(North & South 4-Lane Open in the same year 2013)

2006 Constant Price (Rs.Million)

Year	FINANCIAL COST					TOLL	BALANCE			Accumulated
	Construction	Engineering	Administration	O & M	COST	REVENUE				Surplus
2006										
2007										
2008	0.00	64.14	9.41		73.54	0.00	-73.54	1		
2009	0.00	78.43	12.03		90.46	0.00	-90.46	2		
2010	1567.74	114.06	12.03		1693.83	0.00	-1693.83	3		
2011	2091.94	133.12	12.03		2237.09	0.00	-2237.09	4		
2012	2091.94	133.12	12.03		2237.09	0.00	-2237.09	5	(O & M)/R	
2013				111.49	111.49	280.32	168.83	6	39.8%	168.83
2014				111.49	111.49	298.54	187.05	7	37.3%	355.88
2015				111.49	111.49	316.46	204.96	8	35.2%	560.84
2016				111.49	111.49	335.44	223.95	9	33.2%	784.78
2017				111.49	111.49	355.57	244.07	10	31.4%	**1028.86**
2018				111.49	111.49	376.90	265.41	11		
2019				111.49	111.49	399.52	288.02	12		
2020				111.49	111.49	421.49	310.00	13		
2021				111.49	111.49	444.67	333.18	14		
2022				111.49	111.49	469.13	357.64	15		
2023				510.08	510.08	494.93	-15.15	16		
2024				111.49	111.49	522.15	410.66	17		
2025				111.49	111.49	548.26	436.77	18		
2026				111.49	111.49	575.67	464.18	19		
2027				111.49	111.49	604.46	492.96	20		
2028				111.49	111.49	634.68	523.19	21		
2029				111.49	111.49	666.41	554.92	22		
2030				111.49	111.49	696.40	584.91	23		
2031				111.49	111.49	727.74	616.25	24		
2032				111.49	111.49	760.49	649.00	25		
2033				388.83	388.83	794.71	405.88	26		
2034				111.49	111.49	830.47	718.98	27		
2035				111.49	111.49	863.69	752.20	28		
2036				111.49	111.49	898.24	786.75	29		
2037				111.49	111.49	934.17	822.68	30		
2038				111.49	111.49	971.54	860.04	31		
2039				111.49	111.49	1010.40	898.90	32		
2040				111.49	111.49	1050.81	939.32	33		
2041				111.49	111.49	1050.81	939.32	34		
2042				111.49	111.49	1050.81	939.32	35		
Total	5751.63	522.88	57.52	4020.76	10352.78	19384.92	9032.14			

N+S 4-Lane Open in the same year 2013
(Evaluation Period: 2008-2042)

FIRR (%)	4.7%

Source: Study Team

16.4 Impacts of the 2nd Kohat Tunnel

The construction of the 2nd Kohat Tunnel is expected to provide significant impacts in various aspects at both national and regional levels. Major impacts/ indirect benefits that will be generated from the 2nd Kohat Tunnel are summarised below:

(1) Impacts at National Level

The Indus Highway (N-55) is one of important North - South Axes in Pakistan together with the N-5. However, the existing N-55 has only 2 lanes except for a limited 4-lane section in

the south of Peshawar. The Government of Pakistan is now promoting the widening of 2-lane national highways to 4-lane carriageways to strengthen the national road network, especially putting priority on the North - South Axes. The construction of the 2nd Kohat Tunnel and the 4-lane Access Roads will contribute to the formation of a part of the North - South Corridor providing safe/well maintained 4-lane carriageways in such a steep mountainous area difficult to pass for heavy vehicles. In addition, the 2nd Kohat Tunnel as part of the North - South Corridor meets with the concept/vision of the National Trade Corridor (NTC), the strategic framework initiated by the Prime Minister of Pakistan in August 2005, for reducing costs of doing business by raising the trade and transport logistics chains in Pakistan to international service levels. Pakistan (and the Kohat Tunnel as well) is situated at a geographically strategic location to provide links to international trade with Afghanistan and land-locked Central Asian countries to its sea ports. Therefore, the 2nd Kohat Tunnel will contribute to the formation of NTC by increasing Pakistan's transport competitiveness.

(2) Impacts at Regional Level

The existing Kohat Tunnel was opened to public traffic in 2003. As only three years have passed since its opening, the impacts of the first tunnel are still on-going and have not yet been 100% realised at this moment. The expected impacts/effects of the 2nd Kohat Tunnel in addition to the first tunnel at the regional level (Kohat City, NWFP and surrounding provinces) are briefly explained below:

1) Promotion of Regional Economic Development

The construction of the 2nd Kohat Tunnel will increase the accessibility to/from Peshawar, the provincial capital, to/from the border with Afghanistan and to farther provinces such as Punjab. This increase of accessibility will raise the development potential of the region and result in expansion of job opportunities, business and social activities.

As quantitative forecast of indirect and intangible benefits by the 2nd Kohat Tunnel is difficult, alternative impact analyses are presented below referring to actual impacts by the existing Kohat Tunnel. The actual impacts realized by the existing Kohat Tunnel explained below were taken from the results presented in the Report on Post Evaluation Survey carried out by JBIC in 2005.

a) Increase of Accessibility

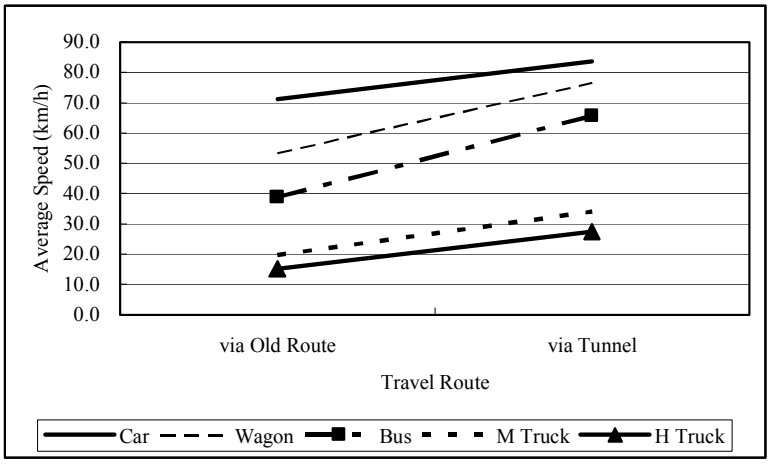
The tables and a figure below show the actual increase of accessibility realized by the existing Kohat Tunnel. Remarkable increase of travel speed is observed in the case of trucks with speed changes from around 15-20 km/hour to around 30 km/hour by using the tunnel route. The travel time of trucks is reduced by about 50-70 minutes.

The travel speed of vehicles on the existing 2-lane tunnel and 2-lane access roads will decrease as the traffic volume increases in future. The 2nd Kohat Tunnel and 4-lane access roads can maintain the high service level providing road users with a smoother route.

Table 16.4.1 Increase of Travel Speed

Vehicle Type	Average Speed by Travel Route (km/h)		Rate of Speed up (%)
	Old Route (N-55)	Tunnel/Access	
Passenger Car	71.0 km/h	83.5 km/h	17.6 %
Wagon	53.3 km/h	76.5 km/h	43.5 %
Bus	38.7 km/h	65.6 km/h	69.5 %
Medium Truck	19.7 km/h	34.0 km/h	72.6 %
Heavy Truck	15.1 km/h	27.4 km/h	81.5 %

Source: Report of the Post Evaluation Survey, JBIC. 2005



Original Source: Report of the Post Evaluation Survey, JBIC, 2005

Figure 16.4.2 Savings in Travel Time

Vehicle Type	Travel Time by Route (minutes)		Rate of Saving (%)	Saved Time (minutes)
	Old Route(N-55)	Tunnel/Access		
Passenger Car	30	22	26.7 %	8
Wagon	40	24	40.0 %	16
Bus	55	28	49.1 %	27
Medium Truck	108	54	50.0 %	54
Heavy Truck	141	67	52.5 %	74

Source: Report of the Post Evaluation Survey, JBIC, 2005

b) Wide Impact Area of the Existing Kohat Tunnel

According to the results of interview survey on drivers (105 samples), almost all vehicles (99%) interviewed were using the tunnel for the business/commercial purpose. In addition, about 40% of them made trips between Kohat and Peshawar and 44% of trips were to/from other provinces. Therefore, the impact of the tunnel spreads over a quite wide area covering not only Peshawar but also outside NWFP, promoting economic activities in the area. The capacity expansion by the 2nd Kohat Tunnel and the 4-lane access roads will accelerate these effects.

c) Expansion of Job Opportunities and Increase of Income

The unemployment rates in NWFP and the Kohat district were 26.8 % and 38.4 % respectively in 2002 ("Socio-economic Indicators at District Level NWFP", Federal Bureau of Statistics, 2002). Under this situation, increasing the job opportunities is actually demanded in NWFP and the Kohat district. The results of above interviews of drivers using the existing tunnel revealed that 62% of them got higher income by the effects of the tunnel (this may be the results of fuel cost savings and increased number of trips). Furthermore, although limited effects, more than 70% of staff for the maintenance works of the existing tunnel are recruited from local people in the Kohat district providing continuous job opportunities. As the 2nd Kohat Tunnel and 4-lane access roads will require more maintenance works, additional employments will be created for the local people.

d) Savings in Freight Value of Perishables (Fresh Fruits and Vegetables)

At present, about 500 trucks are operating and handling goods in the Peshawar fruit and vegetable market, of which about 50% of trucks are arriving and departing through the existing Kohat Tunnel. After the opening of the existing Kohat Tunnel, there have been no delays in arrival of goods and the quality of fresh fruits/vegetables has been maintained, and the handled volumes have increased as well (information from a person in charge of the market). This will result in increase of income of local farmers who are producing perishable

fruits and vegetables. The 2nd Kohat Tunnel will enhance this kind of benefit by keeping/upgrading the road conditions at a high service level.

2) Better Services of Public Transport

The possibility to provide new bus services via the tunnel under operation with reliable time schedule and frequent services will be enhanced by the 2nd Kohat Tunnel. In that case, regional people who have no private cars can expand their daily activities in commuting and attending schools in Peshawar and in other areas.

According to the above Post Evaluation Survey, a bus company that has a bus terminal in Peshawar started new operations via the Kohat Tunnel (5 round trips per day) from September 2005. The 2nd Kohat Tunnel and 4-lane access roads will provide bus companies with incentive to expand their services via the Tunnel.

3) Accessibility to Medical Services and other Public Facilities

There are only 7 hospitals in the Kohat District at present (2002).

With the construction of the 2nd Kohat Tunnel, patients in emergency can be sent more quickly to hospitals that are more qualified and have better medical facilities in Peshawar.

Finally, it should be emphasised that without the 2nd Kohat Tunnel, the functions of the National Highway N-55 will not be maintained and the expected positive impacts on the regional/national economy explained above will be reduced or lost.

(3) Baseline Data Necessary for Impact Analyses

The impact analysis of the existing Kohat Tunnel is based on the very limited baseline data obtained mainly from the interviews of residents and tunnel users in the Post Evaluation Survey. The baseline data collected in the survey and from other sources are summarised below:

Table 16.4.3 Baseline Data for Impact Analysis

Item	Data/Information	Note
1) Traffic volume	5,463/day (2004), 6,149/day (2005)	Actual
2) Travel time	22 minutes (car), 67 minutes (H. truck)	From start to end point
3) Vehicle Operating Cost (VOC)	Tunnel : 3.25 R/km (car), 13.0 R/km (H.truck) N-55: 4.75R/km (car), 26.5 R/km (H.truck)	In 2005 prices
4) Traffic accidents per year	(2004) (2005) Tunnel section: 0 0 Access Roads: 24 42	From NHA
5) Socio-economy - Population (2002) - Unemployment Rate - No. of Hospitals	 NWFP: 17,744,000, Kohat : 563,000 NWFP : 26.8% Kohat : 38.4% NWFP : 123 Kohat : 7	Source: Federal Bureau of Statistics

Source: Original Source: Report of the Post Evaluation Survey, JBIC, 2005

For the purpose of evaluating the 2nd Kohat Tunnel, it is necessary to continue additional data collection.

16.5 Contribution of the 2nd Kohat Tunnel to Solving the Road Sector Issues/Problems

In the PTPS (Master Plan), the issues and problems in the road sector were identified, and based on established policies and strategies, the action plans were formulated. As a result, the 2nd Kohat Tunnel and Access Roads Project was listed as one of the priority projects, of which process is shown in Figure 16.5.1. The 2nd Kohat Tunnel is expected to contribute to solving some road sector issues and problems that are marked with "*" in the figure below.

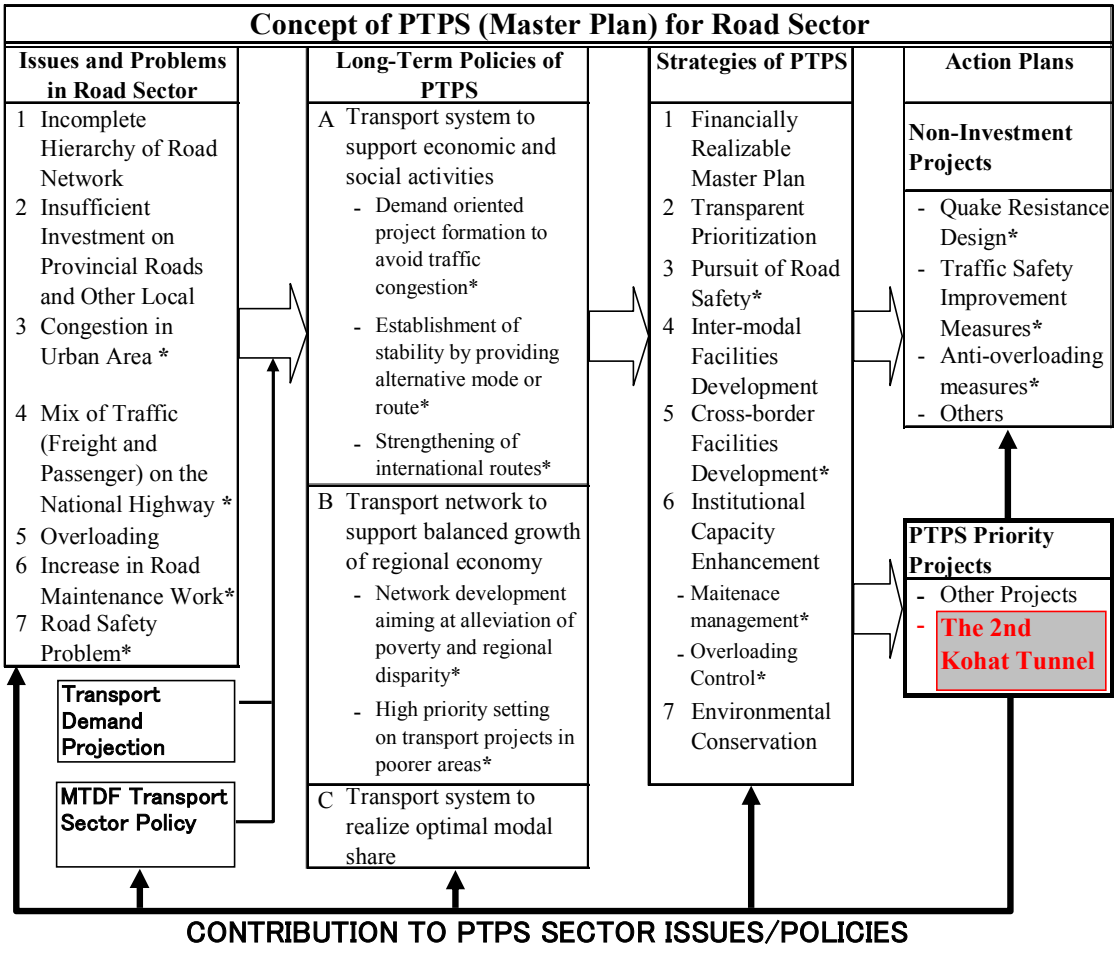


Figure 16.5.1 Contribution of the 2nd Kohat Tunnel to PTPS (Master Plan) Road Sector

(1) Reduction of Overburden on National Highway N-5

The National Highways N-5 and N-55 (Indus Highway) on the north-south axis are the major trunk road transport corridors in Pakistan. Substantial traffic is on N-5 and it has almost been improved to a dual carriageway road. N-55 is an alternative and short cut route in distance between Karachi and Peshawar. The existing N-55 is a 2-lane road, except for the 30km section near Peshawar, and NHA has worked out a plan to improve this route to a dual carriageway (4-lane road).

The 2nd Kohat Tunnel and Access Roads constitute a part of the Indus Highway carriageway plan. The Project will contribute to establishing an alternative route for N-55. The Project will also contribute to reducing congestions along Rawalpindi, Lahore, and other major cities/towns along N-55. The dual carriageway program will be also useful for solving mixed traffic (freight and passenger) on the national highway as heavy vehicles use the left lane and

light vehicles use the right lane in accordance with traffic regulations.

(2) Strengthening International Routes (Cross-border Facilities)

Pakistan has several thousand kilometres of land borders with its neighbouring countries: Iran, Afghanistan, China, and India. Beyond these countries Pakistan could act as a major transhipment route for the land locked countries of central Asia. Pakistan has been implementing the National Trade Corridor (NTC) program to facilitate international trades for those land rocked countries. The two Karachi ports are linked to Torkham (Afghanistan) through N-5 and/or N-55. The Project, as a part of N-55, will contribute to strengthening international routes (cross-border facilities).

(3) Balanced Growth of Regional Economy and Poverty Reduction

Pakistan has two dominant corridors of development: one is the north-south corridor along the Indus basin from Karachi to Lahore/Rawalpindi/Islamabad and the other is the east-west corridor from Lahore to Peshawar via Rawalpindi/Islamabad. Economic activities and population are concentrated along these corridors and significant economic disparity is observed between the corridors and other areas.

Beside this regional disparity, there is an income gap between urban and rural areas. The poverty ratio is much higher in rural areas than in urban areas. As poverty alleviation is one of the most important policies of the Pakistani Government and international donors, proper consideration should be paid to the projects in and around relatively poorer area in addition to economic viability.

N-55 passes through relatively poorer areas including NWFP. It also connects to Quetta (Balochistan) through N-65, N-70 and N-50. The Project will contribute to balanced growth and poverty reduction in the western part, which is relatively less-developed and poorer, of Pakistan.

(4) Overload Control

The slow driving speed of heavy vehicles due to overloading greatly influences that of all other vehicles on the 2-lane road. Overloading also causes earlier pavement failure. Therefore, the overloading control is one of the priority programs in MTDF and PTPS on the aspects of traffic capacity management, asset management and road facility sustainability.

The Kohat Operation and Maintenance Office started overloading control utilizing weigh bridges at the Main Toll Plaza in July 2006 in accordance with the National Highways Safety Ordinance 2000. An introduced computer-assisted system is efficient and transparent. The overloading control will be further strengthened through implementation of the 2nd Kohat Tunnel Project and education of road users and vehicle owners. As there are no advantageous escape roads for through traffic (heavy vehicles) on N-55, the current weigh station and overload control will contribute to reducing overloaded vehicles through this route. This computer controlled system is envisaged to expand to other routes including N-5 and contribute to nationwide overload vehicle control.

(5) Road Maintenance

Operation and maintenance of the Kohat Tunnel are carried out by a private company under contract with NHA. The operation and maintenance works are under the supervision of the Chief Operating Officer of NHA stationed in the Kohat Administration Office. The current operation and maintenance system is working well as evaluated in Table 5.3.5 in Chapter 5. The toll fees collected are sufficient to cover the operation and maintenance cost of the tunnel. NHA has also maintained the access roads appropriately with yearly budget allocated by the head office.

This is one of the new schemes using a private company for national highway maintenance

like a BOT scheme for Motorways. This method is envisaged as a model case for recovering the maintenance costs from road users.

(6) Road Safety

The following Table 16.5.1 indicates accidents and vehicle failures in the existing Kohat Tunnel and Access Roads since their opening to public traffic.

Table 16.5.1 Accidents and Vehicle Failures in the 1st Kohat Tunnel and Access Roads

Category	Section	2003 (Jul-Dec)	2004	2005
Annual Traffic	Tunnel Section	707,559	1,999,519	2,247,894
Accidents	Inside Tunnel	0	0	0
	Outside Tunnel*	7	24	42
	(% to Yearly Traffic)	0.0010	0.0012	0.0019
Breakdown	Inside Tunnel	112	370	430
	(% to Yearly Traffic)	0.0158	0.0185	0.0191

Note: *Approach Roads
Source: NHA

Fortunately no traffic accidents happened inside the tunnel since its opening though it accommodates a 2-way traffic. The reason is slow driving speed forced by heavy vehicle speed in the tunnel as overtaking is not allowed. However, there is a risk of serious accident because of the 2-way traffic. The 2nd Tunnel is planned for one-way carriageway, therefore such risk will be reduced substantially. Evacuation tunnels connected between the 1st and 2nd tunnels will be used in case of serious accidents or fire. However, it would be still necessary to control overtaking in the tunnel as the driving speed of light vehicles will increase from current 15 km/hour to 60 km/hour.

The above table shows that accidents on the approach roads have increased yearly. An accident analysis should be conducted to identify causes and find countermeasures. Meanwhile, Clothoid curves are applied for the tunnel south section to provide user friendly road facilities as one of the 1st cases in Pakistan. Clothoid curve application in road design is envisaged to be a standard method to prevent accidents.

(7) Other Contributions

Other contributions expected through the implementation of the Project are as follows:

- Revision of quake resistance structure (bridge) design based on the new seismic force/zone of NHA after the earthquake of October 8, 2005.
- Sustainable pavement design and construction to minimize serious rutting and earlier failure.
- The demand for tunnel construction is expected to increase in future because about a half of Pakistan is located in steep mountainous typography. The Kohat Tunnel was the 1st road tunnel constructed in Pakistan. As the tunnel technology is still premature, the implementation of the 2nd Kohat Tunnel will provide technology transfer in tunnel engineering.

16.6 Conclusions

The implementation of the Project is economically feasible with an EIRR of 16% - 17%. The results of sensitivity analysis also showed the robustness of feasibility of the Project. In the analysis, two scenarios were prepared for the evaluation and the Scenario 2 (Stagewise construction of the south access road) indicates a higher EIRR than Scenario 1. However, there is no significant difference between the two scenarios (EIRRs of Scenario 1 and 2 are 16.6% and 17.3% respectively).

The results of financial analysis indicated a quite low return with a FIRR of 4.7%, implying that the investment cost cannot be covered by the future toll revenue. However, the annual operation and maintenance costs will be sufficiently covered by the toll revenues.

In addition to the sufficient direct benefits, the 2nd Kohat Tunnel will generate great positive impacts at both national and regional levels. At the same time, the Project will contribute to solving the issues/ problems of the road sector in Pakistan. Therefore, it is necessary to promote the construction of the 2nd Kohat Tunnel at an early date.

Chapter 17. Project Implementation Plan

17.1 Implementation Plan for the Project

17.1.1 General

The 1st Kohat Tunnel and Access Roads between Kohat Toi and Dara Adam Khel were constructed with financial assistance of JBIC. The procurement of the Consultant and the Contractor was typically in accordance with the JBIC guidelines. Though the financial source of construction for the 2nd Kohat Tunnel has not been defined yet, it can be assumed that a similar implementation system as the 1st Kohat Tunnel would be employed.

17.1.2 Executing Agency

NHA under the Ministry of Communication will be the executing agency responsible for construction and operation/maintenance of the Project.

In the detailed design and construction stage, a project management unit will be established in NHA, headed by a Project Director. The project management unit will represent NHA and act as the Employer of the Project.

As mentioned in Chapter 12, it is assumed that the operation and maintenance of the 2nd Kohat Tunnel will be carried out by expanding the present system for the 1st Kohat Tunnel. The Chief Operating Officer of NHA will be responsible for controlling the operation and maintenance works to be carried out by the Management Contractor & Operation (MC&O).

17.1.3 Expected Financial Source

Considering the budgetary constraint of NHA, it is assumed that the Project will be implemented with foreign financial assistance similarly to the other highway network development projects in Pakistan, undoubtedly with JBIC who financed the construction of the 1st Kohat Tunnel being one of the most possible sources.

Recognising the urgency of the Project, given the situation that the tunnel traffic is approaching the capacity of the 1st Kohat Tunnel, the Pakistani Government should start defining a possible donor agency/country and apply for financial assistance for the Project as early as possible based on this Feasibility Study.

17.2 Considerations on Construction Phasing

At present, the Indus Highway (N55) is a 2-lane highway, with a limited 4-lane section in the south of Peshawar (refer to Figure 19.1.1). The Pakistani Government has a plan to upgrade the N55 to a 4-lane highway, by widening or constructing two additional carriageways over its entire length between Kotri and Peshawar. Currently, additional carriageway construction for three sections: Sehwan - Rotodero (200 km), Ratodero - Shikarpur (44 km) and Malana Junction - Sarai Gambila (117 km) has been proposed to ADB and Japan for financial assistance. The remaining 2-lane sections will be upgraded to 4-lane one after another (refer to Chapter 3).

The need to upgrade the Indus Highway to a 4-lane highway is further heightened under the National Trade Corridor (NTC) implementation program, recently formulated with a vision to enhance Pakistan's transport competitiveness, to promote regional trade and cooperation with Afghanistan and land-locked Central Asian Republics, and to make Pakistan a transit hub in the region, by making full use of the Pakistan's ideal location and its ports potential.

The highway sector improvement program to increase the road network capacity will represent a major share of the investment program to support NTC. Under the NTC implementation program, NHA has finalized the route plan of NTC from Karachi to Torkhum that has been approved by the Prime Minister. The route plan includes construction of additional carriageways to convert the existing 2-lane Indus Highway to a 4-lane highway for the Dadu - Ratodero - Shikarpur section.

The implementation of the 2nd Kohat Tunnel and Access Roads construction is along the line of conversion of the Indus Highway to a 4-lane highway.

As discussed in Chapter 7, it is forecast that the traffic in the North Section (15.2 km) between the Kohat Link Road IC and Dara Adam Khel, including the 1st Kohat Tunnel, is approaching the capacity, and the construction of two additional lanes is urgently required, while the traffic in the South Section (15.0 km) between Kohat Toi and the Kohat Link Road IC is still within the capacity. This situation is illustrated in Table 17.2.1.

Table 17.2.1 Capacity of the 1st Kohat Tunnel and Access Roads

Year	Annual Growth Rate (%)	South Section (Kohat Toi - Kohat Link Road IC)				North Section (Link Road IC - Dara Adam Khel) L=15.2km including 2nd Kohat Tunnel		
		Kohat Toi - N80: L=9.6km		N80 - Link Road IC: L=5.4km				
		AADT (veh/day)	LOS of Access Road	AADT (veh/ day)	LOS of Access Road	AADT (veh/ day)	LOS of Tunnel Section	LOS of Access Road
2006-07		4,647	B	5,887	B	7,366	D	C
2007-08	10.0	5,112		6,476	C	8,103		
2008-09	9.0	5,572		7,059		8,832		
2009-10	8.0	6,017	C	7,623		9,538		D
2010-11	7.5	6,469		8,195		10,254		
2011-12	7.0	6,922		8,769		10,972		
2012-13	6.5	7,372		9,339		11,685		
2013-14	6.5	7,851		9,946	D	12,444	E	
2014-15	6.5	8,361		10,592		13,253		
2015-16	6.0	8,863		11,228		14,048		E
2016-17	6.0	9,394		11,901		14,891		
2017-18	6.0	9,958	D	12,615		15,785		
2018-19	6.0	10,556		13,372		16,732		
2019-20	6.0	11,189		14,174		17,736		
2020-21	5.5	11,804		14,954	E	18,711		
2021-22	5.5	12,453		15,777		19,740		
2022-23	5.5	13,138		16,644		20,826	F	
2023-24	5.5	13,861		17,560		21,971		
2024-25	5.5	14,623		18,525		23,180		F
2025-26	5.0	15,355	E	19,452		24,339		

Note: 1. Peak hour traffic/daily traffic = 7.06%
2. PHF (Peak Hour Factor) of peak hour = 0.87

As discussed in the next section, the 2nd Kohat Tunnel would be opened at the beginning of 2013 at the earliest, even a quick decision is made by the Pakistani Government to implement it with high priority.

At that time, the 1st Kohat Tunnel will be in Level of Service (LOS) E operation, i.e. operation in capacity, and the access road of the North Section (Kohat Link Road IC - Dara Adam Khel) in LOS D at which traffic flow becomes unstable, freedom to manoeuvre within the traffic stream is noticeably limited, and even minor incidents can create queuing.

The operation of the South Section will be at LOS C in 2013. However, considering that its northern part (N80 - Kohat Link Road IC) will reach LOS D shortly, and the southern part (Kohat Toi - N80) in 4-5 years after completion of the 2nd Kohat Tunnel, there is no strong reason to postpone the construction of the South Section stagewise separately from the North Section, other than that the related investment can be postponed for several years.

As analysed in Chapter 16, stage-wise construction will increase the EIRR, but the increment is so small as to be negligible (0.7% only).

Therefore, it is recommended to construct the 2nd Kohat Tunnel and the entire length of the access road between Kohat Toi and Dara Adam Khel at once.

Avoidance of twice tendering process will be an associated merit of the simultaneous construction. The engineering services cost and the NHA's administration cost also will be optimized.

17.3 Implementation Schedule

17.3.1 Before Commencement of Construction

After completion of this feasibility study, several steps need to be cleared before commencement of construction. It is noted that land acquisition and compensation are not required for the construction of the 2nd Kohat tunnel because the necessary land for the additional 2-lane construction was already secured along the entire stretch of the Project including the North and South Access Roads. The Project escapes from this normally difficult and time consuming process.

(1) Project screening by the Pakistani government

The project will be submitted by NHA/MOC to the higher committee with high priority, for review and approval for application to the appropriate donor agency/country. The time required for this procedure depends on the official procedure of the Pakistani Government. It is assumed to take at least three months for this step.

(2) Application for external financial assistance

The Pakistani Government will apply to the appropriate donor agency/country for financial assistance for the Project implementation.

(3) Conclusion of external financial assistance

This procedure normally starts from receiving a fact-finding mission from the donor agency/country, followed by dialogue between the Pakistani Government and the donor agency/country and receiving the appraisal mission. After the appraisal is successfully completed, financial assistance will be pledged and the loan agreement be concluded.

This is a lengthy step which normally takes nearly a year.

(4) Selection of the Consultant

The Consultant who will prepare the detailed design and tender documents, assist NHA in tendering, and provide construction supervision, will be selected in accordance with the guideline of the donor agency. Normally the selection of the Consultant will be through international competitive bidding. The time required for this step would be six months including the time required for approval process by the Pakistani authorities and the donor agency.

(5) Detailed design and tender documents

The Consultant will carry out the detailed design and prepare the tender documents for procurement of the Contractor for construction of the Project. The tasks will include review of the feasibility study recommendations, detailed topographic survey and geotechnical investigations, detailed design of tunnel civil and electrical and mechanical (E&M) works and the access roads, preparation of the tender documents and the Engineer's cost estimate. Nine months would be required for this step.

(6) Procurement of the Contractor

The Contractor will be procured through international competitive bidding in accordance with the guideline of the donor agency. For the projects of this type and scale, the selection will be made through separate pre-qualification and tendering among the pre-qualified tenderers. As same as the 1st Kohat Tunnel, one contract package involving all civil and E&M works will be formulated.

This step involves pre-qualification, pre-qualification evaluation, tender including replies to the bidders' questionnaires and preparation of addenda to the tender documents, tender opening and tender evaluation, contract negotiation and signing of the contract, and the approval process by the Pakistani authorities and the donor agency. The time required for this step would be 10 months. A part of prequalification could be overlapped with the step (5) above.

17.3.2 Construction

After signing of the contract, the construction will be started. The construction period is estimated at 36 months for the North Section (north of the Kohat Link Road IC) including the 2nd Kohat Tunnel, and 24 months for the South Section.

17.3.3 Implementation Schedule

The Project implementation schedule is shown in Figure 17.3.1. The estimated time of opening of the 2nd Kohat Tunnel is at the earliest at the beginning of 2013. According to the traffic forecast and capacity analysis discussed in Chapter 7, the tunnel traffic should have reached the capacity of the 1st Kohat Tunnel before the above opening year. Therefore, it is strongly recommended to send the Project to the screening process in the Pakistani Government and expedite the application for financial assistance to appropriate donor agency/country, soon after the completion of this feasibility study.

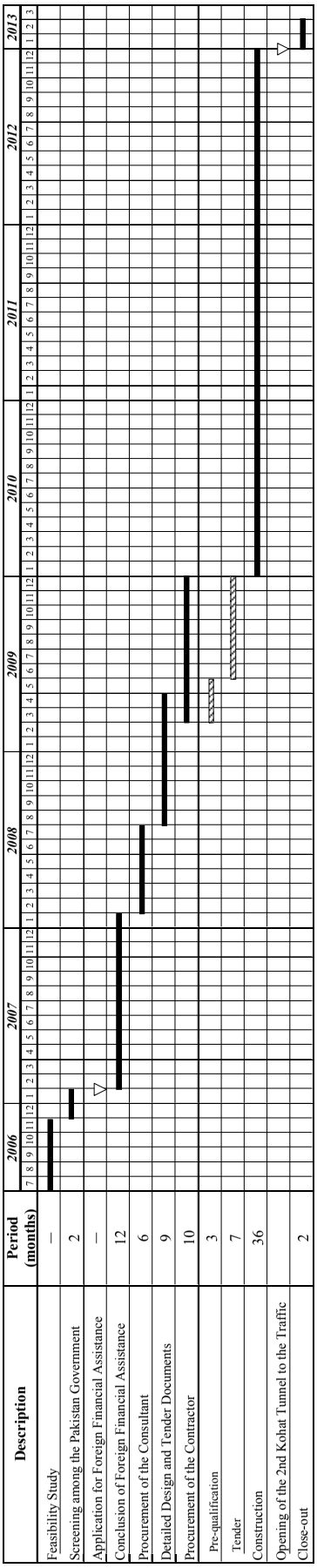


Figure 17.3.1 Implementation Schedule

17.4 Annual Fund Requirements

Based on the construction cost estimated in Chapter 15, and the implementation schedule, the annual fund requirements for construction of the Project are estimated as shown in Table 17.4.1.

Table 17.4.1 Annual Fund Requirements

Item		2008	2009	2010	2011	2012	Total
Foreign Currency Portion (US$ 1,000)							
1. Construction Cost (2006 price)				16,628	22,187	22,187	61,002
2. Price Escalation	0.0% p.a.			0	0	0	0
3. Physical Contingency	(1+2) x 10%			1,663	2,219	2,219	6,101
4. Constructiion Cost Total	1+2+3			18,291	24,406	24,406	67,103
5. Engineering Services		980	980	1,247	1,664	1,664	6,535
6. F.C. Portion Total	4+5	980	980	19,538	26,070	26,070	73,638
Local Currency Portion (Rs.1,000)							0
A. Construction Cost (2006 price)				427,543	570,547	570,545	1,568,635
B. Price Escalation	6.0% p.a.			112,220	192,974	238,784	543,978
C. Physical Contingency	(A+B) x 10%			53,976	76,352	80,933	211,261
D. Constructiion Cost Total	A+B+C			593,739	839,873	890,262	2,323,874
E. Engineering Services		19,632	19,631	24,946	33,284	33,283	130,776
F. Administration		784	784	15,250	20,349	20,349	57,516
G. L.C. Portion Total	D+E+F	20,416	20,415	633,935	893,506	943,894	2,512,166
Total (US$ 1,000)	6+G	1,320	1,320	30,104	40,962	41,802	115,508

Note: Exchange Rate: US$1.00 = Rs. 60.0
Assumed Foreign Currency Portion:
For Construction Cost: 70%
For Engineering Services: 75%
Assumed Price Escalation:
Foreign Currency Portion: 0.0% p.a
Local Currency Portion: 6.0% p.a

Chapter 18. Conclusions and Recommendations

The Final Report of PTPS Master Plan Study was submitted in March 2006. In that report, the 2nd Kohat Tunnel Construction Project was recommended as one of the priority projects to be selected for the next Medium Term Development Framework (MTDF), or in parallel with the current MTDF, in view of their contribution to national economy, alleviation of traffic congestion, and safety improvement.

18.1 Condition of the Existing Kohat Tunnel and Access Road

The existing tunnel (1st Kohat Tunnel) and both access roads were completed and became operational in June 2003. Up to now, no accident has been recorded in the tunnel by severe vehicle checking by NHA monitoring and management agency. The traffic volume at the Kohat Tunnel increased by 12.4% from 2004 to 2005. For the period from January to May, the increase rate was 21.8% from 2005 (Jan-May) to 2006 (Jan-May).

The existing tunnel was constructed as a 2-lane (single carriageway road) at 2.2% up grade to the north. The design speed of the Kohat Tunnel is 60 km/hour. Vehicle running speed has been controlled at 40 km/hour and overtaking is not allowed in the tunnel for safety reason. However, the actual travel speed is 16.7 km/hour and it takes 7-8 minutes for the northbound traffic forming platoons behind slow-moving trucks, which cannot be broken up since passing maneuvers are not possible. The travel speed for the south bound traffic is 30.9 km/hour, that is less than the controlled speed, even though it is a down-grade traffic.

Taking the above situation into consideration, the feasibility study of 2nd Kohat Tunnel Construction Project was selected by JICA as the most appropriate priority project in view of its urgency, technical complexity, and the fact that the 1st Kohat Tunnel is named as the Pakistan-Japan friendship tunnel.

The feasibility study was commenced from the end of April 2006. Hereinafter, major conclusions and recommendations of the study are introduced.

18.2 Traffic Analysis

The current traffic passing through the Kohat Tunnel is 7,370 veh/day and it will continue to increase at a high percentage. The future traffic volume was forecast based on the analysis of the PTPS traffic survey, NHA's toll collection data, and supplemental traffic surveys carried out in the study. The future tunnel traffic is estimated to be 14,050 veh/day in 2015 and 24,340 veh/day in 2025.

The capacity analysis based on Highway Capacity Manual (Transportation Research Board, National Research Council, USA) revealed that the level of service of the existing Kohat Tunnel is already LOS of "D" level at the peak hour, and will experience a LOS of "E" level within a few years.

The traffic on the Access Road in the south of the Kohat Link Road IC, located 4.6 km south of the tunnel (nearly the mid point of the entire Project length), will be 80% of the tunnel traffic and experience a LOS of "D" level in 2013.

18.3 Preliminary Design

(1) Access Road

A new 2-lane access road is designed beside the existing 2-lane access road within the already acquired ROW. The northern access road is 7,780 m long and southern access road 20,607 m long.

In the design of the southern access road, transition curves are employed in its horizontal

alignment. Four intersections and ten bridges are planned.

(2) Tunnel

The location of the south portal is shifted from the original plan proposed in the design stage of the 1st tunnel, to 40 m westward from the economical and technical viewpoints. The distance between the two tunnels will be 30 m centre-to-centre. The location of the north portal is the same as in the original plan. It is proposed to lower the elevation of the south portal for technical reasons. As a result, the grade of the 2nd tunnel will be 2.4%, 0.2% steeper than the 1st tunnel. Since the 2nd tunnel will be used for the southbound traffic in down grade, this grade will not affect traffic flow and safety.

The same tunnel opening and cross section as the 1st tunnel are adopted.

(3) Tunnel Facility Works

For the tunnel facilities such as ventilation, lighting, power supply and emergency facilities, the same systems employed in the 1st tunnel will be adopted from economical and easy maintenance viewpoints.

Since the planned tunnel portal will be located just behind the existing control room, it is necessary to relocate the existing control room and substation prior to starting tunnel excavation.

Two tunnels will be connected by two cross passages, which will be used for evacuation of tunnel users in case of accidents in the tunnels.

18.4 Environmental Study

The results of IEE showed no expected major environmental impacts. Moreover, there do not appear to be any resettlement issues as the necessary ROW has already been acquired by NHA. However, this Project would require a full scale EIA based on the EIA law in Pakistan. NHA has to start EIA procedures by discussing on this with NWFP EPA.

18.5 Construction Plan and O&M Plan

As the tunnel construction work is on the critical path in the construction schedule, the plan of tunnel excavation from both portals is recommended. The New Austrian Tunnelling Method (NATM) will be applied for tunnel excavation and support. For the widening of the access road, the method of hard rock excavation while keeping traffic on the existing access road was examined. Excavation in association with controlled blasting and a hydraulic breaker is recommended.

A construction period of three years is considered to be most realistic and reasonable. Due to the technical complexity of the Project, construction works are recommended to be conducted by a qualified international contractor.

NHA has contracted the operation and maintenance of the 1st Kohat Tunnel and Access Roads to a private company as Maintenance Contractor & Operator (MC&O) since its opening in May 2003 under overall supervision of NHA. As the current operation and maintenance system has worked well, the present system of operation and maintenance will be applied and only the scope of works of MC&O will be expanded to cover both tunnels.

18.6 Cost Estimate

On the basis of the preliminary design and established unit prices, the project cost was estimated at approximately 6,332 million Pakistan rupees using ICB conditions at mid 2006 price level. At the same time, the future operation and maintenance cost was estimated based on the operation record of the existing tunnel.

18.7 Project Evaluation

Economic evaluation was made by the conventional discounted cash flow methodology, and EIRR of the Project was confirmed to be 16.6%. The major economic benefits quantified are vehicle operation cost saving and travel time saving. The results of sensitivity analysis also showed the robustness of feasibility of the Project.

Financial evaluation was carried out based on the project revenue using the current toll rates of the existing tunnel. The result shows a FIRR of 4.7%. The investment cost cannot be covered by the future toll revenue. However, the annual operation and maintenance costs will be sufficiently covered by the toll revenue.

These results indicated that the Project is feasible and sustainable.

18.8 Project Implementation Plan

The need to upgrade the Indus Highway to a 4-lane highway is further heightened under the National Trade Corridor program. A stagewise construction scheme of the Project (postponing the construction of the section in the south of the Kohat Link Road IC) was examined to attain higher EIRR, but the increment is so small as to be negligible (0.7% only).

Therefore, it is recommended to construct the 2nd Kohat Tunnel and Access Roads from Kohat Toi (start point) to Dara Adam Khel (end point) at once.

The implementation schedule is prepared on the basis that the Project will be implemented with foreign financial assistance. The estimated time of opening of the 2nd Kohat Tunnel is at the beginning of 2013 at the earliest.

18.9 Recommendation

(1) Construction of the 2nd Kohat Tunnel is viable from the macro-economic perspective. It will contribute to the development of the regional economy as well as the national economy and have great significance in terms of developing a part of the National Trade Corridor. Moreover, at the earliest possible opening of the 2nd Kohat Tunnel in 2013, the tunnel traffic should have reached the capacity of the 1st Kohat Tunnel. Therefore, the Project should be an urgent project to be implemented at the earliest opportunity.

(2) NHA should prepare the EIA and receive Environmental Clearance from the EPA of NWFP. NHA/MOC should send this Project to the screening process in the Pakistani Government and expedite the application for financial assistance to appropriate donor agency/country, as soon as this feasibility study is completed. Since the 1st Kohat Tunnel and Access Roads Project was financed by JBIC, JBIC will be one of the most possible sources.

(3) Fortunately, no major accident has ever occurred in the Kohat Tunnel since its opening, however, the Pakistani Government should continue to take the following actions to keep and ensure smooth and safe highway operation.

- to reinforce control systems to eliminate truck overloading; and
- to establish education systems for drivers to keep safe driving with good driving manners.