JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

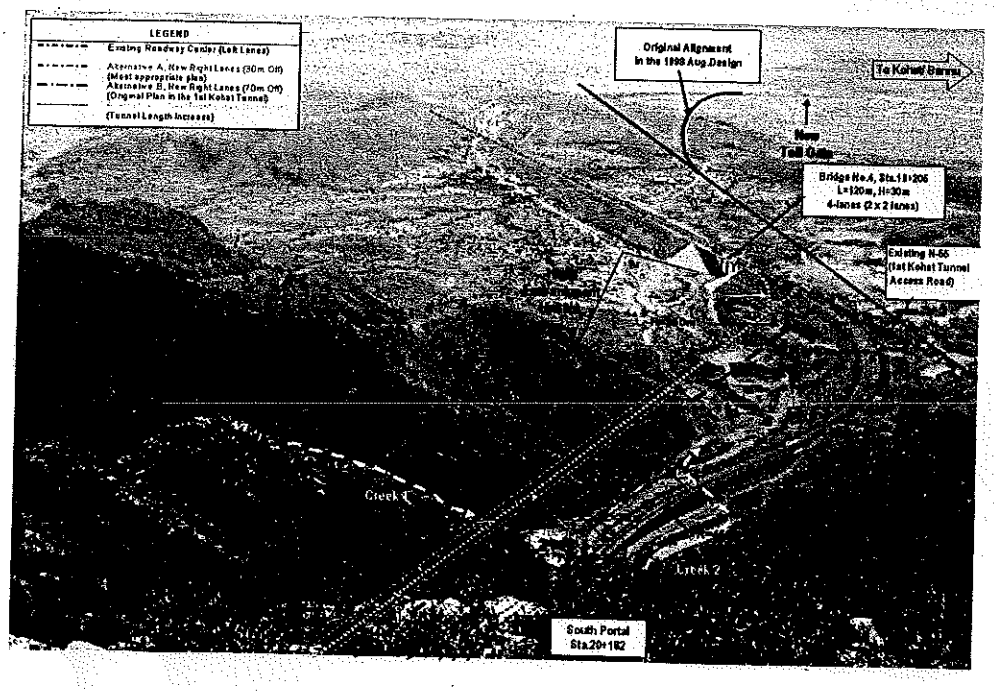
MINISTRY OF COMMUNCIATIONS
NATIONAL TRANSPORT RESERCH CENTRE
NATIONAL HIGHWAY AUTHORITY
GOVERNMENT OF THE ISLAMIC REPUBLIC OF PAKISTAN

PAKISTAN TRASPORT PLAN STUDY (PTPS)
PHASE II

TECHNICAL PRESENTAION 2
ON
THE FEASIBILITY STUDY
ON THE SECOND KOHAT TUNNEL AND ACCESS ROAD PROJECT

Presentation Texts on

1. Progress of the FS Study / Traffic Forecast/Highway Capacity
2. Highway and Pavement Design
3. Tunnel Geology
4. Tunnel Design
5. Tunnel Facilities



JULY 2006

JICA STUDY TEAM

SECOND TECHNICAL PRESENTATION ON FEASIBILITY STUDY OF CONSTRUCTION OF 2 KOHAT TUNNEL PROGRAM

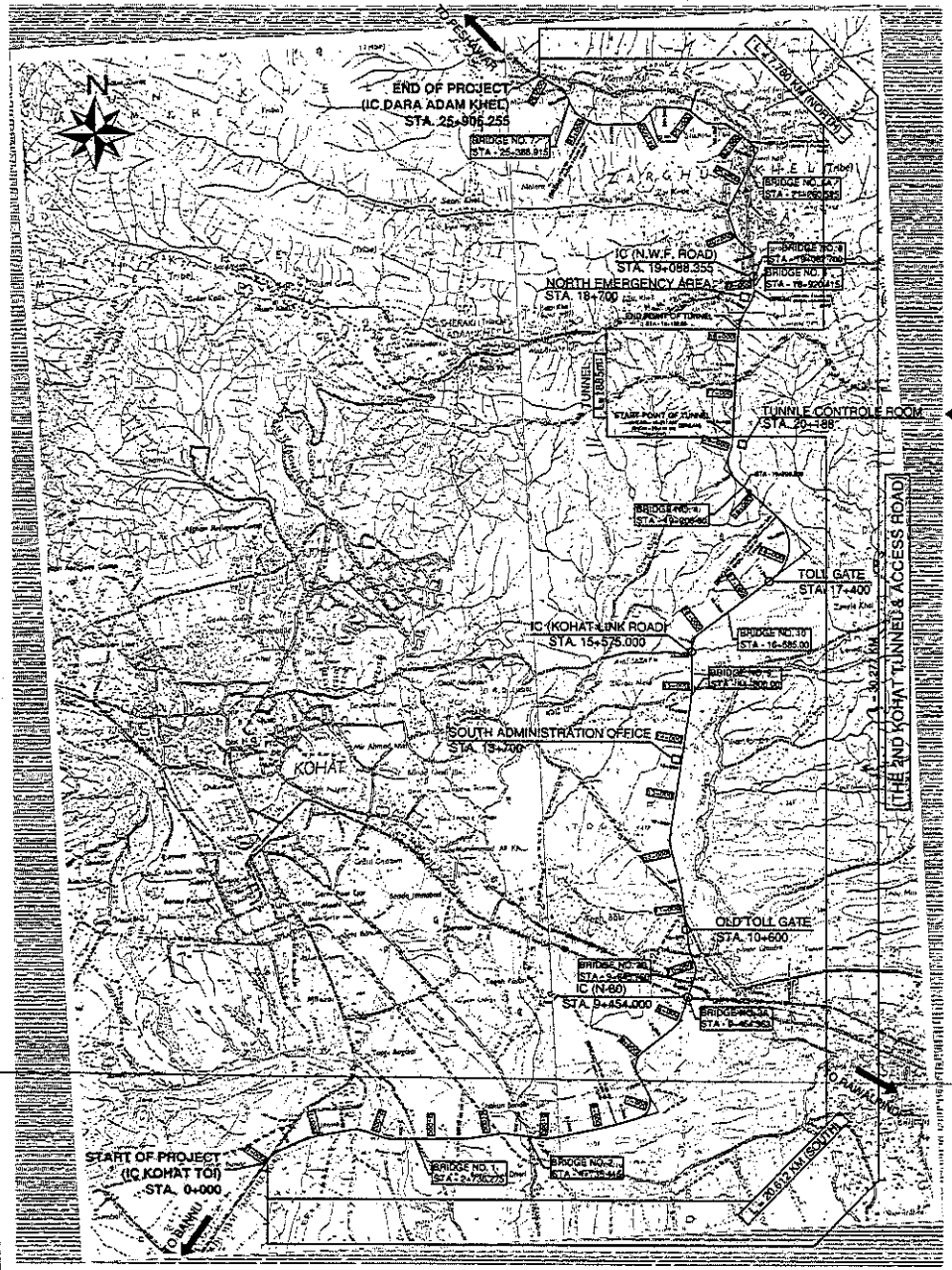
Date 6th July 2006

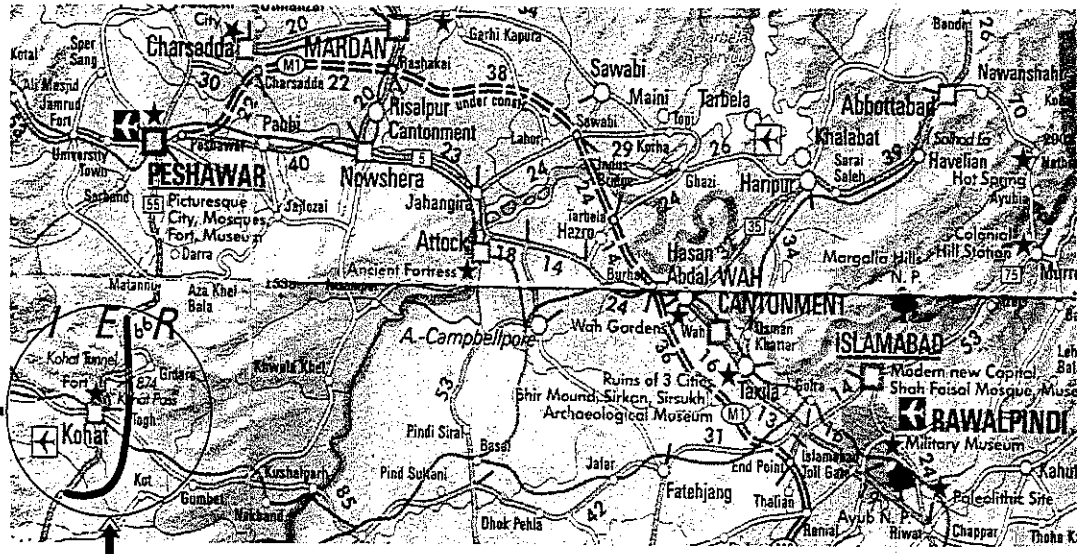
Venue NHA Auditorium

Time	Activity
9:30	Recitation from the Holy Quran
9:35	Opening Remarks by Mr. Takahashi, NHA JICA Advisor

Technical Presentation

09:40	Progress of the study / Traffic Forecast by Mr. Tanuma
10:00	Highway & Pavement Design by Mr. Kondo
10:20	Tunnel Geology by Mr. Sakata
10:40	Tunnel Design by Mr. Kubota
11:00	Tunnel Facilities by Mr. Nishijima
11:20	Closing Remarks by Chairperson
	Discussion





PROJECT NAME	CLIENTS		CONSULTANTS	DRAWING TITLE	SCALE	DWG NO
THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE 2ND KOHAT TUNNEL AND ACCESS ROAD IN THE ISLAMIC REPUBLIC OF PAKISTAN	GOVERNMENT OF PAKISTAN MINISTRY OF COMMUNICATIONS NATIONAL HIGHWAY AUTHORITY	JAPAN INTERNATIONAL COOPERATION AGENCY	NIPPON KOEI CO., LTD AND ALMEC CORPORATION	PROJECT LOCATION MAP	NTS	G-2

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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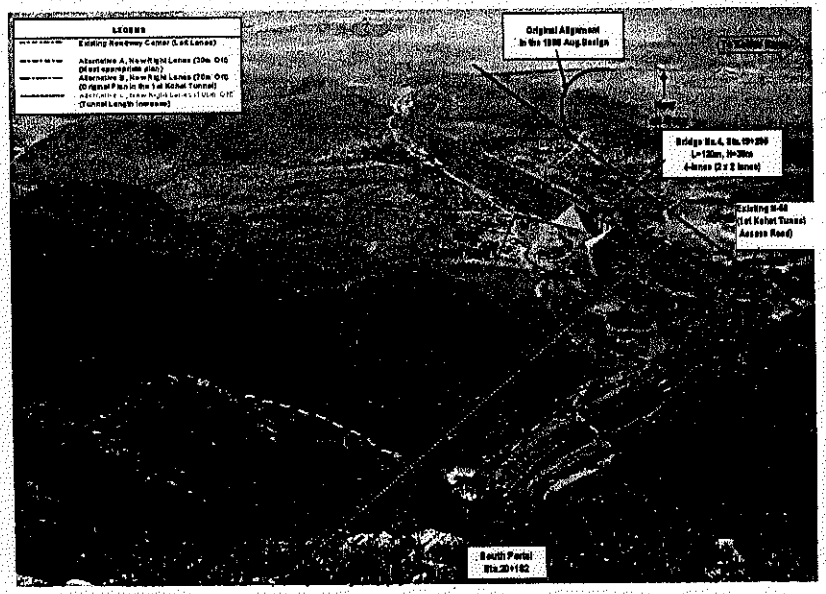


6TH JULY 2006
JICA STUDY TEAM

PROGRAM OF PRESENTATION

1. Progress of Feasibility Study
2. Traffic Forecast / Capacity
3. Highway and Pavement Design
4. Tunnel Geology
5. Tunnel Design
6. Tunnel Facilities

Questions and Answers after each presentation

Study Objective and Project Outline

Objective of the study

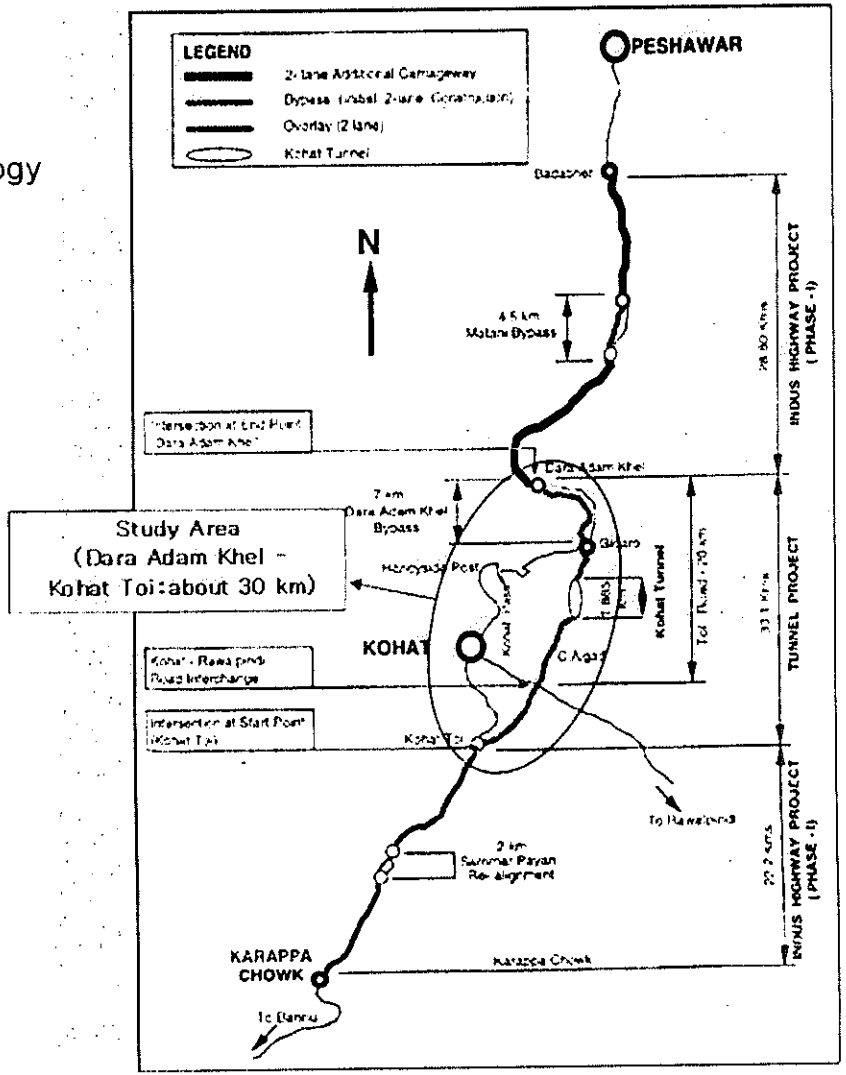
Technical Transfer of feasibility study methodology through the 2nd Kohat Tunnel and Access Road Construction Project FS

Location of the Project

From Kohat Toi to Dara Adam Khel (L=approx.30km)
(Right Figure)

Outline of the Project

Length: Tunnel 1.885km
Access Road 20km
Lane No. & Width:
Existing; 2 ways (single lane)
New; Dual carriage way (4 lanes)
Bridges: 11 Nos
Junctions: 2 (Kohat Toi and Dara Adam Khel)
Intersections: 3 (N80, Kohat Link Road, NW Frontier)
Other facilities (Control center, etc.)



Overall Flow of the Study

Work Flow and Study Period (right figure)

From April 26th – Sep.24th, 2006 in Pakistan

Mile Stones

- Submission of Inception Report
- Draft File Report: Middle of Sept. 2006
- Seminar of Draft Final Report: One week after submission of Draft Report
- Final Report: End of Nov. 2006

Scope of Works for FS

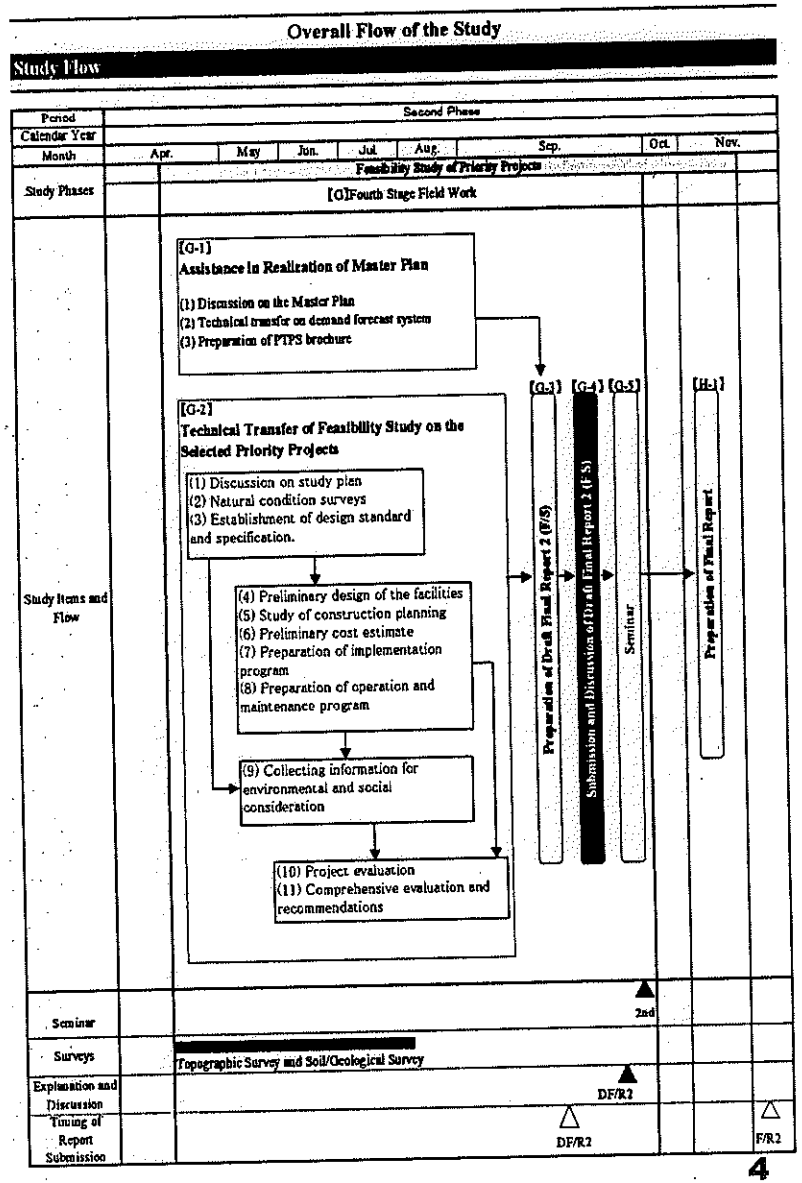
G-2: Technical Transfer of Feasibility Study on Selected Priority Project (2nd Kohat Tunnel and Access Road Construction)

G-3: Preparation of Draft Final Report 2 (F/S)

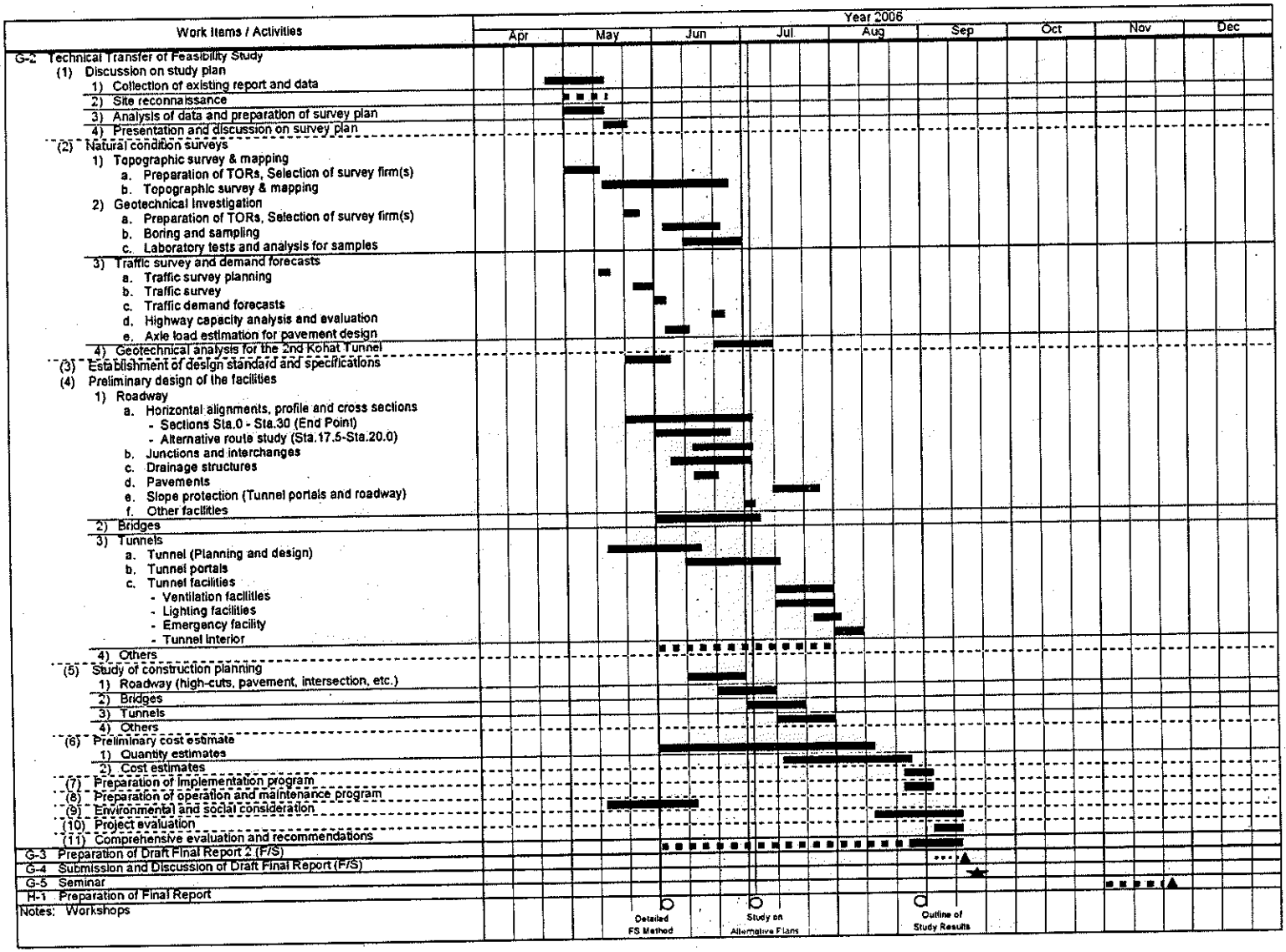
G-4: Submission and Discussion of Draft Final Report 2 (F/S)

G-5: Seminar

G-6: Preparation of Final Report



Detailed Study Schedule



Supplemental Traffic Survey

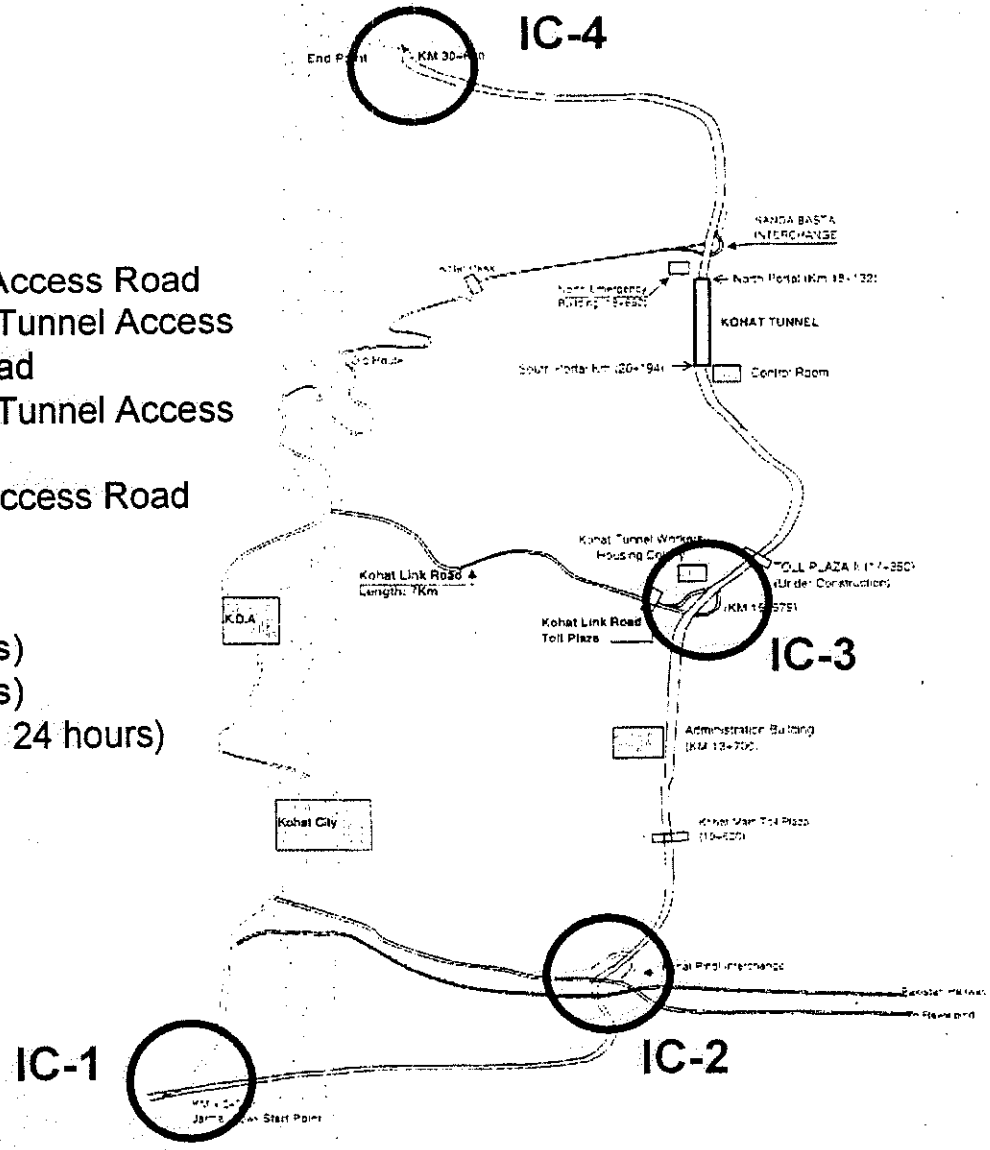
Classified Traffic Count

Location

IC-1: Start point of the Kohat Tunnel Access Road
IC-2: Intersection between the Kohat Tunnel Access Road and Kohat-Rawalpindi Road
IC-3: Intersection between the Kohat Tunnel Access Road and the Kohat Link Road
IC-4: End point of the Kohat Tunnel Access Road

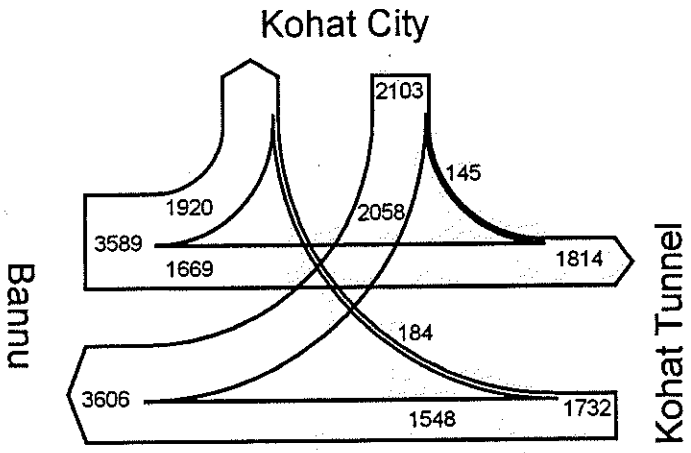
Survey Date and Time

IC-1: 29-May (06:00 – 22:00, 16 hours)
IC-2: 29-May (06:00 – 22:00, 16 hours)
IC-3: 30-May -31 May (06:00 – 06:00, 24 hours)
IC-4: May (06:00 – 22:00, 16 hours)

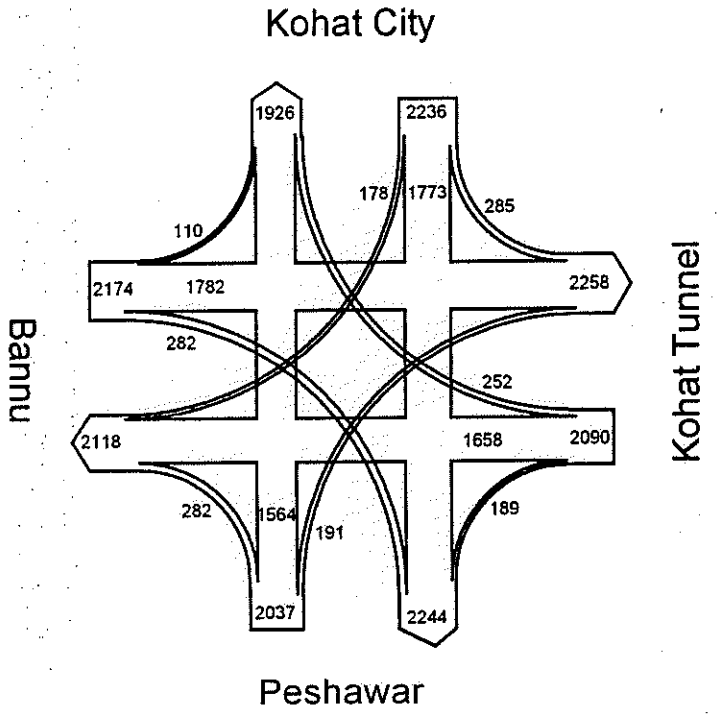


Traffic Volume at Intersections (1)

IC-1 (16-hour count)

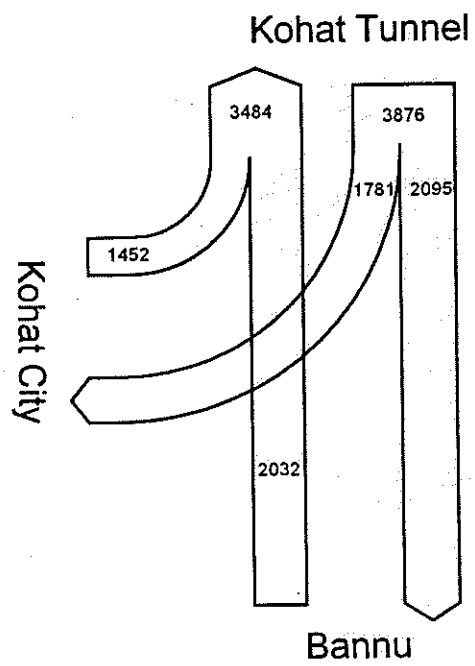


IC-2 (16-hour count)



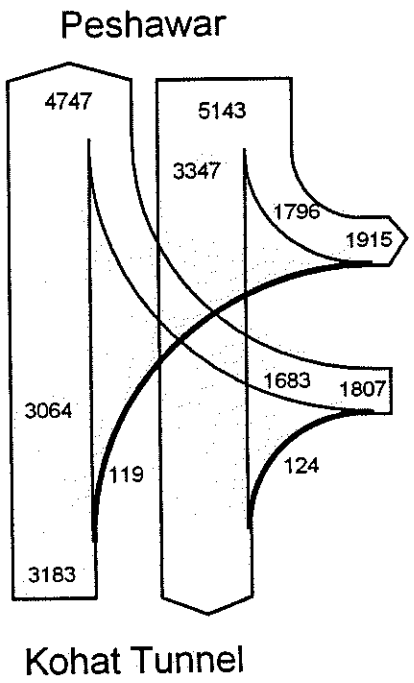
Traffic Volume at Intersections (2)

IC-3 (24-hour count)



- Tunnel Traffic: 7,360 veh/day
- 44% on the Kohat Link Road
- 56% on the southern section of the Access Road

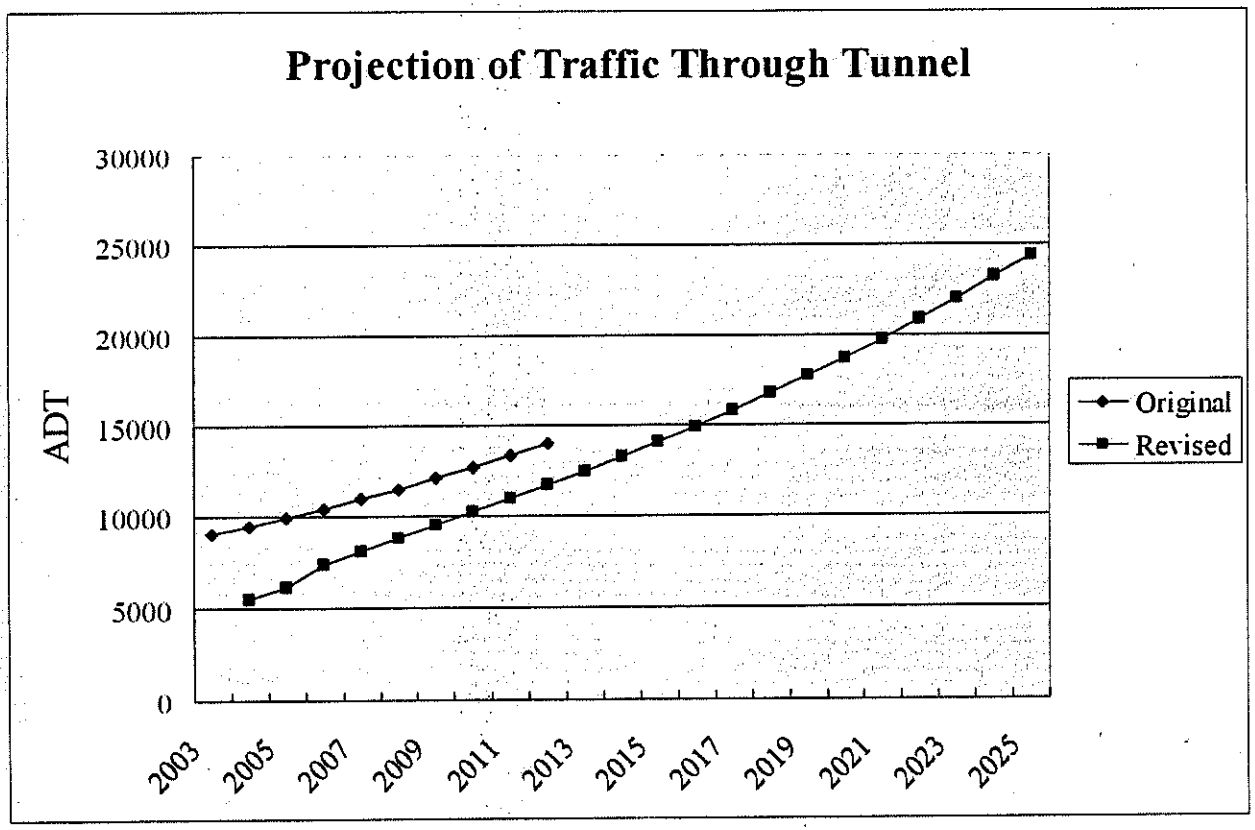
IC-4 (16-hour count)



- Tunnel Traffic : Non-Tunnel Traffic =66 : 34

Traffic Forecast

Year	Original	Revised
2003	9022	
2004	9472	5487
2005	9946	6159
2006	10443	7366
2007	10966	8103
2008	11514	8832
2009	12089	9538
2010	12694	10254
2011	13329	10972
2012	13995	11685
2013		12444
2014		13253
2015		14048
2016		14891
2017		15785
2018		16732
2019		17736
2020		18711
2021		19740
2022		20826
2023		21971
2024		23180
2025		24339



Original (1998): Based on NTRC 1996 traffic data on Rawalpindi - Dara Adam Khel, assumed 70% diversion to the tunnel, 6% growth until 2005 and 5% growth thereafter.

Revised: Based on toll collection data, traffic survey in PTPS Phase-I and supplemental traffic count in Phase-II, assumed high growth in next several years (12% - 7% in 2006 – 2011), then come close to the growth estimated in PTPS Phase-I.

Traffic Capacity

- Tunnel Section

LOS	Speed (mph)	Ideal Capacity (pcph)	v/c	fd	Et	Eb	fw	fhv	SFi (vph)	PHF	Equivalent Hourly Volume
A	≥ 58	2,800	0.04	0.94	2.5	1.8	0.70	0.717	53	0.83	44
B	≥ 55	2,800	0.16	0.94	2.5	2.0	0.70	0.717	211	0.87	184
C	≥ 52	2,800	0.32	0.94	2.5	2.0	0.70	0.717	423	0.91	385
D	≥ 50	2,800	0.57	0.94	2.5	1.6	0.70	0.717	753	0.93	700
E	≥ 45	2,800	1.00	0.94	2.5	1.6	0.88	0.717	1,661	0.95	1,578

- Access Road

LOS	Speed (mph)	Ideal Capacity (pcph)	v/c	fd	Et	Eb	fw	fhv	SFi (vph)	PHF	Equivalent Hourly Volume
A	≥ 58	2,800	0.15	0.94	2.5	1.8	1	0.717	283	0.90	255
B	≥ 55	2,800	0.27	0.94	2.5	2.0	1	0.717	510	0.91	464
C	≥ 52	2,800	0.43	0.94	2.5	2.0	1	0.717	811	0.93	754
D	≥ 50	2,800	0.64	0.94	2.5	1.6	1	0.717	1,208	0.94	1,136
E	≥ 45	2,800	1.00	0.94	2.5	1.6	1	0.717	1,887	0.96	1,812

- Directional Split = 55/45
- 26.1% trucks, 0.4% buses, 73.5% passenger car
- Percent no passing zones = 0% for tunnel, 100% for Access Road
- Usable Shoulder Width = 0 cm

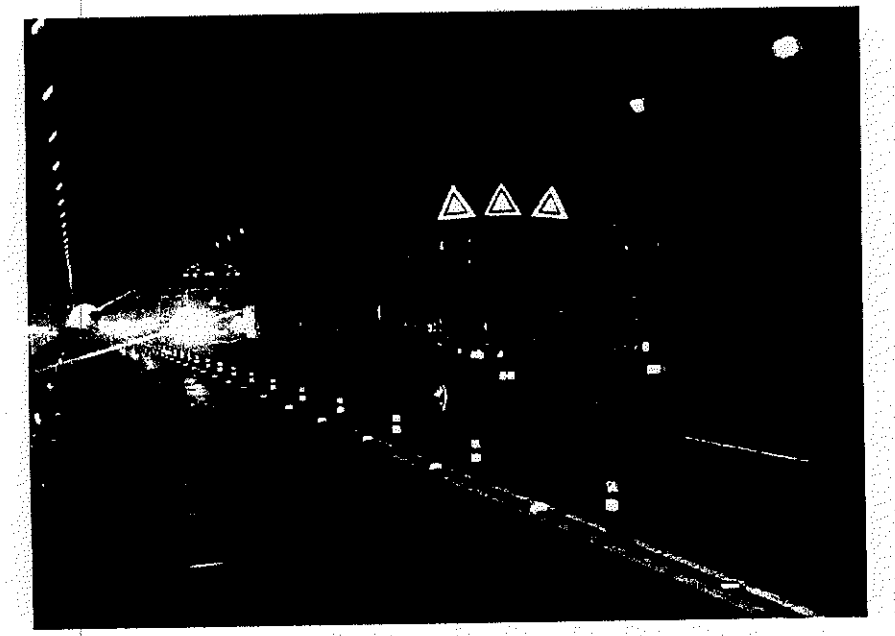
Level of Service (LOS)

Year	Annual Growth Rate (%)	North of Kohat Link Road				South of Kohat Link Road		
		AADT (veh/day)	Hourly Volume (vph)	LOS of Tunnel Section	LOS of Access Road	AADT (veh/day)	Hourly Volume (vph)	LOS of Access Road
2006		7,366	479	D	C	4,125	268	B
2007	10.0	8,103	527			4,537	295	
2008	9.0	8,832	574			4,946	321	
2009	8.0	9,538	620			5,341	347	
2010	7.5	10,254	666			5,742	373	
2011	7.0	10,972	713	E		6,144	399	
2012	6.5	11,685	760		D	6,543	425	
2013	6.5	12,444	809			6,969	453	
2014	6.5	13,253	861			7,422	482	C
2015	6.0	14,048	913			7,867	511	
2016	6.0	14,891	968			8,339	542	
2017	6.0	15,785	1,026			8,839	575	
2018	6.0	16,732	1,088			9,370	609	
2019	6.0	17,736	1,153		E	9,932	646	
2020	5.5	18,711	1,216			10,478	681	
2021	5.5	19,740	1,283			11,054	719	
2022	5.5	20,826	1,354			11,662	758	D
2023	5.5	21,971	1,428			12,304	800	
2024	5.5	23,180	1,507			12,981	844	
2025	5.0	24,339	1,582	F		13,630	886	

Note: 1) Peak hour traffic/daily traffic = 6.5%

2) 44% of the traffic from/to Kohat Tunnel uses the Kohat Link Road

URGENCY OF 2ND KOHAT TUNNEL



1. The travel speed of northbound traffic in the 1st Kohat Tunnel is 10-15 km/hr (against 60 km/hr design speed and 40 km/hr control speed), forming platoons behind slow-moving trucks, which cannot be broken up since passing maneuvers are not possible.

2. The capacity analysis reveals that the present Level of Service (LOS) of the1st Kohat Tunnel is D (approaching unstable condition). LOS would reach E in around 2011.

3. The tunnel section becomes a bottleneck of N-55, and urgent implementation of the 2nd Kohat Tunnel should be programmed.

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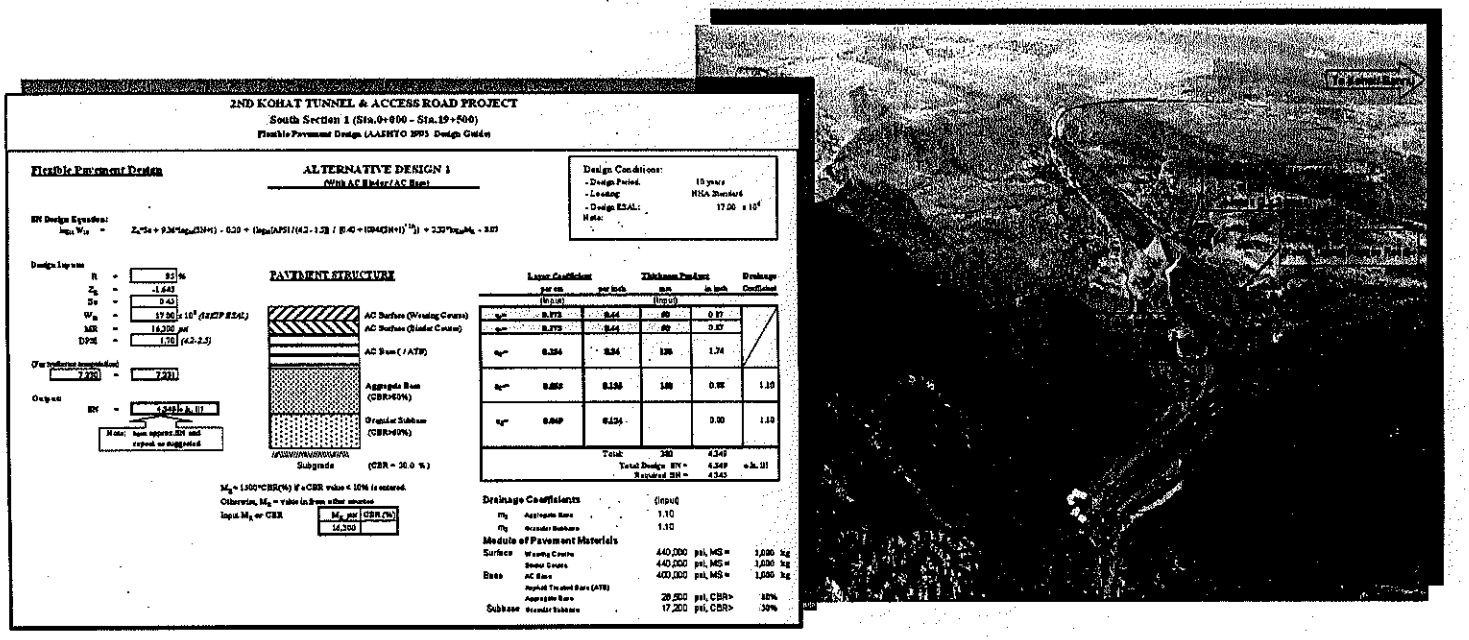
PAKISTAN TRASPORT PLAN STUDY (PTPS) – II
THE 2ND KOHAT TUNNEL & ACCESS ROAD PROJECT

PRESENTATION
ON
THE HIGHWAY AND PAVEMENT DESIGN



6TH JULY 2006
M.S.KONDA
HIGHWAY ENGINEER
JICA STUDY TEAM

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   (1). Design Load and Subgrade Strength
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   (5). Way Forward
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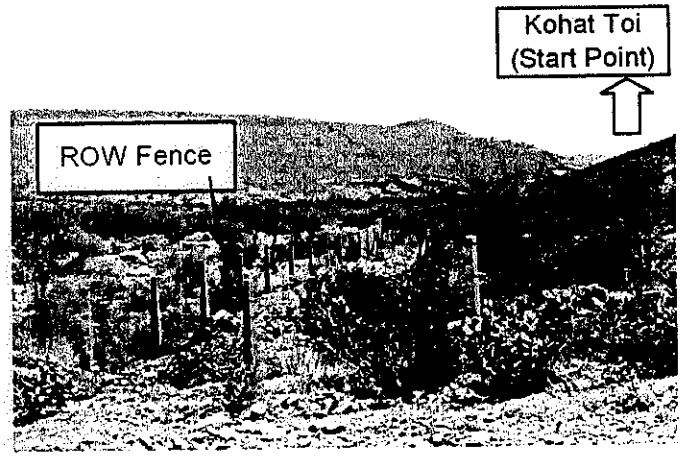
   - Appendix C: Rigid Pavement Design Sheet (Excel Program)
   - Appendix D: Pavement Material Charts (NHA Standard Specifications)

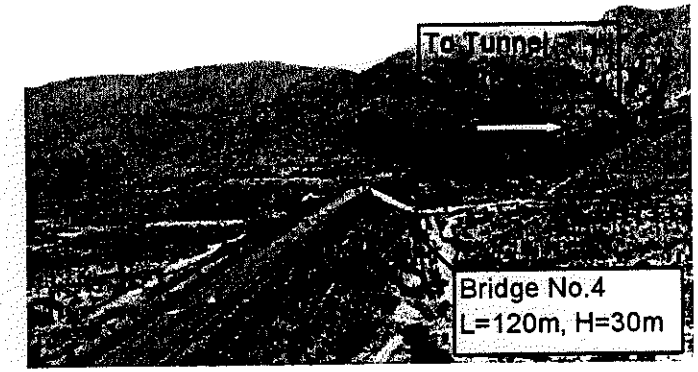
1. Route Alignment of the 2nd Kohat Tunnel & Access Road

Location of the Project
From Kohat Toi to Dara Adam Khel

Scope of the Project
- The 1st Kohat Tunnel Access Road: 2-lane road
- The 2nd Kohat Tunnel Access Road:
  Development to a 4-lane road (Dual Carriageway System)
  at 13.3m for the south section
  at 30.0m for the tunnel section
  at 10.8m for the north section
  } to the east (right) side
  Note: ROW was already secured during the 1st Kohat Tunnel & Access Road Construction (right photo)



Outline of Road Facilities under the 2nd Kohat Tunnel/Road
- Total Length: 30km
  Access Road Length: 28 km
  Tunnel Length 1885m (+/- 20m)
- Bridges: 10 Nos, except Bridge No.4, which was already constructed as a dual carriageway system (right photo)
- Intersection Improvement: 1 (Kohat Link Road)
  Note: Other junctions and Intersections were already constructed as 4-lane dual carriageway system

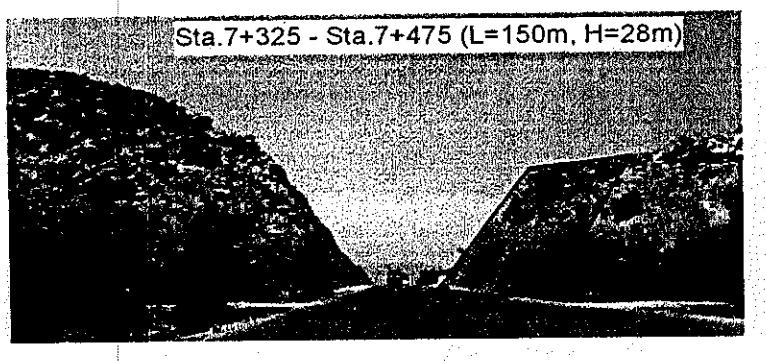


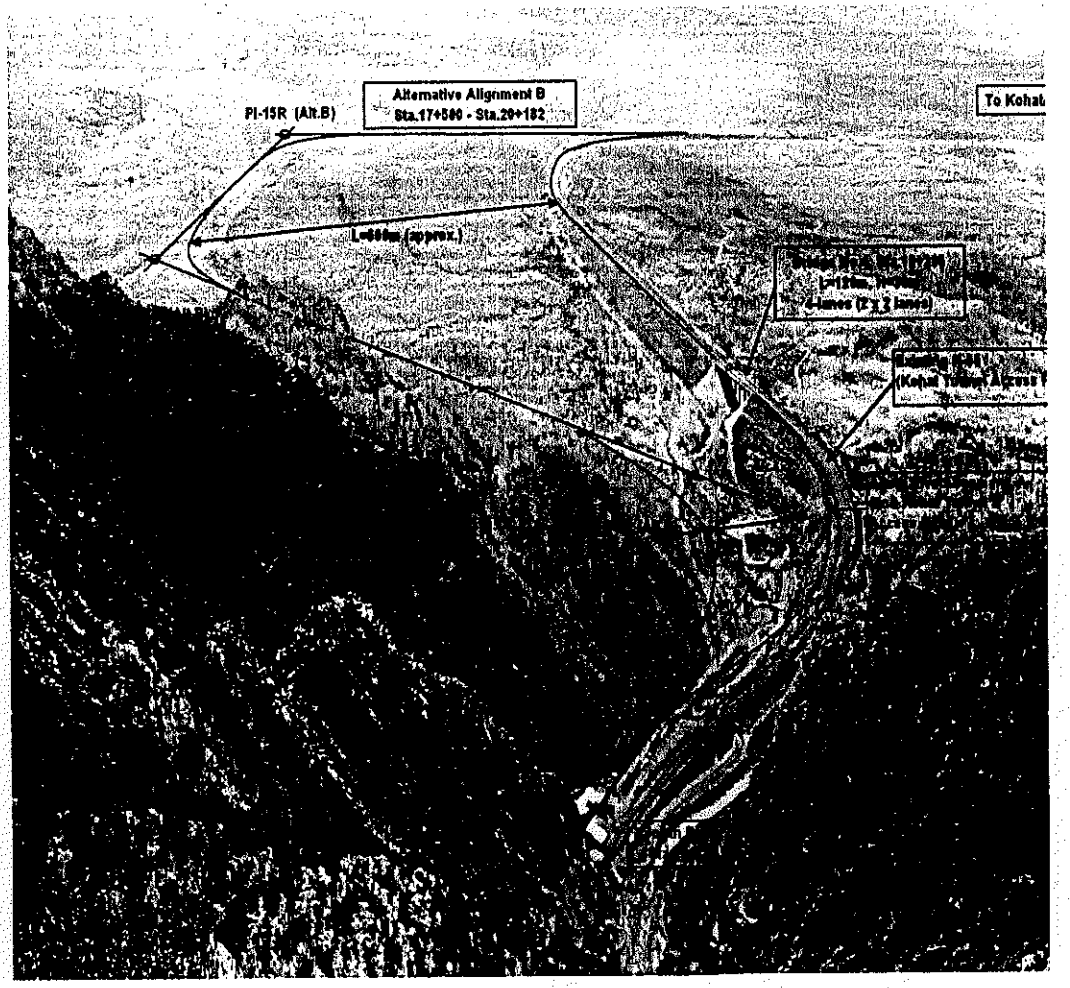
2. Alternative Alignment Study for High Cut /High Fill Section for Sta.17+500 – Sta.20+150

To avoid High-cut H=23m &
(Sta.18+000 – Sta.18+785)
High-embankment H=30m
(Sta.18+785 – Sta.20+150)

Original plan is advantageous as:
- Bridge No.4 was already constructed as dual carriageway
- Alternative alignment is about 600 m longer than existing road
- A river on the alternative route

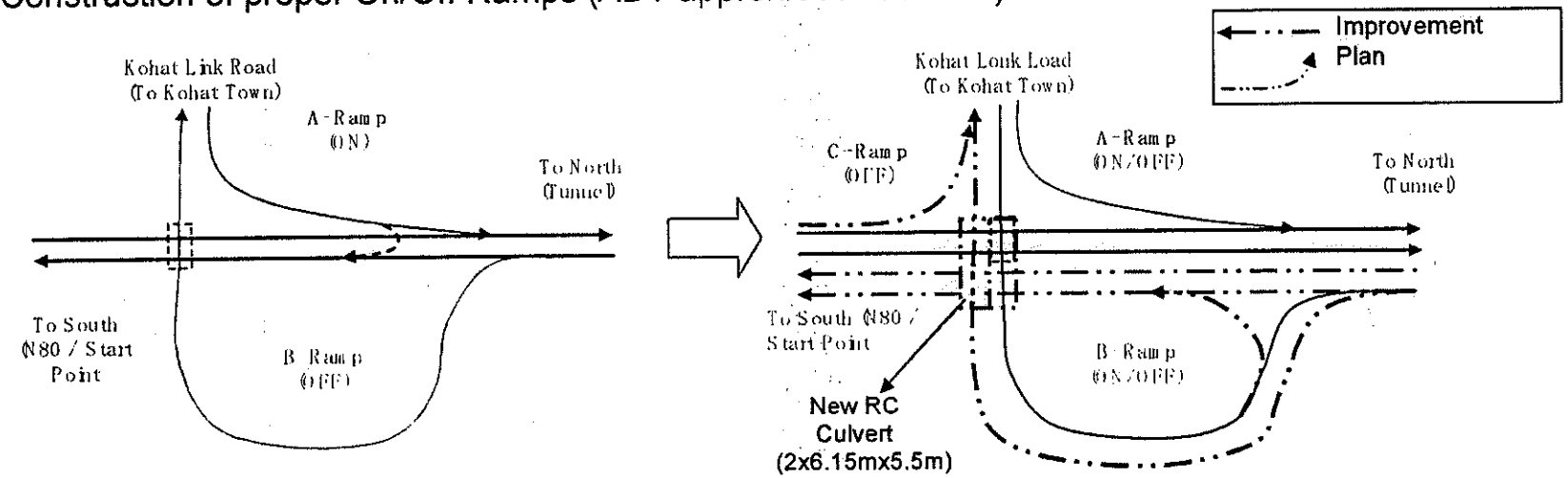
No advantageous alternative alignments for other high-cut sections





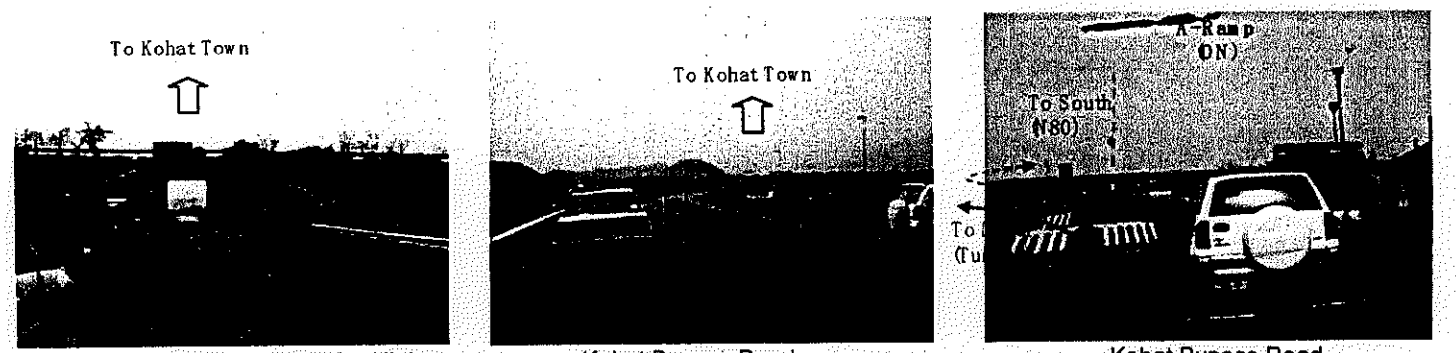
3. Intersection Improvement for Kohat Link Road (Kohat Town Bypass Road)

Construction of proper On/Off Ramps (ADT approx.3000 in 2006)



Current Intersection

Intersection Improvement Plan



Intersection Box-culvert under Highway Direction (To Kohat Town)

Kohat Bypass Road (Off Ramp Exit)

Kohat Bypass Road (On Ramp Entrance)

4. Bridge Planning

New Seismic Design Standard of NHA (Change of Seismic Design Standard after the earthquakes in Muzaffarabad in October 2005) for Bridge Planning

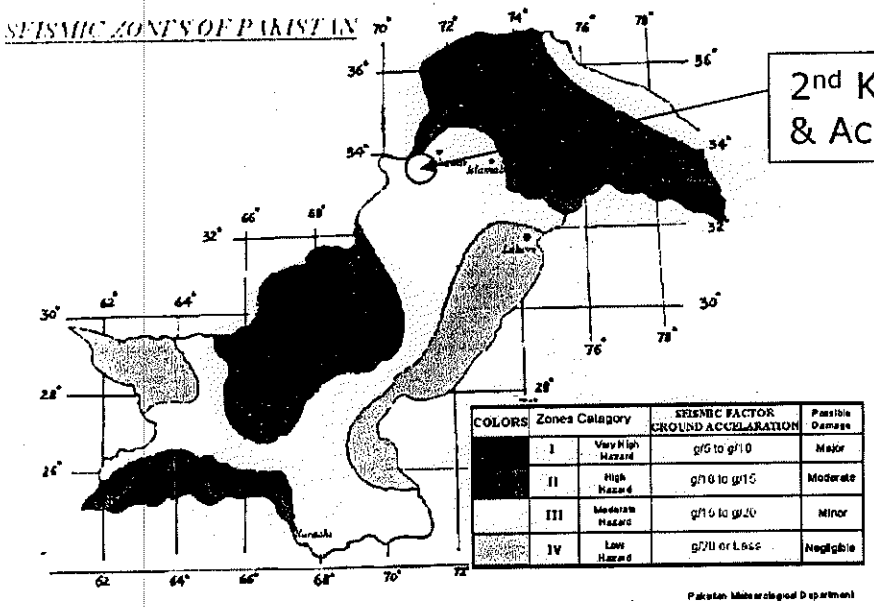
Peak Ground Acceleration (g)

Previous	New
0.05 - 0.07 (zone III)	0.26

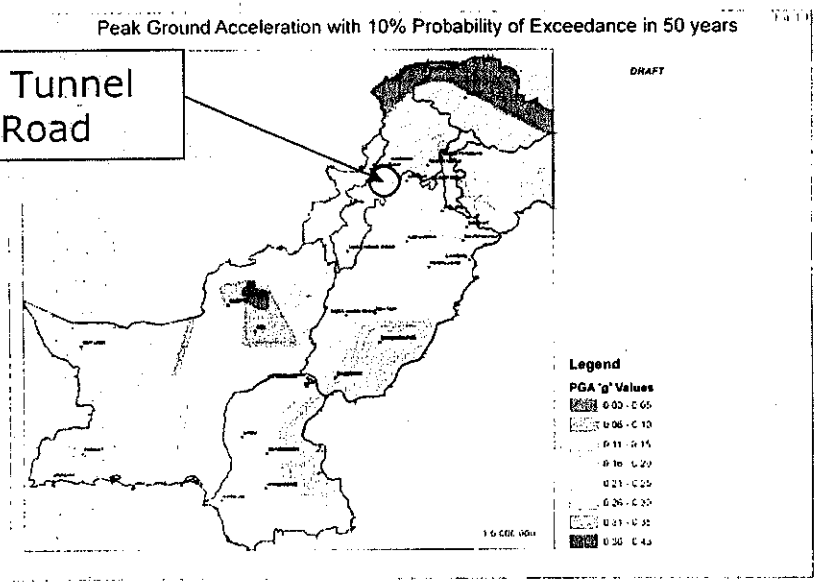
at Kohat Project Area

No.	Station (at center)	Type	Length (m)	Span	Pile Length (m)	Remarks
1 R	2+736.245	PC Girder	120	4 - 30m Span	20	Over 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	RC Girder	12	1-12m Span	20	Over Bazi Khel Road
10 R	16+585	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 river
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 rivers
7 R	25+388.915	PC Girder	40	2-20m Span	20	Over river
Total:			564	m		

Notes: * Break at Sta. 20+182.839 /Sta.16+247.000 (-3935.839)



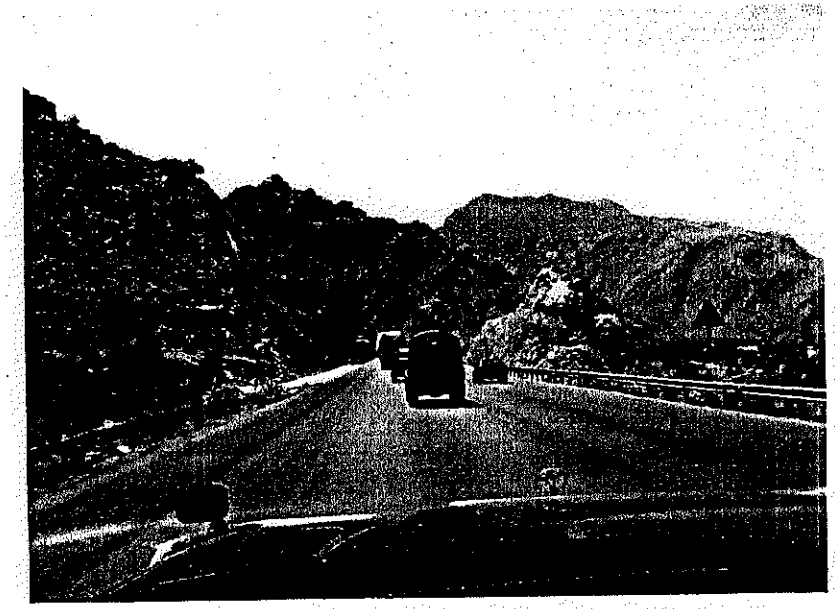
2nd Kohat Tunnel & Access Road



5. Geometric Design Standard

Road Section	Terrain	Area	Design Speed (km/hr)	
			1st Kohat Road	2nd Kohat Road*
Kohat Toi - Changai Algada (Sta.18+000)	Flat to Rolling	Sub-urban to Rural	90	90
Changai Algada (Sta.18+000) - Gidaro	Mountain	Rural	80	80
Gidaro (Sta.19+000)- Dara Adam Khel	Flat to Rolling	Sub-urban	80	80
Kohat Tunnel	Mountain	Rural	60	60

Note: * The design speed is based on the 1st Kohat Tunnel & Access Road Project



Item	Unit	Design Standard			
		1st Kohat Access Road		2nd Kohat Access Road	
Section		South	North	South	North
Design Speed	km hr	90	80	90	80
Cross Section Elements:					
- Lane width	m	3.65	3.65	3.65	3.65
- Outer Shoulder Width	m	3.00	3.00	3.00	3.00
- Outer Shoulder Width for climbing lane	m	1.00	1.00	-	-
- Inner Shoulder Width	m	1.00	1.00	1.00	1.00
		(Future 4-lanes)			
- Median Width	m	6.00	3.00	6.00	3.50
		(Future 4-lanes)			
- Climbing Lane Width	m	3.00	-	-	-
- Crossfall of Travelled Way	%	2	2	2	2
- Crossfall of Shoulder	%	4	4	4	4
- Vertical Clearance	m	5.03	5.03	5.03	5.03
- Railway Vertical Clearance	m	6.71	6.71	6.71	6.71
- Stopping Sight Distance	m	137	120	160	130
- Passing Sight Distance	m	600	550	615	540
Horizontal Alignment:					
Circular Curve:					
- Min. Radius	m	270	220	275	210
- Min. Superelevation Runoff	m	50	46	115	108
		(one lane rotated)		(two lane rotated)	
- Max. Superelevation Rate	%	10	10	10	10
- Tangent Runout	m	16	15	23	22
Transition Curve:					
- Type of transition curve		-	-	Spiral Curve (Clothoid)	-
- Min. Transition Curve Length	m	-	-	50	40
- Max. Radius for Use of a Spiral Curve Transition *	m	-	-	480 (1200)	380 (900)
Vertical Alignment:					
- Max. Grade	%	7	7	4	4
Crest Curve					
- Stopping Sight Distance	m	-	-	160	130
- Passing Sight Distance	m	600	550	615	540
Sag Curve					
- Stopping Sight Distance	m	-	-	160	130

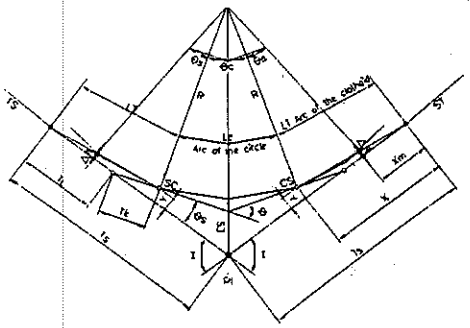
Note: based on the NHA Standard and a Policy on Geometric Design of Highways and Streets 2001, AASHTO

* recommended max. radius for use of a transition curve if site condition allows

6. Geometric Design Standard (Spiral Transition Curve)

1st Kohat Tunnel Access Road
A combination of straight line and simple circular curve

2nd Kohat Tunnel Access Road
A combination of straight line and circular curves with a spiral transition curve (clothoid curve)



SPIRAL CURVE FORMULA:

$R = A^2/Ls$

$\theta s = Ls/2R$

$x = Ls[1-Ls^2/40R^2+ Ls^4/3456\ R^4-Ls^6/599040\ R^6+ \ldots\ldots]$

$Y = Ls^2/6R\ [1-Ls^2/56R^2+ Ls^4/7040\ R^4-Ls^6/1612800\ R^6+\ldots\ldots]$

$\Delta R = Y+R\cos\theta s-R$

$Xm = Y-R\sin\theta s$

$Ts = Xm+W$

$Yc = Y - (\cot\theta s)$

$Ys = Y / \sin\theta$

$Es = \frac{(R+\Delta R)}{\cos I/2} - R$

$Ic = I - 2\theta$

$L = \pi R\ Ic/180$

WHERE :

- PI = POINT OF INTERSECTION
- I = INTERSECTION ANGLE
- R = CURVE RADIUS
- Es = EXTERNAL DISTANCE
- Ls = LENGTH OF SPIRAL
- A = PARAMETER OF CLOTHOID
- θs = SPIRAL ANGLE
- X,Y = COORDINATES OF POINTS SC AND CS WITH RESPECT TO MAIN TANGENTS
- ΔR = OFFSET BETWEEN CIRCULAR CURVE AND MAIN TANGENT ("THROW" OF SPIRAL)
- Xm = LENGTHENING OF TANGENT DUE TO INSERTION OF SPIRAL

- Ts = TOTAL TANGENT DISTANCE
- TL = LONG TANGENT OF SPIRAL
- Ys = SHORT TANGENT OF SPIRAL
- Ls = LENGTH OF SPIRAL
- θs = CENTRAL ANGLE OF CIRCULAR CURVE
- Lc = LENGTH OF CIRCULAR CURVE
- TS = BEGINNING OF TRANSITION CURVE
- SC = BEGINNING OF CIRCULAR CURVE
- CS = END OF CIRCULAR CURVE
- ST = END OF TRANSITION CURVE

Note:

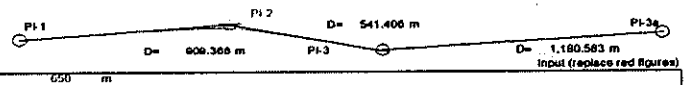
Application only for South Section. No sufficient median and ROW for North Section.

The 2nd Kohat Tunnel & Access Road Project (South Section)
Curve Data Computation Sheet (With Transition Curves)

Design without transition curves

PI No.	Angle (Deg.)			R (m)	T (m)	E (m)	Lc (m)	PI to PI Distance	PI to PC Distance	Transit. Curve Requirment
	Deg.	Min.	Sec.							
PI-1	15	51	48	2000	276.638	19.316	553.711	980.113	316.882	No
PI-2	29	10	5	650	150.11	19.076	305.448	900.366	474.818	Yes
PI-3	18	22	47	800	102.45	8.884	202.943	541.406	282.846	Yes
PI-3a	8	55	13	1500	117.003	4.556	233.533	1400.036	1,180.583	No

Note: No transition curve is required if R >= 480m for design speed of 60 km/h and if R>=380m for 50 km/h (AASHTO 2001). However, it is better to use transition curves up to R=1200m for design speed of 90km/h and R=900m for 60km/h (in Japa



PI-2 — Input (replace red figures)

R= 650 m
I = deg. 29 min. 10 sec. 5 — 29.1681 degrees = 0.5091 radian

A1 = 250.000 — Note: R/3 =< A <= R; 217 =< A1 <= 650
Ls1 = A²/R = 96.154
Note: Design Speed — 90 km/h: Min. Transition Curve Length 50 m; 80 km/h: 44 m
Straight Section Length: From / To PI-1 PI-2 413.387 m; From / To PI-2 PI-3 164.907 m (Note: ST to TS Distance)
Ct1 = Ls1 + Ls2 + Lc = 427.055
Ts1 = Xm1+W2-z1 = 217.341

A2 = 250.000 — R/3 =< A <= R; 217 =< A2 <= 650
Ls2 = A²/R = 96.154
Ts2 = Xm2+W2+z2 = 217.341

θ1 = Ls/2R = 0.0740 radian = degree 4.2379 = deg. 4 min. 14 sec. 16

X1 = Ls (1-Ls²/40R² + Ls⁴/3456R⁴ - Ls⁶/599040R⁶) = 96.101

Y1 = Ls²/6R (1-Ls²/56R²+Ls⁴/7040R⁴-Ls⁶/1612800R⁶) = 2.370

ΔR1 = Y1 + Rcos θs1 - R = 0.593
Xm1 = X1 - Rsin θs = 48.068
W1 = TAN (I/2) x (R+ΔR1) = 169.273
t1 = X1 - Y1 cot (θs1) = 64.121
tk1 = Y1 / sin θs1 = 32.068
σ1 = cot (Y1/X1) = 0.025 radian = degree 1.4126 = deg. 1 min. 24 sec. 45
γ - σ = 0.0493 (radian) = degree 2.8253 = deg. 2 min. 49 sec. 31

θ2 = Ls/2R = 0.0740 radian = degree 4.2379 = deg. 4 min. 14 sec. 16

X2 = Ls (1-Ls²/40R² + Ls⁴/3456R⁴ - Ls⁶/599040R⁶) = 96.101

Y2 = Ls²/6R (1-Ls²/56R²+Ls⁴/7040R⁴-Ls⁶/1612800R⁶) = 2.370

ΔR2 = Y1 + Rcos θs1 - R = 0.593
Xm2 = X1 - Rsin θs1 = 48.068
W2 = TAN (I/2) x (R+ΔR1) = 169.273
t2 = X1 - Y1 cot (θs1) = 64.121
tk2 = Y1 / sin θs1 = 32.068
σ1 = cot (Y2/X2) = 0.025 radian = degree 1.4126 = deg. 1 min. 24 sec. 45
γ - σ = 0.0493 (radian) = degree 2.8253 = deg. 2 min. 49 sec. 31

θc = I-(θs1+θs2)= 0.36115 radian = degree 20.6923 = deg. 20 min. 41 sec. 32

Lc = R * θc = 234.747
t11 = (X1² + Y1²)^1/2 = 96.130
U1 = (Tk1² - Y1²)^1/2 = 31.980
z1 = (ΔR1 - ΔR2) / tan (I) = 0.000
Es = (R+(ΔR1+ΔR2)/2) / cos I/2 - R = 22.253

t12 = (X2² + Y2²)^1/2 = 96.130
U2 = (Tk² - Y²)^1/2 = 31.980
z2 = (ΔR1 - ΔR2) / sin(I) = 0.000

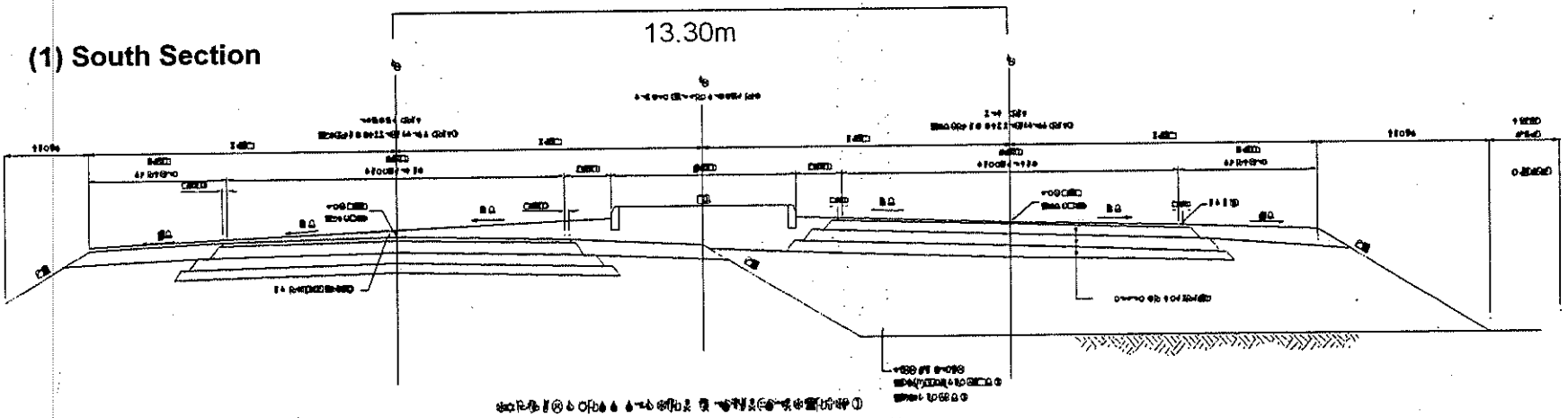
Note: In case of without transition curves (Only Circular Curve)

IA = deg. 29 min. 10 sec. 5 — 29.1681 degrees = 0.5091 radian
R= 650 m
T= R x Tan (IA/2) = 169.119 m
Lc= R x IA (radian) = 330.901 m
E= R x (Sec (IA/2)-1) = 21.641 m

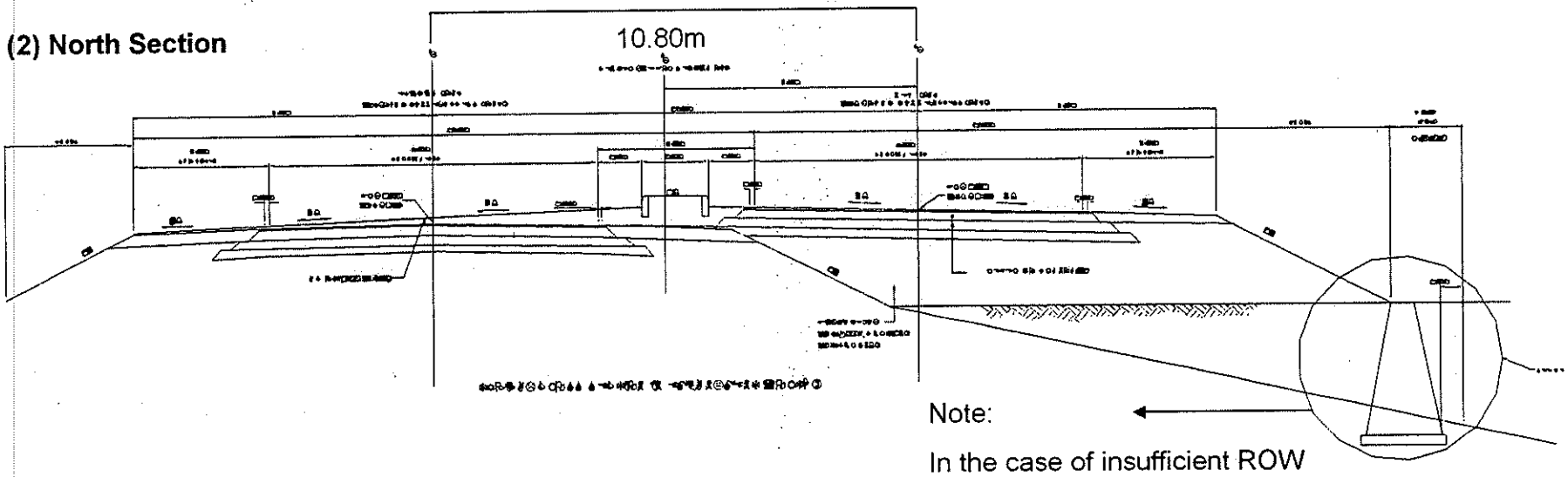
Remarks: Es - E = 0.612 m; CL - Lc = 96.154 m

7. Typical Cross Sections

(1) South Section



(2) North Section



Note:

In the case of insufficient ROW

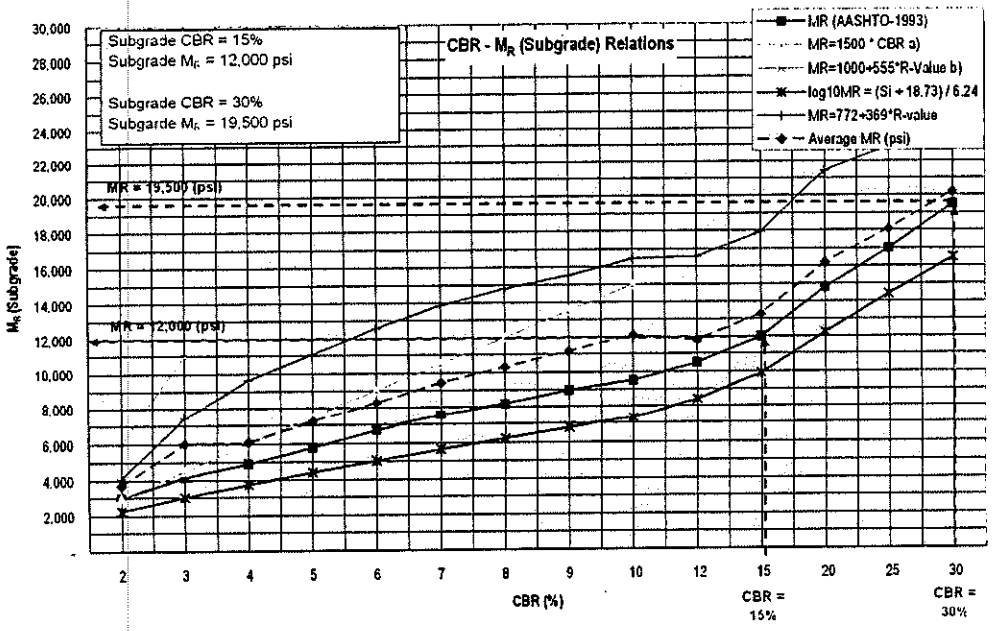
8. Pavement Design
(1). Design Load and Subgrade Strength

Pavement Design Load (CESA)

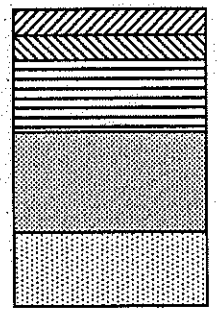
Unit: 10^6

Section	Flexible Pavement Design Period (10 years)		Rigid Pavement Design Period (20 years)		Remarks (CESA for 1st Kohat)	
	AASHTO	Road Note 31	AASHTO	Road Note 31	Flexible	Rigid
Section 1 (Sta.0 - Sta.15+000) Kohat Toi to Kohat Link Road	25.0	42.2	67.8	114.3	17.0 (Sta.0 -Sta.9+000)	40.0
Section 2 (Sta.15+000 - Sta.25+906) Kohat Link Road to Dara Adam Khel	30.3	48.7	82.0	132.0	40.0 (Sta.9+000 - End Point)	40.0

Note: Rigid Pavement for Tool Gate and Tunnel, No climbing lanes for 2nd Kohat Access Road



Pavement Structures



Layer Coefficient

	per cm	per inch
a_1=	0.173	0.44
a_1=	0.173	0.44
a_2=	0.173 (AC Base)	0.44
a_2=	0.053	0.135
a_3=	0.049	0.124

8. Pavement Design
(2). Pavement Materials

List of Asphalt Concrete / Asphalt Treated Materials for Surface and Base Courses

Item	AC Wearing Course		AC Binder Course	AC Base Course (Plant Mix)		Bitumen Stabilized Base or Subbase (Plant Mix)	
	Class A	Class B		Class A	Class B	Base	Subbase
Asphalt Penet. Grade	40-50, 60-70 or 80-100		40-50, 60-70 or 80-100	40-50, 60-70 or 80-100		80-100, (120 - 150)	
AC Content	3.5% (Min.)		3.5% (Min.)	3.0% (Min.)			
Stability	1000 kg (Min)		1000 kg (Min)	1000 kg (Min)		400 kg (Min)	250 kg (Min)
Flow, 0.25mm	8-14		8-14	8-14		2mm (Min.)	2mm (Min.)
Air Void	4% - 7%		4% - 8%	4% - 8%			
Loss in Stability	20% (Max.)		25% (Max.)	25% (Max.)			
Aggregates						Type A	Type B / Type C
Max. Particle Size	25mm	20mm	25mm	50mm	38mm	75mm	50mm / 25mm
LA Abrasion	30% (Max.)		40% (Max.)	40% (Max.)			
Loss by SS Soundness	12% (Max.)		12% (max.)	12% (Max.)			
Flat particles	10% (Max)		15% (Max.)	15% (Max)			
Course Aggregate (>4.75mm)	Crushed rock or crushed gravel (crushed particle =100%)		Crushed rock, crushed gravel or mixture of a natural and crushed gravel (crushed particle =100%)	Crushed rock, crushed gravel or crushed boulder (crushed particle > 85%)		Particles > 4.75mm (crushed particle > 90%)	Particles > 4.75mm (crushed particle > 50%)
Fine Aggregate	100% crushed rock or crushed boulder		100% crushed rock or crushed boulder	100% crushed rock or crushed boulder		Particles < 0.075mm LL < 25mm, PI < 6%	

Source: General Specifications of NHA, Dec.1998

List of Base and Subbase Materials (Aggregate / Granular)

Item	Granular Subbase		Aggregate Base	
	Grading A	Grading A	Grading A	Grading A
Max. Particles	60mm	50mm	50mm	50mm
Uniformity (D60/D10)	3 (Min.)		4 (Min.)	
CBR	50% (min) at 98% max. density		80% (min) at max. density	
LA Abrasion	50% (Max.)		40% (Max.)	
Loss by SS Soundness	-		12% (Max.)	
Fraction < 0.075mm	LL< 25%, PI < 6		LL< 25%, PI < 6	
Materials	Natural or processed aggregate		Crushed aggregate (crushed particle > 90%)	

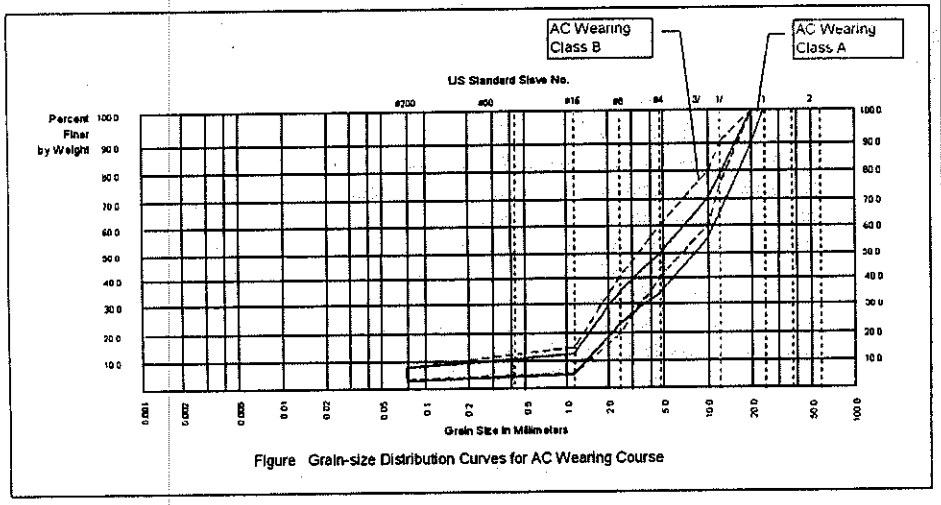


Figure Grain-size Distribution Curves for AC Wearing Course

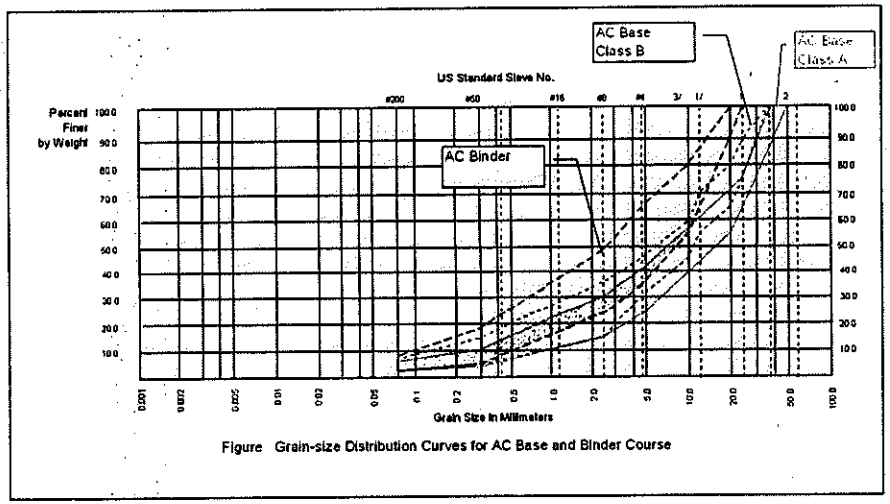


Figure Grain-size Distribution Curves for AC Base and Binder Course

8. Pavement Design
(3). Flexible Pavement Design (ACP)

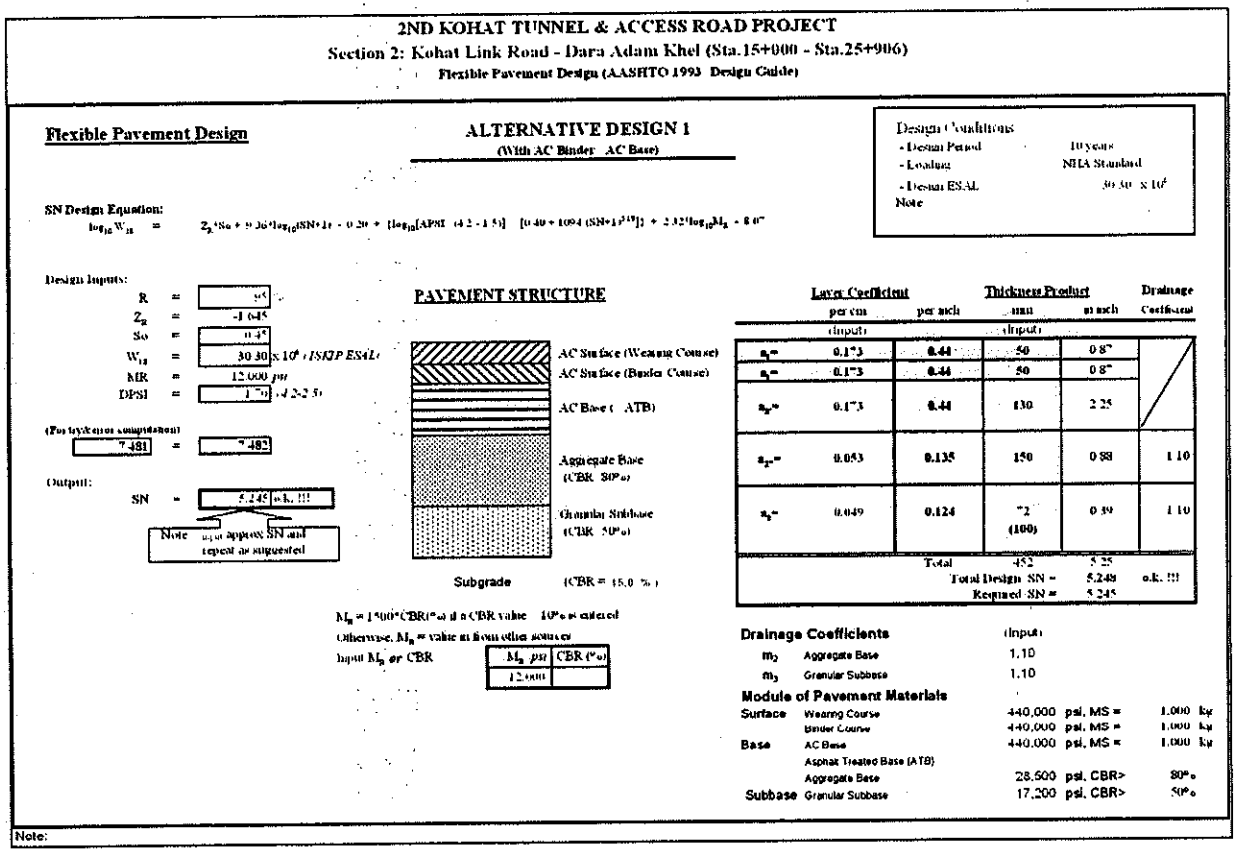
Flexible Pavement Design Summary

2nd Kohat Tunnel Access Road

Pavement Structures From / To	Section 1 Kohat Toi Sta.15+000	Section 2 Sta.15+000 Dara Adam Khel
AC Wearing	5 cm	5 cm
AC Binder	5 cm	5 cm
AC Base	12 cm	13 cm
Aggregate Base	15 cm	15 cm
Granular Subbase	10 cm	10 cm
Subgrade (Borrow Material)	15%	15%
Note: Design SN	5.105 (inch)	5.245 (inch)

1st Kohat Tunnel Access Road

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



8. Pavement Design
(4). Rigid Pavement Design (CCP)

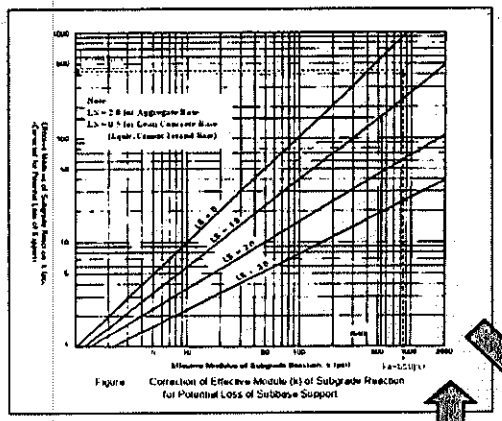


Figure Correction of Effective Module (k) of Subgrade Reaction for Potential Loss of Subbase Support

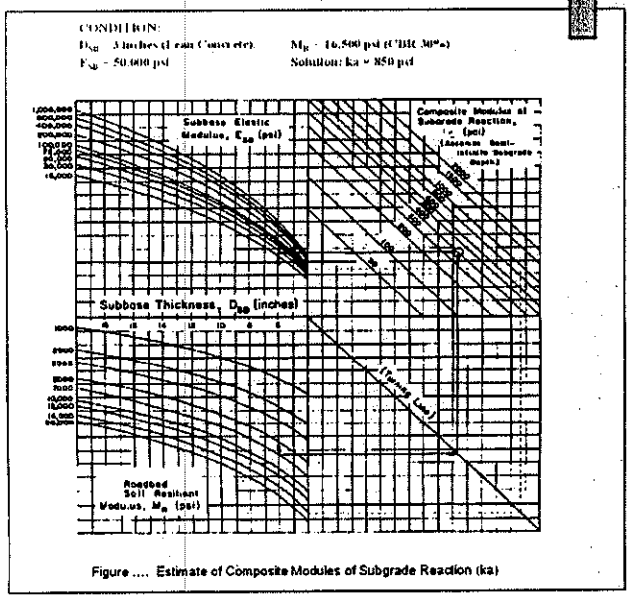


Figure .... Estimate of Composite Modules of Subgrade Reaction (ka)

2ND KOHAT TUNNEL & ACCESS ROAD PROJECT
Section-2 (Toll Gate)
Rigid Pavement Design (AASHTO 1993 Design Guide)

Rigid Pavement Design — **DESIGN 1** (Load based on AASHTO)

Design Equation:

$$\log_{10}W_{18} = Z_R*So + 7.35*\log_{10}(D+1) - 0.06 + \{\log_{10}[\Delta PSI/(4.5-1.5)]\} / \{1 + [(1.624*10^7)/(D+1)^{8.46}]\} + (4.22 - 0.32pt)*\log10\{[Sc' * Cd(D0.75 - 1.132)] / [215.63*J(D0.75-(18.42/(Ec/k)0.25))]\}$$

Design Inputs:

R =	90	%
Z_R =	-1.282	
So =	0.35	
W_{18} =	82.80	x 10^6 *(18 KIP ESAL)*
pt =	2.50	
APSI =	2.00	(4.5-2.5)
S'c =	722	*psi*
Cd =	1.10	
J =	3.20	with Dowel Bars
Ec =	3.40	x 10^6 *psi*
k =	440	pci

(For trial-error computation)

7.914	7.914

Output:

D = 11.77 inches — o.k. !!!

Note: Input approx D and repeat as suggested

29.90 cm,
Say 30.0 cm (= 11.8 in.)

Ec = $57,000(f'c)^{0.5}$ = 3.40 x 10^6 psi
where, fc (28 days) = 3,500 psi
= 250 kg cm^2)

S'c = Sc + z (SDs) = 722 psi
where, Sc (28 days) = 640 psi
= 45 kg cm^2)
z = standard normal variate
1.037 for PS = 15 %
1.282 for PS = 10%
SDs = Sc x 10% = 64 psi

Design Conditions (input):

- **Design Period:** 20 years
- **Loading:** NHA Standard
- **Design ESA:** 82.00 x 10^6
- **Concrete Strength at 28 days:**

Compression	250	kg cm^2
Flexual	45	kg cm^2

Note:

PAVEMENT STRUCTURE

PCC Thickness T=	30.0 cm
Lean Concrete T=	7.0 cm
Aggregate Base (CBR 80%) T=	10.0 cm
Subgrade CBR =	30.0%
(M_R =	16,500.0 psi)

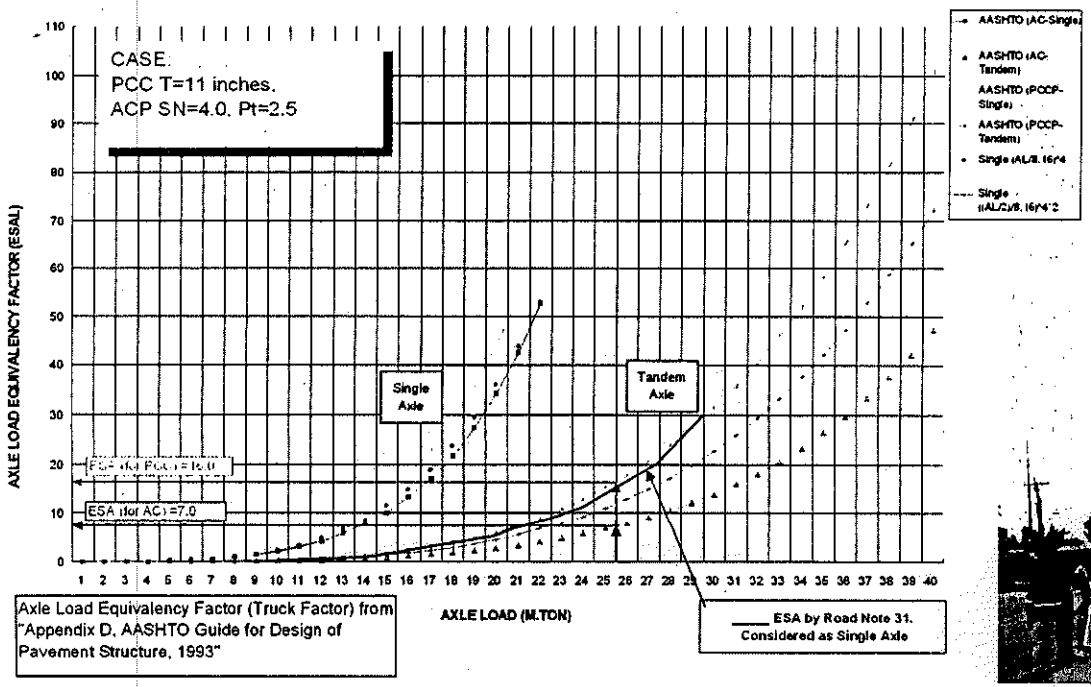
(input)
Drainage Coefficient (Cd): 1.10
Load Transfer Coefficient (J): 3.20

Note:

8. Pavement Design
(5). Way Forward

- Key Issuess: Earlier Deterioration of Pavement
  - Increase of Axle Load (Traffic Regulation)
  - Overloaded Vehicles
  - Pavement Technology to meet Pakistan Environment
  - Life Cycle Cost (Investment and Maintenance Cost)
  - Pavement Management System

- Key Issuess: Pavement Technology
  - AC Materials (Split Mastic Asphalt, etc.)
  - Concrete Pavement (CCP)
  - Composite Pavement (CCP + AC)
  - Recycling of Pavement (Rehabilitation)



ESA (TruckFactor) for CCP Design

CCP Construction

In the Philippines by

Slip Form Paver & Dowel Inserter

W=3.35m, T=30cm

L=200m/day

9. Appendix

Appendix A: Spiral Transition Curve Computation Sheet (Excel Program)
Appendix B: Flexible Pavement Design Sheet (Excel Program)
Appendix C: Rigid Pavement Design Sheet (Excel Program)
Appendix D: Pavement Material Charts (NHA Standard Specifications)

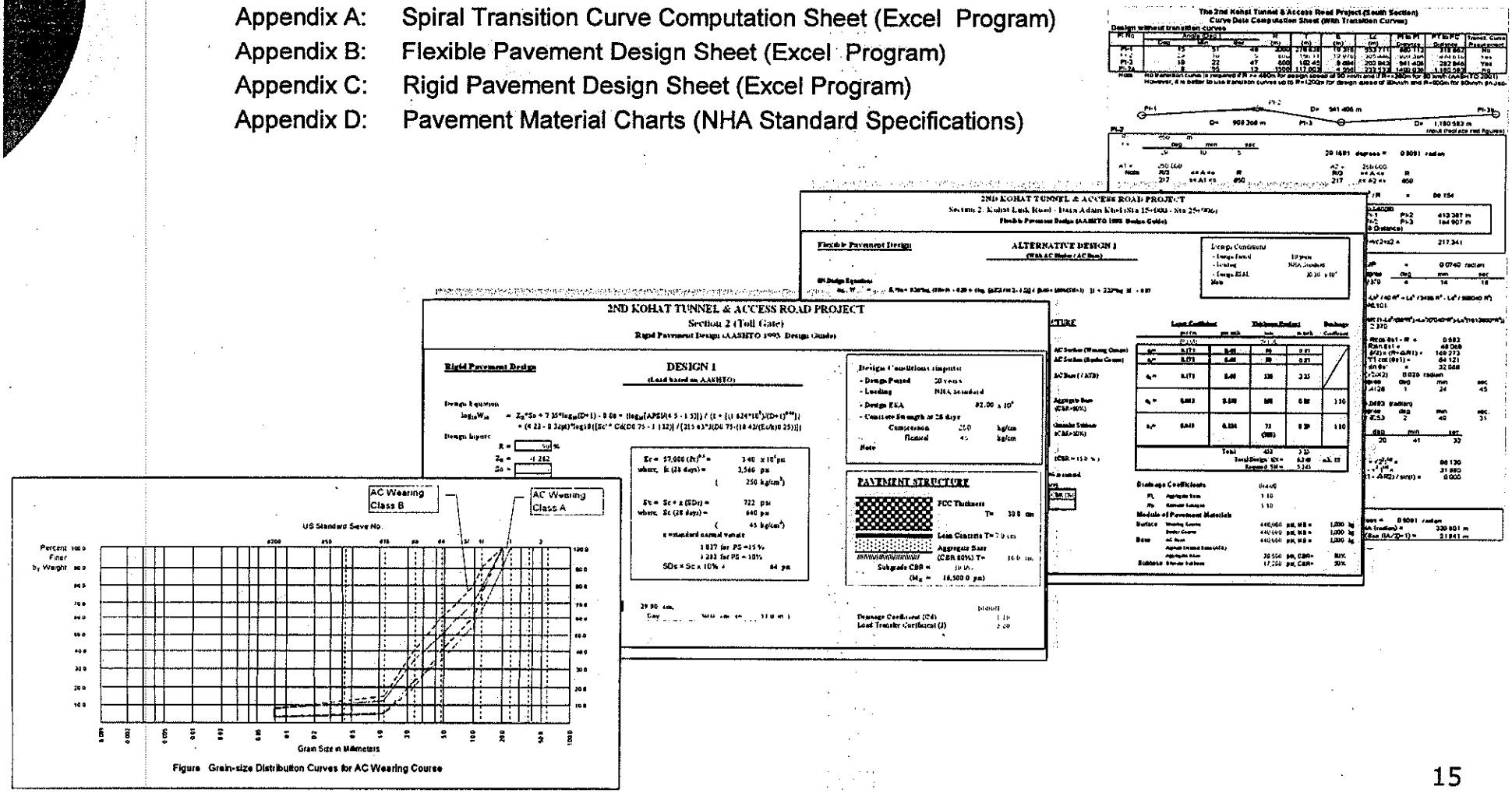
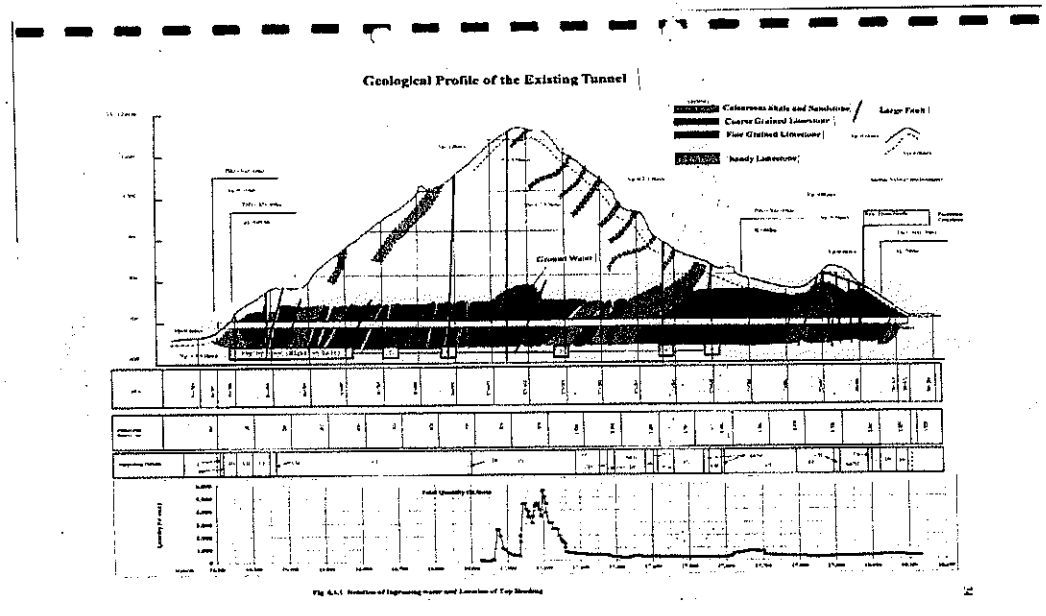


Figure Grain-size Distribution Curves for AC Wearing Course


THANK YOU

TUNNEL GEOLOGY



6TH JULY 2006

JICA STUDY TEAM

TABLE OF CONTENTS

- Geological Map
- Stratigraphic Column
- Geological Profile of the Existing Kohat Tunnel
- Classification of Ground Condition
- Geological Consideration on the New Kohat Tunnel

GEOLOGICAL SURVEY
OF PAKISTAN

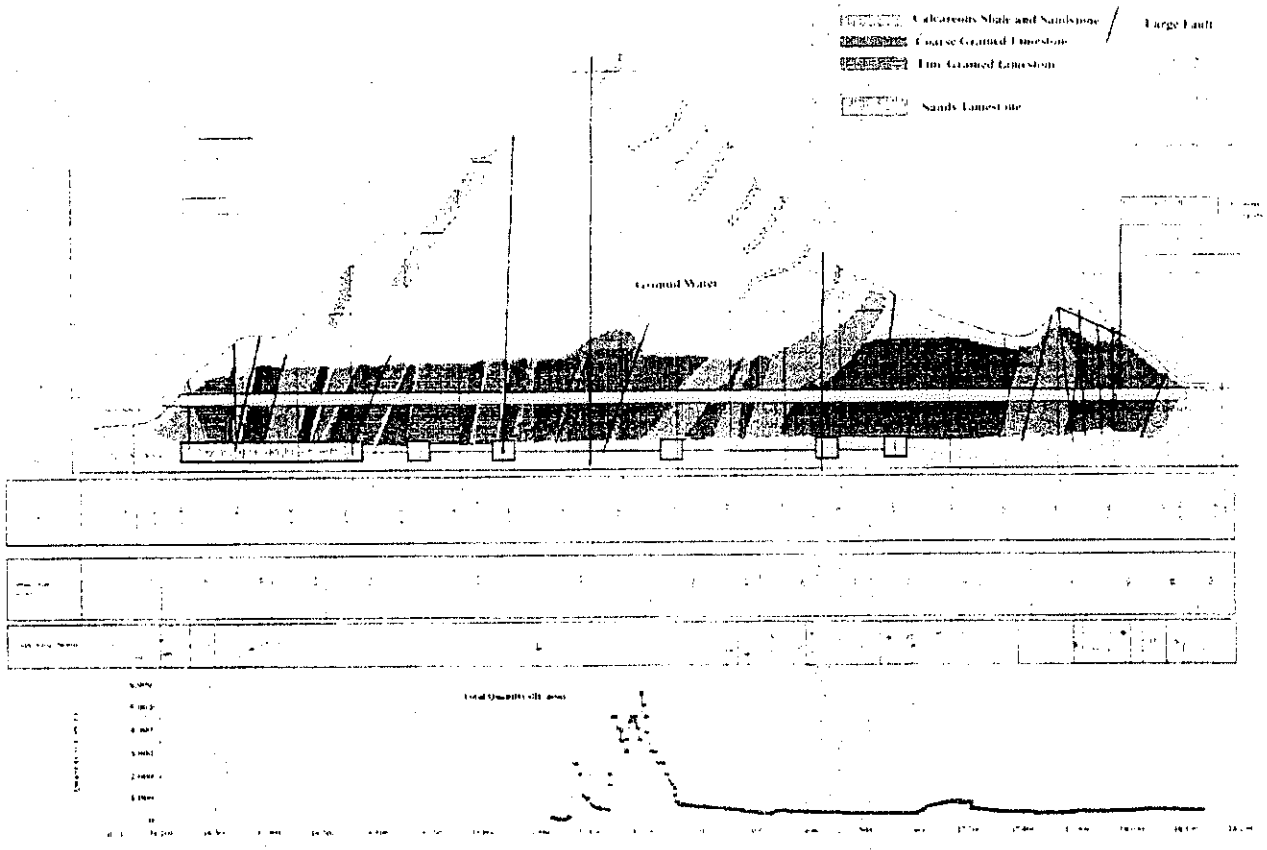
Table 4.1.1 Stratigraphic Column

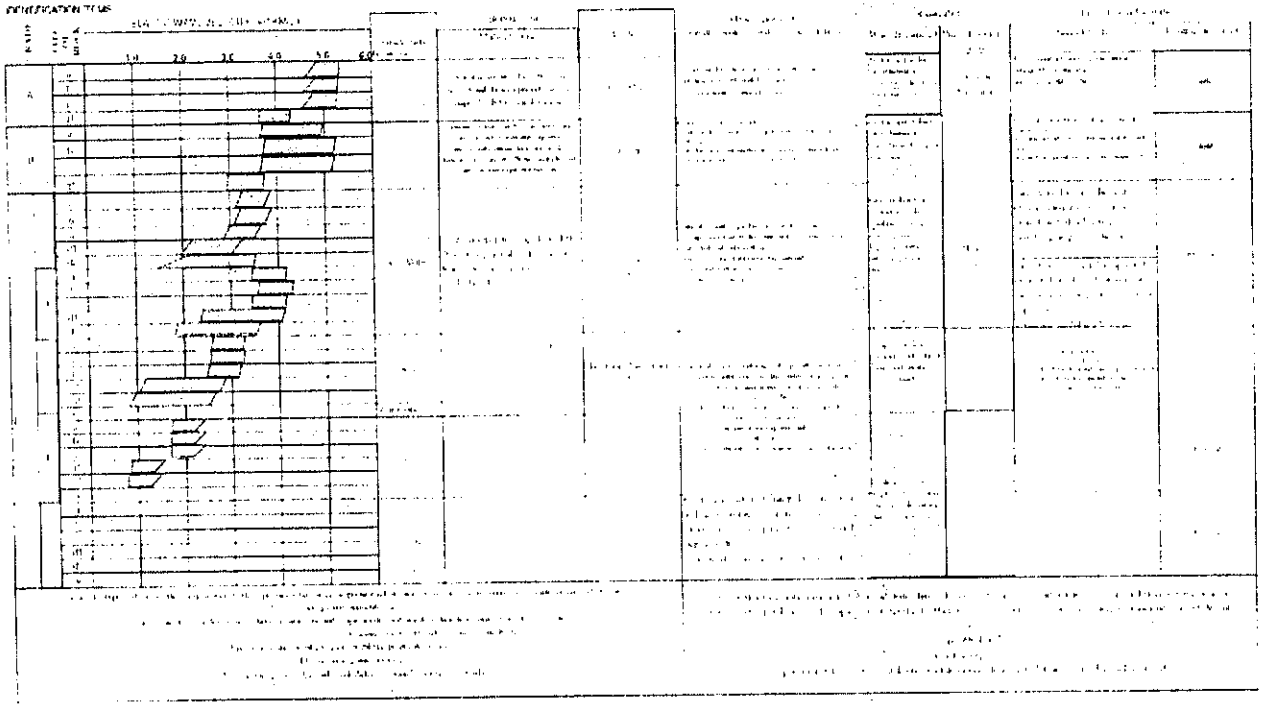
Era	Period		Formation	Column	Lithology	Remarks
Mesozoic 65 m.y.	Paleocene	Upper	Patala 40%		Greenish gray and khaki colored shale with yellowish gray limestone and sandstone.	Weak. Generally incompetent.
		Middle	Lockhart 30%		Medium grained, dark gray to black, force, nodular limestone	Generally hard.
		Lower	Hangu under 1%		[illegible]	Small scale.
	Cretaceous	Upper	Kawagarh 20%		Fine grained, conchoidal fractured [illegible]. Shale is interealated	Generally hard
	Jurassic	Middle	Samana Suk 10%		Limestone	Small scale

Ratio of Rocks in the Existing Tunnel

Limestone	70%	Very hard
Sandstone	15%	Hard
Shale	15%	Weak
Total	100%	

Geological Profile of the Existing Tunnel





Geological Consideration the New Kohat Tunnel

- **Geological Condition**

The mountain projected Kohat tunnel consists of geological formations of Mesozoic era and Cenozoic era. 70 percent of rocks composing tunnel is very hard limestone. And the other rocks are hard sandstone and soft shale. Generally limestone is very stable so that there are few problems for excavation of the tunnel.

Cont…

- **Fault System**

  By the technical report of geological supervision (PCI,,2003),more than 10 faults were found in the tunnel. These faults are mainly thrust faults. And maximum fracture zone among these faults is about 5 meters in width. It seems that these faults are not so active. But it needs attention to drill the tunnel for collapse of rocks.

Cont...

- **Ground Water**

Above existing tunnel between St.No.17+50 and St.No.17+100, there was a pool of ground water. Generally ground water is drained passing through faults. 3 years ago, quantity of ground water from the tunnel was about more than 5ton/ min. . But at the present time the quantity of ground water is about less than 1ton/ min. and its quantity changes by influence of annual rainfalls. So it seems that existing tunnel take the part of big drain during construction of new tunnel.

Cont...

- **North Portal**

The new north portal is located on the gentle slope of the mountain. This slope consists of limestone covered with thin talus deposits. It seems that this slope is geologically stable. So there is no problem for drilling new north portal.

Cont...

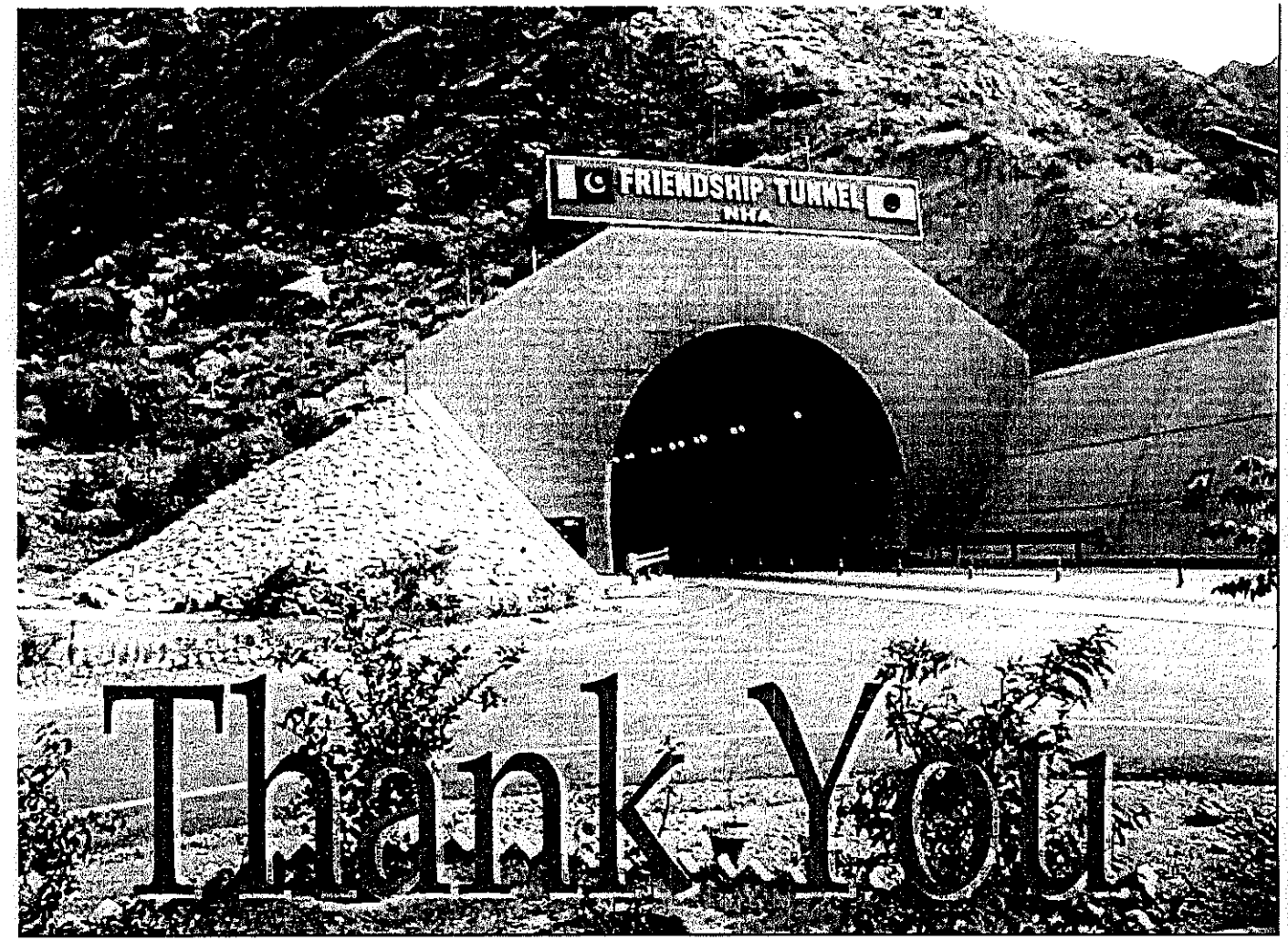
- **South Portal**

The new south portal is located on the exit of a valley with steep slope opened to south. In the bottom of valley, thick debris flow deposit is found on the basement rock of limestone. During construction or after completion of new south portal, there is a possibility that it may be destroyed by unexpected strong debris flow. So that reason, some structure shall be required to protect the south portal on the bottom of valley.

Cont...

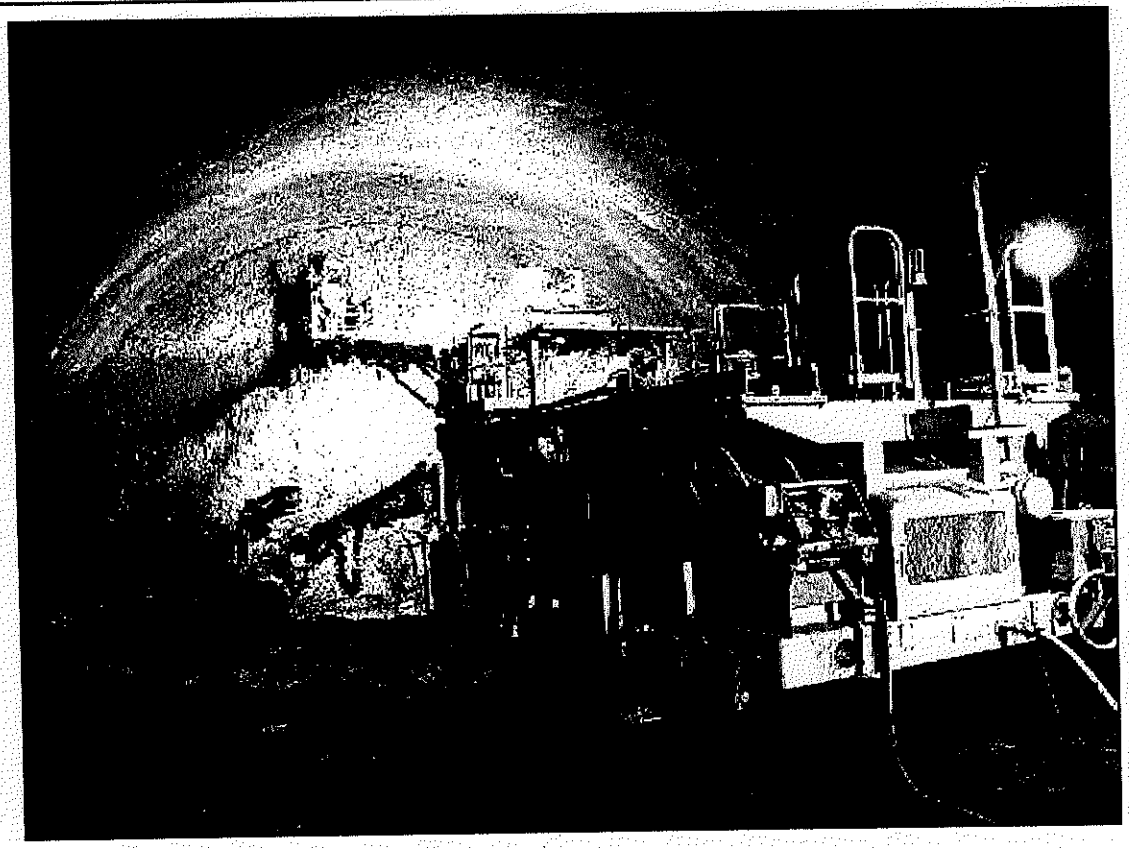
- **Access Road**

The new access road is projected on the east side of existing road. Cutting slope works shall be done on it at some places. It seems that these slopes are geologically stable after checking of the existing road. Though, some protection works like shot Crete, grouted riprap and rock net shall be needed accordingly for cutting slopes..


FRIENDSHIP TUNNEL
NHA
Thank You

PAKISTAN TRASPORT PLAN STUDY (PTPS) – II
THE 2ND KOHAT TUNNEL & ACCESS ROAD PROJECT

TUNNEL DESIGN



JULY 2006
PRESENTED BY
JICA STUDY TEAM

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8. Capacity in Drainage Facilities
9. Mechanism of Overflow and Improvement Plan
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11. Construction Outline Chart
12. Tunnel Construction Schedule (Draft)

1. Road Parameter & Design Standard

ITEM	THE 2ND KOHAT TUNNEL
Road Type	Two-lane road tunnel
Design Speed	60km/hr
Longitudinal Slope	2.4% Down for South bound traffic (1st: 2.2% Up for North bound traffic)
Clearance Limit	Design standard of Pakistan
Design Standard	Technical Standards for Road Tunnel in Japan
Geological Condition	The construction results of 1st KOHAT tunnel

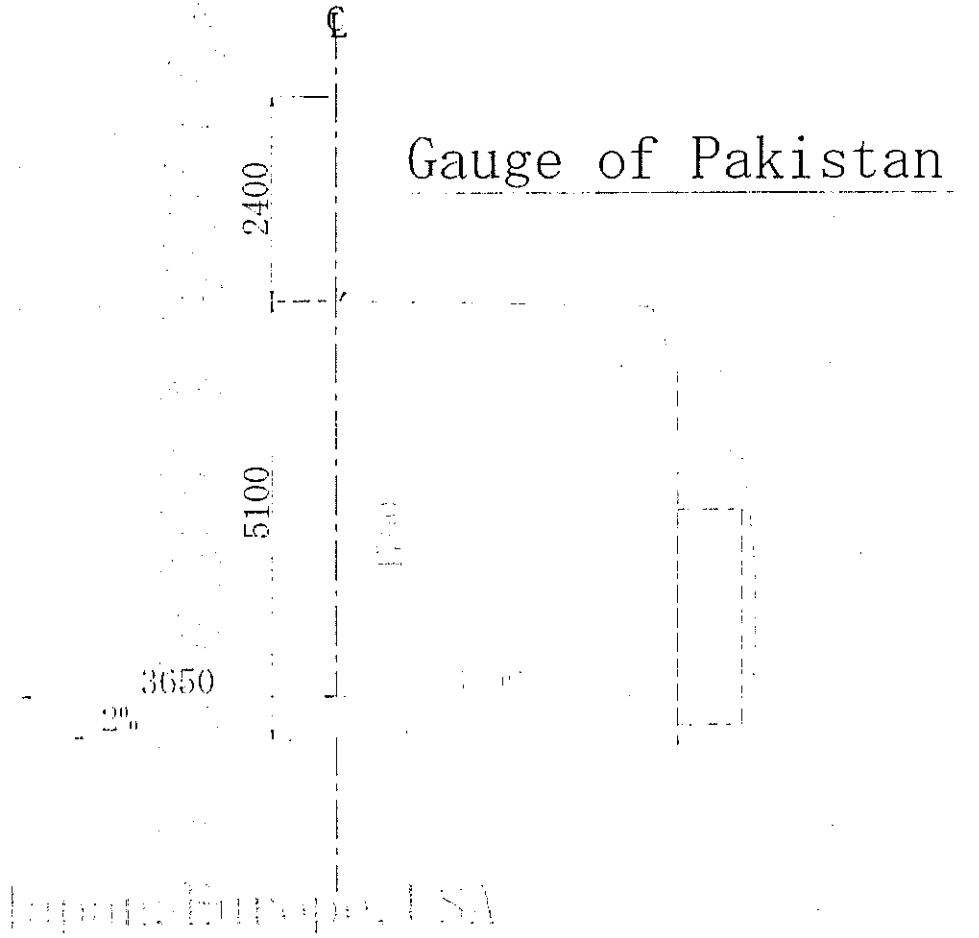
2. Clearance Limit of KOHAT Tunnel

Gauge of KOHAT tunnel

- Lain Width : 3.65m x 2
- Shoulder : 0.3m x 2
- Road Width : 7.9m
- Clearance : 5.1m

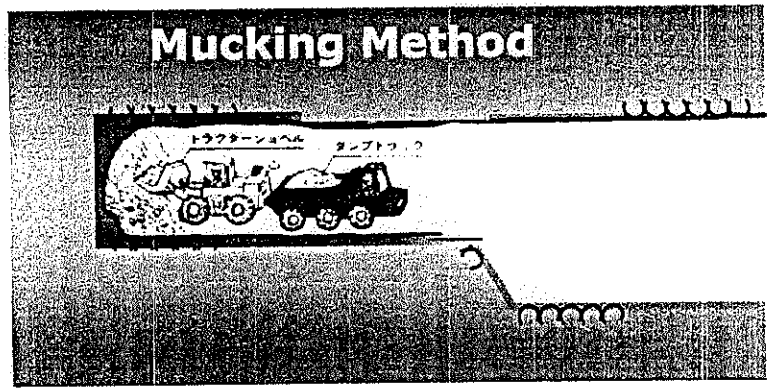
Gauge of Japan, Europe, USA

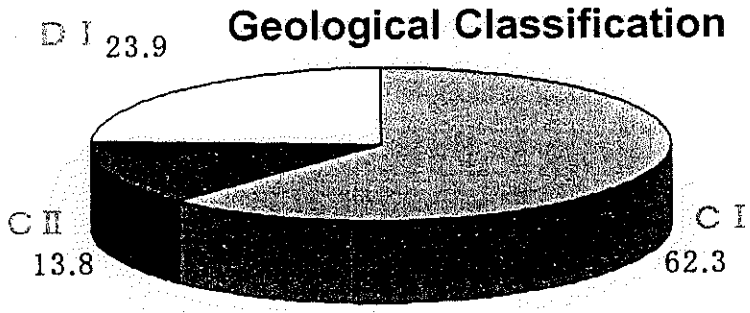
- Lain Width : 3.50m x 2
- Shoulder : 0.5m x 2
- Road Width : 8.0m
- Clearance : 4.7m



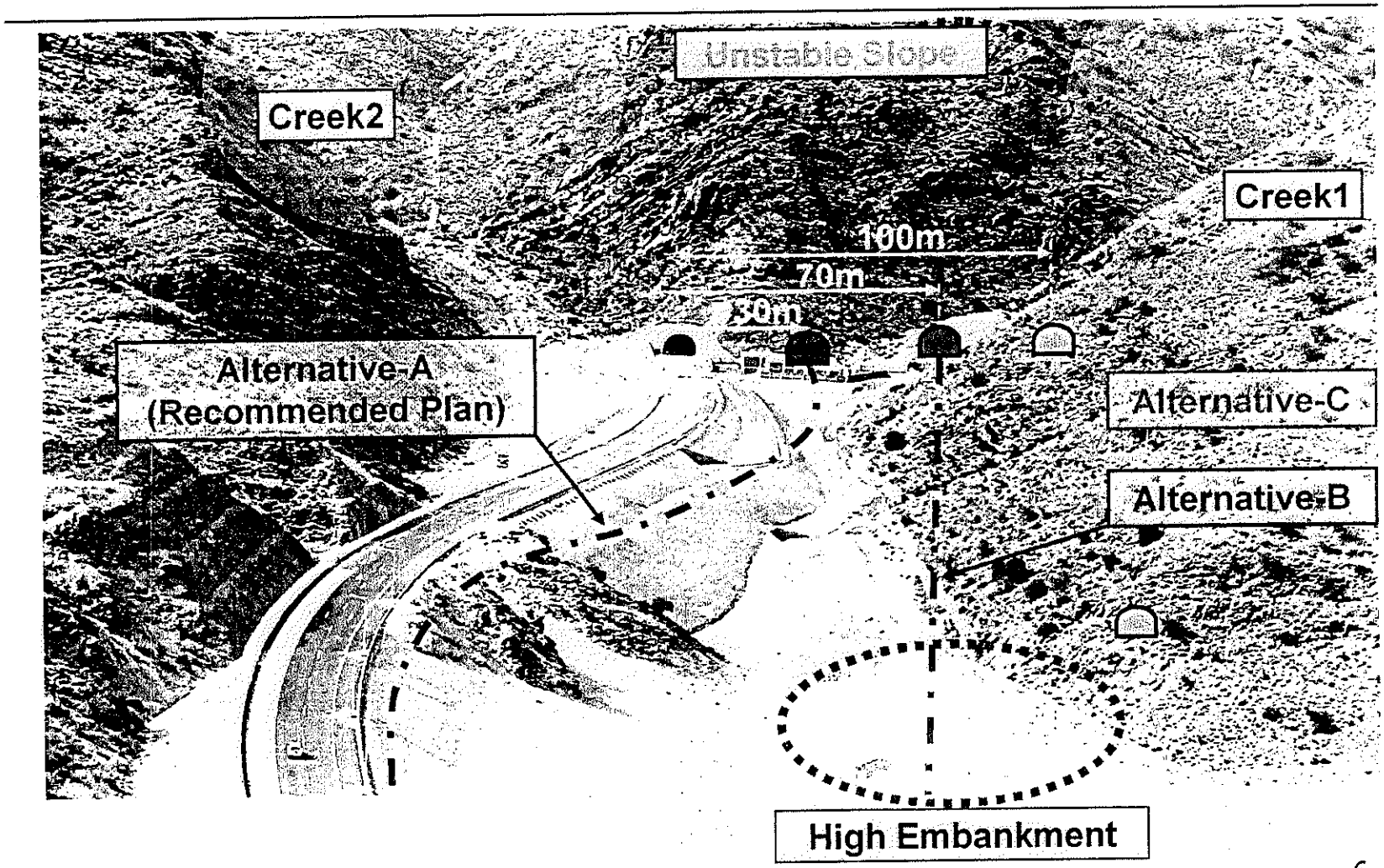
3. Basic Condition of Tunnel Planning

ITEN		THE 2ND KOHAT TUNNEL
Tunnel length		L=1885m
Longitudinal Slope		i=2.4% (for climbing down traffic)
Excavation Methods	C I 、C II	NATM、Top Heading and Bench Method
	D I	
Mucking Method		Haulage of muck by Rubber-tired Vehicles
Direction of construction		One-way excavation (from south portal)

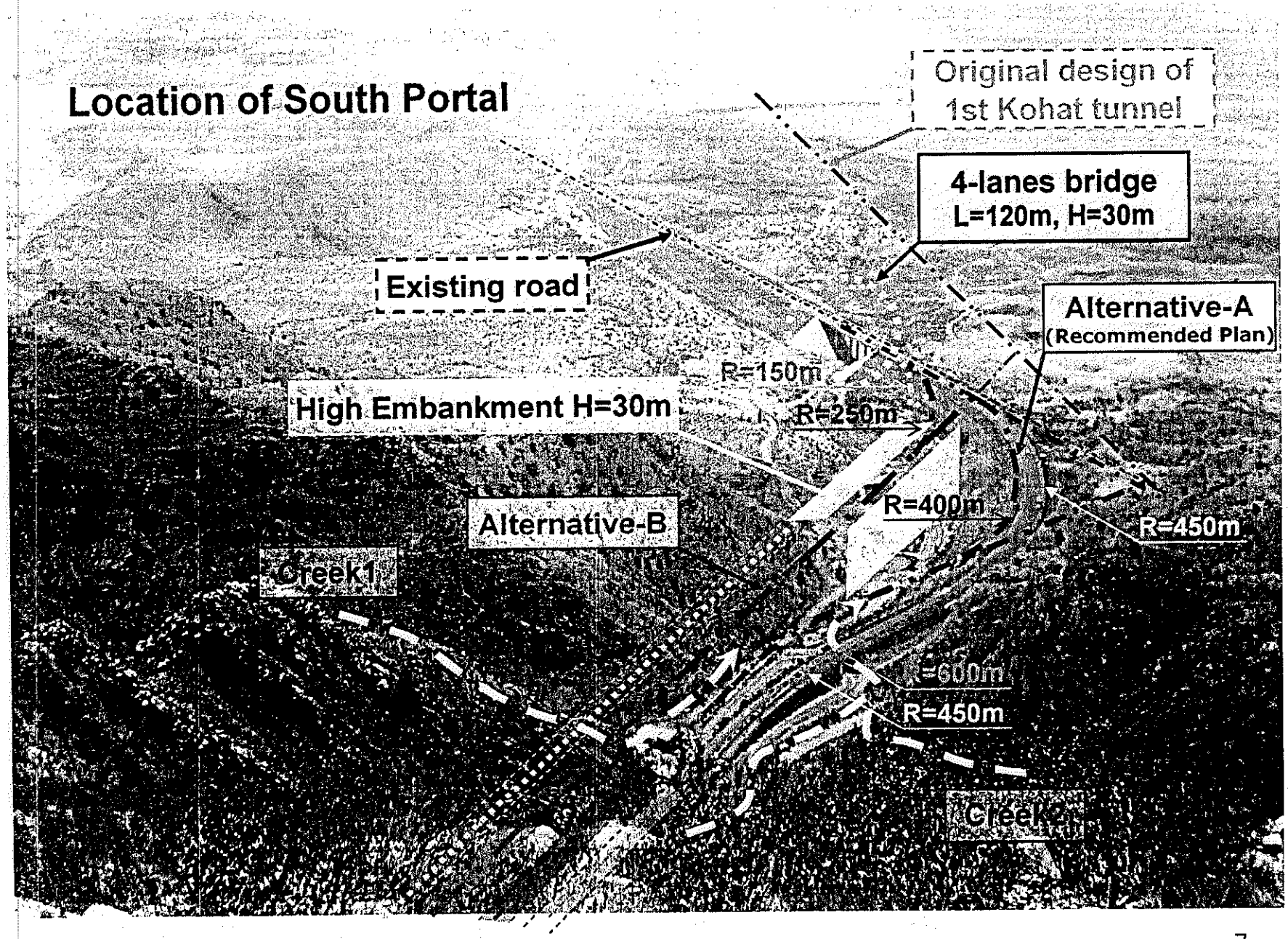




4. Plan of the South Portal Position



Location of South Portal

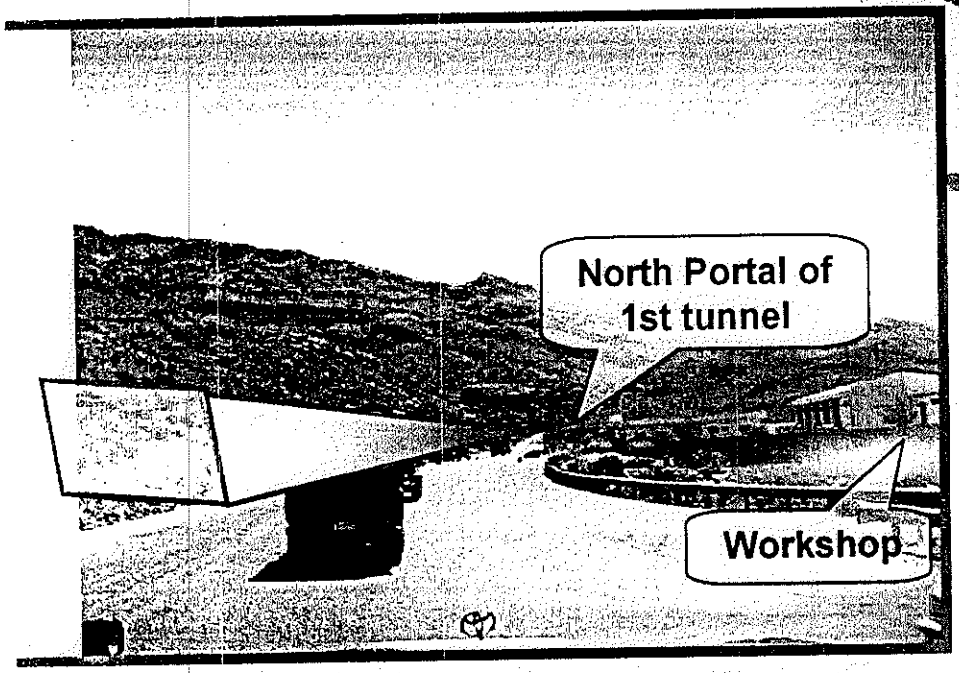


Position Selection of Tunnel South Portal

Existing tunnel 	Alternative-A  30m	Alternative-B  70m	Alternative-C  100m
Topographic condition	○	△	○
Radius of curve (m) at Bridge	400m : OK	250m : Poor	150m : NG
Earthworks Quantities (FILL) (m^3)	390,000	1,010,000	660,000
Earth Quantities (Cut) (m^3)	500	24,500	——
Increase of tunnel length (m)	——	——	420m
Cost	◎	○	X
Risks	——	Rock fall, Debris Flow, High Embankment	——
Overall Assessment	◎	△	X

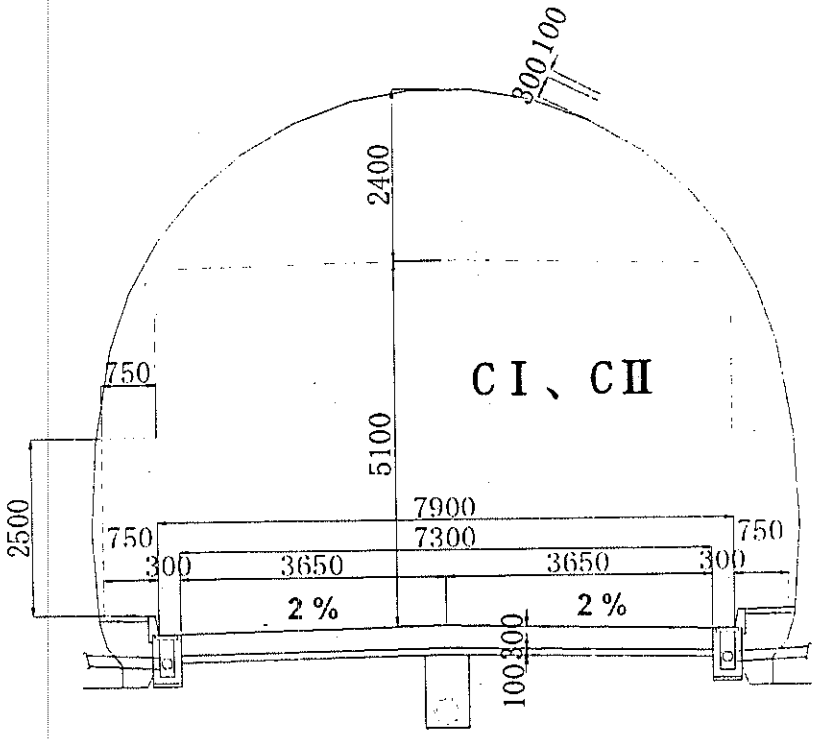
Recommended

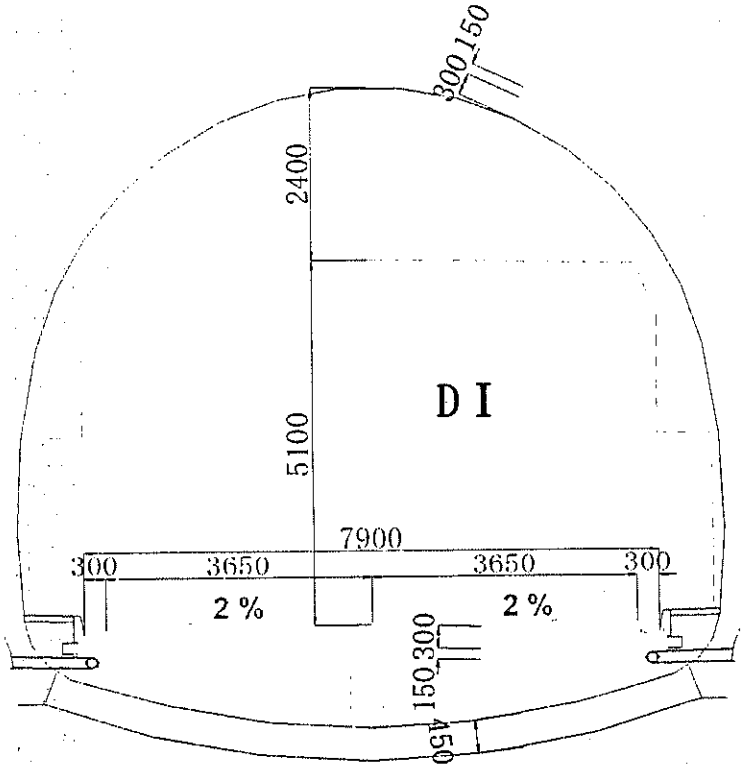
5. Plan of the North Portal Position



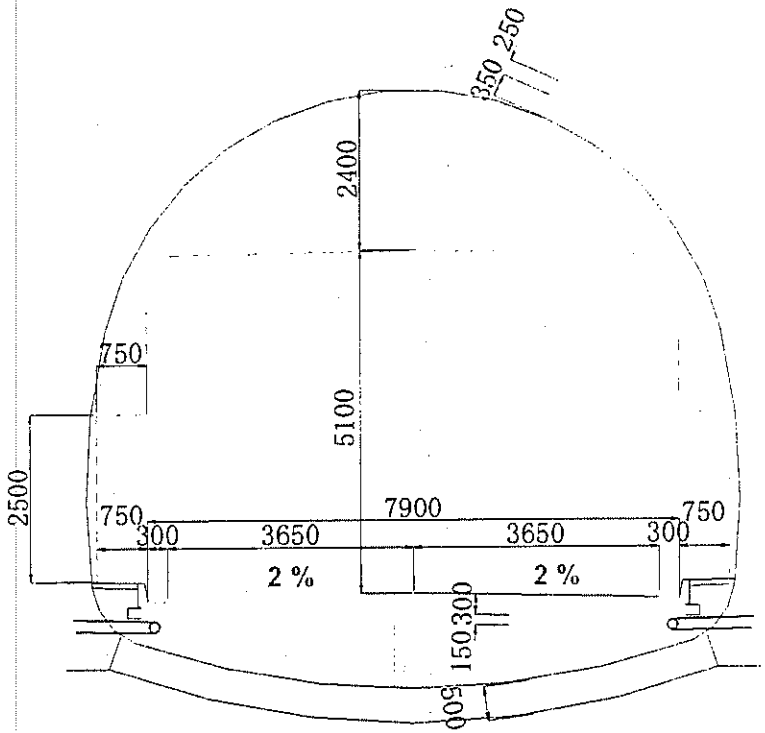
6. Cross Sections of Tunnel

- Cross Section type : C Ⅰ , C Ⅱ , D Ⅰ , Portal, Emergency
- Clearance limit of Roadway : 7.9m × 5.1m
- Clearance limit of Maintenance way : 0.75m × 2.5m
- Emergency parking bay : 10.9m × 2.5m

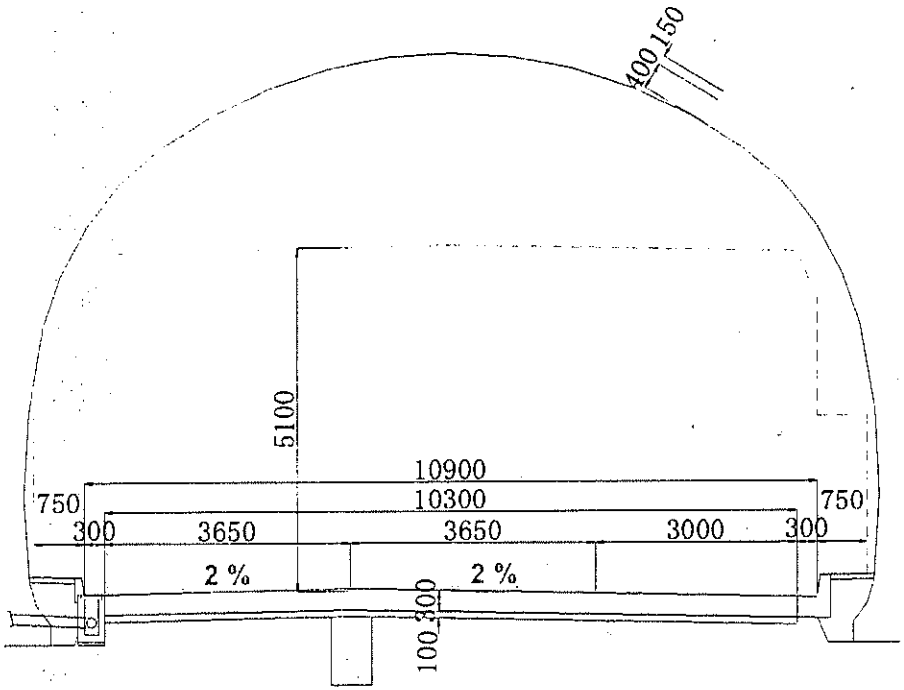




Portal, Emergency



Portal

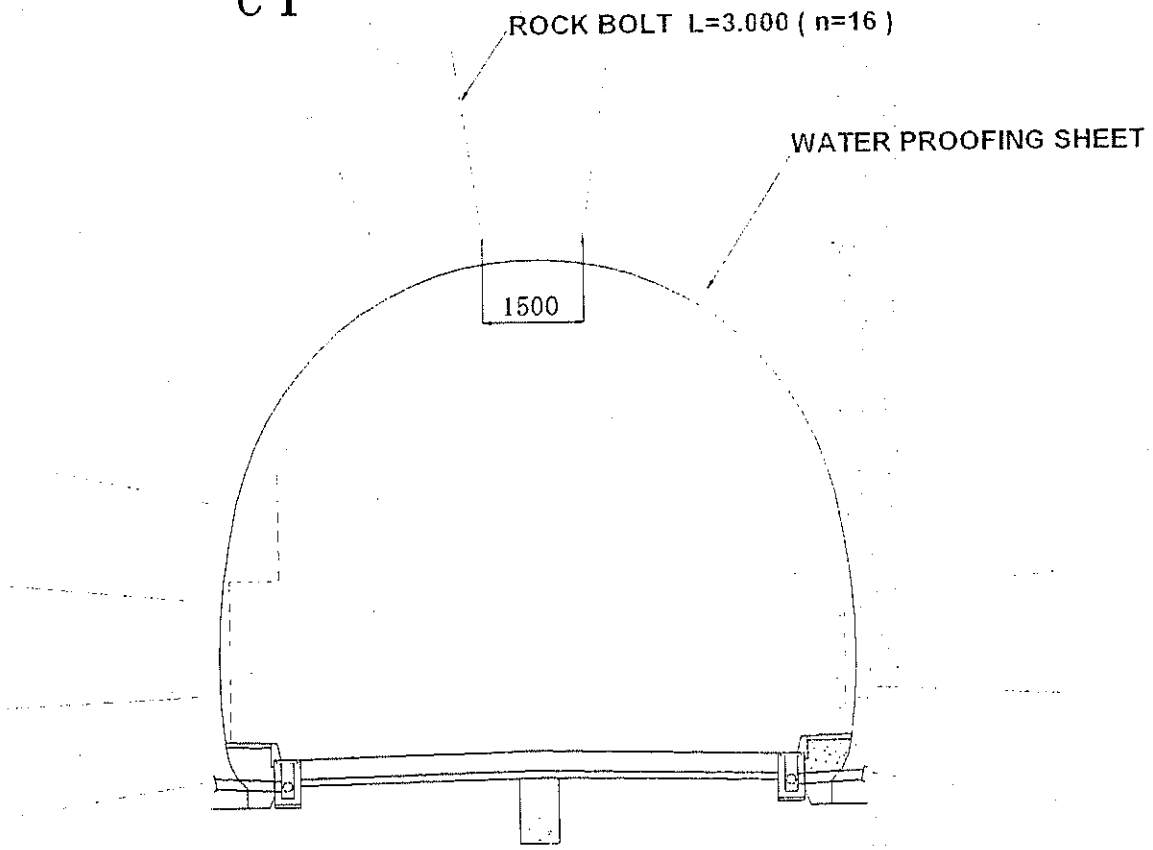


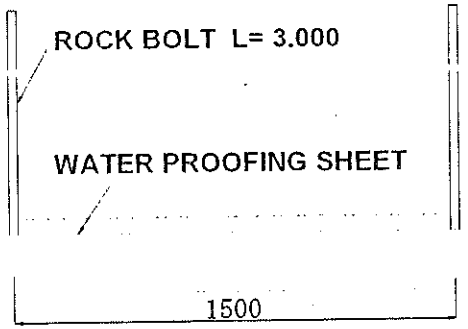
Emergency

7. Support type of Tunnel

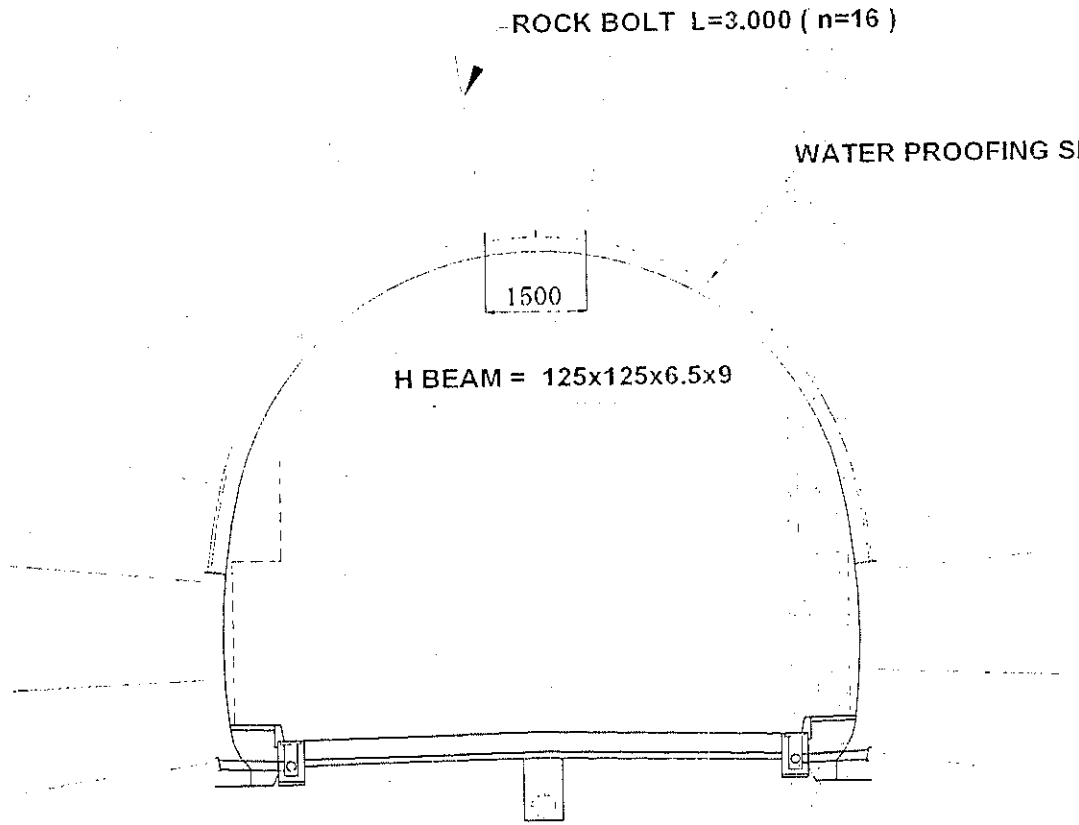
- Cross Section type : C Ⅰ , C Ⅱ , D Ⅰ , Portal, Emergency

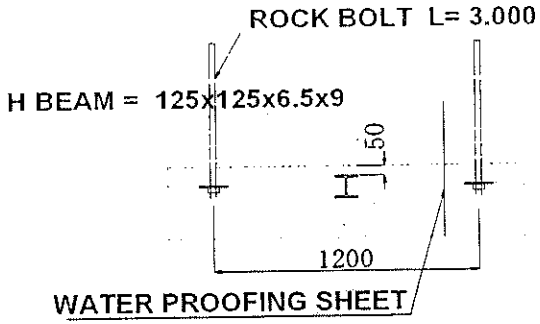
C Ⅰ



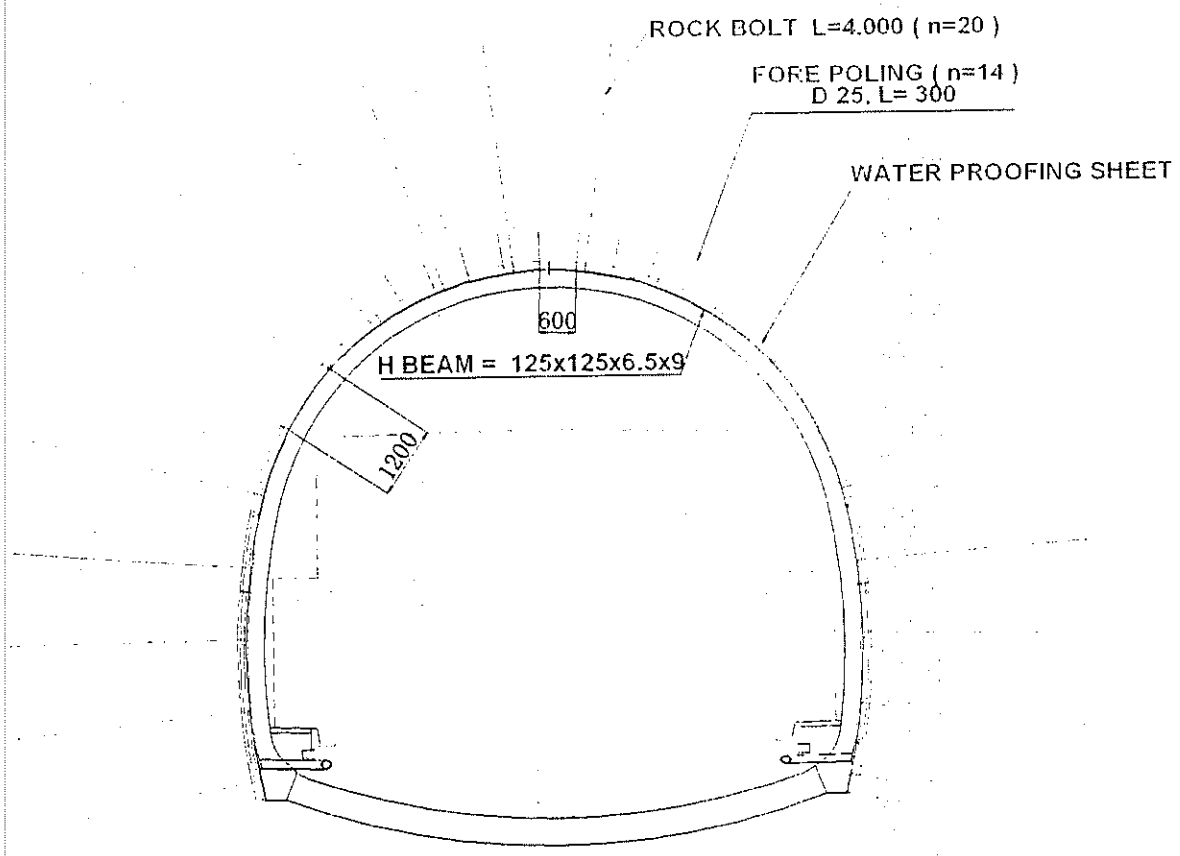


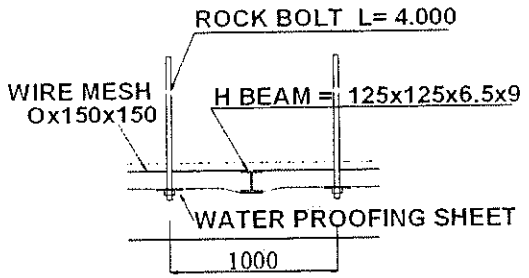
C II

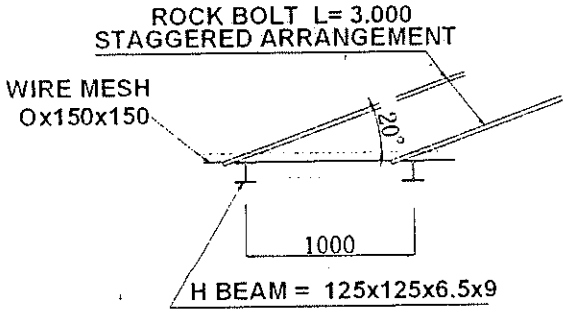

ROCK BOLT L=3.000 (n=16)
WATER PROOFING SHEET
1500
H BEAM = 125x125x6.5x9


ROCK BOLT L= 3.000
H BEAM = 125x125x6.5x9
L50
1200
WATER PROOFING SHEET

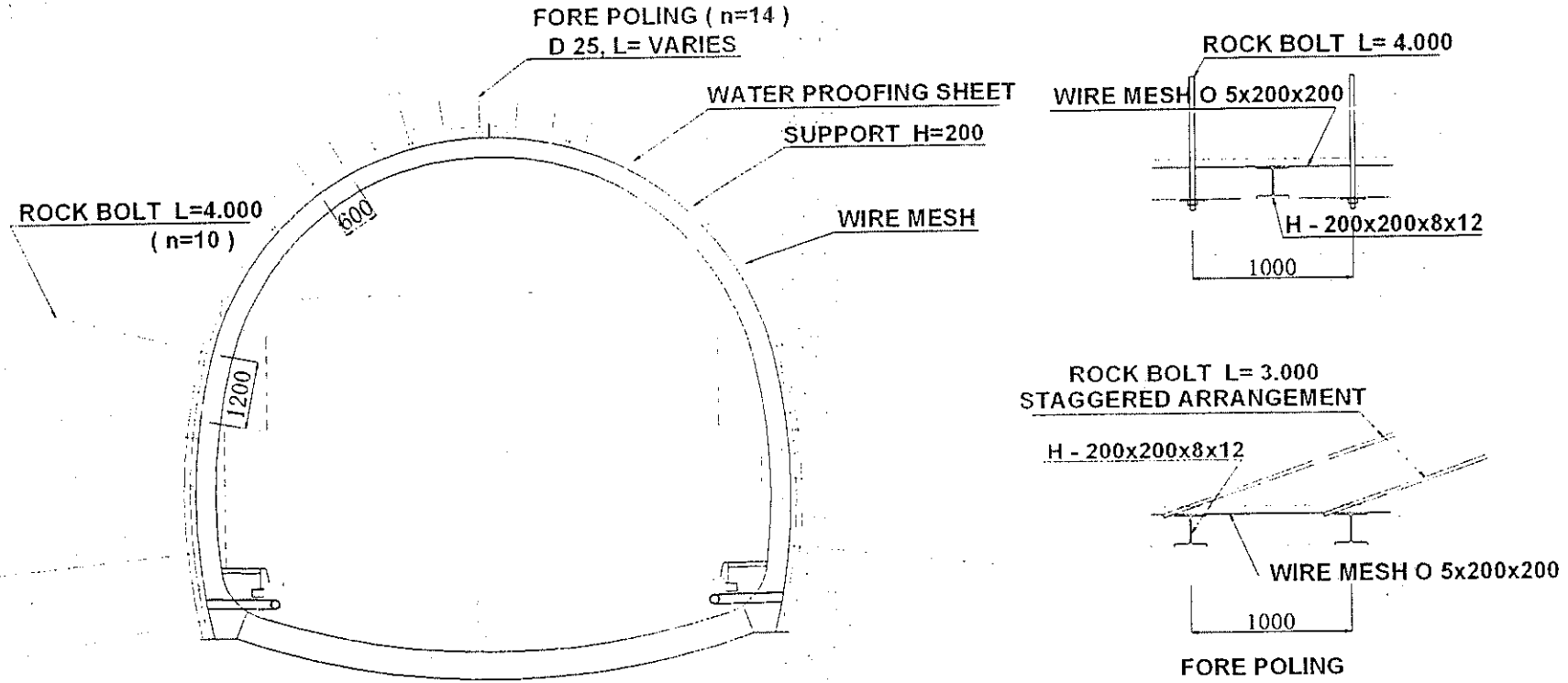
D I


ROCK BOLT L=4.000 (n=20)
FORE POLING (n=14)
D 25, L= 300
WATER PROOFING SHEET
600
H BEAM = 125x125x6.5x9
1200

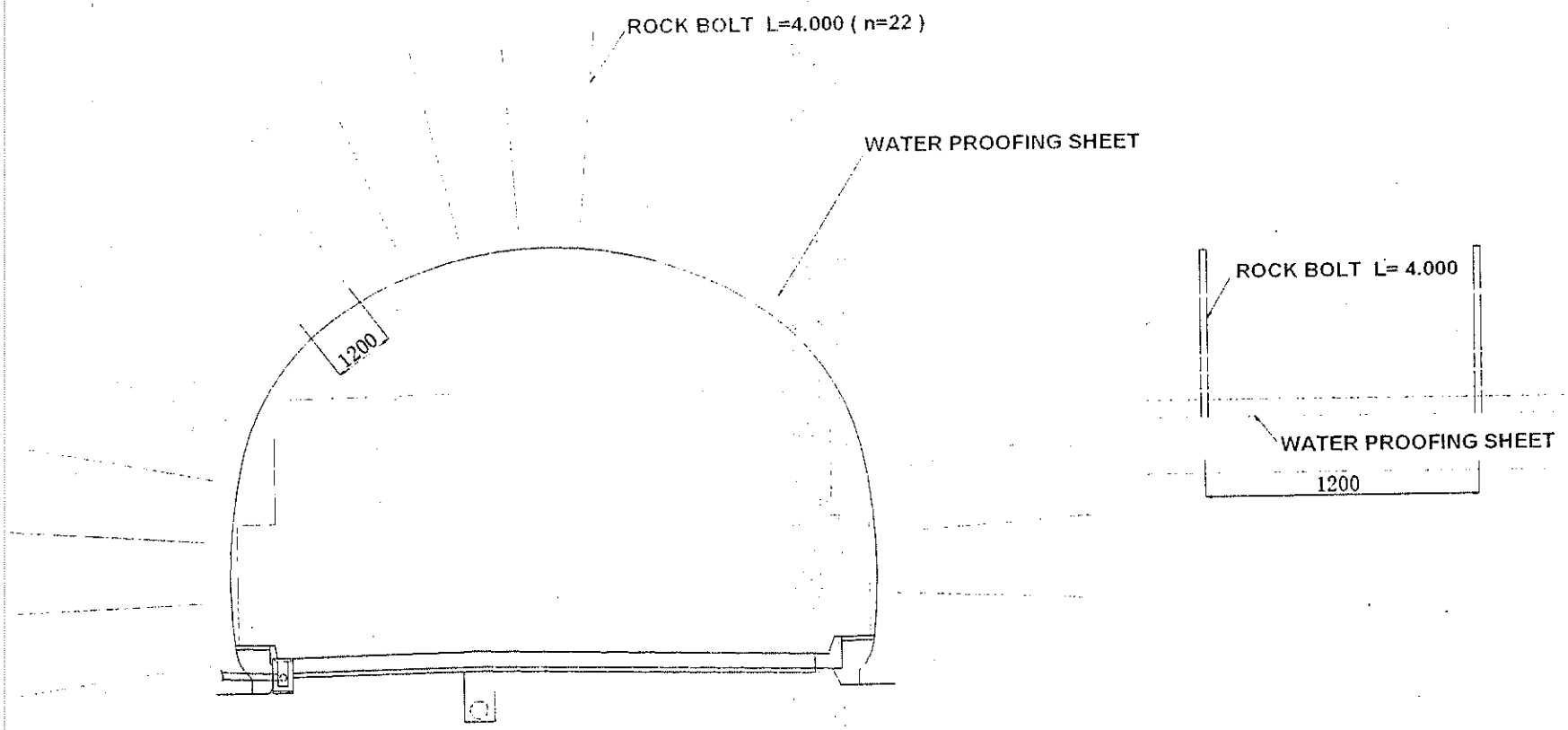

ROCK BOLT L= 4.000
WIRE MESH
Ox150x150
H BEAM = 125x125x6.5x9
WATER PROOFING SHEET
1000


ROCK BOLT L= 3.000
STAGGERED ARRANGEMENT
WIRE MESH
Ox150x150
20°
1000
H BEAM = 125x125x6.5x9

Portal

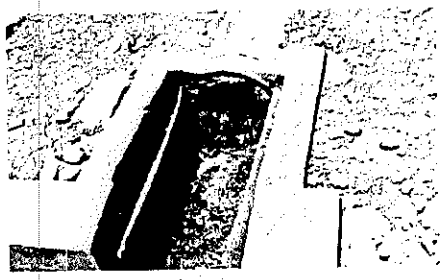

FORE POLING (n=14)
D 25, L= VARIES
WATER PROOFING SHEET
SUPPORT H=200
WIRE MESH
ROCK BOLT L=4.000
(n=10)
600
1200
ROCK BOLT L= 4.000
WIRE MESH O 5x200x200
H - 200x200x8x12
1000
ROCK BOLT L= 3.000
STAGGERED ARRANGEMENT
H - 200x200x8x12
WIRE MESH O 5x200x200
1000
FORE POLING

Emergency


ROCK BOLT L=4.000 (n=22)
WATER PROOFING SHEET
1200
ROCK BOLT L= 4.000
WATER PROOFING SHEET
1200

8. Capacity in Drainage Facilities

○



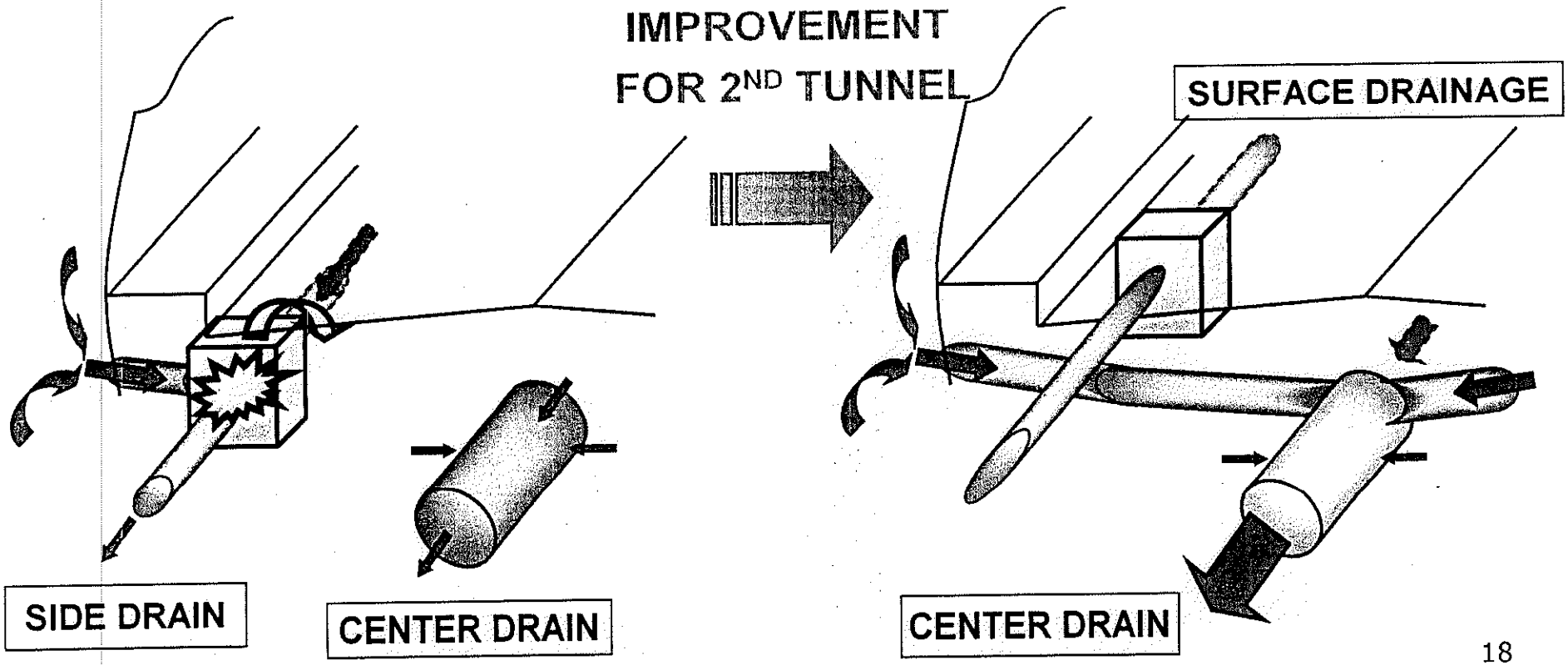
CENTER DRAIN

Capacity in Drainage Facilities

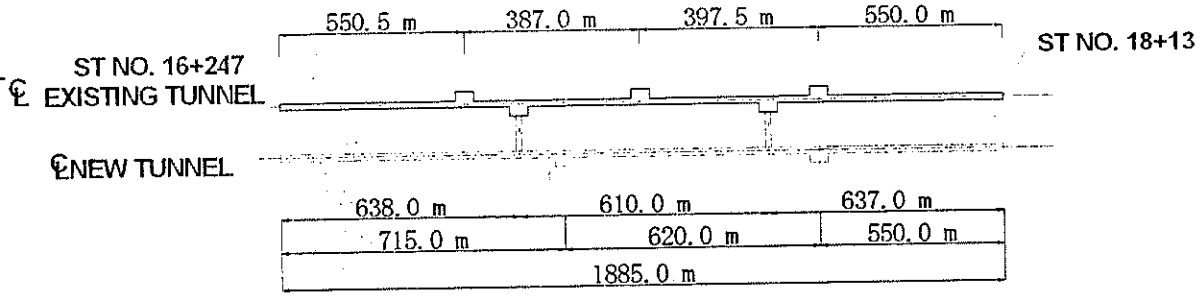
	Diameter (mm)	Coefficient of Roughness	80% Discharge (m^3/min)	
			i =2.2%	i =2.4%
CENTER DRAIN (Perforated Pipe)	Φ300	0.025	3.84	4.02
SIDE DRAIN (P.V.C)	Φ150	0.013	1.14×2	1.20×2
	Φ200		2.58×2	2.70×2
	Φ250		4.62×2	4.80×2

9. Mechanism of Overflow & Improvement Plan

Note: This will also contribute to the 1st Tunnel drainage improvement

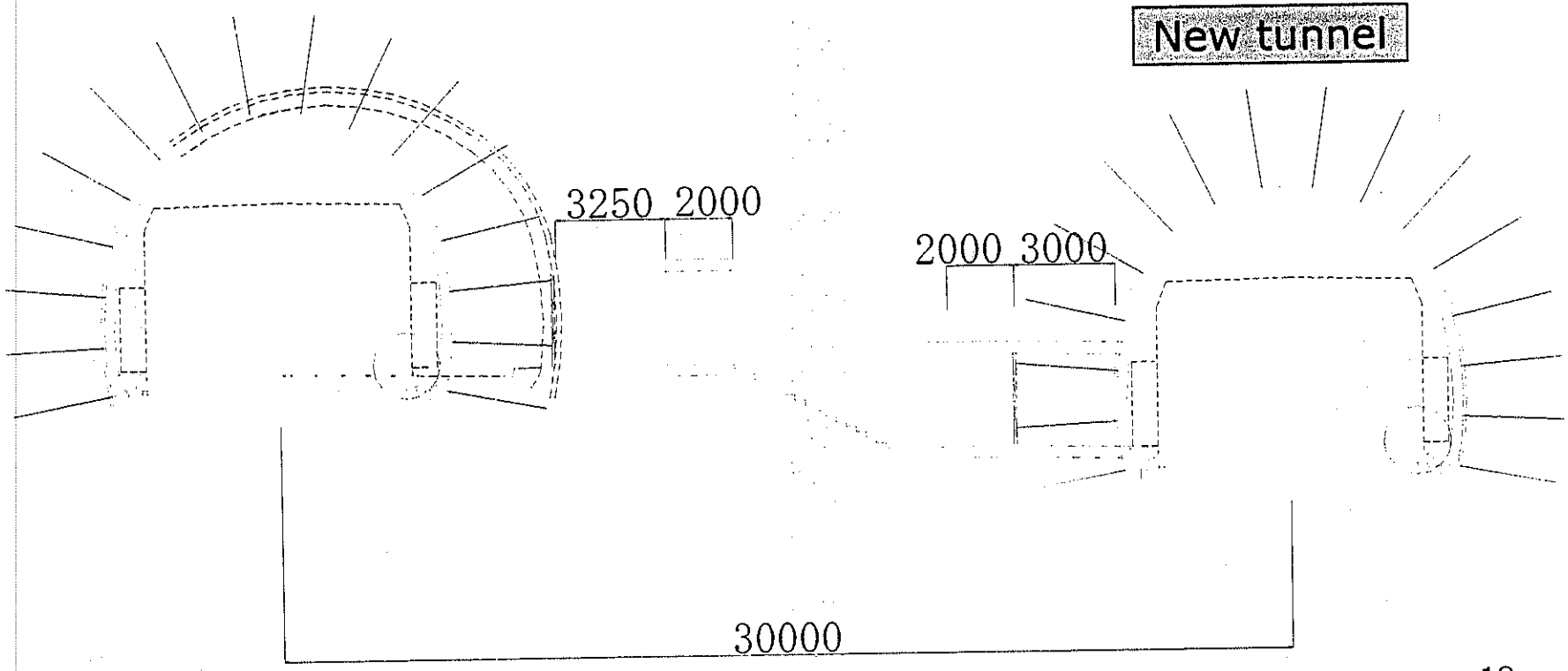


10. Cross Passage



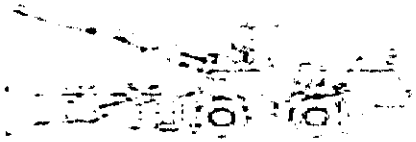
Existing tunnel

New tunnel

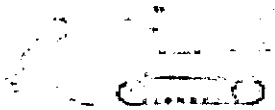


11. Construction Outline Chart

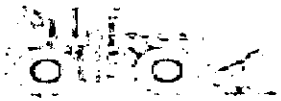
WHEEL JUMBO



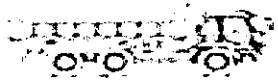
SHOVEL & BREAKER



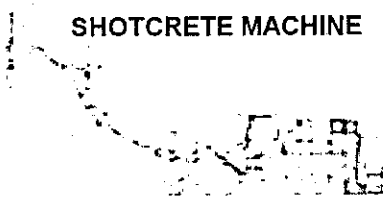
WHEEL LOADER



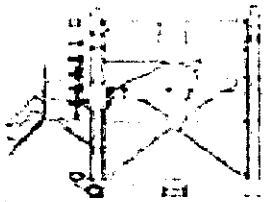
DUMP TRUCK



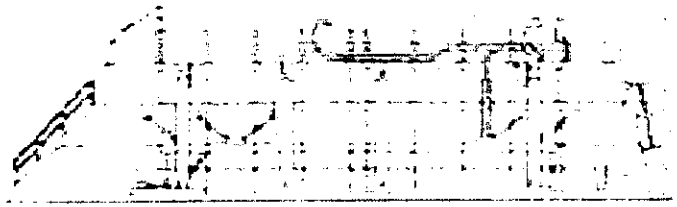
SHOTCRETE MACHINE



MIXER CAR

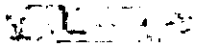


WATERPROOFING STAGE



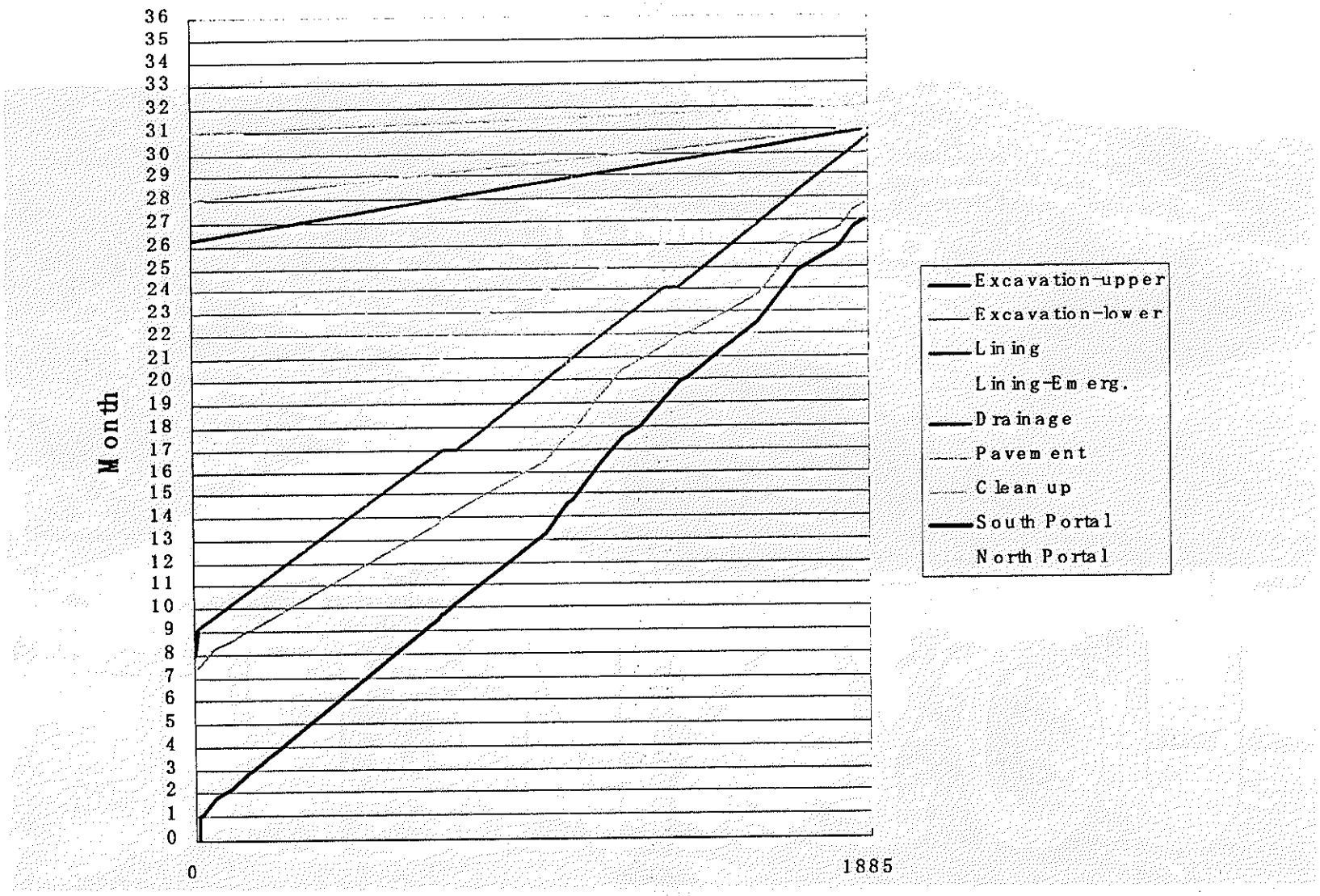
LINING FORM

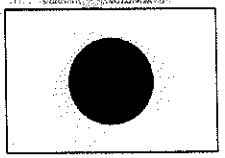
PUMP CAR



MIXER CAR

12. Tunnel Construction Schedule (Draft)





NHA

NTRC

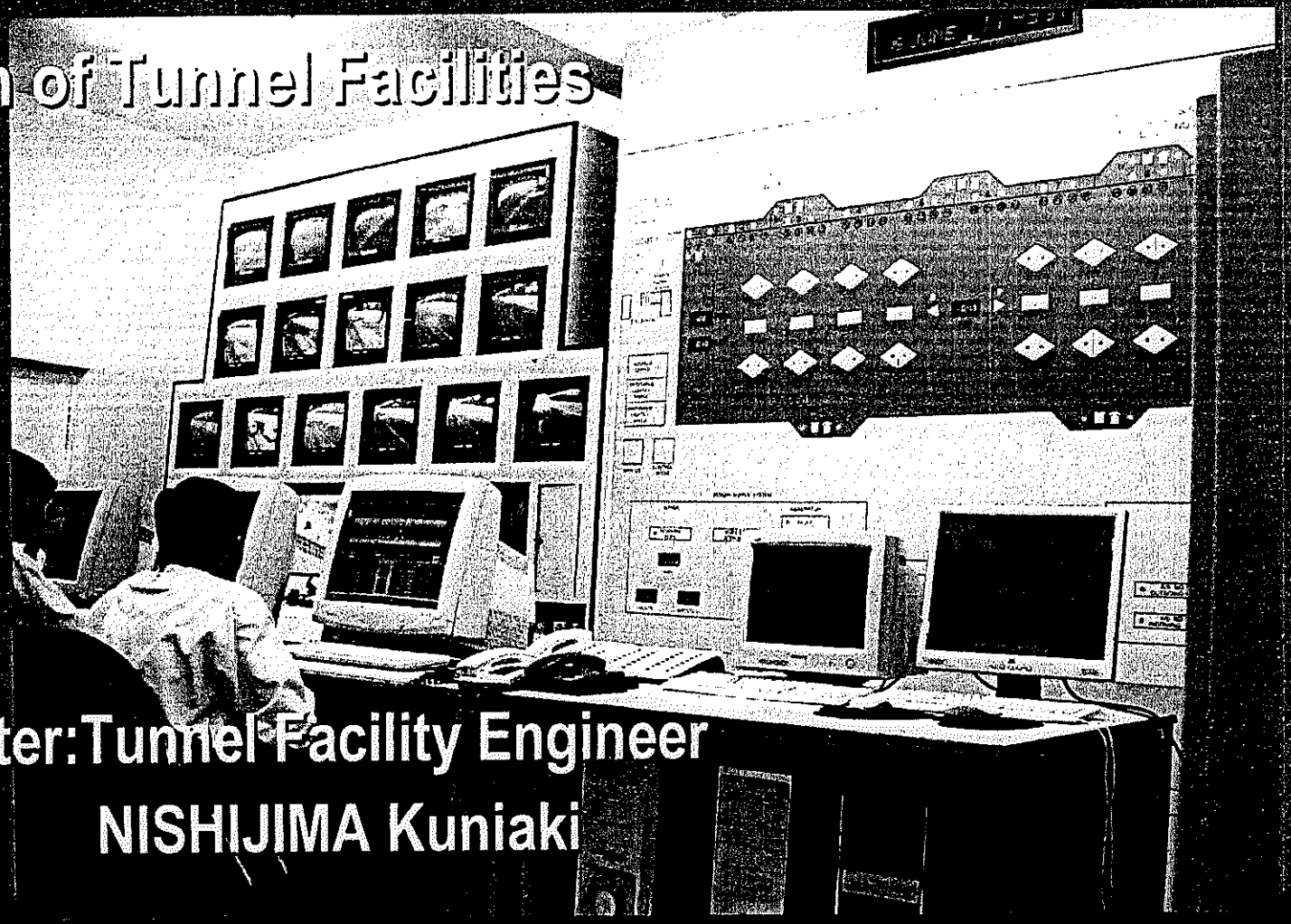
JICA

Pakistan 2nd Kohat Tunnel Feasibility Study

Mechanical & electrical Facilities

Introduction

اسلام علیکم



- Design of Tunnel Facilities
- Presenter:Tunnel Facility Engineer

NISHIJIMA Kuniaki

2006/7/3

Tunnel Facilities

- Ventilation
- Lighting
- Emergency Facilities
- Power supply
- Control Facilities

Ventilation Facilities

- Design Procedure
- 1) Fresh Air Requirement
- 2) Ventilation System selection
- 3) Natural Ventilation volume
- 4) Required Jet fan numbers

Calculation of Fresh air requirement

➲ Fresh air requirements

$Q = K \cdot Q0$

$K = K1 \cdot K2$

$Q0 = q \cdot N \cdot L$

where Q0 : Standard fresh air requirement

K1 : coefficient for speed and grade

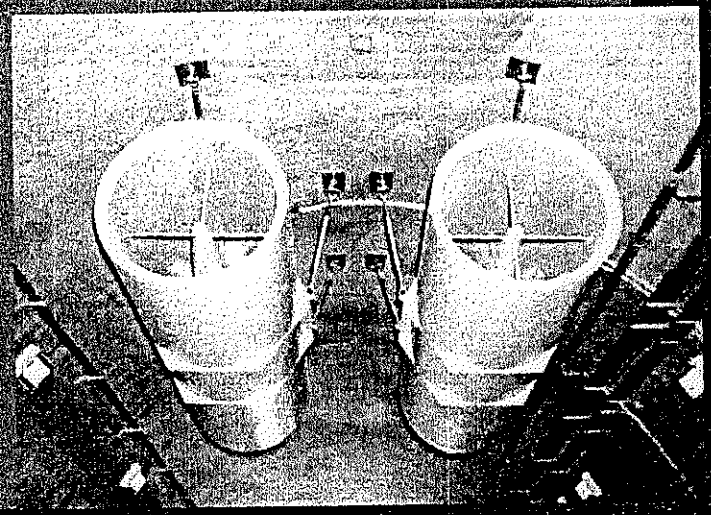
K2 : coefficient for altitude

q : ventilation volume coefficient

N : traffic volume (veh./h)

L : total length of tunnel (km)

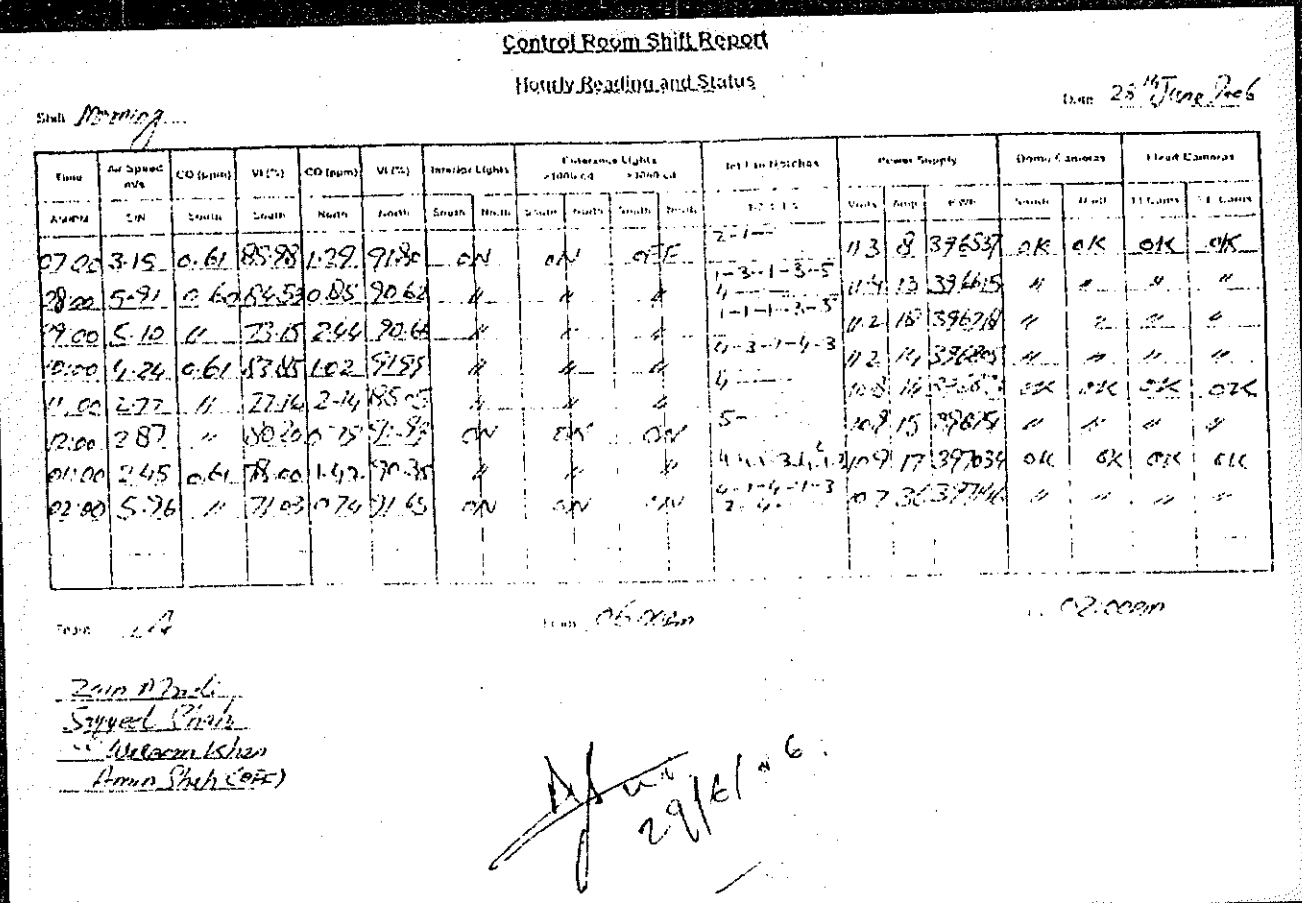
Mechanical Ventilation system



Present situation of Kohat tunnel Ventilation

- Record of measurements
- Letter from EPA(Environmental Protection Agency)
- Counter Argument for the letter
- Construction of new tunnel: Permanent solution for this problem

Present situation of Kohat tunnel Ventilation + Record of measurement



Control Room Shift Report

Hourly Reading and Status

Shift Morning

Date 25th June 2006

Time	Air Speed m/s	CO (ppm)	VI (%)	CO (ppm)	VI (%)	Interior Lights		Entrance Lights >1000 cd		>3000 cd		Jet Fan Notches		Power Supply			Dome Cameras		Head Cameras	
AM/PM	S/N	South	South	North	North	South	North	South	North	South	North	S-1 S-2 S-3	N-1 N-2 N-3	Volts	Amps	KVA	South	North	S Cams	N Cams
07:00	3.15	0.61	85.98	1.29	91.85	ON		ON		OFF		2-1		113	8	396537	OK	OK	OK	OK
08:00	5.91	0.60	84.53	0.85	90.62	"		"		"		1-3-1	1-3-5	114	13	396615	"	"	"	"
09:00	5.10	0	73.65	2.66	90.66	"		"		"		1-1-1	3-3-5	112	15	396718	"	"	"	"
10:00	4.24	0.61	83.85	1.02	91.55	"		"		"		3-3-1	4-3-3	112	14	396805	"	"	"	"
11:00	2.77	"	77.14	2.14	85.53	"		"		"		4		108	16	396858	OK	OK	OK	OK
12:00	2.87	"	80.20	0.75	92.85	ON		ON		ON		5		109	15	396815	"	"	"	"
01:00	2.45	0.61	78.00	1.47	90.35	"		"		"		4	3 1 3	109	17	397039	OK	OK	OK	OK
02:00	5.76	"	71.03	0.76	91.65	ON		ON		ON		3	4-1-4-1-3	107	36	397146	"	"	"	"

Team 2+4 Team 06:00am 02:00pm

Zain Nadir
Sajjad Shah
" Waseem Ishaq
Aman Shah (OFF)

29/6/06

2006/7/2 20060630 8

Present situation of Kohat tunnel Ventilation

+ Letter from EPA(Environmental Protection Agency)

- Dated: 22, May, 2006
- From: EPA To: NHA
- Monitoring team of EPA visited Kohat Tunnel and observed the ambient air quality exceed the WHO guide line.
- EPA direct NHA that NHA failing necessary action should be initiated against Paper.

First and Second Kohat Tunnel

: Existing First Kohat portion
: Planning Second Kohat portion

Relocation of Control Room

Thank you for listening

بہت بہت شکریہ

خدا حافظ

JAPAN

JICA