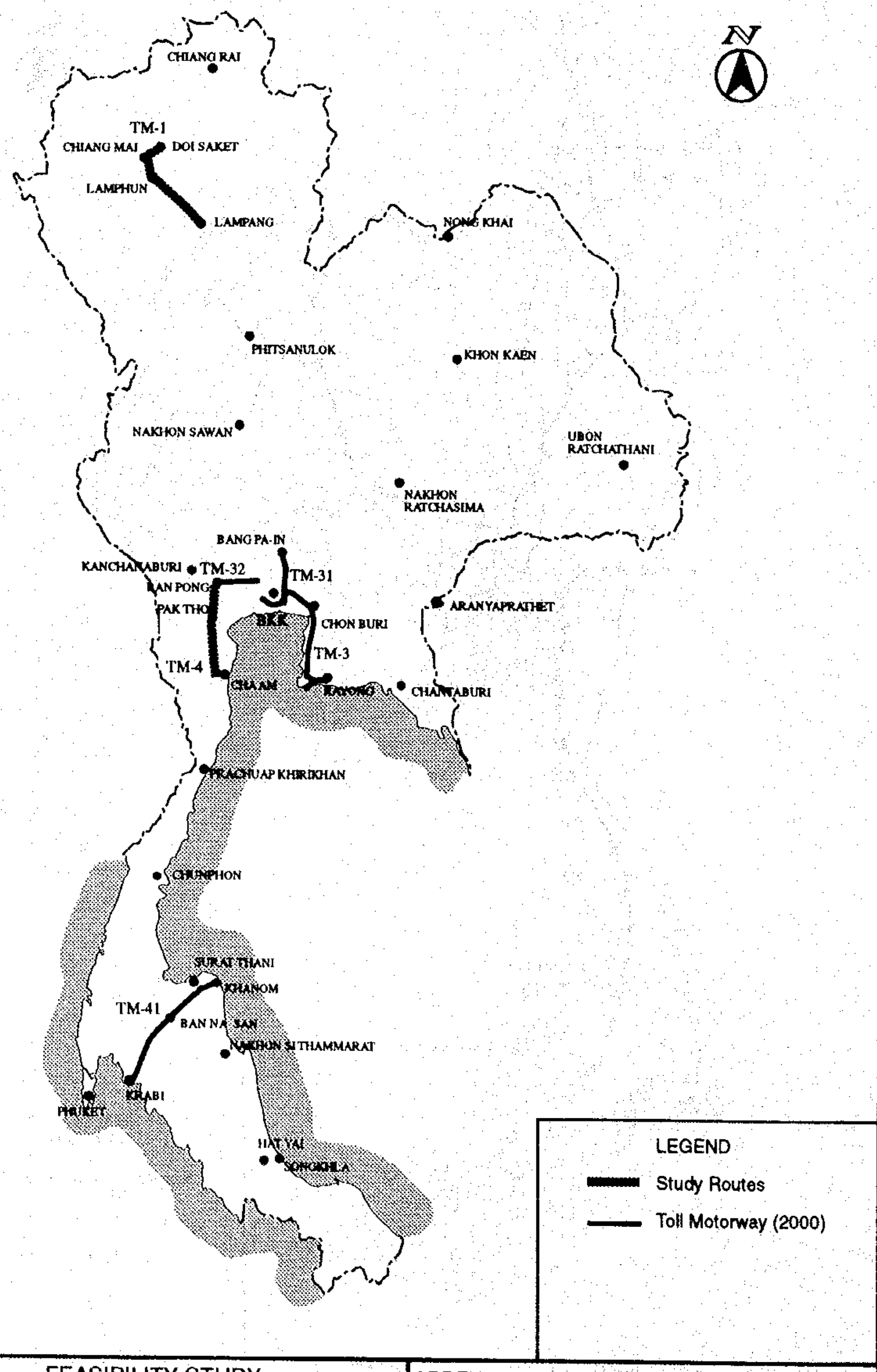
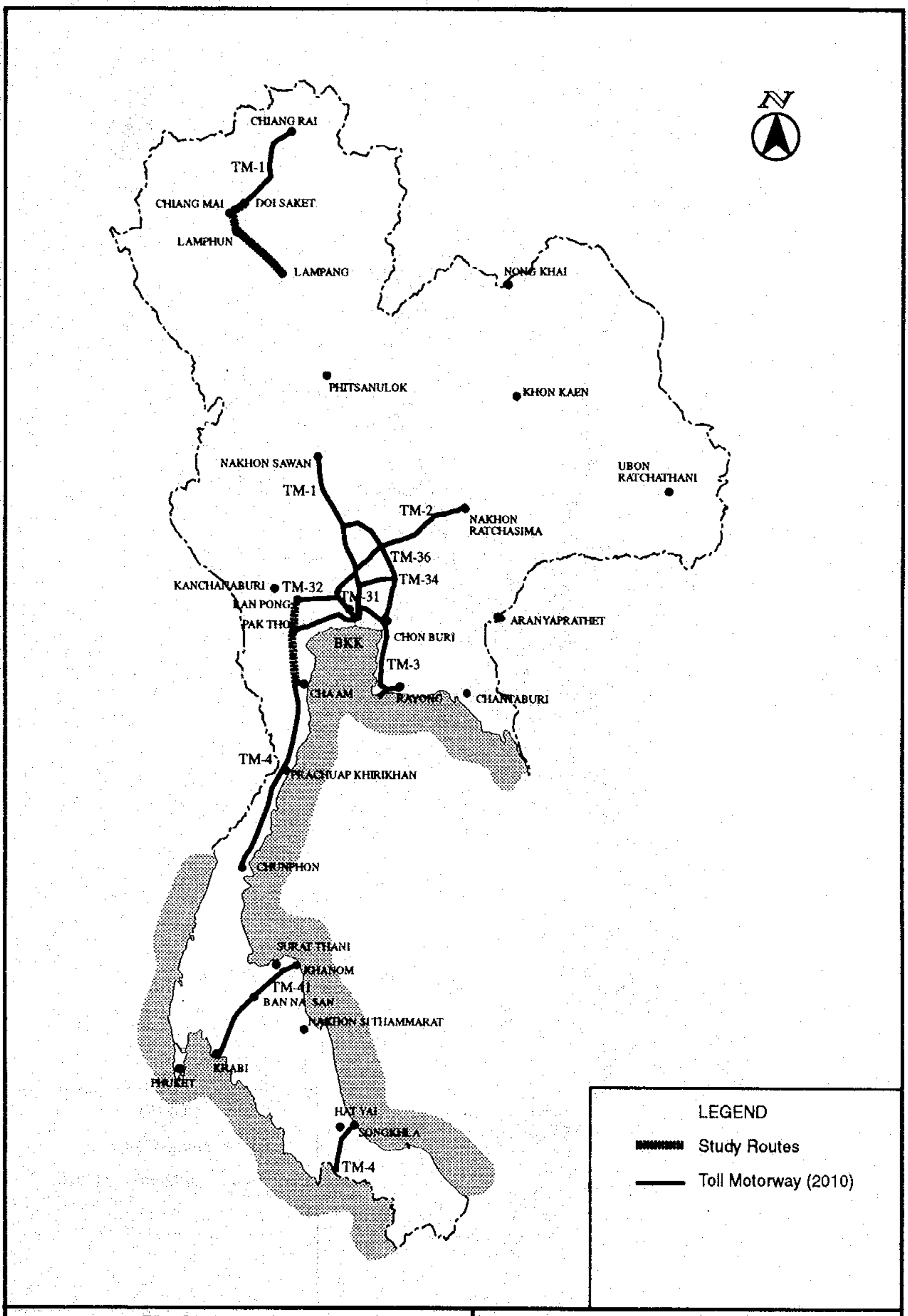
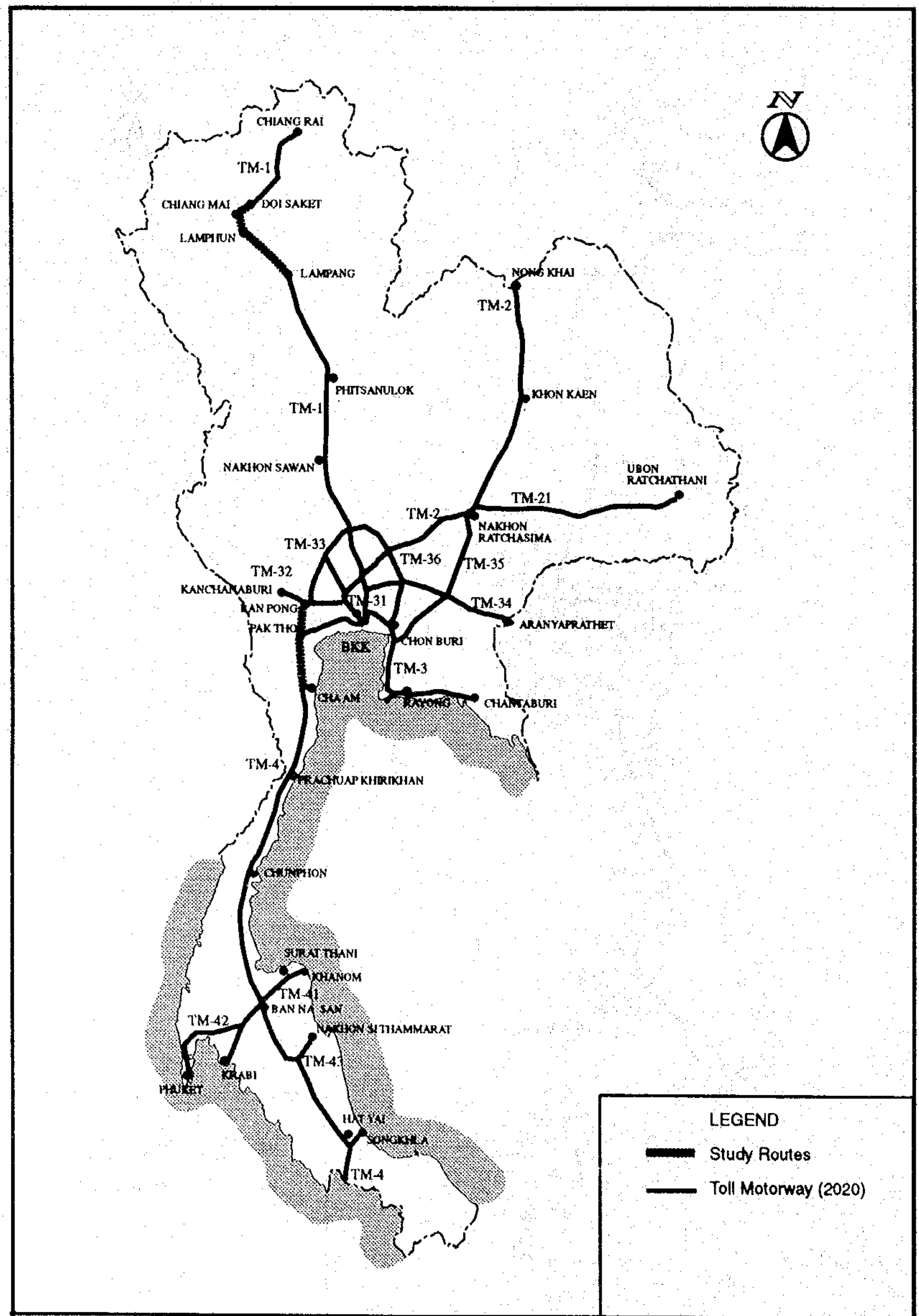


FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	APPENDIX 3.3-3 FUTURE MOTORWAY NETWORK (2000) (1/3)



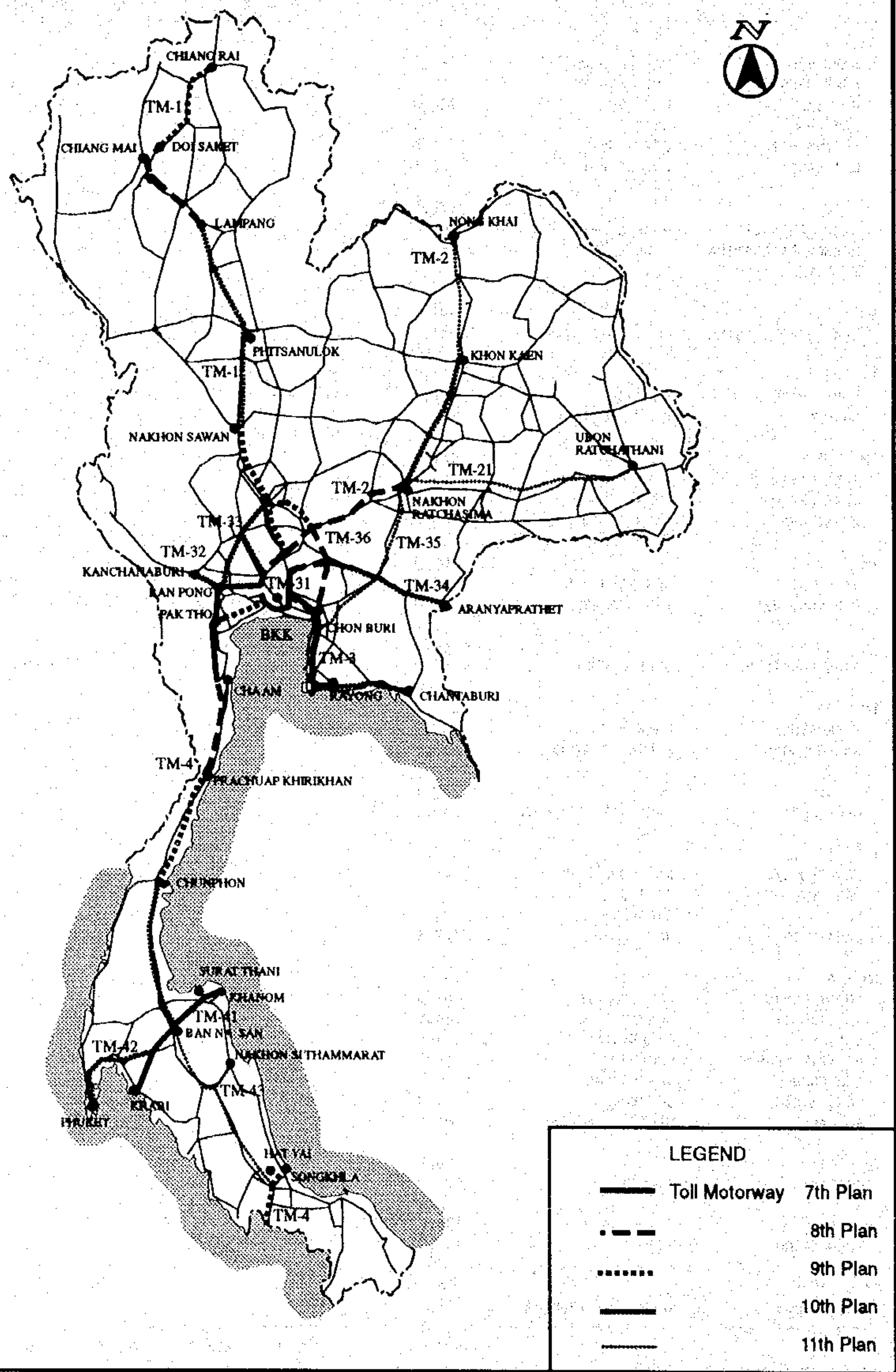
FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	APPENDIX 3.3-3 FUTURE MOTORWAY NETWORK (2010) (2/3)



FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	APPENDIX 3.3-3 FUTURE MOTORWAY NETWORK (2020) (3/3)

APPENDIX 3.3-4 TENTATIVE IMPLEMENTATION PLAN FOR TOLL MOTORWAY NETWORK (1/2)

Motorway Origin	-	Destination	Distance (km)	7th Plan 1992-1996	8th Plan 1997-2001	9th Plan 2002-2006	10th Plan 2007-2011	11th Plan 2012-2016
TM - 1			745.4					
BANG PA-IN J/C	-	NAKHON SAWAN	175.5			----------		
NAKHON SAWAN	-	PHITSANULOK	141.5				----------	
PHITSANULOK	-	LAMPANG	182.0				----------	
LAMPANG	-	CHIANG MAI	80.5		----------			
CHIANG MAI	-	DOI SAKET	15.8		----------			
DOI SAKET	-	CHIANG RAI	150.1			----------		
TM - 2			375.4					
BANG PA-IN J/C	-	NAKHON RATCHASIMA	206.0		----------			
NAKHON RATCHASIMA	-	KHON KAEN	169.4				----------	
KHON KAEN	-	NONG KHAI	160.1					----------
TM - 21			301.1					
NAKHON RATCHASIMA	-	UBON RATCHATANI	301.1					----------
TM - 3			291.9					
PHRA KHANONG	-	RAYONG	197.3	----------				
RAYONG	-	CHANTABURI	94.6				----------	
TM - 31			167.7					
BANG PA-IN J/C	-	PHRA KHAONG	53.1	----------				
PHRA KHAONG	-	PHASI CHAROEN	51.2	----------				
PHASI CHAROEN	-	BANG PA-IN J/C	63.4		----------			
TM - 32			100.0					
BANG YAI	-	BAN PONG J/C	53.0	----------				
BAN PONG J/C	-	KANTCHANABURI	47.0				----------	
TM - 33			62.0					
BANG BUA THONG	-	SUPHAN BURI	62.0				----------	
TM - 34			211.7					
THANYABURI	-	NAKHON NAYOK	59.0		----------			
NAKHON NAYOK	-	ARRANYAPRATCHET	152.7				----------	
TM - 35			239.1					
CHON BURI	-	NAKHON RATCHASIMA	239.1					----------
TM - 36			373.0					
PAK THO J/C	-	BAN PONG J/C	48.5	----------				
BAN PONG J/C	-	RT 1 J/C	130.7				----------	
RT 1 J/C	-	SARABURI	71.5			----------		
SARABURI	-	BANG PAKONG	122.3		----------			
TM - 4			956.0					
PHASI CHAROEN	-	PAK THO J/C	67.3			----------		
PAK THO J/C	-	CHA AM	83.5	----------				
CHA AM	-	P. KHIRIKHAN	111.5		----------			
P. KHIRIKHAN	-	CHUMPHON	164.8			----------		
CHUMPHON	-	BAN NA SAN	200.5				----------	
BAN NA SAN	-	SONGKHLA	244.0					----------
SONGKHLA	-	MALAYSIA BORDER	84.4			----------		
TM - 41			190.7					
KRABI	-	KHANOM	190.7	----------				
TM - 42			136.0					
PHRA SAENG	-	PHUKET	136.0				----------	
TM - 43			36.9					
RON PHIBUN	-	NAKHON SI THAMARAT	36.9					----------
TOTAL			4347.0	677.3	658.5	713.6	1316.4	981.2



FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	APPENDIX 3.3-4 TENTATIVE IMPLEMENTATION PLAN OF TOLL MOTORWAY NETWORK (2/2)

APPENDIX 3.3-5 SHIFT FACTORS AND TIME EVALUATION VALUE

Shift Factors are calculated for the target years and to adjust the diversion rate formula of Japan Highway Public Corporation which is Yen-base on 1980 to be Baht-base on 1993 as follows:

GNP/Capita - Japan 1980	2,096,000 Yen
GDP/Capita - Thai 1993	51,611 Baht
(At 1988 current price)	
CRF (2,096,000/51,611)	40.6112

Year	GDP (million Baht)	Population	GDP/Capita (Baht)
2000	4,237,834	62,857,426	67,420
2010	8,336,099	68,205,357	122,221
2020	15,706,707	73,205,561	214,556

SF 1993	(1.0/CRF)	0.024624
SF 2000	((GDP/Capita 2000/GDP/Capita 1993) * SF 1993)	0.032157
SF 2010	((GDP/Capita 2010/GDP/Capita 2000) * SF 2000)	0.058296
SF 2020	((GDP/Capita 2020/GDP/Capita 2010) * SF 2010)	0.102337

Time Evaluation Value (TEV) is calculated based on the GDP per capita, to evaluate the time consumed on links of toll motorways in use for persons, as follows:

GDP/Capita - 1991	44,085	Baht
GDP Annual Growth Rate	1.082	
GDP/Capita - 1993	51,611	Baht
Working Hours	2,288	hour/year
Average time value/person	0.376	Baht/minute

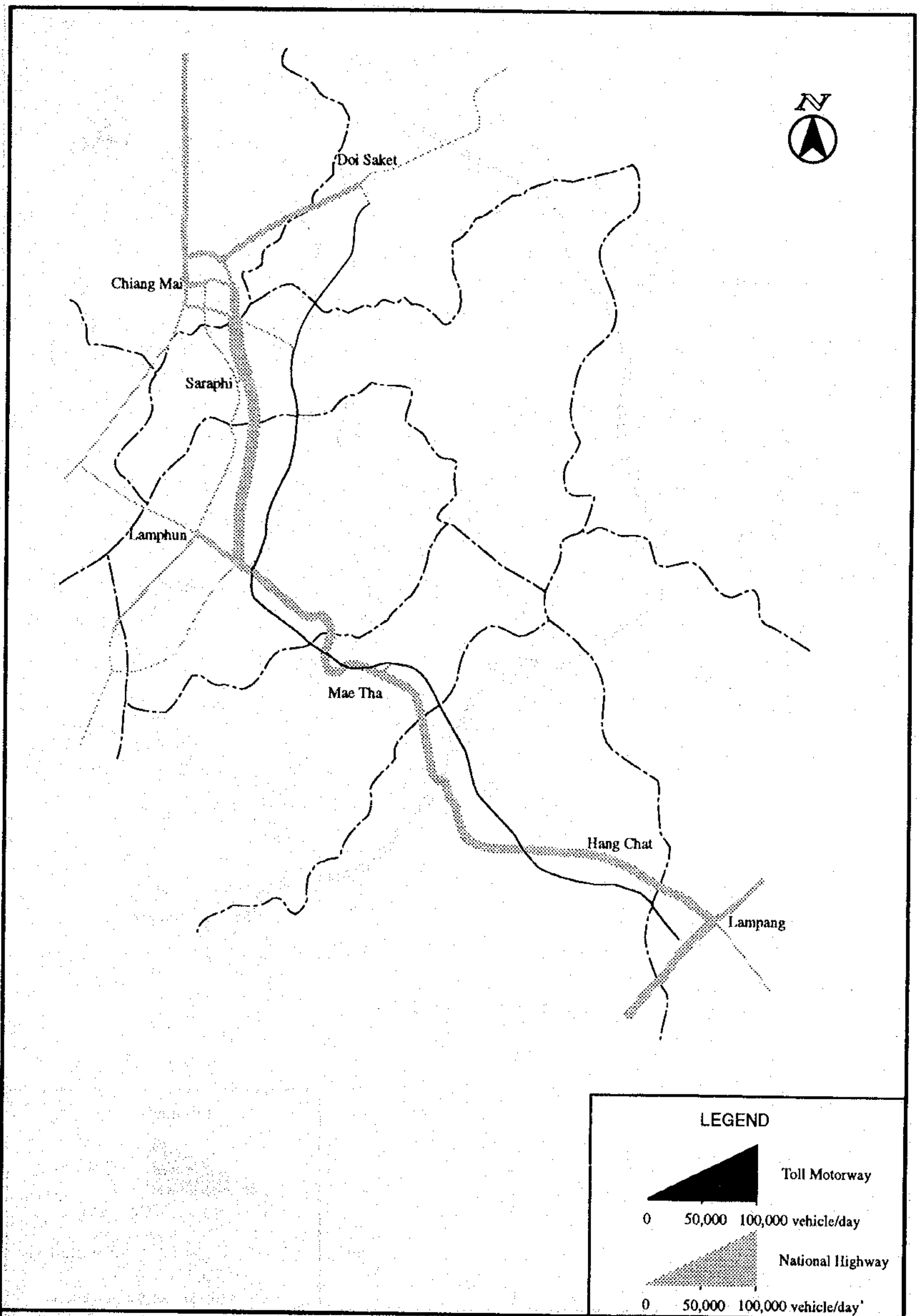
APPENDIX 3.3-6 TRAFFIC VOLUME MATCHING RATES - 1993

Station No.	Highway No.	Estimated ADT	Assigned Volume	Matching Rate
a. Lampang - Doi Saket Route				
N-1	11	8,276	8,402	0.985
N-2	11	15,032	14,982	1.003
N-3	118	7,777	7,796	0.998
N-4	107	7,296	6,855	1.064
b. Ban Pong - Cha Am Route:				
S-1	4	23,552	25,628	0.919
S-2	4	18,192	21,645	0.840
S-3	4	11,978	11,836	1.012
S-4	4	16,021	15,894	1.008
S-5	4	16,678	18,890	0.883

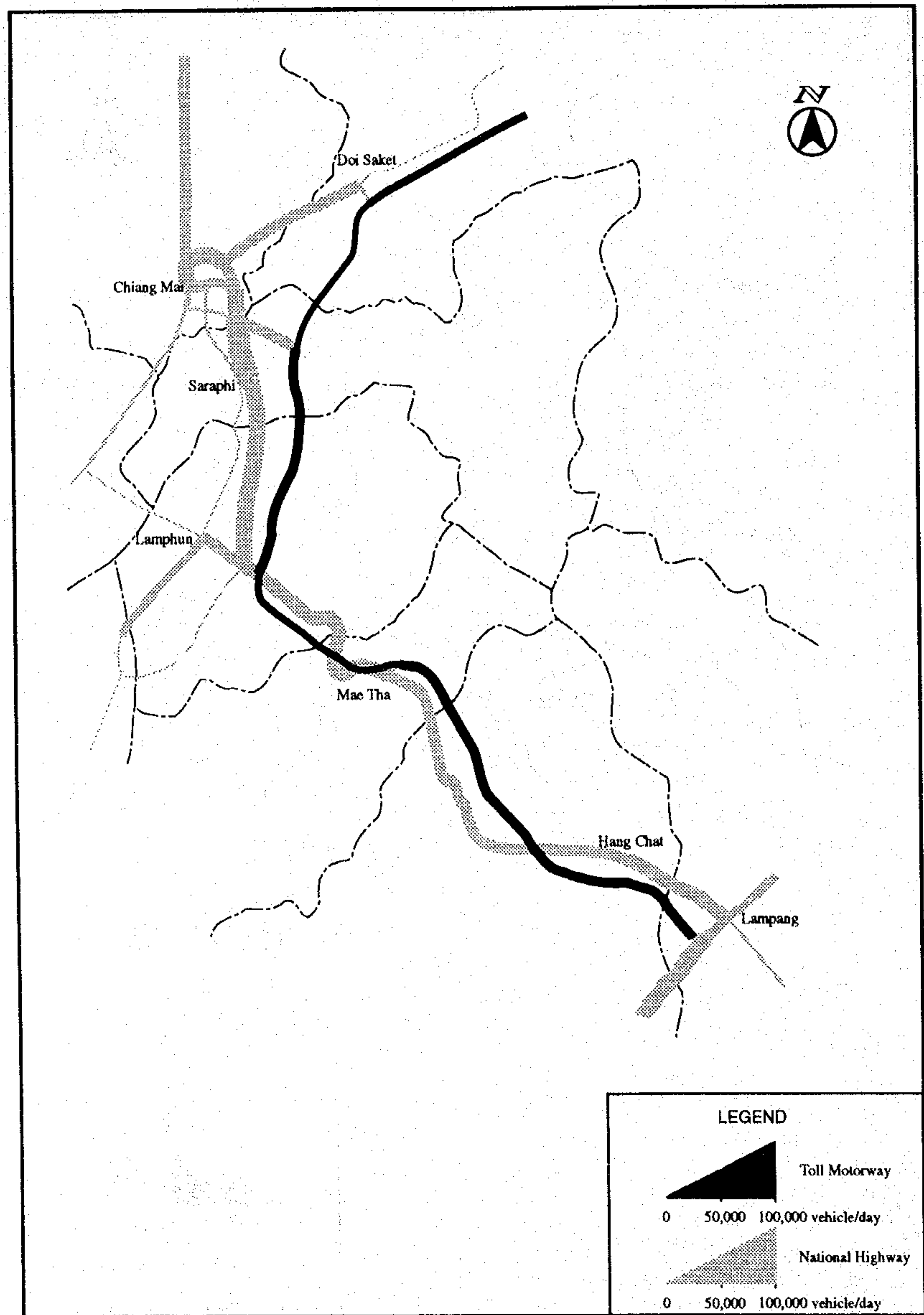
APPENDIX 3.3-7 ASSIGNMENT CASES

No.	Year	Motorway Network		Toll Rate
1	1993			
2	2000	Without L/D Route	Without B/C Route	0.50
3				0.75
4				1.00
5		Without L/D Route	With B/C Route	0.50
6				0.75
7				1.00
8		With L/D Route	Without B/C Route	0.50
9				0.75
10				1.00
11	2010	Without L/D Route	Without B/C Route	0.50
12				0.75
13				1.00
14		Without L/D Route	With B/C Route	0.50
15				0.75
16				1.00
17		With L/D Route	Without B/C Route	0.50
18				0.75
19				1.00
20	2020	Without L/D Route	Without B/C Route	0.50
21				0.75
22				1.00
23		Without L/D Route	With B/C Route	0.50
24				0.75
25				1.00
26		With L/D Route	Without B/C Route	0.50
27				0.75
28				1.00

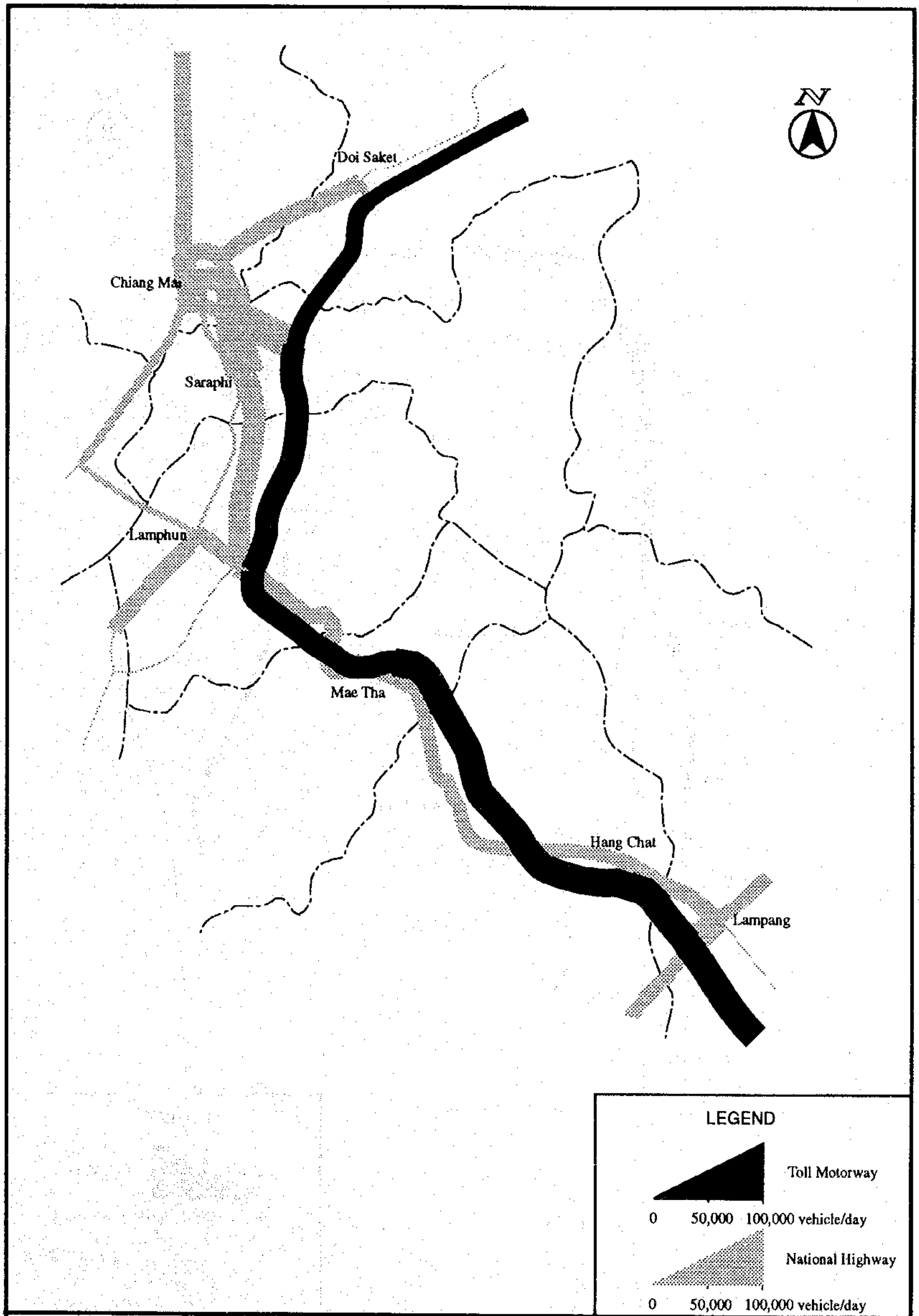
Note
L/D Route: Lampang - Doi Saket Route
B/C Route: Ban Pong - Cha Am Route



FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	APPENDIX 3.3-8 FUTURE TRAFFIC VOLUMES ON LAMPANG - DOI SAKET ROUTE - 2000 (1/3)



FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	APPENDIX 3.3-8 FUTURE TRAFFIC VOLUMES ON LAMPANG - DOI SAKET ROUTE - 2010 (2/3)



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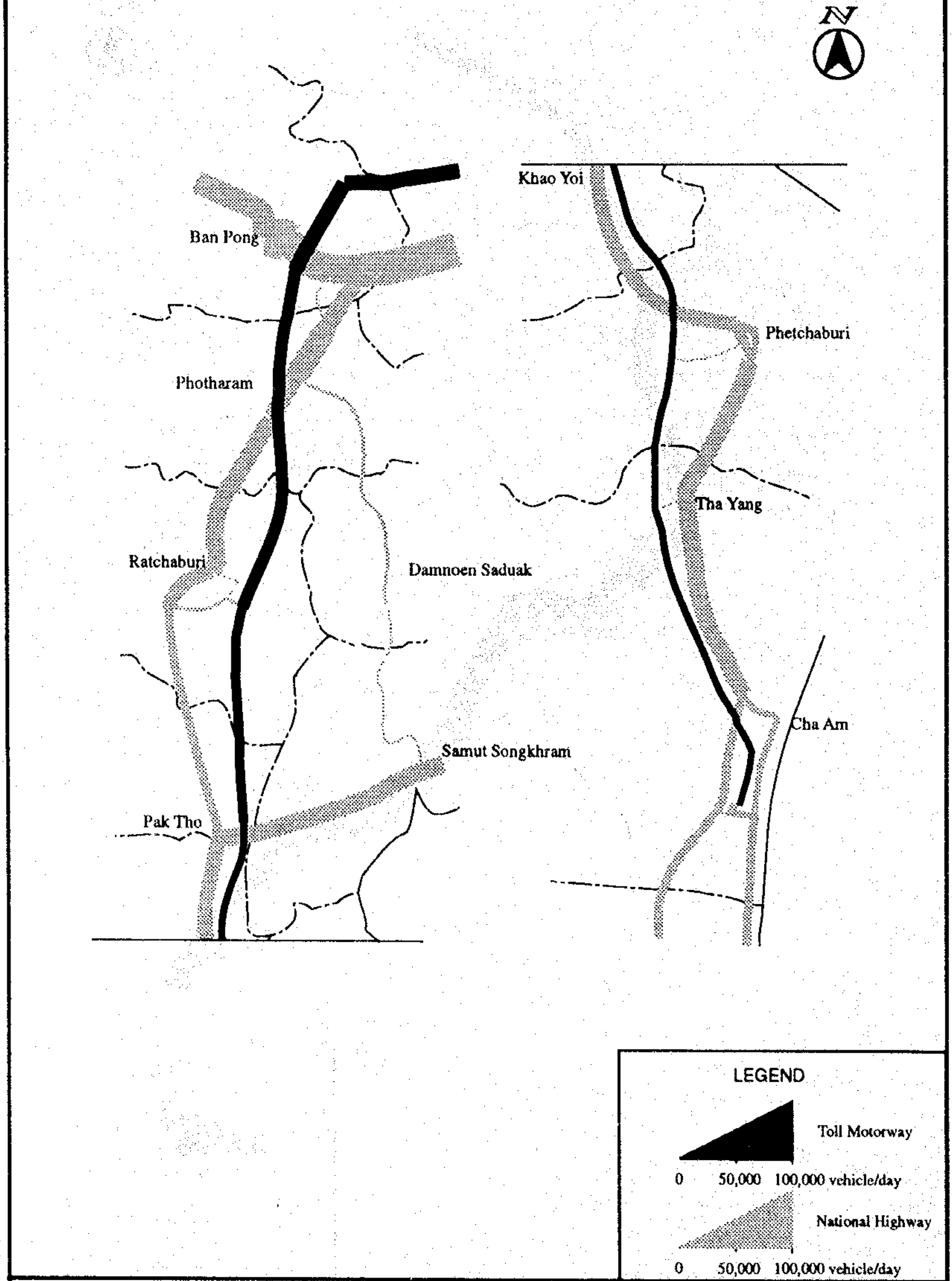
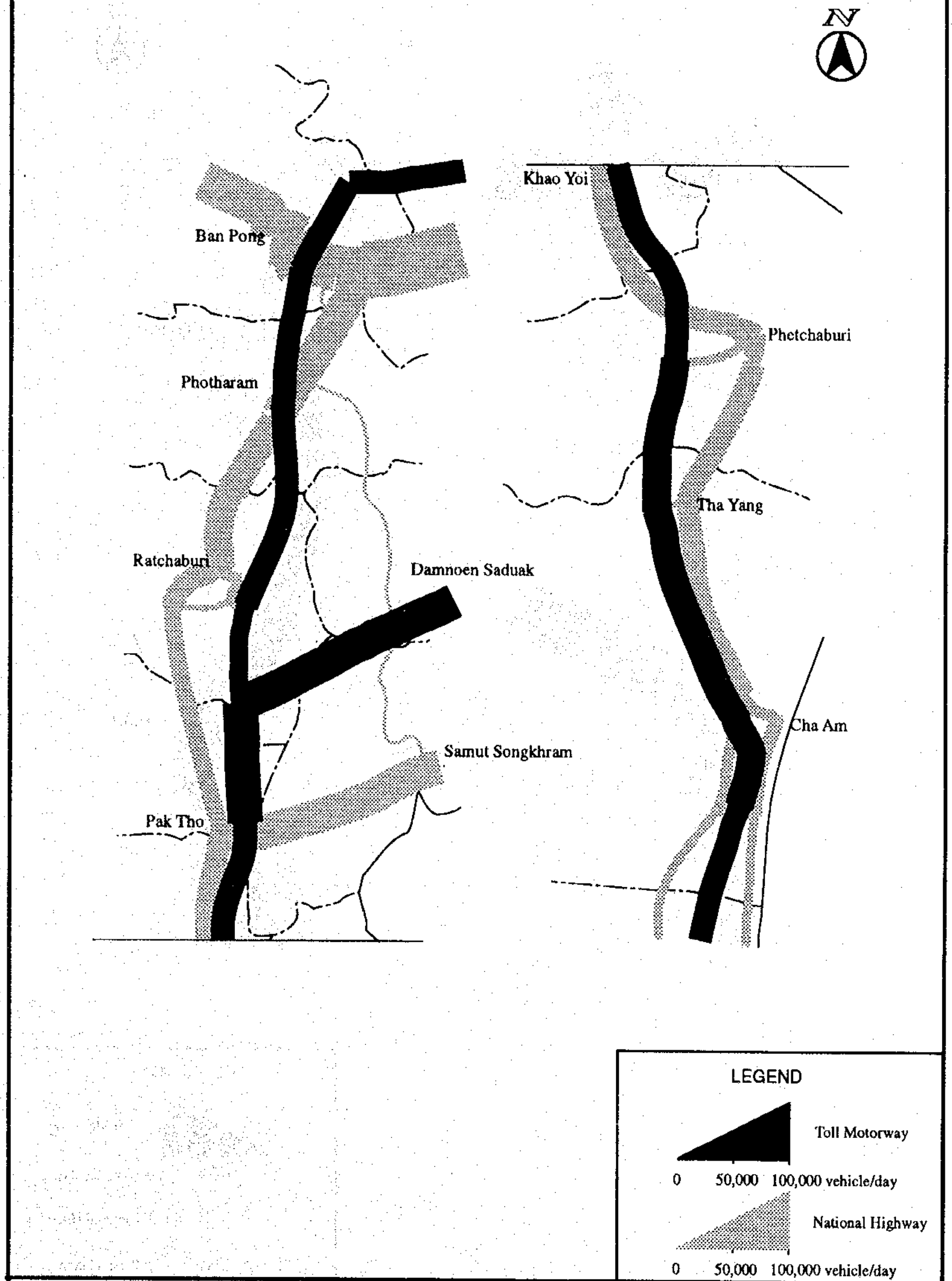


FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	APPENDIX 3.3-9 FUTURE TRAFFIC VOLUMES ON BAN PONG - CHA AM ROUTE - 2000 (1/3)



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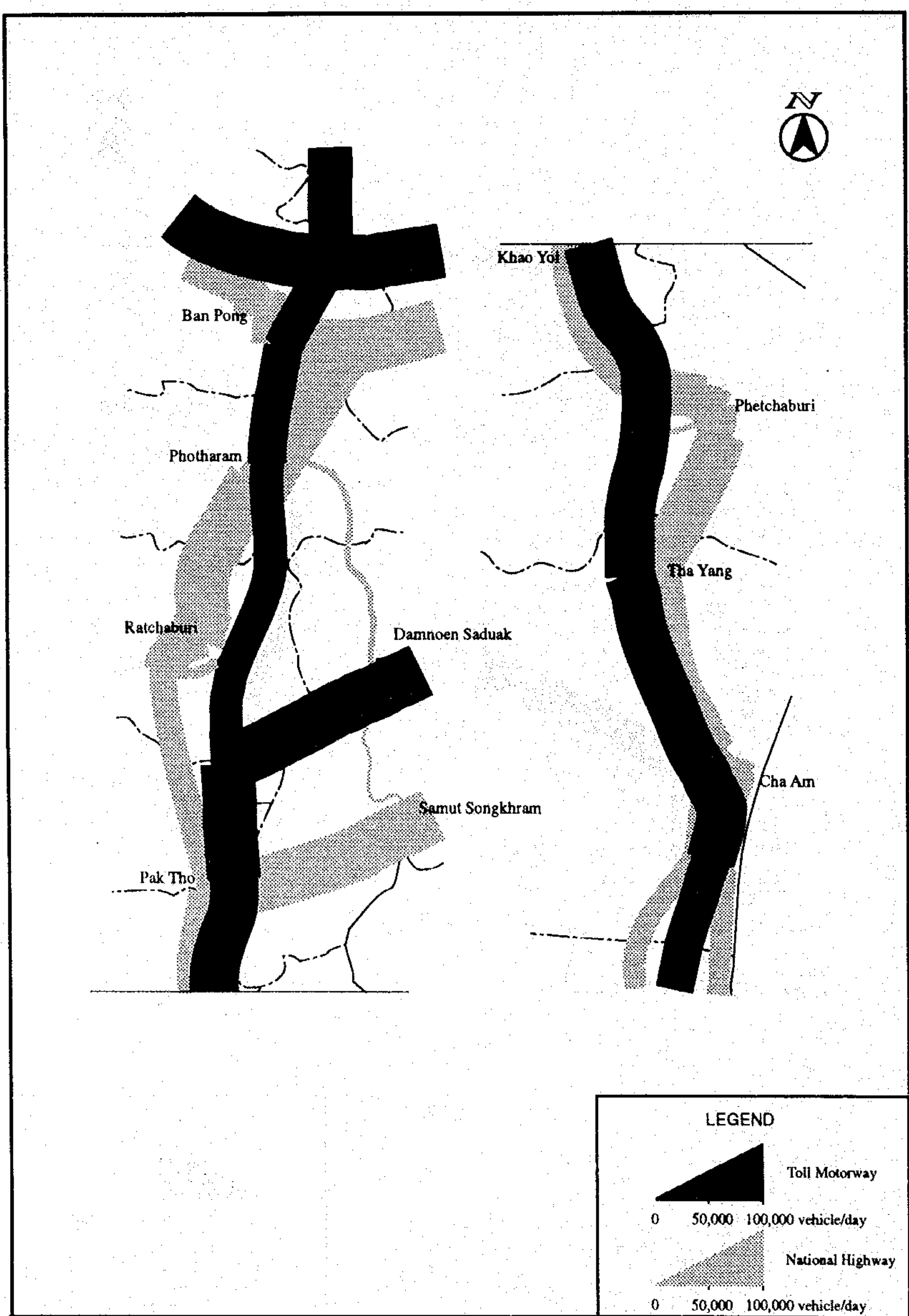
APPENDIX 3.3-9 FUTURE TRAFFIC VOLUMES ON BAN PONG - CHAAM ROUTE - 2010 (2/3)



FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	APPENDIX 3.3-9 FUTURE TRAFFIC VOLUMES ON BAN PONG - CHA AM ROUTE - 2020 (3/3)

APPENDIX 3.3-10 FUTURE TRAFFIC VOLUMES BY VEHICLE CATEGORY

a. LAMPANG - DOI SAKET ROUTE - 2000

Road Type	Section	Assigned Traffic Volume (vehicle/day)								Heavy Vehicle	Induced Traffic	Volume-Capacity Rate	Average Trip Length(km)
		PC	LB	HB	PP	LT	MT	HT	Total				
Toll Motorway	Doi Saket I/C -	199	144	5	300	58	39	12	757	56	3	0.02	42
	Chiang Mai I/C	(26.3)	(19.0)	(0.7)	(39.6)	(7.7)	(5.2)	(1.6)	(100.0)	(7.4)	(0.4)		
	Chiang Mai I/C -	892	89	122	877	122	39	57	2,198	218	35	0.05	357
	Lamphun I/C	(40.6)	(4.0)	(5.6)	(39.9)	(5.6)	(1.8)	(2.6)	(100.0)	(9.9)	(1.6)		
	Lamphun I/C -	816	86	130	774	105	32	73	2,016	235	36	0.05	450
	Mae Tha I/C	(40.5)	(4.3)	(6.4)	(38.4)	(5.2)	(1.6)	(3.6)	(100.0)	(11.7)	(1.8)		
	Mae Tha I/C -	804	86	130	760	112	31	74	1,997	235	36	0.05	457
	Lampang I/C	(40.3)	(4.3)	(6.5)	(38.1)	(5.6)	(1.6)	(3.7)	(100.0)	(11.8)	(1.8)		
National Highway	Doi Saket -	2,313	1,502	73	4,248	853	1,247	423	10,659	1,743	40	0.39	50
(Rt.11 & Rt.118)	Chiang Mai	(21.7)	(14.1)	(0.7)	(39.9)	(8.0)	(11.7)	(4.0)	(100.0)	(16.4)	(0.4)		
	Chiang Mai -	8,475	420	911	11,777	1,773	2,230	2,791	28,377	5,932	252	1.07	156
	Saraphi	(29.9)	(1.5)	(3.2)	(41.5)	(6.2)	(7.9)	(9.8)	(100.0)	(20.9)	(0.9)		
	Saraphi -	6,822	473	1,084	8,802	1,287	1,460	2,074	22,002	4,618	286	0.83	238
	Lamphun	(31.0)	(2.1)	(4.9)	(40.0)	(5.8)	(6.6)	(9.4)	(100.0)	(21.0)	(1.3)		
	Lamphun -	5,309	392	1,073	6,803	1,015	1,237	2,312	18,141	4,622	309	0.70	324
	Mae Tha	(29.3)	(2.2)	(5.9)	(37.5)	(5.6)	(6.8)	(12.7)	(100.0)	(25.5)	(1.7)		
	Mae Tha -	4,877	375	1,068	6,035	895	1,102	2,154	16,506	4,324	310	0.64	355
	Hang Chat	(29.5)	(2.3)	(6.5)	(36.6)	(5.4)	(6.7)	(13.0)	(100.0)	(26.2)	(1.9)		
	Hang Chat -	5,634	509	1,095	8,171	954	1,316	2,212	19,891	4,623	310	0.76	300
	Lampang	(28.3)	(2.6)	(5.5)	(41.1)	(4.8)	(6.6)	(11.1)	(100.0)	(23.2)	(1.6)		

b. BAN PONG - CHA AM ROUTE - 2000

Road Type	Section	Assigned Traffic Volume (vehicle/day)								Heavy Vehicle	Induced Traffic	Volume-Capacity Rate	Average Trip Length(km)
		PC	LB	HB	PP	LT	MT	HT	Total				
Toll Motorway	Ban Pong J/C -	7,487	1,112	1,934	5,713	4,646	1,381	6,674	28,947	9,989	436	0.80	250
	Ban Pong I/C	(25.9)	(3.8)	(6.7)	(19.7)	(16.1)	(4.8)	(23.1)	(100.0)	(34.5)	(1.5)		
	Ban Pong I/C -	6,519	682	1,747	5,736	4,179	1,034	4,703	24,600	7,484	750	0.66	263
	Photharam I/C	(26.5)	(2.8)	(7.1)	(23.3)	(17.0)	(4.2)	(19.1)	(100.0)	(30.4)	(3.0)		
	Photharam I/C -	6,251	668	1,635	5,208	3,754	947	4,246	22,709	6,828	753	0.61	276
	Ratchaburi I/C	(27.5)	(2.9)	(7.2)	(22.9)	(16.5)	(4.2)	(18.7)	(100.0)	(30.1)	(3.3)		
	Ratchaburi I/C -	5,106	513	1,324	3,219	2,273	675	2,743	15,853	4,742	613	0.42	353
	Pak Tho J/C	(32.2)	(3.2)	(8.4)	(20.3)	(14.3)	(4.3)	(17.3)	(100.0)	(29.9)	(3.9)		
	Pak Tho J/C -	5,106	513	1,324	3,219	2,273	675	2,743	15,853	4,742	613	0.42	353
	Pak Tho I/C	(32.2)	(3.2)	(8.4)	(20.3)	(14.3)	(4.3)	(17.3)	(100.0)	(29.9)	(3.9)		
	Pak Tho I/C -	4,749	388	1,168	2,440	1,760	622	2,169	13,296	3,959	334	0.35	421
	Phetchaburi I/C	(35.7)	(2.9)	(8.8)	(18.4)	(13.2)	(4.7)	(16.3)	(100.0)	(29.8)	(2.5)		
	Phetchaburi I/C -	4,503	373	1,148	2,806	1,907	630	2,063	13,430	3,841	301	0.36	413
	Tha Yang I/C	(33.5)	(2.8)	(8.5)	(20.9)	(14.2)	(4.7)	(15.4)	(100.0)	(28.6)	(2.2)		
	Tha Yang I/C -	4,486	372	1,148	2,798	1,903	630	2,060	13,397	3,838	299	0.35	414
	Cha Am I/C	(33.5)	(2.8)	(8.6)	(20.9)	(14.2)	(4.7)	(15.4)	(100.0)	(28.6)	(2.2)		
National Highway	Ban Pong -	5,738	460	1,206	9,303	7,213	2,632	14,747	41,299	18,585	1,060	1.86	82
(Rt.4)	Photharam	(13.9)	(1.1)	(2.9)	(22.5)	(17.5)	(6.4)	(35.7)	(100.0)	(45.0)	(2.6)		
	Photharam -	5,040	549	1,022	8,385	5,646	2,283	11,885	34,810	15,190	959	1.56	87
	Ratchaburi	(14.5)	(1.6)	(2.9)	(24.1)	(16.2)	(6.6)	(34.1)	(100.0)	(43.6)	(2.8)		
	Ratchaburi -	2,495	353	700	5,021	2,770	1,300	6,890	19,529	8,890	699	0.88	105
	Pak Tho	(12.8)	(1.8)	(3.6)	(25.7)	(14.2)	(6.7)	(35.3)	(100.0)	(45.5)	(3.6)		
	Pak Tho -	6,766	593	1,985	4,929	3,229	2,828	9,033	29,363	13,846	560	1.34	327
	Kyao Yoi	(23.0)	(2.0)	(6.8)	(16.8)	(11.0)	(9.6)	(30.8)	(100.0)	(47.2)	(1.9)		
	Khao Yoi -	6,785	598	2,016	5,304	3,394	2,825	8,842	29,764	13,683	545	1.35	325
	Phetchaburi	(22.8)	(2.0)	(6.8)	(17.8)	(11.4)	(9.5)	(29.7)	(100.0)	(46.0)	(1.8)		
	Phetchaburi -	6,800	667	1,942	6,490	3,936	2,925	8,216	30,976	13,083	488	1.36	322
	Tha Yang	(22.0)	(2.2)	(6.3)	(21.0)	(12.7)	(9.4)	(26.5)	(100.0)	(42.2)	(1.6)		
	Tha Yang -	6,817	668	1,942	6,498	3,940	2,925	8,219	31,009	13,086	490	1.37	322
	Cha Am	(22.0)	(2.2)	(6.3)	(21.0)	(12.7)	(9.4)	(26.5)	(100.0)	(42.2)	(1.6)		

c. LAMPANG - DOI SAKET ROUTE - 2010

Road Type	Section	Assigned Traffic Volume (vehicle/day)								Heavy Vehicle	Induced Traffic	Volume-Capacity Ratio	Average Trip Length(km)
		PC	LB	HB	PP	LT	MT	HT	Total				
Toll Motorway	Doi Saket I/C -	1,912	810	477	4,351	845	407	403	9,205	1,287	127	0.22	291
	Chiang Mai I/C	(20.8)	(8.8)	(5.2)	(47.3)	(9.2)	(4.4)	(4.4)	(100.0)	(14.0)	(1.4)		
	Chiang Mai I/C -	5,955	493	1,335	6,341	862	640	1,235	16,861	3,210	286	0.41	426
	Lamphun I/C	(35.3)	(2.9)	(7.9)	(37.6)	(5.1)	(3.8)	(7.3)	(100.0)	(19.0)	(1.7)		
	Lamphun I/C -	3,967	332	1,100	3,866	509	463	1,410	11,647	2,973	209	0.30	533
	Mae Tha I/C	(34.1)	(2.9)	(9.4)	(33.2)	(4.4)	(4.0)	(12.1)	(100.0)	(25.5)	(1.8)		
	Mae Tha I/C -	5,216	459	1,442	4,859	656	527	1,631	14,790	3,600	274	0.38	552
	Lampang I/C	(35.3)	(3.1)	(9.7)	(32.9)	(4.4)	(3.6)	(11.0)	(100.0)	(24.3)	(1.9)		
National Highway	Doi Saket -	4,428	2,848	244	9,877	2,016	2,368	813	22,594	3,425	134	0.81	74
(Rt.11 & Rt.118)	Chiang Mai	(19.6)	(12.6)	(1.1)	(43.7)	(8.9)	(10.5)	(3.6)	(100.0)	(15.2)	(0.6)		
	Chiang Mai -	12,895	689	1,022	20,261	3,132	4,166	5,231	47,396	10,419	396	1.80	107
	Saraphi	(27.2)	(1.5)	(2.2)	(42.7)	(6.6)	(8.8)	(11.0)	(100.0)	(22.0)	(0.8)		
	Saraphi -	8,786	597	1,205	12,617	1,793	2,458	3,549	31,005	7,212	431	1.19	188
	Lamphun	(28.3)	(1.9)	(3.9)	(40.7)	(5.8)	(7.9)	(11.4)	(100.0)	(23.3)	(1.4)		
	Lamphun -	7,703	604	1,423	10,181	1,417	2,147	3,624	27,099	7,194	488	1.06	297
	Mae Tha	(28.4)	(2.2)	(5.3)	(37.6)	(5.2)	(7.9)	(13.4)	(100.0)	(26.5)	(1.8)		
	Mae Tha -	5,686	451	1,070	7,614	1,077	1,826	3,084	20,808	5,980	542	0.83	292
	Hang Chat	(27.3)	(2.2)	(5.1)	(36.6)	(5.2)	(8.8)	(14.8)	(100.0)	(28.7)	(2.6)		
	Hang Chat -	7,247	689	1,126	11,334	1,177	2,263	3,195	27,031	6,584	492	1.04	233
	Lampang	(26.8)	(2.5)	(4.2)	(41.9)	(4.4)	(8.4)	(11.8)	(100.0)	(24.4)	(1.8)		

d. BAN PONG - CHA AM ROUTE - 2010

Road Type	Section	Assigned Traffic Volume (vehicle/day)								Heavy Vehicle	Induced Traffic	Volume-Capacity Ratio	Average Trip Length(km)
		PC	LB	HB	PP	LT	MT	HT	Total				
Toll Motorway	Ban Pong J/C -	7,733	1,313	1,207	9,086	7,984	2,193	11,032	40,548	14,432	1,092	1.14	143
	Ban Pong I/C	(19.1)	(3.2)	(3.0)	(22.4)	(19.7)	(5.4)	(27.2)	(100.0)	(35.6)	(2.7)		
	Ban Pong I/C -	7,831	1,039	1,863	13,019	9,147	1,900	10,888	45,687	14,651	2,490	1.25	125
	Photharam I/C	(17.1)	(2.3)	(4.1)	(28.5)	(20.0)	(4.2)	(23.8)	(100.0)	(32.1)	(5.5)		
	Photharam I/C -	7,756	1,170	1,822	12,725	8,787	1,813	10,591	44,664	14,226	2,560	1.22	128
	Ratchaburi I/C	(17.4)	(2.6)	(4.1)	(28.5)	(19.7)	(4.1)	(23.7)	(100.0)	(31.9)	(5.7)		
	Ratchaburi I/C -	6,199	1,008	1,768	9,252	6,711	1,859	10,774	37,571	14,401	3,221	1.08	146
	Pak Tho J/C	(16.5)	(2.7)	(4.7)	(24.6)	(17.9)	(4.9)	(28.7)	(100.0)	(38.3)	(8.6)		
	Pak Tho J/C -	18,308	1,779	5,509	12,622	8,462	3,432	14,327	64,439	23,268	5,474	1.80	327
	Pak Tho I/C	(28.4)	(2.8)	(8.5)	(19.6)	(13.1)	(5.3)	(22.2)	(100.0)	(36.1)	(8.5)		
	Pak Tho I/C -	16,124	1,281	4,221	8,732	6,381	2,943	10,048	49,730	17,212	4,334	1.38	400
	Phetchaburi J/C	(32.4)	(2.6)	(8.5)	(17.6)	(12.8)	(5.9)	(20.2)	(100.0)	(34.6)	(8.7)		
	Phetchaburi I/C -	15,743	1,258	4,344	10,207	7,315	3,039	9,643	51,549	17,026	4,369	1.41	391
	Tha Yang I/C	(30.5)	(2.4)	(8.4)	(19.8)	(14.2)	(5.9)	(18.7)	(100.0)	(33.0)	(8.5)		
	Tha Yang I/C -	15,454	1,245	4,420	10,489	7,668	3,099	9,599	51,974	17,118	4,359	1.42	389
	Cha Am I/C	(29.7)	(2.4)	(8.5)	(20.2)	(14.8)	(6.0)	(18.5)	(100.0)	(32.9)	(8.4)		
National Highway	Ban Pong -	8,523	632	1,836	13,772	11,234	4,523	26,436	66,956	32,795	2,633	3.11	84
(Rt.4)	Photharam	(12.7)	(0.9)	(2.7)	(20.6)	(16.8)	(6.8)	(39.5)	(100.0)	(49.0)	(3.9)		
	Photharam -	7,607	794	1,517	12,773	8,690	3,934	20,930	56,245	26,381	2,317	2.57	89
	Ratchaburi	(13.5)	(1.4)	(2.7)	(22.7)	(15.5)	(7.0)	(37.2)	(100.0)	(46.9)	(4.1)		
	Ratchaburi -	3,482	531	1,219	7,671	3,749	2,100	12,369	31,121	15,688	1,042	1.46	108
	Pak Tho	(11.2)	(1.7)	(3.9)	(24.6)	(12.0)	(6.7)	(39.7)	(100.0)	(50.4)	(3.3)		
	Pak Tho -	8,448	769	2,815	7,158	4,514	4,685	15,401	43,790	22,901	2,748	2.07	309
	Kyao Yoi	(19.3)	(1.8)	(6.4)	(16.3)	(10.3)	(10.7)	(35.2)	(100.0)	(52.3)	(6.3)		
	Khao Yoi -	8,465	776	2,907	7,917	4,910	4,685	14,998	44,658	22,590	2,760	2.08	308
	Phetchaburi	(19.0)	(1.7)	(6.5)	(17.7)	(11.0)	(10.5)	(33.6)	(100.0)	(50.6)	(6.2)		
	Phetchaburi -	8,741	927	2,732	10,077	5,733	4,944	13,999	47,153	21,675	2,826	2.13	302
	Tha Yang	(18.5)	(2.0)	(5.8)	(21.4)	(12.2)	(10.5)	(29.7)	(100.0)	(46.0)	(6.0)		
	Tha Yang -	9,030	940	2,656	9,795	5,380	4,884	14,043	46,728	21,583	2,836	2.12	304
	Cha Am	(19.3)	(2.0)	(5.7)	(21.0)	(11.5)	(10.5)	(30.1)	(100.0)	(46.2)	(6.1)		

APPENDIX 3.3-10 FUTURE TRAFFIC VOLUMES BY VEHICLE CATEGORY

e. LAMPANG - DOI SAKET ROUTE - 2020

Road Type	Section	Assigned Traffic Volume (vehicle/day)								Heavy Vehicle	Induced Traffic	Volume-Capacity Rate	Average Trip Length(km)
		PC	LB	HB	PP	LT	MT	HT	Total				
Toll Motorway	Doi Saket I/C - Chiang Mai I/C	5,109 (17.0)	2,483 (8.3)	1,403 (4.7)	14,750 (49.0)	2,912 (9.7)	1,862 (6.2)	1,570 (5.2)	30,089 (100.0)	4,835 (16.1)	486 (1.6)	0.72	269
	Chiang Mai I/C - Lamphun I/C	15,756 (32.1)	1,354 (2.8)	3,652 (7.4)	18,838 (38.4)	2,693 (5.5)	2,443 (5.0)	4,369 (8.9)	49,105 (100.0)	10,464 (21.3)	1,387 (2.8)	1.23	390
	Lamphun I/C - Mae Tha I/C	14,765 (31.2)	1,225 (2.6)	3,671 (7.8)	16,918 (35.8)	2,489 (5.3)	2,414 (5.1)	5,792 (12.3)	47,274 (100.0)	11,877 (25.1)	1,469 (3.1)	1.22	438
	Mae Tha I/C - Lampang I/C	16,155 (32.1)	1,418 (2.8)	4,246 (8.4)	17,499 (34.7)	2,622 (5.2)	2,379 (4.7)	6,072 (12.0)	50,391 (100.0)	12,697 (25.2)	1,693 (3.4)	1.30	475
National Highway (Rt.11 & Rt.118)	Doi Saket - Chiang Mai	6,136 (17.9)	4,503 (13.1)	336 (1.0)	15,008 (43.8)	3,091 (9.0)	3,836 (11.2)	1,343 (3.9)	34,253 (100.0)	5,515 (16.1)	180 (0.5)	1.24	70
	Chiang Mai - Saraphi	18,475 (25.7)	1,043 (1.5)	1,313 (1.8)	30,871 (43.0)	4,755 (6.6)	6,829 (9.5)	8,549 (11.9)	71,835 (100.0)	16,691 (23.2)	672 (0.9)	2.76	100
	Saraphi - Lamphun	11,845 (28.3)	906 (2.2)	1,801 (4.3)	16,170 (38.6)	2,294 (5.5)	3,528 (8.4)	5,325 (12.7)	41,869 (100.0)	10,654 (25.4)	880 (2.1)	1.63	233
	Lamphun - Mae Tha	9,804 (26.7)	838 (2.3)	1,865 (5.1)	13,062 (35.5)	1,855 (5.0)	3,213 (8.7)	6,133 (16.7)	36,770 (100.0)	11,211 (30.5)	1,027 (2.8)	1.49	318
	Mae Tha - Hang Chat	7,081 (25.5)	594 (2.1)	1,266 (4.6)	9,469 (34.1)	1,395 (5.0)	2,770 (10.0)	5,212 (18.8)	27,787 (100.0)	9,248 (33.3)	830 (3.0)	1.15	305
	Hang Chat - Lampang	10,244 (26.1)	1,044 (2.7)	1,366 (3.5)	15,987 (40.7)	1,570 (4.0)	3,634 (9.3)	5,439 (13.8)	39,284 (100.0)	10,439 (26.6)	836 (2.1)	1.55	227

f. BAN PONG - CHA AM ROUTE - 2020

Road Type	Section	Assigned Traffic Volume (vehicle/day)								Heavy Vehicle	Induced Traffic	Volume-Capacity Rate	Average Trip Length(km)
		PC	LB	HB	PP	LT	MT	HT	Total				
Toll Motorway	Ban Pong J/C - Ban Pong I/C	10,892 (14.4)	1,191 (1.6)	2,826 (3.7)	20,749 (27.4)	14,371 (19.0)	3,885 (5.1)	21,849 (28.8)	75,763 (100.0)	28,560 (37.7)	4,582 (6.0)	2.16	156
	Ban Pong I/C - Photharam I/C	11,605 (15.2)	1,506 (2.0)	3,000 (3.9)	22,422 (29.3)	14,069 (18.4)	3,515 (4.6)	20,292 (26.6)	76,409 (100.0)	26,807 (35.1)	6,255 (8.2)	2.14	158
	Photharam I/C - Ratchaburi I/C	10,560 (15.9)	1,463 (2.2)	2,495 (3.8)	18,655 (28.1)	12,182 (18.3)	3,052 (4.6)	18,017 (27.1)	66,424 (100.0)	23,564 (35.5)	5,524 (8.3)	1.86	175
	Ratchaburi I/C - Pak Tho J/C	10,139 (15.3)	1,473 (2.2)	2,998 (4.5)	16,056 (24.2)	11,306 (17.0)	3,591 (5.4)	20,883 (31.4)	66,446 (100.0)	27,472 (41.3)	7,211 (10.9)	1.94	185
	Pak Tho J/C - Pak Tho I/C	29,749 (24.9)	3,277 (2.7)	9,847 (8.2)	22,850 (19.1)	15,408 (12.9)	6,936 (5.8)	31,549 (26.4)	119,616 (100.0)	48,332 (40.4)	10,840 (9.1)	3.46	361
	Pak Tho I/C - Phetchaburi I/C	25,458 (27.5)	2,255 (2.4)	7,462 (8.1)	16,133 (17.4)	11,819 (12.8)	6,161 (6.6)	23,394 (25.2)	92,682 (100.0)	37,017 (39.9)	8,295 (8.9)	2.67	445
	Phetchaburi I/C - Tha Yang I/C	25,450 (26.6)	2,304 (2.4)	7,638 (8.0)	18,169 (19.0)	12,990 (13.6)	6,332 (6.6)	22,928 (23.9)	95,811 (100.0)	36,898 (38.5)	8,345 (8.7)	2.73	435
	Tha Yang I/C - Cha Am I/C	24,220 (25.0)	2,170 (2.2)	7,894 (8.1)	19,146 (19.7)	14,258 (14.7)	6,621 (6.8)	22,673 (23.4)	96,982 (100.0)	37,188 (38.3)	8,161 (8.4)	2.76	431
National Highway (Rt.4)	Ban Pong - Photharam	18,353 (13.1)	1,271 (0.9)	3,845 (2.8)	28,481 (20.4)	25,135 (18.0)	9,037 (6.5)	53,464 (38.3)	139,586 (100.0)	66,346 (47.5)	6,312 (4.5)	6.41	91
	Photharam - Ratchaburi	17,026 (14.0)	1,773 (1.5)	3,474 (2.8)	28,786 (23.6)	20,185 (16.6)	7,974 (6.5)	42,691 (35.0)	121,909 (100.0)	54,139 (44.4)	6,055 (5.0)	5.48	94
	Ratchaburi - Pak Tho	7,034 (11.7)	1,031 (1.7)	2,532 (4.2)	14,876 (24.8)	7,083 (11.8)	3,844 (6.4)	23,549 (39.3)	59,949 (100.0)	29,925 (49.9)	2,041 (3.4)	2.79	119
	Pak Tho - Kyao Yoi	15,952 (18.7)	1,704 (2.0)	5,524 (6.5)	14,825 (17.3)	9,423 (11.0)	8,890 (10.4)	29,129 (34.1)	85,447 (100.0)	43,543 (51.0)	5,428 (6.4)	4.00	276
	Khao Yoi - Phetchaburi	15,868 (18.3)	1,703 (2.0)	5,700 (6.6)	16,050 (18.5)	10,084 (11.7)	8,846 (10.2)	28,303 (32.7)	86,554 (100.0)	42,849 (49.5)	5,389 (6.2)	4.01	277
	Phetchaburi - Tha Yang	15,786 (17.3)	1,886 (2.1)	5,411 (5.9)	20,659 (22.7)	11,967 (13.1)	9,312 (10.2)	25,995 (28.6)	91,016 (100.0)	40,718 (44.7)	5,359 (5.9)	4.08	274
	Tha Yang - Cha Am	17,016 (18.9)	2,020 (2.2)	5,155 (5.7)	19,682 (21.9)	10,699 (11.9)	9,023 (10.0)	26,250 (29.2)	89,845 (100.0)	40,428 (45.0)	5,543 (6.2)	4.04	276

CHAPTER 4

ROUTE SELECTION

APPENDIX 4.1-1 REQUIRED NUMBER OF LANE

OPTION 1

Per Direction

Section	AADT 2010	AADT 2020	Design Traffic Volume 2010	Design Traffic Volume 2020	N 2010(B)	N 2020(c)	Required Number of lane
Lampang - Doi Saket Route							
Doi Saket-Chiang Mai	9,200	30,100	405	1324	0.6	1.3	2
Chiang Mai-Mae Tha	16,300	49,100	744	2160	1.0	2.1	2
Mae Tha-Lampang	14,800	50,400	651	2218	0.9	2.2	2
Ban Pong - Cha Am Route							
Ban Pong-Pak Tho J/C	45,700	76,400	2011	3362	2.8	3.3	3
Pak Tho J/C-Pak Tho I/C	64,400	119,600	2834	5262	3.9	5.6	5
Pak Tho I/C-Cha Am I/C	52,000	97,000	2288	4268	3.2	4.2	4

OPTION 2

Per Direction

Section	AADT 2010	AADT 2020	Design Traffic Volume 2010	Design Traffic Volume 2020	N 2010(B)	N 2020(c)	Required Number of lane
Lampang - Doi Saket Route							
Doi Saket-Chiang Mai	9,200	30,100	405	1324	0.4	1.1	2
Chiang Mai-Mae Tha	16,300	49,100	744	2160	0.7	1.8	2
Mae Tha-Lampang	14,800	50,400	651	2218	0.7	1.8	2
Ban Pong - Cha Am Route							
Ban Pong-Pak Tho J/C	45,700	76,400	2011	3362	1.9	2.7	3
Pak Tho J/C-Pak Tho I/C	64,400	119,600	2834	5262	2.8	4.3	4
Pak Tho I/C-Cha Am I/C	52,000	97,000	2288	4268	2.2	3.5	4

OPTION 3

Per Direction

Section	AADT 2010	AADT 2020	Design Traffic Volume (per day)	N 2010	N 2020	Required Number of lane
Lampang - Doi Saket Route						
Doi Saket-Chiang Mai	9,200	30,100	9,000	0.5	1.7	2
Chiang Mai-Mae Tha	16,300	49,100	9,000	0.9	2.7	3
Mae Tha-Lampang	14,800	50,400	9,000	0.8	2.8	3
Ban Pong - Cha Am Route						
Ban Pong-Pak Tho J/C	45,700	76,400	12,000	1.9	3.2	3
Pak Tho J/C-Pak Tho I/C	64,400	119,600	12,000	2.7	5.0	5
Pak Tho I/C-Cha Am I/C	52,000	97,000	12,000	2.2	4.0	4

APPENDIX 4.2-1 DESIGN RESULT OF LAMPANG - DOI SAKET ROUTE

ALTERNATIVE ROUTE

WORK ITEM		AR-1 A1+A2	AR-2 A1+B1+B5+B3	AR-3 A1+B1+B5+B4	AR-4 A1+B2+B5+B3	AR-5 A1+B2+B5+B4
Length (km)		107.7	99.8	96.3	100.3	96.8
Number of Junctions		0	0	0	0	0
Number of Interchanges		6	6	5	6	5
Number of Service Areas		1	1	1	1	1
Tunnels (lm)		8,000	5,000	5,000	6,300	6,300
Flyover Bridges (no & sqm)		6 5,760	5 4,800	4 3,840	6 5,760	5 4,800
Viaducts (lm)		23,000	18,100	9,800	18,100	9,800
Bridges (lm)	L<100m	1,100	1,050	1,000	1,000	950
	L>100m	200	200	200	200	200
Length by Grade	1.0%-2.0%	22,300	6,050	6,050	16,000	16,000
(lm)	2.5%-3.0%	4,250	5,000	5,000	3,500	3,500
Curve Length	R=1,500m	0	2,200	2,200	0	0
(lm)	R=1,000m	4,400	2,200	2,200	3,300	3,300

LINK

WORK ITEM		A1	A2	B1	B2	B3	B4	B5
Length (km)		14.5	93.2	27.5	28.0	21.8	18.3	36.0
Number of Junctions		0	0	0	0	0	0	0
Number of Interchanges		1	5	0	0	3	2	2
Number of Service Areas		0	1	0	0	0	0	1
Tunnels (lm)		0	8,000	3,200	4,500	0	0	1,800
Flyover Bridges (no & sqm)		1 960	5 4,800	0 0	1 960	3 2,880	2 1,920	1 960
Viaducts (lm)		1,000	22,000	3,000	3,000	12,000	3,700	2,100
Bridges (lm)	L<100m	200	900	150	100	200	150	500
	L>100m	200	0	0	0	0	0	0
Length by Grade	1.0%-2.0%	0	22,300	6,050	16,000	0	0	0
(lm)	2.5%-3.0%	0	4,250	5,000	3,500	0	0	0
Curve Length	R=1,500m	0	0	2,200	0	0	0	0
(lm)	R=1,000m	0	4,400	2,200	3,300	0	0	0

APPENDIX 4.2-2 RATING CRITERIA FOR LAMPANG - DOI SAKET ROUTE

I. SOCIO-ECONOMIC ASPECTS

I.1 Adaptability for City Planning

1. Rating Criteria

- To run very closely to the city planning area or mainly through agricultural land designated in the city planning : Rate 3
- To run near the city planning area : Rate 2
- To run through residential / commercial / industrial areas designated in the city planning : Rate 1

2. Rating for Adaptability for City Planning

City	AR-1	AR-2	AR-3	AR-4	AR-5
Lampang	3	3	3	3	3
Lamphun	1	3	3	3	3
Chiang Mai	1	3	3	3	3
Total	5	9	9	9	9
Average	1.6	3	3	3	3
Rate	2	3	3	3	3

I.2 Split of Community

1. Rating Criteria

Total motorway length causing split of communities:

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

2. Rating for Split of Community

	AR-1	AR-2	AR-3	AR-4	AR-5
Length (km)	3.9	3.2	2.3	3.2	2.3
Rate	1	2	3	2	3

I.3 Development Impact

1. Rating Criteria

- To run through rural area with development potential : Rate 3
- Intermediate : Rate 2
- To run through relatively developed area : Rate 1

2. Rating for Development Impact

	AR-1	AR-2	AR-3	AR-4	AR-5
Rate	1	3	2	3	2

II. ENVIRONMENTAL ASPECTS

II.1 Wildlife Sanctuary

1. Rating Criteria

- To run apart from wildlife sanctuary : Rate 3
- To run closely to wildlife sanctuary : Rate 2
- To run through wildlife sanctuary : Rate 1

2. Rating for Wildlife Sanctuary

	AR-1	AR-2	AR-3	AR-4	AR-5
Rate	1	2	2	3	3

II.2 Watershed Class 1-A

1. Rating Criteria

Total motorway length affecting watersheds Class 1-A:

- To completely avoid watersheds Class 1-A : Rate 3
- To run closely to watersheds Class 1-A : Rate 2
- To run through watersheds Class 1-A : Rate 1

2. Rating for Watershed Class 1-A

	AR-1	AR-2	AR-3	AR-4	AR-5
Length (km)	3.2	0.2	0.2	0.0	0.0
Rate	1	2	2	3	3

II.3 Forest Reserve

1. Rating Criteria

Total motorway length affecting forest reserves:

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

2. Rating for Forest Reserve

	AR-1	AR-2	AR-3	AR-4	AR-5
Length (km)	16.2	9.0	9.0	6.5	6.5
Rate	1	2	2	3	3

II.4 Pollution (Air, Noise and Vibration)

1. Rating Criteria

a. Total motorway length affecting settlements:

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

b. Total number of affected temples and schools:

- Lowest : Rate 3
- Midst : Rate 2
- Highest : Rate 1

2. Rating for Pollution

	AR-1	AR-2	AR-3	AR-4	AR-5
Length (km) Sub-Rate	18.6 1	14.3 2	12.7 3	13.7 2	12.5 3
Temples and Schools Sub-Rate	41 1	24 2	19 3	22 2	17 3
Total	2	4	6	4	6
Average	1	2	3	2	3
Rate	1	2	3	2	3

III. TRAFFIC ASPECTS

III.1 Interchange Location

1. Rating Criteria

The distance from the city center:

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

2. Rating for Interchange Location

	AR-1	AR-2	AR-3	AR-4	AR-5
Lampang (km)	7.5	7.5	7.5	7.5	7.5
Lamphun	2.5	9.0	9.0	9.0	9.0
Chiang Mai (1)	6.5	9.5	11.5	9.5	11.5
Chiang Mai (2)	6.5	9.5	None *	9.5	None *
Doi Saket	1.5	1.5	1.5	1.5	1.5
Total Distance (km)	24.5	37.0	49.5	37.0	49.5
Rate	3	2	1	2	1

* An additional distance of 8.5 km to Chiang Mai (1) interchange is added.

III.2 Expected Traffic Volume

1. Rating Criteria

Total inter-city trip length:

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

2. Rating for Expected Traffic Volume

	AR-1	AR-2	AR-3	AR-4	AR-5
Lampang/Lamphun (km)	77.0	76.0	76.0	76.0	76.0
Lampang/Chiang Mai	104.0	100.5	99.0	100.5	99.0
Lampang/Doi Saket	116.0	108.5	105.3	108.5	105.3
Lamphun/Chiang Mai	32.0	42.5	41.0	42.5	41.0
Lamphun/Doi Saket	44.0	50.5	47.3	52.5	47.3
Chiang Mai/ Doi Saket	18.0	19.5	29.3	19.5	29.3
Total Trip Length (km)	391.0	397.5	397.9	397.5	397.9
Rate	3	2	1	2	1

III.3 Connection with Highway Network

1. Rating Criteria

- Well connected highway network : Rate 3
- Intermediate : Rate 2
- Poorly connected with highway network : Rate 1

2. Rating for Connection with Highway Network

	AR-1	AR-2	AR-3	AR-4	AR-5
Rt. 11 : Sub-Rate Rt. 107 : Sub-Rate	1 3	3 3	3 1	3 3	3 1
Total	4	6	4	6	4
Average	2	3	2	3	2
Rate	3	3	1	3	1

IV. TECHNICAL ASPECTS

IV.1 Alinement

1. Rating Criteria

a. Gradient

The height (GL) in meters calculated by multiplying each gradient % (G) by its length (L) in kilometers.

- Lowest : Rate 3
- Midst : Rate 2
- Highest : Rate 1

b. Curvature

The ratio (L/R) calculated by dividing each curve length (L) by its radius (R).

- Lowest : Rate 3
- Midst : Rate 2
- Highest : Rate 1

2. Rating for Alinement

	AR-1	AR-2	AR-3	AR-4	AR-5
GL (m) Sub-Rate	217 2	257 1	257 1	192 3	192 3
L/R Sub-Rate	4.4 1	3.7 2	3.7 2	3.3 3	3.3 3
Total	3	3	3	6	6
Average	1.5	1.5	1.5	3	3
Rate	2	2	2	3	3

IV.2 Difficulty of Construction

1. Rating Criteria

a. Total Length of Tunnel

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

b. Total Length of Long-Span Bridges and Viaducts

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

c. Traffic Build-up during Construction

- At rural area / apart from heavy traffic highway : Rate 3
- Intermediate : Rate 2
- At urbanized area / close to heavy traffic highway : Rate 1

2. Rating for Difficulty of Construction

	AR-1	AR-2	AR-3	AR-4	AR-5
Tunnel Length (km)	8.0	5.0	5.0	6.3	6.3
Sub-Rate	1	3	3	2	2
Bridge & Viaduct Length (km)	22.6	15.0	7.5	15.5	7.5
Sub-Rate	1	2	3	2	3
Traffic Build-up Sub-Rate	1	2	3	2	3
Total	3	7	9	6	8
Average	1	2.3	3	2	2.6
Rate	1	2	3	2	3

Remarks: Tunnel:
AR-1: One Tunnel (8.0 km)
- Planned considering the conservation of wildlife sanctuary
- Very difficult in construction
- Trucks loaded with dangerous materials are not allowed

AR-2 and AR-3: Three Tunnels (3.2 + 0.8 + 1.0 = 5.0 km)
AR-4 and AR-5: Three Tunnels (4.5 + 0.8 + 1.0 = 6.3 km)

Long-Span Bridge:
There are only two long-span bridges in all alternatives (100 + 100 = 200 m)

IV.3 Construction Cost

1. Rating Criteria

The percentage of construction cost considering the lowest cost as 100 %.

- Between 100 % and 110 % : Rate 3
- Between 110 % and 130 % : Rate 2
- More than 130 % : Rate 1

2. Rating for Construction Cost

	AR-1	AR-2	AR-3	AR-4	AR-5
Construction Cost (million Baht) Percentage	170	117	100	121	104
Rate	1	2	3	2	3

IV.4 Maintenance Cost

1. Rating Criteria

a. Total Length of Tunnel

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

b. Route Length

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

2. Rating for Maintenance Cost

	AR-1	AR-2	AR-3	AR-4	AR-5
Tunnel Length (km)	8.0	5.0	5.0	6.3	6.3
Sub-Rate	1	3	3	2	2
Route Length (km)	107.0	99.5	96.3	99.5	96.3
Sub-Rate	1	2	3	2	3
Total	2	5	6	4	5
Average	1	2.5	3	2	2.5
Rate	1	3	3	2	3

APPENDIX 4.2-3 DESIGN RESULT OF BAN PONG - CHA AM ROUTE

ALTERNATIVE ROUTE

WORK ITEM		AR-1 A1 + A2	AR-2 A1 + B1 + B2	AR-3 A1 + B1 + B3
Length (km)		125.5	126.0	126.5
Number of Junctions		2	2	2
Number of Interchanges		6	6	6
Number of Service Areas		1	1	1
Tunnels (lm)		0	0	0
Flyover Bridges (no & sqm)		27 22,920	29 27,840	23 22,080
Viaducts (lm)		10,000	6,600	13,100
Bridges (lm)	L<100m	1,800	2,400	2,300
	L>100m	1,200	900	900
Length by Grade	1.0%-2.0%	0	0	0
(lm)	2.5%-3.0%	0	0	0
Curve Length	R=1,500m	0	0	0
(lm)	R=1,000m	0	0	0

LINK

WORK ITEM		A1	A2	B1	B2	B3
Length (km)		48.5	77.0	36.5	41.0	41.5
Number of Junctions		2	0	0	0	0
Number of Interchanges		3	3	1	2	2
Number of Service Areas		0	1	1	0	0
Tunnels (lm)		0	0	0	0	0
Flyover Bridges (no & sqm)		9 8,640	18 17,280	5 4,800	15 14,400	9 8,640
Viaducts (lm)		4,000	6,000	1,100	1,500	8,000
Bridges (lm)	L<100m	1,000	800	400	1,000	900
	L>100m	700	500	0	200	200
Length by Grade	1.0%-2.0%	0	0	0	0	0
(lm)	2.5%-3.0%	0	0	0	0	0
Curve Length	R=1,500m	0	0	0	0	0
(lm)	R=1,000m	0	0	0	0	0

APPENDIX 4.2-4 RATING CRITERIA FOR BAN PONG - CHA AM ROUTE

I. SOCIO-ECONOMIC ASPECTS

I.1 Adaptability for City Planning

1. Rating Criteria

- To run very closely to the city planning area or mainly through agricultural land designated in the city planning : Rate 3
- To run near the city planning area : Rate 2
- To run through residential / commercial / industrial areas designated in the city planning : Rate 1

2. Rating for Adaptability for City Planning

City	AR-1	AR-2	AR-3
Ban Pong	2	2	2
Ratchaburi	3	3	3
Phetchaburi	2	2	3
Cha Am	2	3	3
Total	9	10	11
Average	2.25	2.5	2.75
Rate	2	3	3

I.2 Split of Community

1. Rating Criteria

Total motorway length causing split of communities:

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

2. Rating for Split of Community

	AR-1	AR-2	AR-3
Length (km)	5.3	4.0	5.1
Rate	1	3	2

I.3 Development Impact

1. Rating Criteria

- To run through rural area with development potential : Rate 3
- Intermediate : Rate 2
- To run through relatively developed area : Rate 1

2. Rating for Development Impact

	AR-1	AR-2	AR-3
Rate	3	2	2

I.4 Specific Project

1. Rating Criteria

- To positively affect specific Project : Rate 3
- Intermediate : Rate 2
- To negatively affect specific Project : Rate 1

2. Rating for Specific Project

	AR-1	AR-2	AR-3
Rate	1	3	3

II. ENVIRONMENTAL ASPECTS

II.1 Pollution (Air, Noise and Vibration)

1. Rating Criteria

a. Total motorway length affecting settlements:

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

b. Total number of affected temples and schools:

- Lowest : Rate 3
- Midst : Rate 2
- Highest : Rate 1

2. Rating for Pollution

	AR-1	AR-2	AR-3
Length (km) Sub-Rate	16.6 1	14.4 3	15.7 2
Temples and Schools Sub-Rate	14 1	13 2	12 3
Total	2	5	5
Average	1	2.5	2.5
Rate	1	3	3

II.2 Soft Ground

1. Rating Criteria

- To mostly avoid soft ground : Rate 3
- To partially run through soft ground : Rate 2
- To mostly run through soft ground : Rate 1

2. Rating for

	AR-1	AR-2	AR-3
Rate	3	2	2

III. TRAFFIC ASPECTS

III.1 Interchange Location

1. Rating Criteria

The distance from the city center:

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

2. Rating for Interchange Location

	AR-1	AR-2	AR-3
Ban Pong (km)	3.0	3.0	3.0
Ratchaburi	4.0	4.0	4.0
Pak Tho	6.0	2.3	2.3
Phetchaburi	11.5	7.0	3.7
Cha Am: Distance	10.0	9.0	9.0
Total Distance (km)	34.5	25.3	22.0
Rate	1	2	3

III.2 Expected Traffic Volume

1. Rating Criteria

Total inter-city trip length:

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

2. Rating for Expected Traffic Volume

	AR-1	AR-2	AR-3
Ban Pong/Ratchaburi	39.5	39.5	39.5
Ban Pong/Phetchaburi	94.8	92.5	88.7
Ban Pong/Cha Am	138.5	136.5	137.0
Ratchaburi/Phetchaburi	63.3	61.0	57.2
Ratchaburi/Cha Am	107.0	105.0	105.5
Phetchaburi/Cha Am	66.7	58.0	55.7
Total Trip Length (km)	509.8	492.5	483.6
Rate	1	2	3

III.3 Connection with Highway Network

1. Rating Criteria

- Well connected with highway network : Rate 3
- Intermediate : Rate 2
- Poorly connected with highway network : Rate 1

2. Rating for Connection with Highway Network

	AR-1	AR-2	AR-3
Connection with Rt 35:			
Rate	1	3	3

IV. TECHNICAL ASPECTS

IV.1 Alinement

1. Rating Criteria

For all alternatives, minimum curve radius is more than 3,000 m and maximum gradient is less than 1 %.

2. Rating for Alinement

	AR-1	AR-2	AR-3
Rate	3	3	3

IV.2 Difficulty of Construction

1. Rating Criteria

a. Total Length of Long-Span Bridges and Viaducts

- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

b. Traffic Build-up during Construction

- At rural area and apart from heavy traffic highway : Rate 3
- Intermediate : Rate 2
- At urbanized area and close to heavy traffic highway : Rate 1

2. Rating for Difficulty of Construction

	AR-1	AR-2	AR-3
Bridge & Viaduct Length (km)	10.35	7.2	13.9
Sub-Rate	2	3	1
Traffic Build-up Sub-Rate	3	2	2
Total	5	5	3
Average	2.5	2.5	1.5
Rate	3	3	2

IV.3 Construction Cost

1. Rating Criteria

The percentage of construction cost considering the lowest cost as 100 %.

- Lowest : Rate 3
- Midst : Rate 2
- Highest : Rate 1

2. Rating for Construction Cost

	AR-1	AR-2	AR-3
Construction Cost (million Baht)			
Percentage	103	100	107
Rate	2	3	1

IV.4 Maintenance Cost

1. Rating Criteria

Route length:

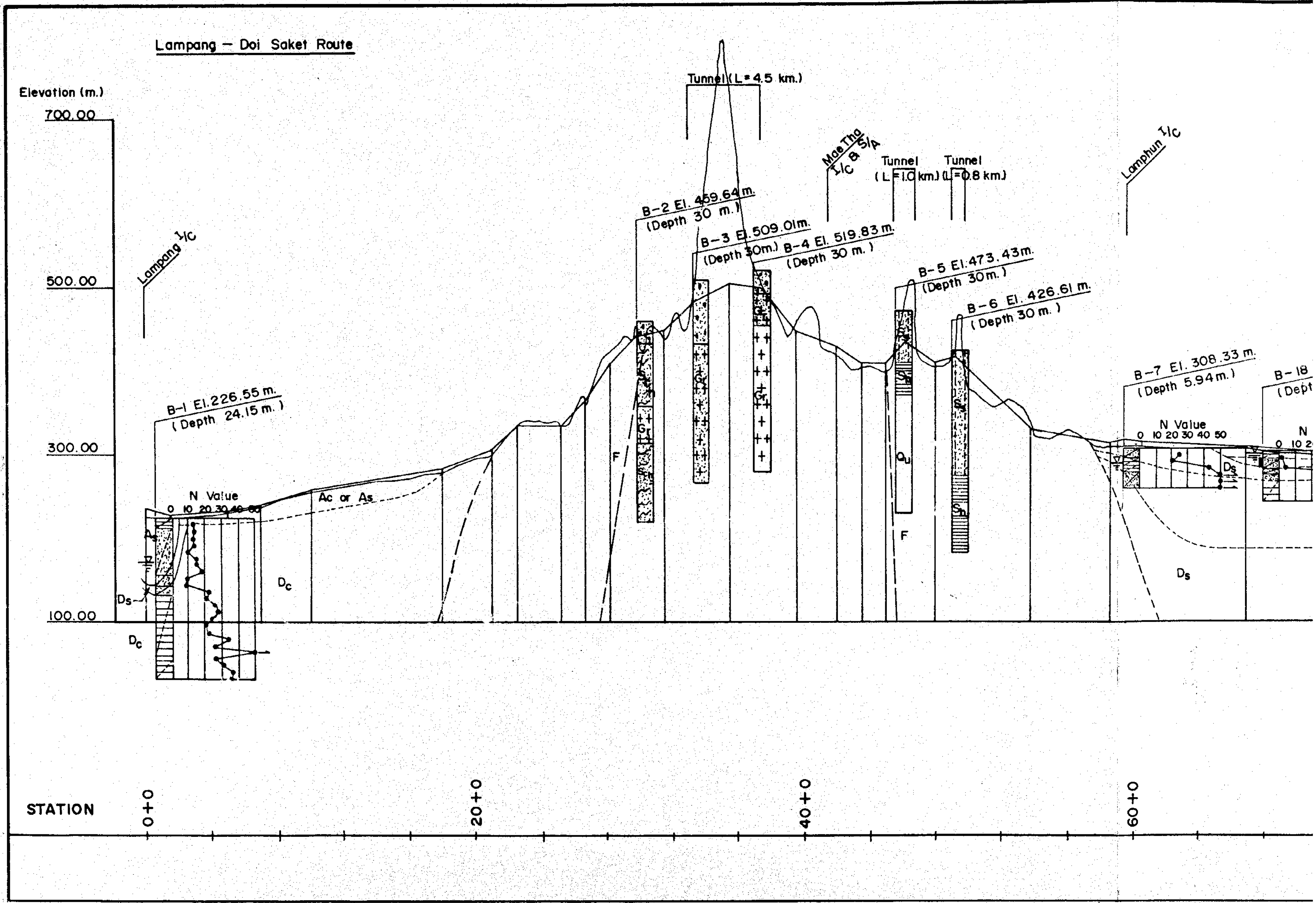
- Shortest : Rate 3
- Midst : Rate 2
- Longest : Rate 1

2. Rating for Maintenance Cost

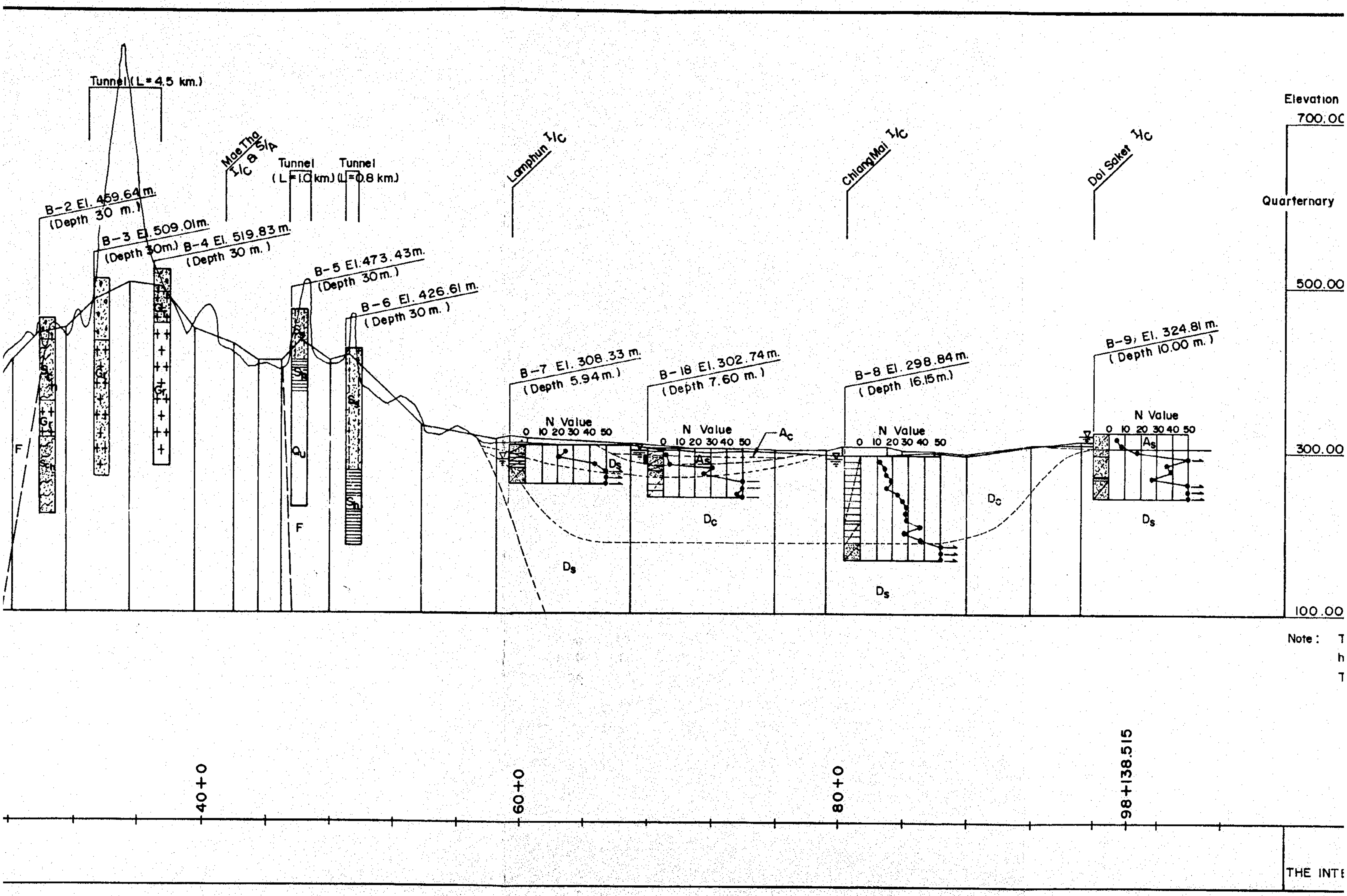
	AR-1	AR-2	AR-3
Route Length (km)	133.0	132.0	132.5
Rate	1	3	2

CHAPTER 6

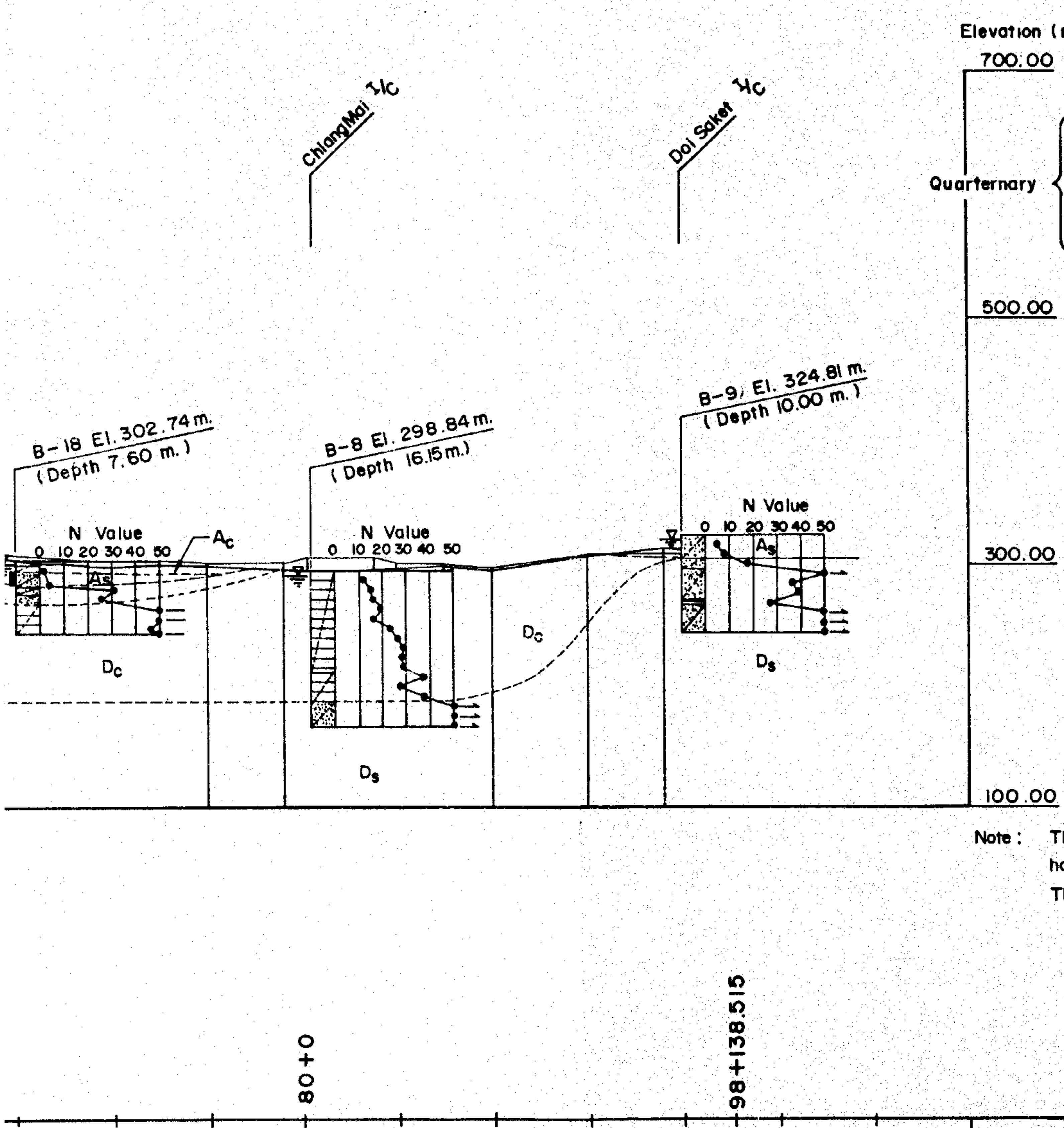
PRELIMINARY DESIGN



Lampang – Doi Saket Route
Elevation (m.)
700.00
500.00
300.00
100.00
Lampang I/C
Tunnel (L = 4.5 km.)
Mae Tha I/C & S/A
Tunnel (L = 1.0 km.)
Tunnel (L = 0.8 km.)
Lamphun I/C
B-1 El. 226.55 m. (Depth 24.15 m.)
B-2 El. 459.64 m. (Depth 30 m.)
B-3 El. 509.01m. (Depth 30m.)
B-4 El. 519.83 m. (Depth 30 m.)
B-5 El. 473.43 m. (Depth 30m.)
B-6 El. 426.61 m. (Depth 30 m.)
B-7 El. 308.33 m. (Depth 5.94 m.)
B-18
N Value
0 10 20 30 40 50
Ac or As
Dc
Ds
F
Gr
Sh
Qu
STATION
0+0
20+0
40+0
60+0



Tunnel (L=4.5 km.)
Mae Tha I/C & S/A
Tunnel (L=1.0 km.)
Tunnel (L=0.8 km.)
Lamphun I/C
Chiang Mai I/C
Doi Saket I/C
Elevation
700.00
500.00
300.00
100.00
Quarternary
B-2 El. 459.64 m. (Depth 30 m.)
B-3 El. 509.01 m. (Depth 30 m.)
B-4 El. 519.83 m. (Depth 30 m.)
B-5 El. 473.43 m. (Depth 30 m.)
B-6 El. 426.61 m. (Depth 30 m.)
B-7 El. 308.33 m. (Depth 5.94 m.)
B-18 El. 302.74 m. (Depth 7.60 m.)
B-8 El. 298.84 m. (Depth 16.15 m.)
B-9, El. 324.81 m. (Depth 10.00 m.)
N Value
0 10 20 30 40 50
F
Gr
Sh
Qu
Ss
Ac
As
Ds
Dc
Note :
40+0
60+0
80+0
98+138.515
THE INTE



LEGEND

Quarternary
- Holocene
  - A_c Alluvial Clay
  - A_s Alluvial Sand
- Pleistocene
  - D_c Diluvial Clay
  - D_s Diluvial Sand

Sand

Silty Sand

Clayey Sand

Silty Clay

Ground Water Level

Undisturbed Sample

Sandy Gravel (Laterite)

Silurian— Devonian Don Chai Group
- S_{ch} Highly weathered Micaceous Schist
- G_r Highly weathered Granite

Mesozoic Khun Tan Group
- G_r Highly weathered Granite
- G_r Coarse grain Granite

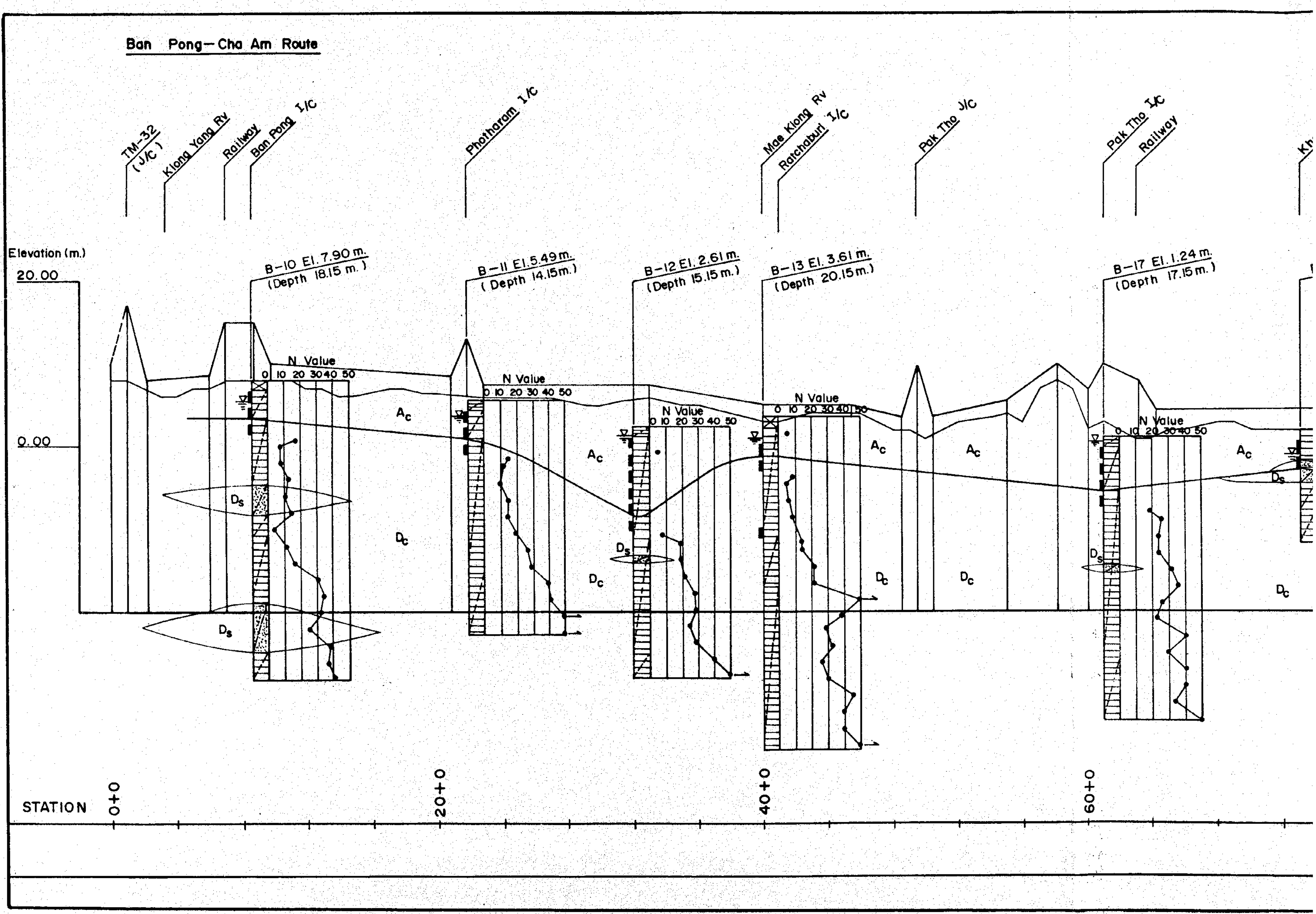
Carboniferous Mae Tha Group
- S_s Weathered Sandstone
- S_h Weathered Shale
- Q_u Quartzite

F —— Supposed Fault

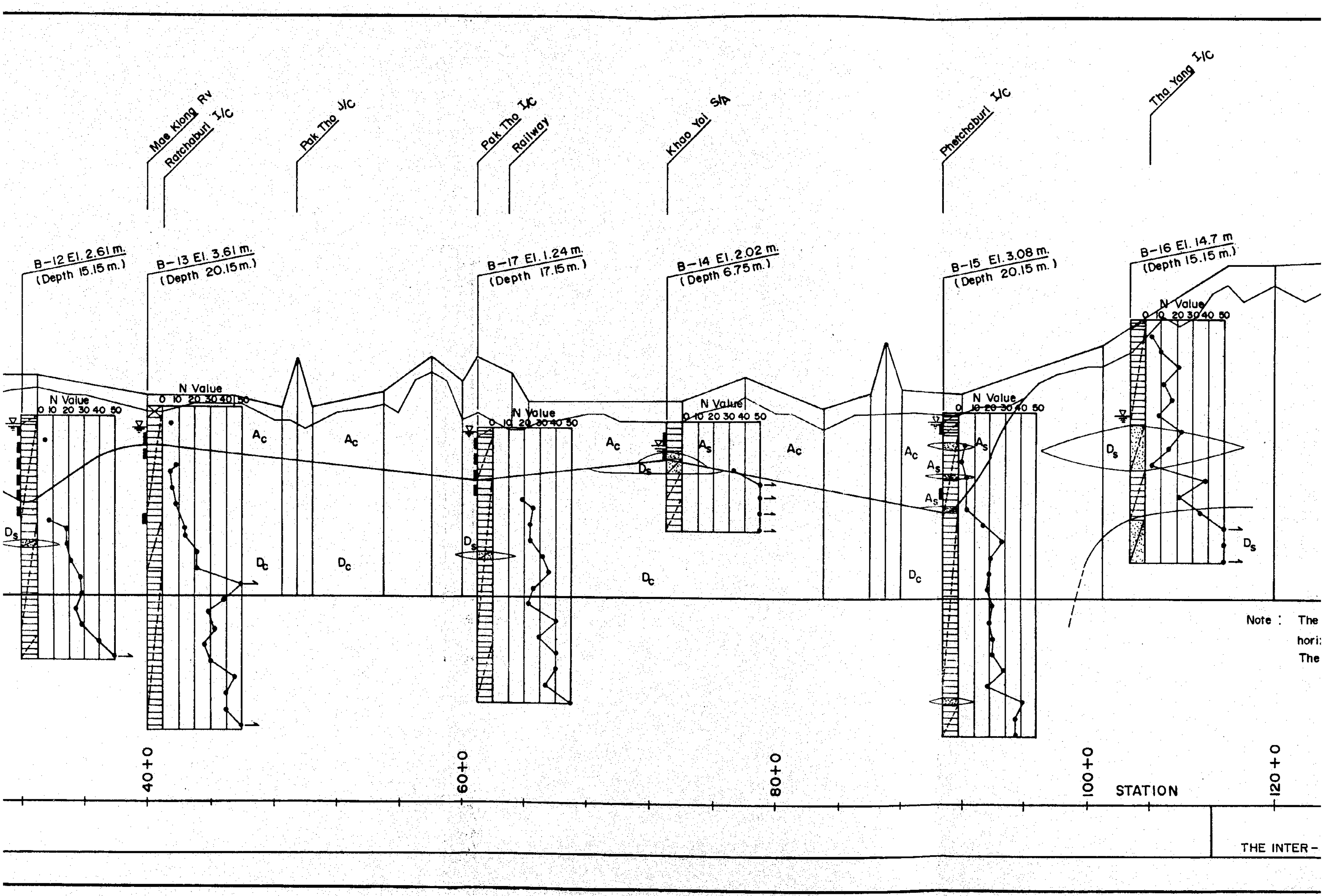
Note : The original ground surface and proposed profile of Motorway are drawn with a scale of horizontal (1 : 200,000) and vertical (1 : 4,000).
The geological logs are drawn with a scale of vertical (1 : 500).

FEASIBILITY STUDY
ON
THE INTER-CITY TOLL MOTORWAY PROJECTS

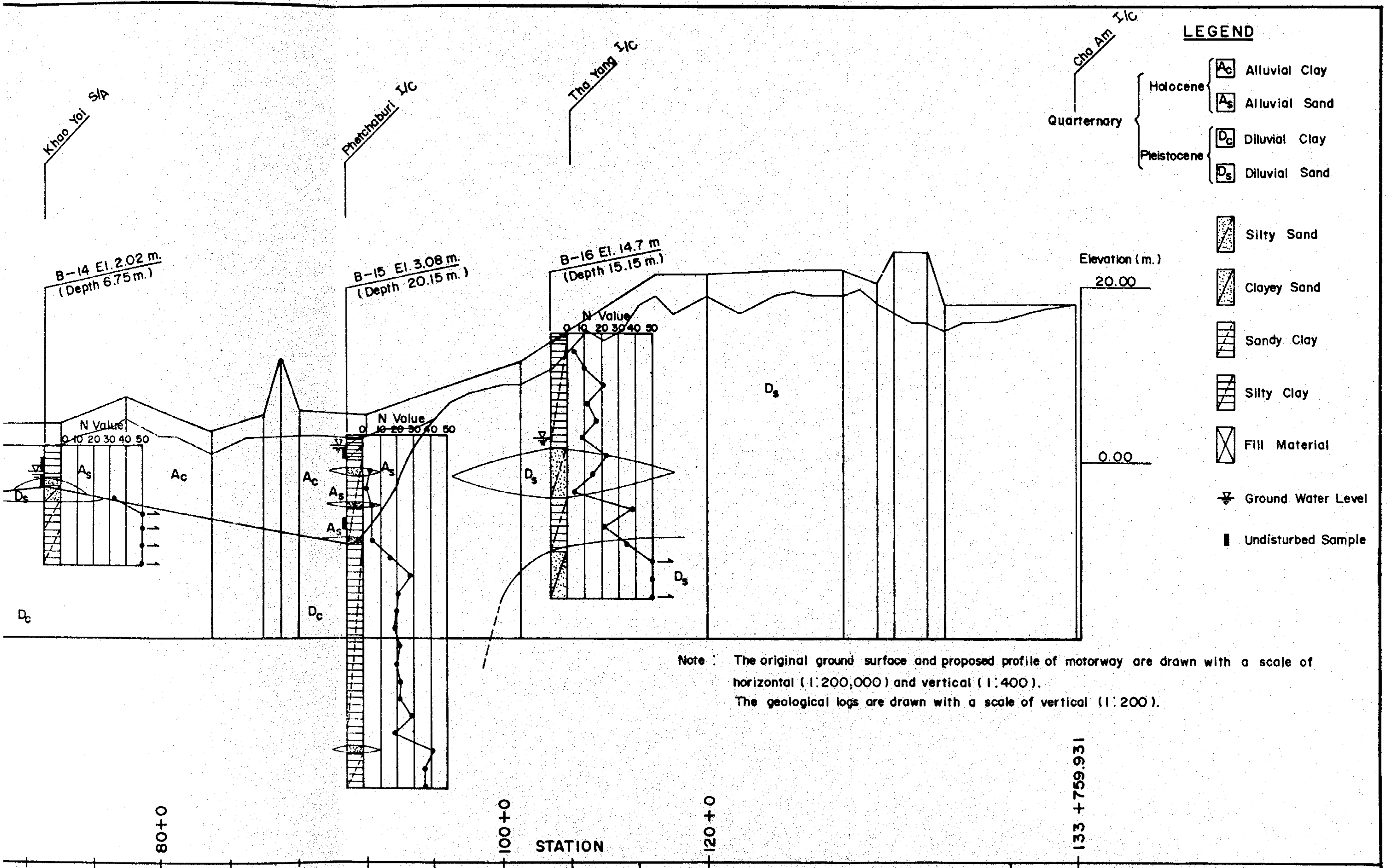
APPENDIX 6.1-1 GEOLOGICAL PROFILE
OF LAMPANG - DOI SAKET ROUTE



Ban Pong—Cha Am Route
TM-32 (J/C)
Klong Yang Rv
Railway
Ban Pong I/C
Photharam I/C
Mae Klong Rv
Ratchaburi I/C
Pak Tho J/C
Pak Tho I/C
Railway
Elevation (m.)
20.00
0.00
B-10 El. 7.90 m. (Depth 18.15 m.)
B-11 El. 5.49 m. (Depth 14.15 m.)
B-12 El. 2.61 m. (Depth 15.15 m.)
B-13 El. 3.61 m. (Depth 20.15 m.)
B-17 El. 1.24 m. (Depth 17.15 m.)
N Value
0 10 20 30 40 50
Ac
Dc
Ds
STATION
0+0
20+0
40+0
60+0



Mae Klong Rv
Ratchaburi I/C
Pak Tho J/C
Pak Tho I/C
Railway
Khao Yai S/A
Phetchaburi I/C
Tha Yang I/C
B-12 El. 2.61 m. (Depth 15.15 m.)
B-13 El. 3.61 m. (Depth 20.15 m.)
B-17 El. 1.24 m. (Depth 17.15 m.)
B-14 El. 2.02 m. (Depth 6.75 m.)
B-15 El. 3.08 m. (Depth 20.15 m.)
B-16 El. 14.7 m (Depth 15.15 m.)
N Value
0 10 20 30 40 50
Ac
As
Ds
Dc
40+0
60+0
80+0
100+0
120+0
STATION
Note : The
hori:
The
THE INTER-



Note : The original ground surface and proposed profile of motorway are drawn with a scale of horizontal (1:200,000) and vertical (1:400).
The geological logs are drawn with a scale of vertical (1:200).

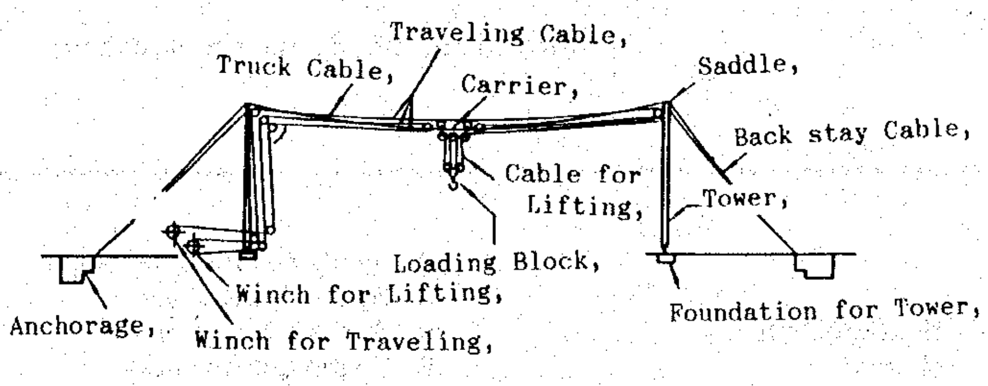
FEASIBILITY STUDY
ON
THE INTER-CITY TOLL MOTORWAY PROJECTS

APPENDIX 6.1-2 GEOLOGICAL PROFILE
OF BAN PONG - CHA AM ROUTE

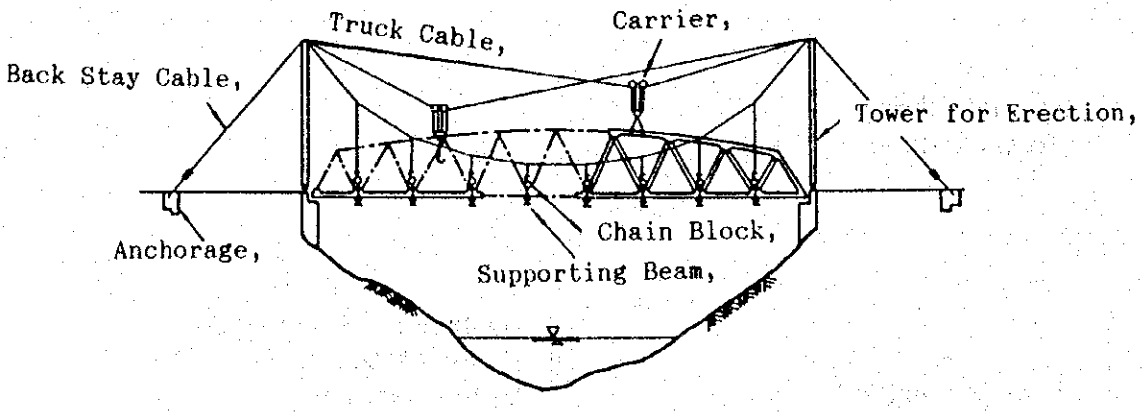
Clacification of Erection Method

1) Bent Erection Method	a) By the self movable crane b) By the cable crane c) By the stiff legs crane d) By the goliath crane c) By the floating crane
2) Cable Erection Method	a) Virtical suspend by the Cable b) Diagonal suspend by the Cable
3) Erection Girder (Truss) Method	
4) Push Out method	a) By the lunching erection b) By the erection girder c) By the carry cart d) By the pontoon c) By the traveling bent
5) Cantilever Method	a) By the traveling crane b) By the cable crane c) By the stiff legs crane d) By the floating crane c) Balanced cantilever method

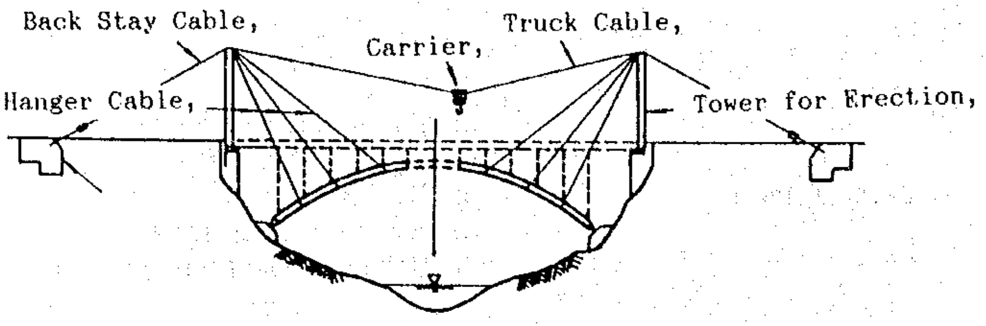
Cable Erection Method



Concept of the Cable Crane,

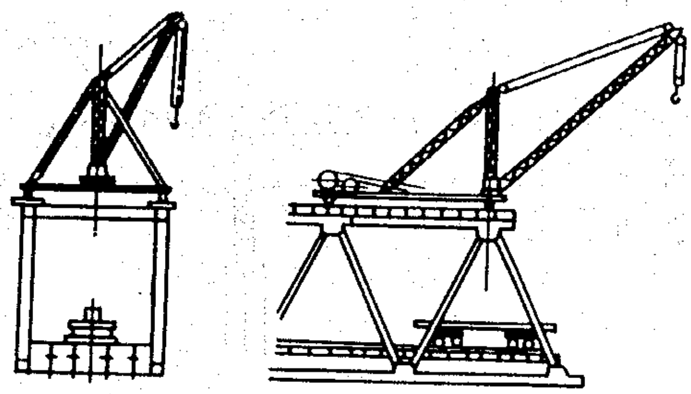


Vertical Suspend Method

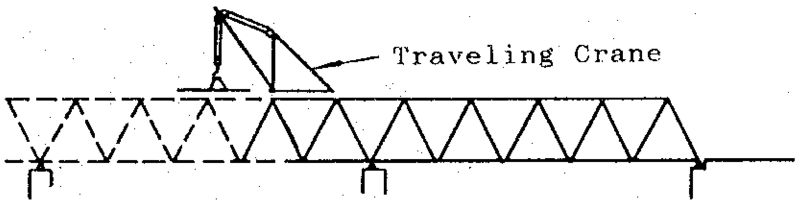


Diagonal Suspend Method

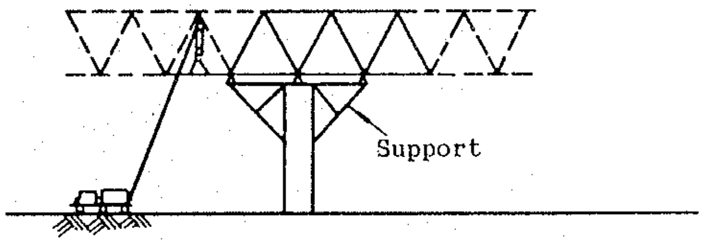
Traveling Crane Method



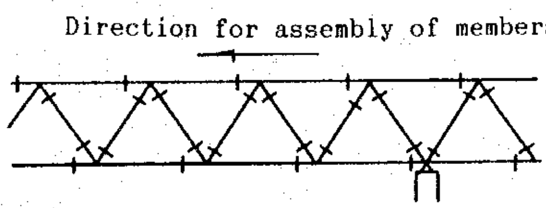
Outline of Traveling Crane Method



Cantilever Erection by the Traveling Crane

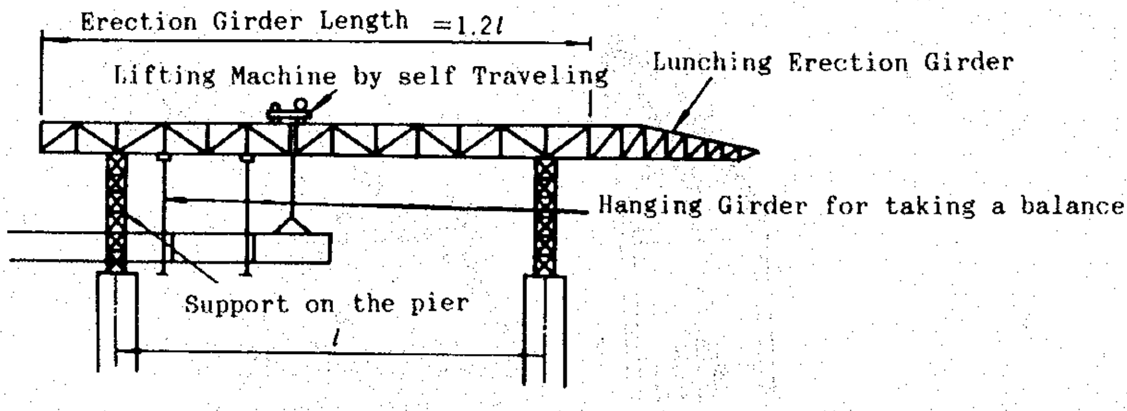


Balanced Erection by the Traveling



Joint point of Truss girder for the Traveling Crane

Erection Girder Method



Outline of Lunching Erection Method

Facilities of the Traveling Crane Method

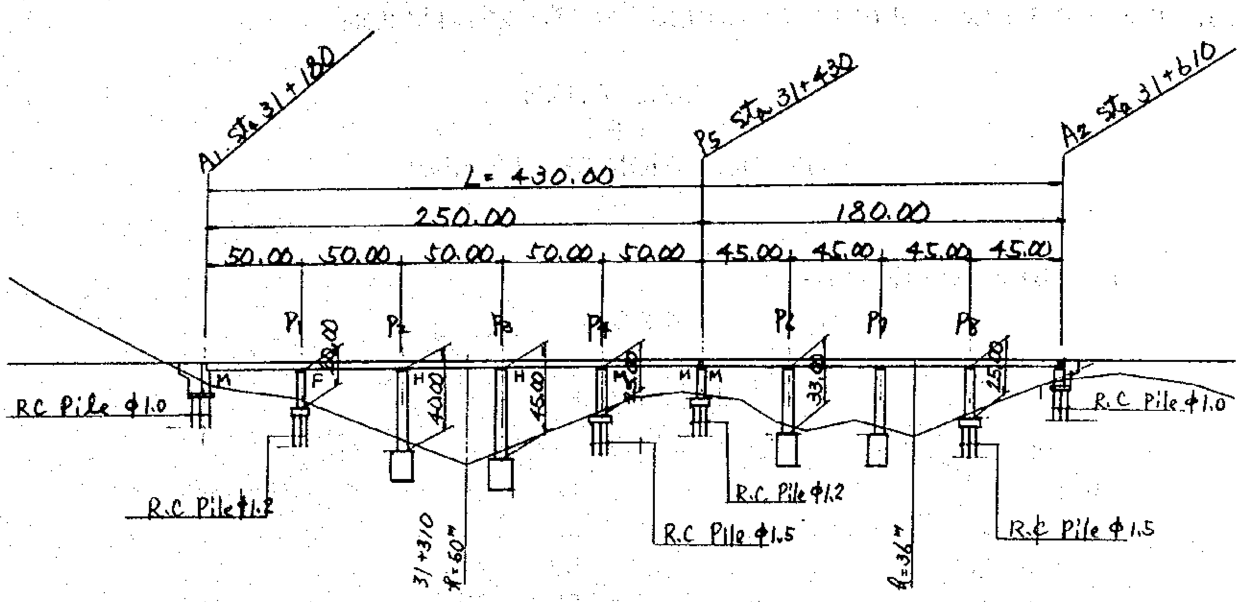
Name of Machine Description	Specification of Machine			
	Hanging Ability (txm)	Length of Boom (m)	Turning Angle	Weight (t)
Three Legs Crane	6 x 12	12	195°	20
Three Legs Crane	15 x 20	25	150°	40
Three Legs Crane	16 x 22	25	250°	22
Three Legs Crane	20 x 43	60	95°	129
Three Legs Crane	25 x 25	28	270°	41
Three Legs Crane	35 x 18	25	270°	62
Three Legs Crane	50 x 12	17	230°	60
Three Legs Crane	60 x 25	49	240°	129
Full Turning Crane	8 x 13	33.7	360°	34
Full Turning Crane	10 x 10	17.5	360°	28
Full Turning Crane	20 x 30	39.5	360°	201
Portable Crane	5 x 15	17	195°	27
Portable Crane	6 x 12	17	160°	18
Portable Crane	8 x 15	20	210°	23
Rail	30kg/m, 37kg/m, 50kg/m		Attachement Wooden Sleeper	

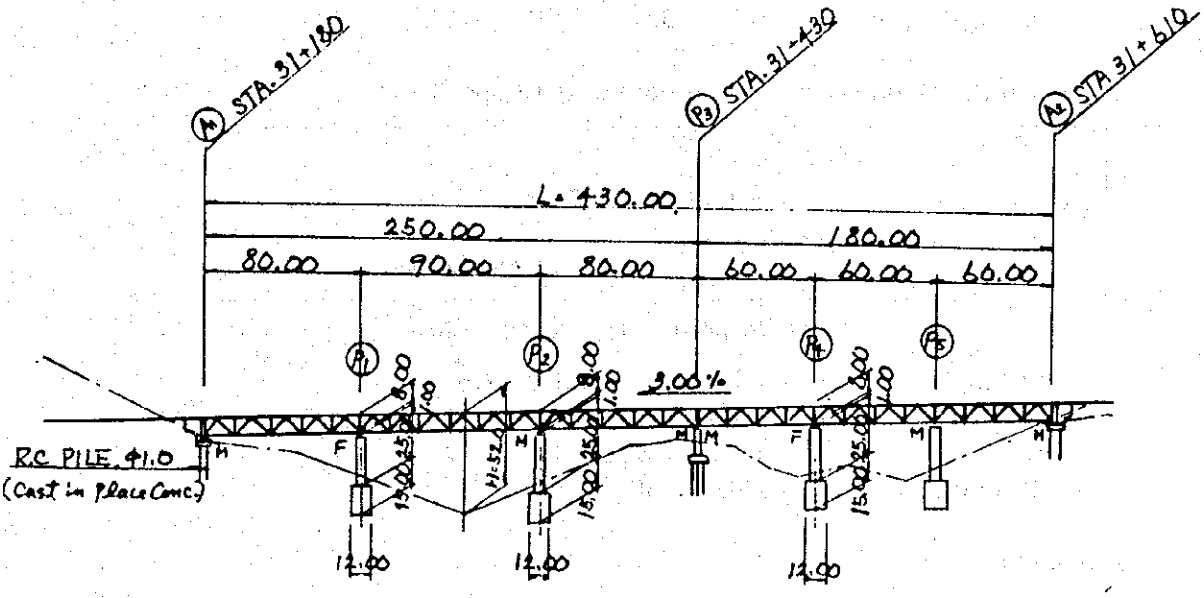
APPENDIX 6.4-2 COST COMPARISON BETWEEN STEEL TRUSS AND PC GIRDER

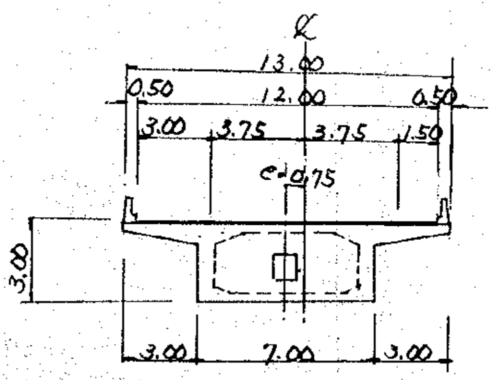
Comparison of Cost Estimation

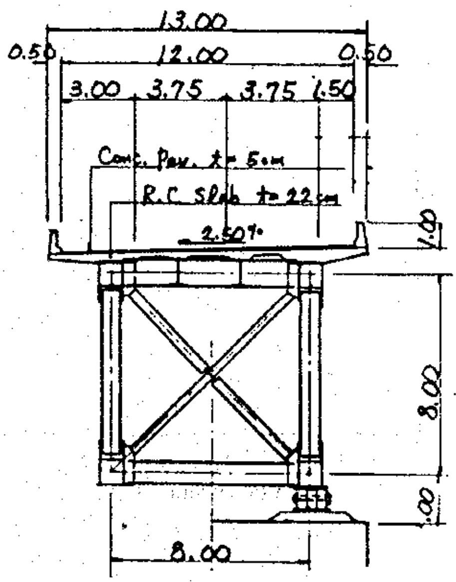
Bridge Length: L = 340 m. (Sta. 31+180 – Sta. 31+640)

	BRIDGE OF TRUSS					BRIDGE OF PC GIRDER				
	Span (m)	No.	Unit(m^2)	Unit Cost(B/m^2)	Cost(M.B)	Span (m)	No.	Unit(m^2)	Unit Cost(B/m^2)	Cost(M.B)
1. Super Structure	80	2	1,920	65,000	124.8	50	5	3,000	50,000	150.0
	90	1	1,080	71,000	76.7	45	4	2,160	50,000	108.0
	60	3	2,160	54,800	118.4					
	Sub-total				319.9	Sub-total				258.0
2. Sub-Structure	Abut	(A_1+A_2)	13^m x 2^{ea}	$500,000^{B/ea}$	13.0	Abut	(A_1+A_2)	13^m x 2^{ea}	$500,000^{B/ea}$	13.0
	Pier	(P_1,P_2,P_5) h = 25.0^m	11^m x 4^{ea}	$8,850,000^{B/ea}$	35.4	Pier	(P_1 h=20^m)	1^{ea}	$4,750,000^{B/ea}$	4.8
						Pier	(P_4+P_8 h=25^m)	2^{ea}	$7,250,000^{B/ea}$	14.5
	Pier	P_3 h = 15.0^m	1^{ea}	$3,900,000^{B/ea}$	3.9	Pier	(P_6+P_7 h=33^m)	2^{ea}	$14,500,000^{B/ea}$	29.0
						Pier	(P_2 h=40^m)	1^{ea}	$18,750,000^{B/ea}$	18.8
						Pier	(P_3 h=45^m)	1^{ea}	$21,750,000^{B/ea}$	21.8
						Pier	(P_5 h=15^m)	1^{ea}	$3,700,000^{B/ea}$	3.7
	Sub-total				52.3	Sub-total				105.6
3. Foundation	Abut	(A_1+A_2) 1.0	n=10, l=15^m	$13,200^{B/m}$	4.0	Abut	(A_1+A_2) 1.0	n=15, l=15^m	$13,200^{B/m}$	8.9
		P_3 1.0	n=15, l=15^m	$13,200^{B/m}$	3.0	Pier	(P_1+P_5) 1.2	n=15, l=15^m	$15,100^{B/m}$	6.8
						Pier	(P_4+P_8) 1.5	n=15, l=15^m	$20,450^{B/m}$	4.6
	Sub-total				7.0	Sub-total				17.3
			TOTAL		$379.2^{M/B}$			**TOTAL**		$380.9^{M/B}$


A1 Sta 31+180
P5 Sta 31+430
A2 Sta 31+610
L= 430.00
250.00
180.00
50.00 50.00 50.00 50.00 50.00 45.00 45.00 45.00 45.00
P1 P2 P3 P4 P6 P7 P8
RC Pile φ1.0
R.C Pile φ1.2
R.C Pile φ1.2
R.C Pile φ1.5
R.C Pile φ1.5
R.C Pile φ1.0
31+310
40.00
45.00
33.00
25.00


A1 STA 31+180
P3 STA 31+430
A2 STA 31+610
L= 430.00
250.00
180.00
80.00 90.00 80.00 60.00 60.00 60.00
P1 P2 P4 P5
3.00%
RC PILE φ1.0
(Cast in Place Conc.)
12.00
12.00
12.00

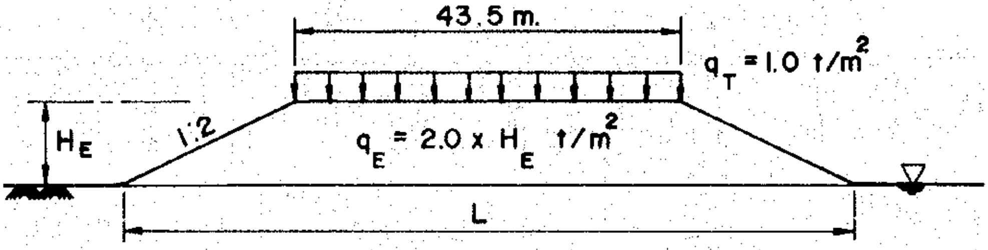

℄
13.00
0.50
12.00
0.50
3.00 3.75 3.75 1.50
3.00
3.00 7.00 3.00


13.00
0.50
12.00
0.50
3.00 3.75 3.75 1.50
Conc. Pav. t= 5cm
R.C Slab t= 22cm
2.50%
8.00
8.00

APPENDIX 6.5-1 CALCULATION OF CONSOLIDATION SETTLEMENT

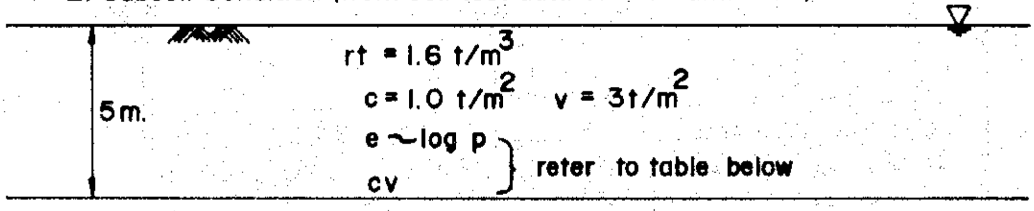
CALCULATION
OF
CONSOLIDATION SETTLEMENT

1. Embankment Condition



H_E (m)	1.5	3.5	5.5	7.5
L (m)	49.5	57.5	65.5	73.5
$q = q_E + q_T$ (t/m²)	4.0	8.0	12.0	16.

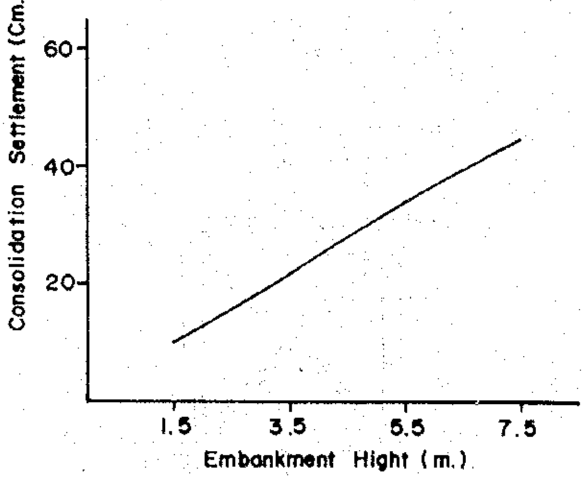
2. Subsoil Condition (from soil test data of B-12 and B-17)

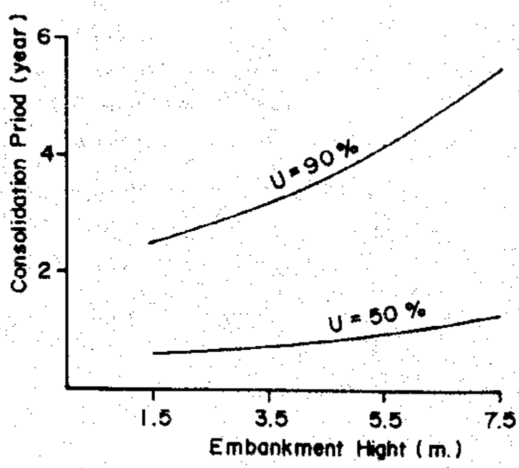


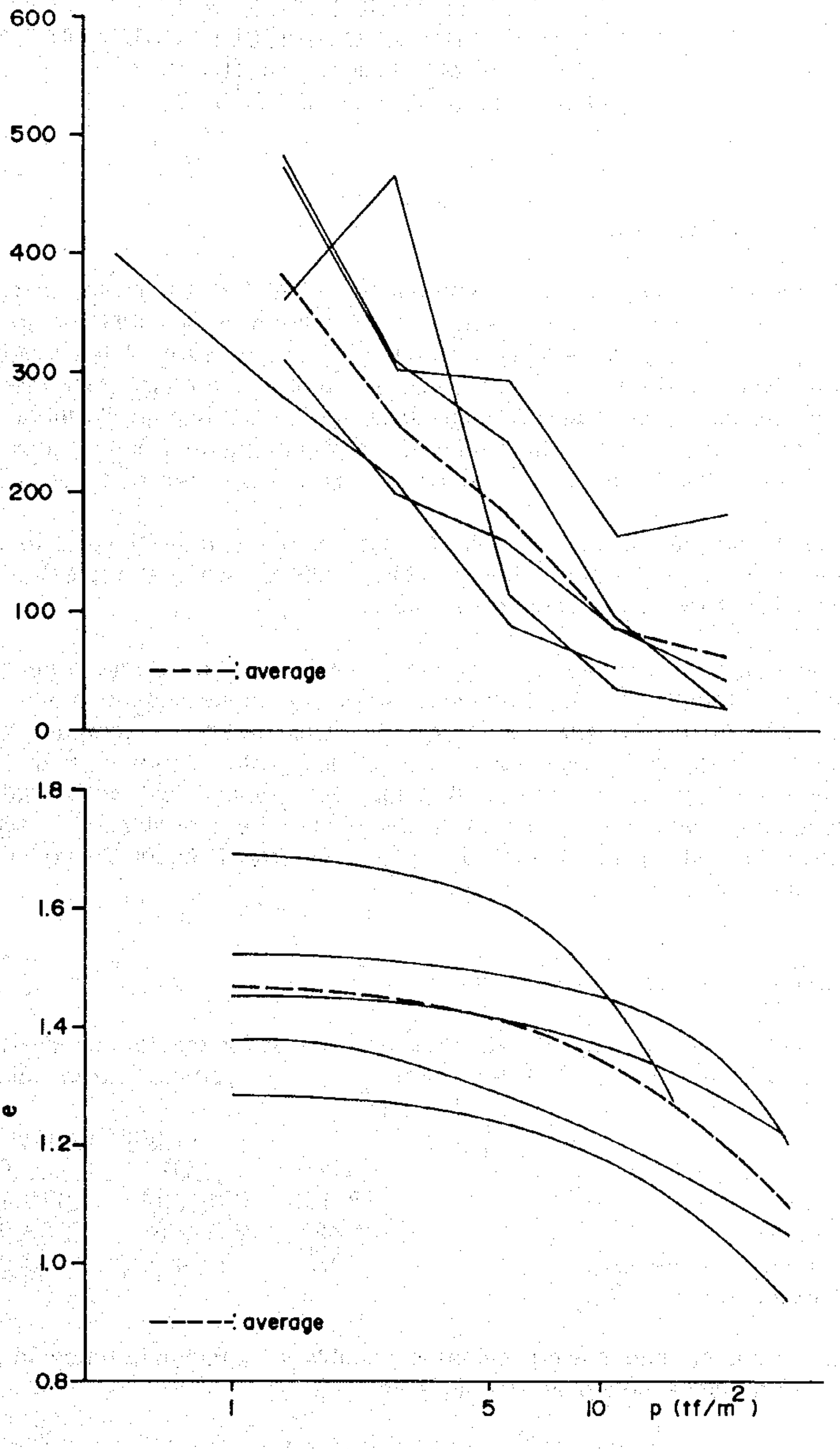
Stiff to hard Silty / Sandy Clay

H_E (m)	1.5	3.5	5.5	7.5
e_0	1.46	1.46	1.46	1.46
e	1.41	1.35	1.29	1.24
C_v (cm²/day)	230	180	140	105

3. Results







600
500
400
300
200
100
0
Cv (cm2/ day)
---: average
1.8
1.6
1.4
1.2
1.0
0.8
e
---: average
1
5
10
p (tf/m2)

APPENDIX 6.6-1 PRELIMINARY COST BENEFIT ANALYSIS OF TUNNEL NO. 2 SECTION

A TENTATIVE RESULT
ON COMPARISON OF No.2 TUNNEL OF ORIGINAL ROUTE(ROUTE A) AND ALTERNATIVE ROUTE(ROUTE B) FROM AN ECONOMIC POINT OF VIEW

1. Method for Comparison

This tentative analysis on the comparison of the 2(two) routes is based on the incremental benefit and incremental cost analysis because of no information on the total benefit of each routes at present. If the values of IRR (Internal Rate of Return) of each route are required for the comparison, we have to calculate the VOC (Vehicle Operating Cost) in both "Without Project" and "With Project" cases. However, the only information we have now are differences in route length and in construction costs between the two routes.

Under these situations, the method adopted in the analysis was to compare an additional benefit (difference of total benefit between 2 routes) and an additional cost in the case of the Route A.

In the case of the Route A, VOC will be lower than the Route B because of redaction in length but construction cost will be higher because of construction of tunnel. The incremental analysis means to compare these additional benefit and additional cost focusing on the Route A. If the additional cost get higher return than the Opportunity Cost of Capital in Thailand, the route will be recommendable and the tunnel section will contribute to push up the level of IRR and NPV (Net Present Value) in the whole route. vice versa.

2. Incremental Benefit (VOC Saving)

The incremental benefit it explained above was calculated as differences in VOC applying the unit cost (1994 price) by vehicle type as shown below:

(1,000 Baht/year)

	2000	2010	2020
(1) Route A	38,453	246,784	1,019,746
(2) Route B	45,423	291,208	1,202,999
(3) Incremental Benefit of Route A = (2) - (1)	6,970	44,424	183,253

The benefit of time saving will be negligible because difference in length is only 1.3 km with a speed of 100 km/hour.

3. Incremental Cost

(1) Construction Cost

(Route A - Route B)
= 2,750,000 - 2,000,000
= 750,000 (in 1,000 Baht)

(2) Operation and Maintenance Cost

Case 1: O & M cost was estimated at 900,000 Baht/km/year the previous Master Plan Study (1991-1994). Assuming a 5% of annual rate of Price increase, increase ratio (1991-1994) of 1.16 was applied which resulted in the following:

Incremental M & O Cost (1994)
900,000 Baht/km x 1.16 x 1.3 km = 1,357 (in 1,000 Baht)

Case 2 ; Incremental O & M Cost = 0 (zero)

In this case, it i8 assumed the incremental O & M cost due to the reduction in length may be offset by the higher maintenance cost for the tunnel section.

4. Incremental Cost Benefit Cashflows

The cost benefit cashflows for this analysis are presented in the attached tables. Assumptions adopted here are:

- Construction period for the tunnel = 2 years (1998-1999)
- Project Life: 30 years from the opening year

5 Conclusions

The values of NPV in case I and 2 are estimated at -424,010 (1,000 Baht) and -433,805 (1,000 Baht) respectively applying the Opportunity Cost of Capital in Thailand at 12% . The values of B/C ratio are at 0.394 and 0.389. The values of IRR are lower than 12% in both cases.

These results mean that the NPV of the Route A will be lower by about 400 Million Baht than that of the Route B and this incremental investment for the Original Route will pull down the value of IRR toward a lower side.

Therefore, the Route B is more recommendable than the Route A.

COST BENEFIT CASH FLOW (1,000 Baht)
CASE 1

YEAR	INCREMENTAL CONSTRUCTION COST	INCREMENTAL MAINTENANCE COST	TOTAL INCREMENTAL COST	INCREMENTAL BENEFIT	GROWTH RATE	B-C
1998	37,500		37,500	0		-37,500
1999	37,500		37,500	0		-37,500
2000		-1,357	-1,357	6,970		8,327
2001		-1,357	-1,357	8,388	1.203	9,745
2002		-1,357	-1,357	10,095		11,452
2003		-1,357	-1,357	12,149		13,506
2004		-1,357	-1,357	14,621		15,978
2005		-1,357	-1,357	17,596		18,953
2006		-1,357	-1,357	21,177		22,534
2007		-1,357	-1,357	25,486		26,843
2008		-1,357	-1,357	30,672		32,029
2009		-1,357	-1,357	36,913		38,270
2010		-1,357	-1,357	44,424		45,781
2011		-1,357	-1,357	51,187	1.152	52,544
2012		-1,357	-1,357	58,980		60,337
2013		-1,357	-1,357	67,959		69,316
2014		-1,357	-1,357	78,305		79,662
2015		-1,357	-1,357	90,227		91,584
2016		-1,357	-1,357	103,963		105,320
2017		-1,357	-1,357	119,790		121,147
2018		-1,357	-1,357	138,027		139,384
2019		-1,357	-1,357	159,041		160,398
2020		-1,357	-1,357	183,253		184,610
2021		-1,357	-1,357	183,253		184,610
2022		-1,357	-1,357	183,253		184,610
2023		-1,357	-1,357	183,253		184,610
2024		-1,357	-1,357	183,253		184,610
2025		-1,357	-1,357	183,253		184,610
2026		-1,357	-1,357	183,253		184,610
2027		-1,357	-1,357	183,253		184,610
2028		-1,357	-1,357	183,253		184,610
2029		-1,357	-1,357	183,253		184,610
2030		-1,357	-1,357	183,253		184,610
			P.V.C. 700,026	P.V.B. 276,016	IRR(%) NPV(*) B/C(*)	7.10% -424,010 0.394

Opportunity Cost of Capital = 12%

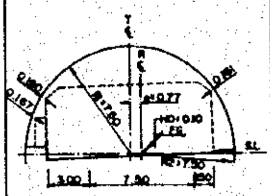
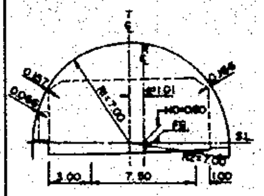
COST BENEFIT CASH FLOW (1,000 Baht)
CASE 2

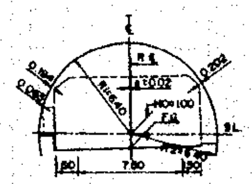
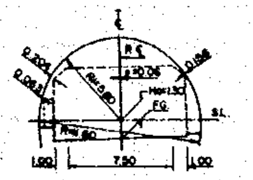
YEAR	INCREMENTAL CONSTRUCTION COST	INCREMENTAL MAINTENANCE COST	TOTAL INCREMENTAL COST	INCREMENTAL BENEFIT	GROWTH RATE	B-C
1998	37,500		37,500	0		-37,500
1999	37,500		37,500	0		-37,500
2000		0	0	6,970		6,970
2001		0	0	8,388	1.203	8,388
2002		0	0	10,095		10,095
2003		0	0	12,149		12,149
2004		0	0	14,621		14,621
2005		0	0	17,596		17,596
2006		0	0	21,177		21,177
2007		0	0	25,486		25,486
2008		0	0	30,672		30,672
2009		0	0	36,913		36,913
2010		0	0	44,424		44,424
2011		0	0	51,187	1.152	51,187
2012		0	0	58,980		58,980
2013		0	0	67,959		67,959
2014		0	0	78,305		78,305
2015		0	0	90,227		90,227
2016		0	0	103,963		103,963
2017		0	0	119,790		119,790
2018		0	0	138,027		138,027
2019		0	0	159,041		159,041
2020		0	0	183,253		183,253
2021		0	0	183,253		183,253
2022		0	0	183,253		183,253
2023		0	0	183,253		183,253
2024		0	0	183,253		183,253
2025		0	0	183,253		183,253
2026		0	0	183,253		183,253
2027		0	0	183,253		183,253
2028		0	0	183,253		183,253
2029		0	0	183,253		183,253
2030		0	0	183,253		183,253
			P.V.C.	P.V.B.	IRR(%)	6.98%
			709,821	276,016	NPV(*)	-433,805
					B/C(*)	0.389

Opportunity Cost of Capital = 12%

APPENDIX 6.6-2 TUNNEL SIZE AND CONSTRUCTION COST

(Design Speed = 100 Km./h)

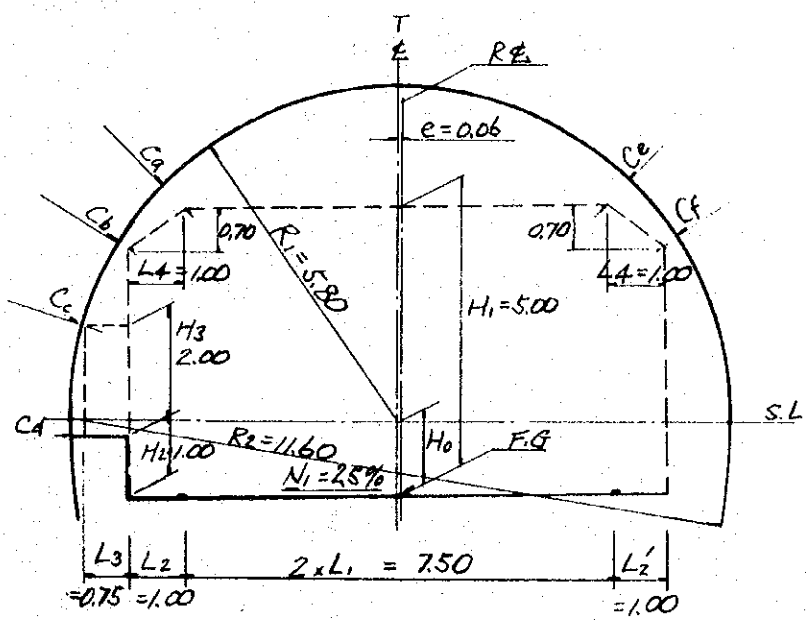
Item		Case – 1	Case – 2
Cross Section and Tunnel Size			
Lane width (m.)		3.75x2	3.75x2
Shoulder width (m.)		3.00 (L) + 1.50 (R)	3.00(L) + 1.00(R)
Inner Area (m^2)		98.8	93.5
Emergency Paking Zone		—	—
Quantities per/m length as of standard section	Tunnel Excavation	(Case – 4 = 100%) 111.4 m^3/m (131.3 %)	106.1 m^3/m (125.0 %)
	Lining Concrete	10.1 m^3/m (153.0 %)	9.9 m^3/m (150.0 %)
	Shotcrete	(t = 15 cm.) 3.919 m^3/m (170.8 %)	(t = 15 cm.) 3.834 m^3/m (167.1 %)
	Rock Bolt	(l = 4 m.) 58.5 m/m (190.0 %)	(l = 4 m.) 57.3 m/m (186.0%)
Approx. Tunneling Cost (3800m.) as for standard section per one tunnel		3800^m x 0.72^{MB} = 2736^{MB} (141 %)	3800^m x 0.67^{MB} = 2546^{MB} (132 %)
Comments		Full shoulder width Same width as open section	Reduce right shoulder to 1.0 m.

Item		Case – 3	Case – 4
Cross Section and Tunnel Size			
Lane width (m.)		3.75x2	3.75x2
Shoulder width (m.)		1.50 (L) + 1.50 (R)	1.00 (L) + 1.00 (R)
Inner Area (m^2)		84.5	74.3
Emergency Paking Zone		Required with every 750m.	Required with every 750 m.
Quantities per/m length as of standard section	Tunnel Excavation	95.3 m^3/m (112.3%)	84.9 m^3/m (100.0%)
	Lining Concrete	7.0 m^3/m (106.1 %)	6.6 m^3/m (100.0 %)
	Shotcrete	(t = 10 cm.) 2.423 m^3/m (105.6 %)	(t = 10 cm) 2.294 m^3/m (100.0 %)
	Rock Bolt	(l = 3 m.) 32.5 m/m (105.6 %)	(l = 3 m.) 30.8 m/m (100.0%)
Approx. Tunneling Cost (3800m.) as for standard section per one tunnel		3640^m x 0.55^{MB} + 1.60^m x 0.72^{MB} (E.P) = 2117^{MB} (109 %)	3640^m x 0.50^{MB} + 1.60^m x 0.72^{MB} (E.P) = 1.935^{MB} (100 %)
Comments		Reduce left shoulder to 1.5 m.	1.0 m of shoulder on both side Same shoulder in tunnel as minimum width of JHPC at 100 Km/h. spee

APPENDIX 6.6-3 CALCULATION OF TUNNEL SIZE

Design conditions

1 (one) lane width	L1	(m) =	3.750
Shoulder width (left side)	L2	(m) =	1.000
Shoulder width (right side)	L2'	(m) =	1.000
Side walk width	L3	(m) =	0.750
Haunch width	L4	(m) =	1.000
Vertical clearance	H1	(m) =	5.000
[Including overlay thickness (= 0.20 m)]			
Grade for cross section	N1	(%) =	2.500
Radius for tunnel arch	R1	(m) =	5.800
Radius for side wall	R2	(m) =	11.600
SL hight from FG	H0	(m) =	1.300
Shift value of tunnel center	e	(m) =	0.060



·Point (a)

Xa = L1 + L2 - L4 + H1 * N1 - e

= 3.750 + 1.000 - 1.000 + 5.000 * 0.025 - 0.060

= 3.8150

Ya = H1 - H0 - Xa * N1

= 5.000 - 1.300 - 3.8150 * 0.025

= 3.6046

Ra = SQR (Xa * Xa + Ya * Ya)

= SQR (3.8150 * 3.8150 + 3.6046 * 3.6046)

= 5.2486

Ca = R1 - Ra

= 5.800 - 5.2486

= 0.5514 > 0.15 [O.K]

·Point (b)

Xb = L1 + L2 + (H1 - H4) * N1 - e

= 3.750 + 1.000 + (5.000 - 0.700) * 0.025 - 0.060

= 4.7975

Yb = H1 - H0 - H4 - Xb * N1

= 5.000 - 1.300 - 0.700 - 4.798 * 0.025

= 2.8801

Rb = SQR (Xb * Xb + Yb * Yb)

= SQR (4.7975 * 4.7975 + 2.8801 * 2.8801)

= 5.5956

Cb = R1 - Rb

= 5.800 - 5.5956

= 0.2044 > 0.15 [O.K]

·Point (c)

Xc = L1 + L2 + L3 + (H2 + H3) * N1 - e

= 3.750+ 1.000+ 0.750 + (1.00+ 2.00) * 0.025 - 0.060

= 5.5150

Yc = - H0 - (L1 + L2) * N1 + H2 + H3

= - 1.300 - (3.750 + 1.000) * 0.025 + 1.000 + 2.000

= 1.5813

Rc = SQR (Xc * Xc + Yc * Yc)

= SQR (5.5150 * 5.5150 + 1.5813 * 1.5813)

= 5.7372

Cc = R1 - Rc

= 5.800 - 5.7372

= 0.0628 > 0.05 [O.K]

·Point (d)

Xd = L1 + L2 + L3 + (H2 + H3) * N1 - e

= 3.750+ 1.000+ 0.750 + (1.00+ 2.00) * 0.025 - 0.060

= 5.5150

Xdo = Xd + (R2 - R1)

= 5.5150 + (11.600 - 5.800)

=11.3150

Yd = - H0 - (L1 + L2) * N1 + H2 + L3 * N2

= - 1.300 - (3.750 + 1.000) * 0.025 + 1.000

+ 0.750 * 0.020

= -0.4038

Rd = SQR (Xdo * Xdo + Yd * Yd)

= SQR (11.3150 *11.3150 + 0.4038 * 0.4038)

=11.3222

Cd = R2 - Rd

=11.600 -11.3222

= 0.2778 > 0.00 [O.K]

·Point (e)

Xe = L1 + L2' - L4 - H1 * N1 + e

= 3.750 + 1.000 - 1.000 - 5.000 * 0.025 + 0.060

= 3.6850

Ye = H1 - H0 + Xe * N1

= 5.000 - 1.300 +3.6850 * 0.025

= 3.7921

Re = SQR (Xe * Xe + Ye * Ye)

= SQR (3.6850 * 3.6850 + 3.7921 * 3.7921)

= 5.2877

Ce = R1 - Re

= 5.800 - 5.2877

= 0.5123 > 0.15 [O.K]

·Point (f)

Xf = L1 + L2' - (H1 - H4) * N1 + e

= 3.750 + 1.000 - (5.000 - 0.700) * 0.025 + 0.060

= 4.7025

Yf = H1 - H0 - H4 + Xf * N1

= 5.000 - 1.300 - 0.700 +4.7025 * 0.025

= 3.1176

Rf = SQR (Xf * Xf + Yf * Yf)

= SQR (4.7025 * 4.7025 + 3.1176 * 3.1176)

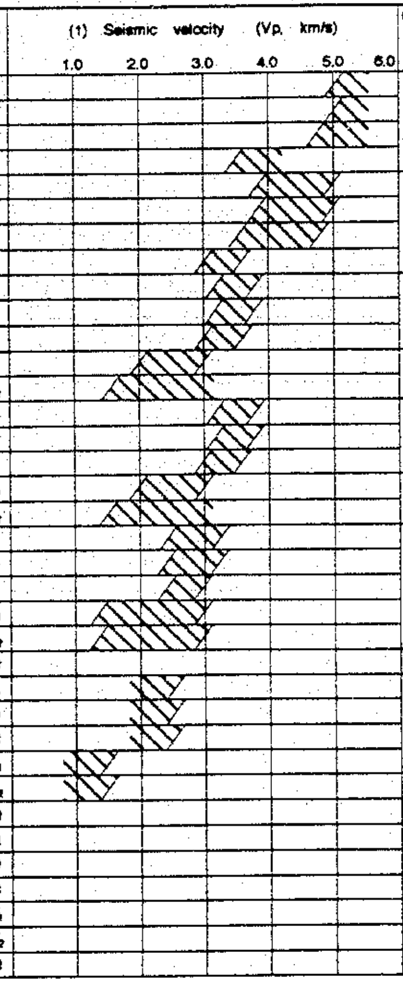
= 5.6421

Cf = R1 - Rf

= 5.800 - 5.6421

= 0.1580 > 0.05 [O.K]

APPENDIX 6.6-4 STANDARD ROCK MASS CLASSIFICATION



Rock Mass Classes	Rock Types	(2) Rock Mass Strength Ratio	(3) Boring Core: Core Conditions	(3) Boring Core: RQD(%)	(4) Geological Conditions (Results of geological survey, or conditions of excavated surface)	(5) Observation: Cracking by Hammering	(5) Observation: Crack Spacing (cm)	(6) Conditions after Excavation: Self-sustenance of Cutting Face	(6) Conditions after Excavation: Inner Section Displacement (mm)
A	a, b, c, d1	—	Core recovery is 90% or more, each core presenting a complete column form with a length of about 20cm or more. Small pieces be scarcely contained.	90 or more	o Very hard and fresh lithologic character, presenting a form of massive block; Continuously stable with little cracking. o No deterioration with water.	Hammer bouncing; Broken only when strongly hit. Cracking in a fresh surface.	100~50 or higher	o Very good self-sustenance ; Not loosened over a long period. o Loosening height< 1.0m	Minimal
B	a, b, c, d1	—	Core recovery is generally 70% or more, cores presenting forms of large rock piece -short colum-rod with a length of about 10~20cm, including some of a length of about 5cm.	90~70	o Fresh and hard with relatively less cracks included. o Relatively hard rock with more or less deterioration due to weathering. o Lithologically hard layered rock with stratification or schistosity noted and tending to crack along the surface. o No deterioration it after.	Cracking when strongly hit with a hammer; Cracking relatively largely along fissure or joint.	70~30	o Cutting face self-sustaining; Surface cut without support locally has spalling observed but is generally stable. o Ground partially requiring supports for these parts which have locally loosened. o Loosened height, 1.5~3.0m.	Minimal
C I	a, b, c	—	Core recovery is 40~70%; Cores containing a number of cracks and are subject to crush into a number of small pieces of about 5cm; Difficult or impossible to restore to the original form.	70~10	o Lithologically more or less soft with alteration under weathering. o Relatively hard but fine cracks present with inclusions of thin clay in the gaps. o Rock of clear heading, very thin and subject to cleavage. o Including narrow, small faults. o Less deterioration with water.	Readily crushing when hit with a hammer. Crushing hit relatively small pieces along fissures, and hardly cracking at any other faces.	About 50 or less	o Cutting face sustaining by itself. o Ground requiring spraying of the crown immediately after blasting for the face cut without support. o Loosened height, 2.0~4.0m.	50 or less
	d1, d2	4 or more							
C II	a, b, c	—						o Cutting face self-sustaining. Ground spalling at about crown of the face cut without timberingand thus requiring forepoling support. o Loosened height, 2.0~4.0m.	
	d1, d2	4 or more							
D I	a, b, c, d1, d2	4 ~ 2	Core recovery decreasing generally to 40% or less, cores reduced to small pieces and often to brecciated sand or clay.	About 10 or less	o Undergoing considerable weathering into a soft and brittle mass including parts transformed to soil as well as some hard parts. o A very large number of cracks involved, allowing to cut at any other places than fissures. o Fracture zone with not much argillization into a mixture of clayey soil and small pieces of rock, including more or less hard parts. o Sandy soil, talus. etc.. o DII when specular surface is softened with water.	Readily crushed with a hammer. Brittle rock readily cracking with a finger tip.	—	o Both cutting face and face cut without support presenting appreciable spalling in one case, or some squeezing from the side noted in another. Ground requiring forepoling support and early landslide protection. o Plastic range, or loosened height, 3.0~6.0 m.	60 or less
	e	2 or more							
D II	a, b, c, d1, d2, e	2 ~ 1				Crushed with a slight force of hammering. Hammer's tip and running into.	—	o Spalling of cutting face noticeable. Face cut without support having squeezing from the side. o Plastic range, or loosened height, 3.0~6.0m.	200 or less
E	a, b, c, d1, d2, e	1 or less	—	—	o Fault, fracture zone or large talus with argillization noticeable in a considerable width accompanying appreciable biased or confining earth pressure. o Considerable deterioration with water, resulting in softening.		—	o Cutting face having squeezing and collapsing in an extreme case . o Face cut without support having confining squeezing produced . o Plastic range > 7.0m.	400 or less

Note : 1. Rock Types
a : Metamorphic rock (phyllite, graphite schist, silicic graphite schist, quartz schist, greenschist, gneiss, serpentine, hornfels, etc..)
b : Palaeozoic and mesozoic formations (slate, sandstone, and conglomerate, greywacke, limestone, quartzite, schalstein, etc..)
c : Volcanic rock (liparite, andesite, basalt, etc..)
Dike rock (granite porphyry, quartz porphyry, porphyrite, diabase, etc..)
Plutonic rock (granite, diorite, etc..)
d: Tertiary and lower diluvium (mudstone, shale, siliceous shale, sandstone, and conglomerate, tuff, tuff breccia, agglomerate, etc.)
Further classified into d1 and d2 with the unconfined compression strength (qu) of 200kgf/cm² of a fresh rock material as a standard:
d1: qu ≧ 200kgf/cm²; and
d2: qu < 200kgf/cm²
e: Upper diluvium (loam and clay, pyroclastic material); Alluvium (talus, surface soil, etc.)
2. "Boring Core Condition," "RQD" and "Clack Spacing" are applied to rock types a, b, c and d1.

APPENDIX 6.6-5 STANDARD SUPPORT PATTERNS

Rock mass classification	Excavation method	One drive length (upper half) (m)	Rock bolt			Steel arched support			Depth of shotcrete (cm)	Lining thickness (cm)		Deformation allowance (cm)		
			Length (m)	Spacing		Upper half	Lower half	Support spacing (m)		Arch & side wall	Invert	Upper half	Lower half	Invert
				Circumferential direction	Longitudinal direction									
B	upper half method	2.0	3.0	1.5 upper section only	2.0	None	None	—	5	30	0	0	0	0
CI	upper half method	1.5	3.0	1.5	1.5	None	None	—	10	30	0	0	0	0
CII	upper half method	1.2	3.0	1.5	1.2	H-125	None	1.2	10	30	0	0	0	0
DI	upper half method	1.0	4.0	1.2	1.0	H-125	H-125	1.0	15	30	45	0	0	0
DII	upper half method	1.0 or less	4.0	1.2	1.0 or less	H-150	H-150	1.0 or less	20	30	50	10	0	0

Note: For rock mass classes A and B, support patterns are separately designed in consideration of the conditions of rock mass.

APPENDIX 6.6-6 CALCULATION FOR JET FAN REQUIREMENT AND DUST COLLECTOR

This item involves the investigation of the neseccity of ventilation system and volume for the future against exhaust gas by vehicles.

1 Basic Conditions

a) The number of lanes in this tunnel are single-directional two (2) per one tunnel.

b) The tunnel ventilation is designed against soot and carbon monoxide (CO) in exhaust gas.

c) The velocity of air flow in tunnel is usually less than 20~25 m/sec, so the influence caused by compression of air can be disregarded. The air flow is dealt as non-compressioned fluid.

d) The air flow in tunnel is dealt as the constant fluid.

e) The wind caused by traffic flow is hypothetucally assumed as the constant fluid.

f) Theory and unknown factors in this country will quote from JHPC's standard which based on PIARC (Permanent International Association Congresses).

2 The Conditions of Natural Air

a) The density of air is assumed as that of pure air, whether it is ventilated or exhausted.

b) The density of air used for ventilation designning is assumed as 0.1224 ($kg \cdot s^2/m^4$). This numerical value is in the case of 760mmHg of atmospheric pressre, 20°C of temperature and 75% of humiduty.

3 Constants

Constants which are used in computation of ventilation are as follows, except in the case of using measurement result.

ρ	air density		0.1224 ($kg \cdot s^2/m^4$)
ν	coefficient of air vescocity		$1.45*10^{-5}$ (m^3/s)
λ	factor of frictional loss as below		
	λr	concrete lining	0.025
	λb	inside of tunnel air duct	0.025
	λn	inside of connecting air duct	0.015
ζe	factor of loss at the tunnel entarance		0.6

4 Signs

Q	(m^3/sec)	fresh air requirement
N	(num/hr)	traffic flow volume per one hour
n+	(number)	number of vehicles running toward the wind in tunnel
n-	(number)	number of vehicles running against the wind in tunnel
Ae	(m^2)	obstruction area of equivalent vehicle size
Ut	(m/sec)	traffic speed
τ	(%)	visibility index
L	(m)	tunnel length
Ar	(m^2)	cross sectional area of roadway
Dr	(m)	key width of roadway (Dr = 4*Ar/tunnel circumference)
Vr	(m/sec)	longitudinal air velocity in the tunnel (Vr = Q/Ar)

5 Traffic Flow Volume for Ventilation

When hourly traffic volume at terget year is forecasted more than 65% of design capacity, normally traffic flow volume for ventilation will be expressed by design capacity because of error in the forecast and economical reasons.

a) Forecast average annual drively traffic (AADT)

Future traffic flow volume at Mae Tha-Lampang on Toll Motorway has been forecasted in Chapter 3 as follows.

Table A.2.6.1 Traffic Flow Volume at Mae Tha - Lampang Section

Year	Traffic Flow Volume (AADT)	Commercial Vehicles Ratio
2000	2,000 vehicle/day	11.8 %
2010	14,800	24.3
2020	50,400	25.2

This foecasted AADT in 2020 is almost full or over of 4-lanes capacity, so design capacity is adopted as to traffic flow volume for the computation of ventilation in this study.

b) Hourly design capacity

Typical flow characterristics under ideal conditions are illustrated in Fig A.2.6.1, which depicts the relationships between average travel speed and rate of flow.

The ideal conditions means:

.Twelve-foot minimum lane width (3.6m)

.Six-foot minimum lateral clearance (1.8m)

.All passenger cars in the traffic stream

.Regular users

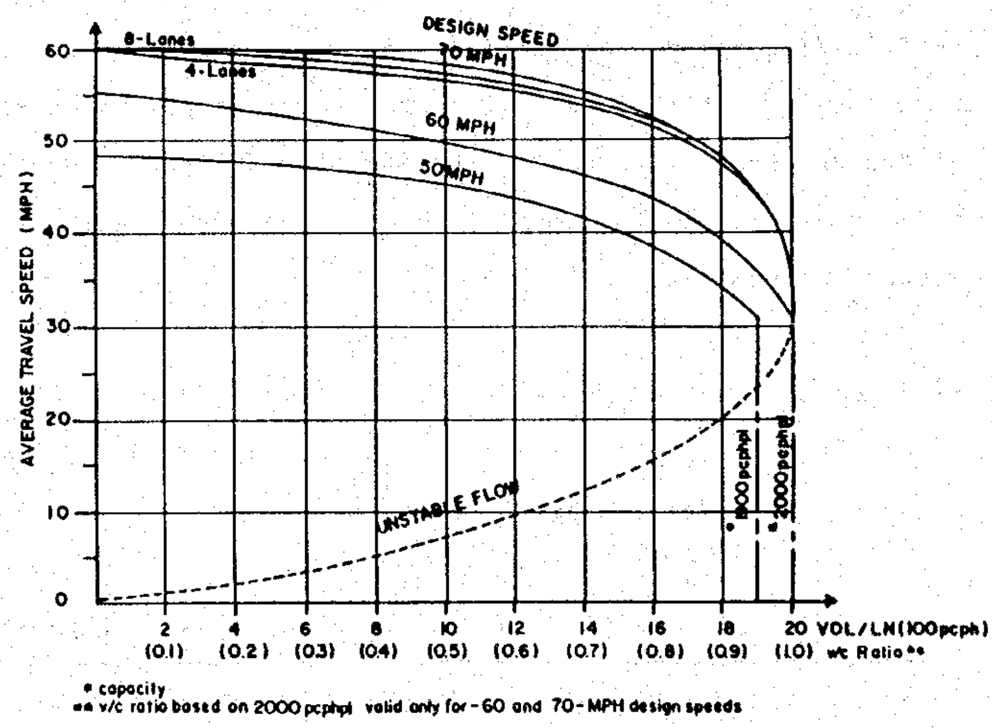


Fig. A.2.6.1 Speed-Flow Relationships under Ideal Conditions

This tunnel size is full ideal conditions and 100 km/h(60MPH) of design speed, so;

Design capacity = 2,000 pcphpl

Pcu for commercial vehicle = 2.0

Average travel speed = 50 km/h (30 mph)

c) Average annual commercial vehicles ratio

The exhaust gas of diesel engine and that of gasoline engine is different in their composition. The exhaust gas of diesel engine contains more soot and less carbon monoxide than that of gasoline engine. This defference is corrected in the factor for fresf air requirement. Commercial vehicles, hereafter, will regard to deasel vehicles.

d) Design commercial vehicles ratio

From topographical condition, α and β given from Table A.2.6.2 are factors to adjust commercial vehicles ratio at the peak of traffic flow.

Table A.2.6.2 Adjustment factor for commercial vehicles

topographical condition	adjustment factor α (for smoke)	β (for CO)
mountainous	0.8	0.1
flat	0.9	0.2
urban	1.0	0.3

6 Ventilation Volume

a) Standard ventilation volume

Standard ventilation volume is required under the condition of 0% grade, less 400m of elevation and 40～60 km/hr travel speed.

Standard ventilation volume is determined for soot and carbon monoxide, and use Eq.(A.2.1).

$$Q_0 = q \cdot N \cdot L \qquad (A.2.1)$$

where

Q_0 = standard ventilation volume : m^3/sec

q = factor for fresh air requirement from Fig. A.2.6.2

N = hourly traffic volume : num/hr

L = tunnel length : km

Factor for fresh air requirement(q) follows to the admissible consentration of carbon monoxide, and the admissible transmittance of light affected by soot.

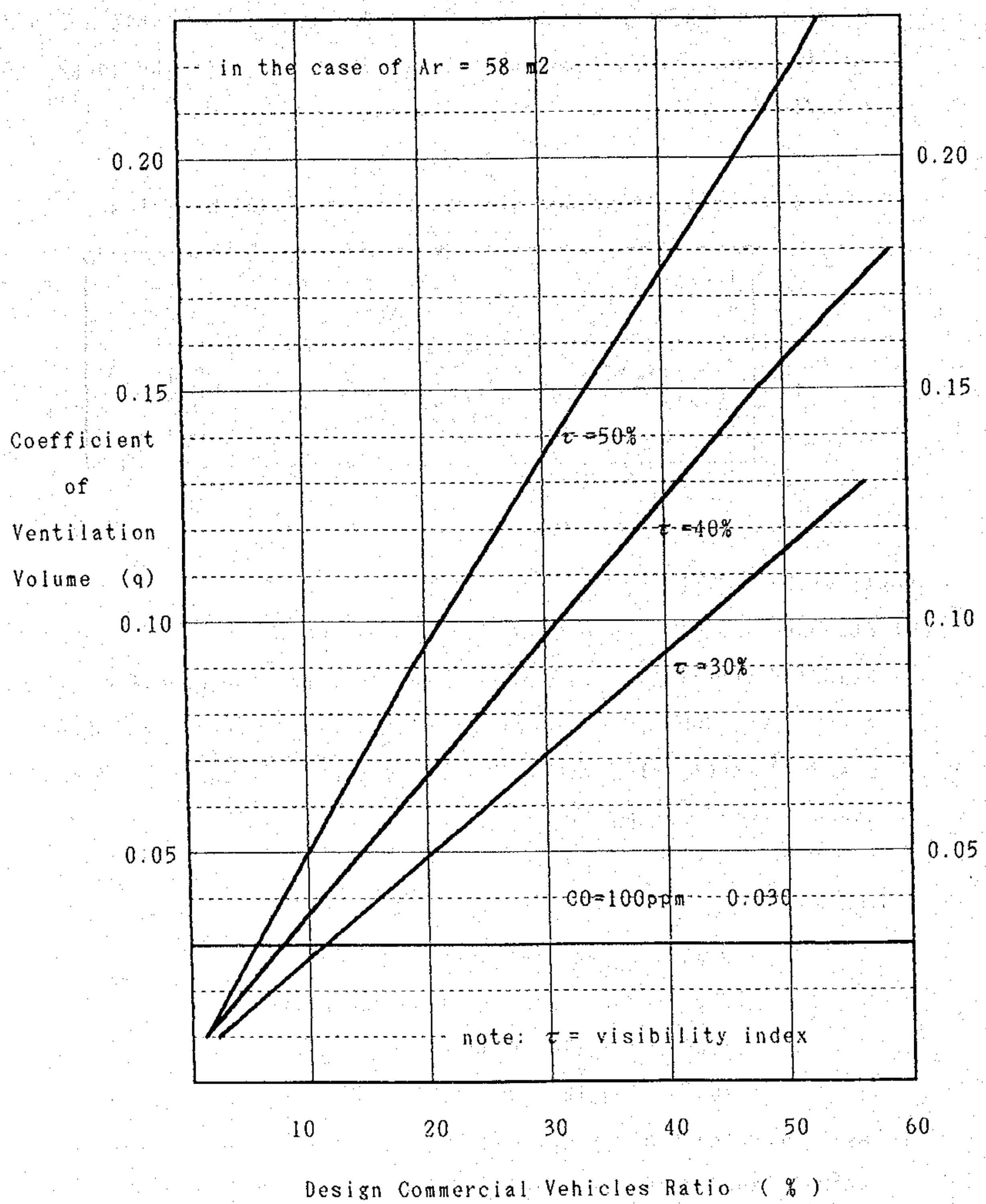


Fig A.2.6.2 Relation of the Factor for Fresh Air Requirement and Design Commercial Vehicles Ratio

b) Required ventilation volume

Required ventilation volume is based on the standard ventilation volume, and adjust for the effects of tunnel grade and elevation.

$$Q = k_1 \cdot k_2 \cdot Q_0 \qquad (A.2.2)$$

where

Q = required ventilation volume, m3/sec

Q_0 = standard ventilation volume, m3/sec

k_1 = factor to adjust for the effect of grade

k_2 = factor to adjust for the effect of elevation

k_1 and k_2 are illastrated in Fig A.2.6.3 and A.2.6.4.

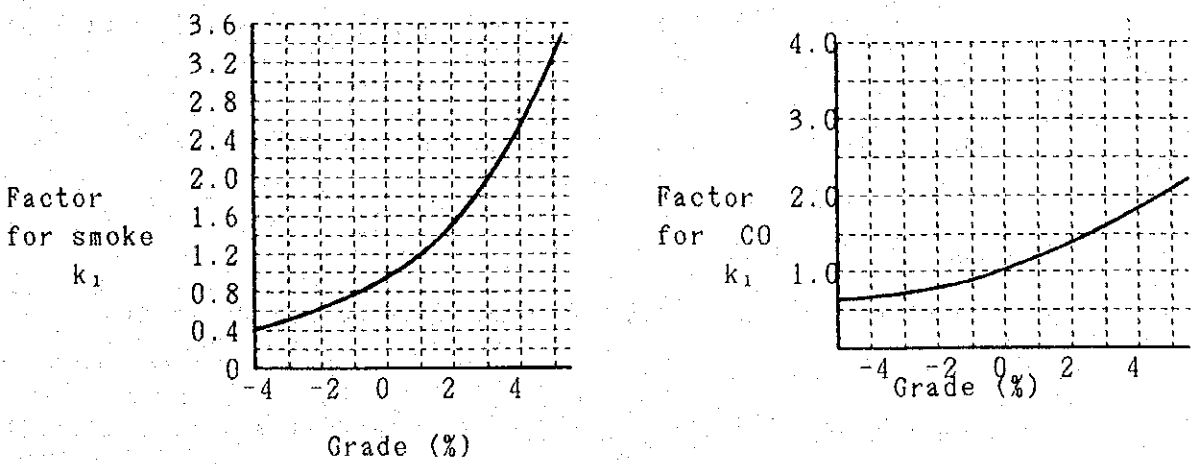


Fig. A.2.6.3 Relation of Grade and Adjustment Factor of Fresh Air Requirement

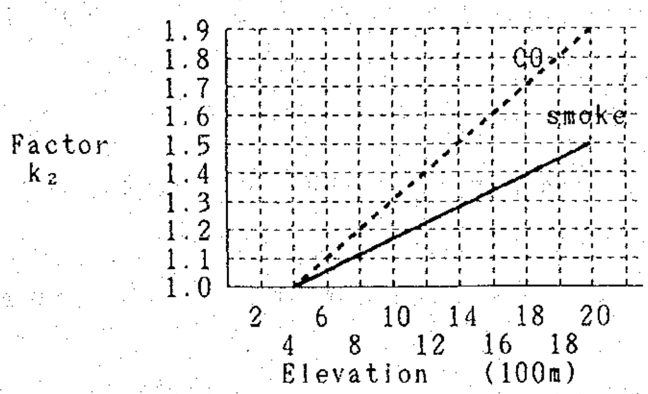


Fig. A.2.6.4 Relation of Elevation and Adjustment Factor of Fresh Air Requirement

7 Computation of Jet Fan Vntilation Method

a) Required increasing pressure in tunnel (ΔP)

$$\Delta P = \Delta P_R + \Delta P_M - \Delta Pt$$

where

ΔP_R : Loss of pressure by friction

ΔP_M : Pressure by natural wind

ΔPt : Ventilating pressure by traffic flow

b) Loss of pressure by friction

Loss of pressure by friction of concrete lining and tunnel entarance (ΔP_R) is determined according to Eq.(8.4).

$$\Delta P_R \text{ (mmAq)} = \rho/2 * (1 + \zeta e + \lambda r*L/Dr) * Vr^2 \qquad \text{(A.2.3)}$$

where

Vr = velocity of wind in tunnel (m/sec) : Vr = Q/Ar

c) Pressure by natural wind

Pressure by natural wind (ΔP_M) is determined according to Eq.(A.2.4).

$$\Delta P_M \text{ (mmAq)} = \rho/2 * (1 + \zeta e + \lambda r*L/Dr) * V_n^2 \qquad \text{(A.2.4)}$$

where

Vn = velocity of wind in tunnel caused by natural wind, m/sec

This velocity (Vn) will fix to 2.5 m/sec for this design.

d) Ventilating pressure by traffic flow

Ventilating pressure by piston action of vehicles (ΔPt) is determined according to Eq.(A.2.5).

$$\Delta Pt \text{ (mmAq)} = Ae/Ar * \rho/2 * n(Ut - Vr)^2 \qquad \text{(A.2.5)}$$

where

Ae = obstruction area of equivalent vehicle size

Ae is determined according to Fig. A.2.6.5.

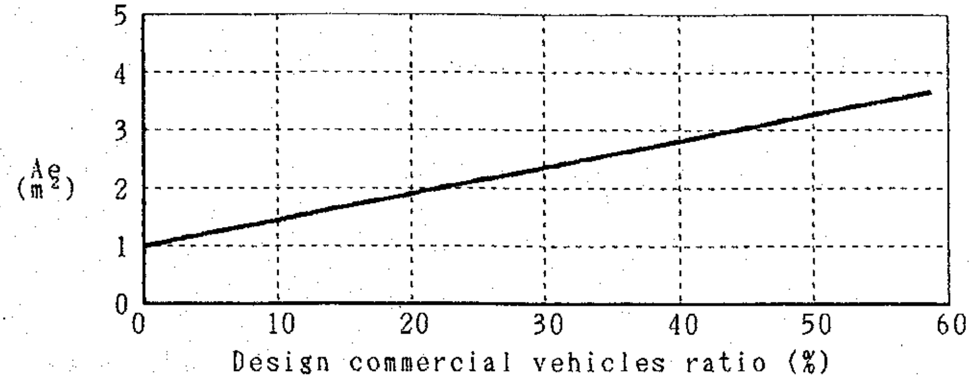


Fig A.2.6.5 Relation of Ae and Design commercial vehicles ratio

8 Computation

8.1 A-line Of NO.1 tunnel (to Doi Saket)

a) Design Conditions

1) Location of Tunnel : Rolling

2) Tunnel Length : L = 3.830 km

3) Travel Speed : Ut = 50 km/h = 13.9 m/sec

4) Tunnel Grade : g = +0.5%(1.77km),-0.5%(2.06km)

5) Tunnel Elevation : 510 m height from sea level

6) Transmittance of light : τ = 40 %

(for traffic vollume express to traffic capacity)

7) Allowable density of CO : K = 100 ppm

8) Cross sectional area of roadway : Ar = 68 m^2

9) Key width of roardway : Dr = 4*68/32.4 = 8.395 m

b) Traffic volume

Design traffic capacity for 2 lanes = 2,000 * 2 = 4,000 pcu/h

Average commercial vehicles ratio = 25.1 %

Adjustment of topographical condition for traffic peak (from Table A.2.6.2)

Design commercial vehicles ratio for soot = 25.1 * 0.8 = 20.1

for CO = 25.1 * 0.1 = 2.5

Pcu for commercial vehicle = 2.0

Desin hourly traffic volume (DHV) for soot

= 4000 / {(1-0.201)+2.0*0.201} = 3,331 num./h (2-lanes)

DHV for CO

= 4000 / {(1-0.025)+2.0*0.025} = 3,902 num./h (2-lanes)

c) Required Ventilation Volume

Q_0 (standard ventilation volume) is determined according to Eq.(A.2.1)

$$Q_0 = q \cdot N \cdot L$$

where q = 0.0679 for soot at τ = 40% (from Fig. A.2.6.2)

q = 0.0300 for CO = 100ppm (from Fig. A.2.6.2)

Q_0(for soot) = 0.0679 * 3331 * 3.830 = 866 m^3/s

Q_0(for CO) = 0.0300 * 3902 * 3.830 = 448 m^3/s

Q (required ventilation volume) is determined according to Eq.(A.2.2)

$$Q = k_1 \cdot k_2 \cdot Q_0$$

where k_1 &k_2 are caused on Fig 8.3 , Fig 8.4

k_1 (for soot) = (1.115*1.77+0.898*2.06)/3.83 = 0.998

k_1 (for CO) = (1.067*1.77+0.937+2.06)/3.83 = 0.997

k_2 (for soot) = 1.035

k_2 (for CO) = 1.062

Q(for soot) = 0.998 * 1.035 * 866 = 895 m^3/s

Q(for CO) = 0.997 * 1.062 * 448 = 475 m^3/s

d) Required number of jet fan for CO

$\triangle P_R$ (loss of power by concrete lining friction and tunnel entarance) is according to Eq.(A.2.3)

where Vr = Q/Ar = 475/68

= 6.98 m/sec

$\triangle P_R = \rho/2 * (1 + \zeta e + \lambda r*L/Dr) * Vr^2$

$= 0.1224/2 * (1 + 0.6 + 0.025*3830/8.395)*(6.98)^2$

= 38.78 mmAq

ΔP_M (pressure by natural wind) is according to Eq.(A.2.4).

$\Delta P_M = \rho/2 * (1 + \zeta e + \lambda r*L/Dr) * Vn^2$

$= 0.1224/2 * (1 + 0.6 + 0.025*3830/8.395)*(2.5)^2$

$= 4.97$ mmAq

ΔPt (ventilating pressure by traffic) is according to Eq.(A.2.5).

$\Delta Pt = Ae/Ar * \rho/2 * n(Ut - Vr)^2$

where $Ae = 1.166$ m^2 (from Fig. A.2.6.5)

$n = 3902/3600 * 3830/13.9 = 298.7$ num

(from Item 8,b)

$\Delta Pt = 1.166/68 * 0.1224/2 * 298.7 * (13.9 - 6.98)^2$

$= 15.01$ mmAq

ΔP(required increasing pressure in tunnel)

$= \Delta P_R + \Delta P_M - \Delta Pt$

$= 38.78 + 4.97 - 15.01 = 28.74$ mmAq

Number of jet fan (ϕ 1500)

Capacity of jet fan (ϕ 1500 size)

Slot air velocity (Vj) = 30 m/s

Slot area (Aj) = 1.83 m^2

Interval to set = 180 m

Increase pressure of air per 1 jet fan (ΔPj)

$= \rho * Vj^2 * Aj/Ar * (1 - Vr/Vj)$

$= 0.1224 * 30^2 * (1.83/68) * (1 - 6.98/30)$

$= 2.27$ mmAg

Required number of jet fan (i)

$= \Delta P/\Delta Pj = 28.74/2.27$

$= 12.7 \rightarrow 13$ each

e) Required number of jet fan for soot

Computaion method of jet fan number for smoke is same as of CO.

$Vr = 895/68 = 13.16$ m/sec

and

$\Delta P_R = 137.85$ mmAq

$\Delta P_M = 4.97$ mmAq

$\Delta Pt = 0.15$ mmAq

$\Delta Pj = 1.66$ mmAq

so, required number of jet fan (i)

$= (137.85 + 4.97 - 0.15) / 1.66$

$= 86$ each

f) Check by interval

Jet fan of ϕ 1500 will set 2 per 1 section, and should keep interval at least 180 metre distance.

Tunnel length = 3,830 m

Maximum section to set jet fan = 3830/180 - 1 = 20

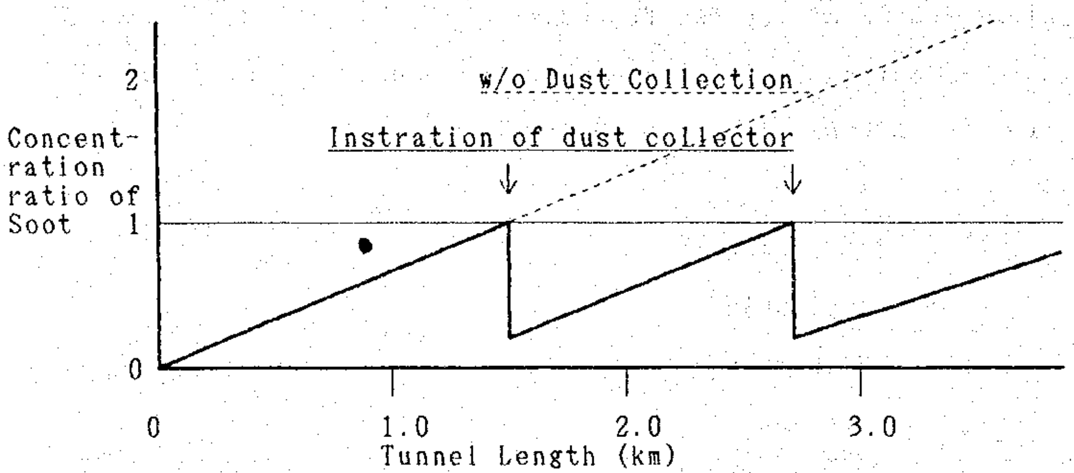
Maximum number of jet fan to be set = 20 * 2 = 40 each

This is good number for ventilation of CO but insufficient number for ventilation of soot.

g) Installation of dust collector systems

Dust collector systems are required for dust collection in the polluted air because of above reason. This type is more economical than the other type like as vertical shaft or transverse ventilation system for the length of this tunnel.

2-section of dust collector systems are required, and the relation of concentration ratio of soot and tunnel length is shown in Fig. A.2.6.6.



note :When taw is 40%, concentration ratio is 1.0

Fig.A.2.6.6 Relation of Concentration Ratio of Soot and Tunnel Length

h) Result

For the ventilation of A-line tunnel

14 each of φ1500 Jet fans and

2 section of dust collector equipments and rooms

are required.

i) Reference

Relation of traffic volume and required number of jet fan, and average travel speed of passenger car at that traffic volume is as fillows.

Traffic:	Travel Speed, Required Fresh Air & Jet Fan					
Volume :	for Soot		:		for CO	
(pcpu) :	(km/h):	(m3/s):	(num.):	(km/h):	(m3/s):	(num.)
2000	77	537	11	80	243	0
2100	76	564	14	79	255	0
2200	76	591	17	78	268	0
2300	75	618	21	78	280	0
2400	74	645	25	77	292	0
2500	72	672	29	76	304	0
2600	71	699	34	75	316	0
2700	70	725	40	75	328	0
2800	69	752	45	74	341	0
2900	67	779	52	73	353	0
3000	65	806	58	72	365	0
3100	63	833	66	71	377	0
3200	60	860	74	70	389	0
3300	56	887	82	68	401	0
3331	50	895	86			
3400	50			67	414	1
3500	50			66	426	2
3600	50			64	438	4
3700	50			62	450	6
3800	50			59	462	8
3900	50			52	474	12
3902				50	475	13

8.2 B-line of NO.1 tunnel (to Lampang)

a) Design Conditions

1) Location of Tunnel : Rolling

2) Tunnel Length : L = 3.810 km

3) Travel Speed : Ut = 50 km/h = 13.9 m/sec

4) Tunnel Grade : g = +0.5%(2.06km), -0.5%(1.75km)

5) Tunnel Elevation : 510 m height from sea level

Computation is the same way as of A-line and the results are as follows.

b) Computation result

Desin hourly traffic volume (DHV)

DHV for soot = 3,331 num./h (2-lanes)

DHV for CO = 3,902 num./h (2-lanes)

Required Ventilation Volume (Q)

Q for soot = 910 m^3/s

Q for CO = 479 m^3/s

Air velocity in the tunnel (Vr)

Vr for soot = 7.05 m/sec

Vr for CO = 13.38 m/sec

Required number of jet fan [ϕ 1500 size] (JF)

JF for soot = 80 each

ΔP_R = 141.84 mmAq, ΔP_M = 4.95 mmAq

ΔPt = 0.08 mmAq, ΔPj = 1.86 mmAg

JF for CO = 14 each

ΔP_R = 39.38 mmAq, ΔP_M = 4.95 mmAq

ΔPt = 14.71 mmAq, ΔPj = 2.27 mmAq

So, 2-section of dust collector systems are required.

c) Result

For the ventilation of B-line tunnel

14 each of φ1500 jet fans and

2 section of dust collector equipments and rooms

are required.

d) Reference

Relation of traffic volume and required number of jet fan, and average travel speed of passenger car at that traffic volume is as follows.

Traffic Volume	Travel Speed, Required Fresh Air & Jet Fan for Soot			for CO		
(pcpu)	(km/h)	(m3/s)	(num.)	(km/h)	(m3/s)	(num.)
2000	77	544	11	80	245	0
2100	76	571	14	79	257	0
2200	76	598	18	78	269	0
2300	75	625	22	78	281	0
2400	74	652	26	77	293	0
2500	72	680	31	76	306	0
2600	71	707	36	75	318	0
2700	70	734	41	75	330	0
2800	69	761	47	74	342	0
2900	67	788	53	73	355	0
3000	65	815	60	72	367	0
3100	63	843	68	71	379	0
3200	60	870	76	70	391	0
3300	56	897	85	68	403	0
3331	50	905	88			
3400	50			67	416	1
3500	50			66	428	2
3600	50			64	440	4
3700	50			62	452	6
3800	50			59	465	8
3900	50			52	477	12
3902				50	477	13

8.3 NO.3 tunnel

Ventilation at NO.3 tunnel computes for B-line tunnel only because vertical grade of B-line is going up but that of A-Line is going down, so required ventilation volume of A-line tunnel is less than that of B-line.

a) Design Conditions

1) Location of Tunnel : Flat

2) Tunnel Length : L = 0.720 km

3) Tunnel Grade : g = +0.5%(0.72km)

4) Tunnel Elevation : 400 m height from sea level

Computation is the same way as of NO.1 tunnel and the results are as follows.

b) Computation result

Desin hourly traffic volume (DHV)

DHV for soot = 3,260 num./h (2-lanes)

DHV for CO = 3,808 num./h (2-lanes)

Required Ventilation Volume (Q)

Q for soot = 315 m^3/s

Q for CO = 159 m^3/s

The worst case for natural ventilation is that the natural wind blows against traffic stream at the time of required Q for soot. Resistance pressure against the traffic pressure (ΔPt) at that time are pressure by natural wind (ΔP_M) and friction loss (ΔP_R).

For soot in here, ΔP_R = 4.42 mmAq

ΔP_M = 1.29 mmAq

ΔPt = 7.38 mmAq

and $\Delta P_R + \Delta P_M < \Delta Pt$

So, ventilation by traffic is sufficient for this tunnel and jet fan is not required.

APPENDIX 6.7-1 VARIOUS STANDARDS OF RAMP DESIGN SPEED

AASHTO

Desirably, ramp design speeds should approximate the low volume running speed on the intersecting highways. This design speed is not always practicable and lower design speeds may be necessary, but they should not be less than the low range in Table 1.

For diagonal ramps of a diamond interchange, a value in the middle range is usually practical.

For highway design speeds of more than 50 mph, the loop design speed preferably should be not less than 25 mph.

For semi direct connection ramps, design speed between the middle and upper ranges show in Table 1 should be used. For direct connection ramps, design speeds between the middle and upper ranges shown in Table 1 should be used. The minimum preferably should 40 mph and in no case less than 35 mph.

TABLE 1 AASHTO'S RAMP DESIGN SPEEDS

Unit:mph

	Design Speed of Motorway					
	70	65	60	50	40	30
Upper range (85%)	60	55	50	45	35	25
Middle range (70%)	50	45	45	35	30	20
Lower range (50%)	35	30	30	25	20	15

Note: km/h = 1.609 x mph

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Tables 2 and 3 provide ramp design speeds in accordance with design speeds of the roads to be connected each other. These ramp design speeds are specified after general consideration of volume and composition of traffic, terrain, obstacles, transition of running speeds and condition of traffic flow.

TABLE 2 MOC'S RAMP DESIGN SPEEDS FOR MOTORWAY - MOTORWAY

Unit:km/h

Motorway Design Speed	120	100
120	80, 60, 50	80, 60, 50
100		80, 60, 50

TABLE 3 MOC'S RAMP DESIGN SPEED6 FOR MOTORWAY - HIGHWAY

Unit:km/h

	Highway				
Motorway	80	60	50	40	Street
120	60,50,40	50,40	50,40	40	40,35,30
100	60,50,40	50,40	50,40	40	40,35,30

Tables 4, 5 and 6 provide ramp design speeds in accordance with average on/off daily traffic volume (ADT).

TABLE 4 JHPC'S RAMP DESIGN SPEEDS FOR MOTORWAY - MOTORWAY

Unit:km/h

	Motorway Design Speed 120	100
ADT > 20,000	80(60)	80(50)
10,000 < ADT < 20,000	80(60)	60(50)
10,000 > ADT	60(50)	60(50)

Note:Values in ( ) are the absolute minimum.

TABLE 5 JHPC'S RAMP DESIGN SPEEDS FOR MOTORWAY - HIGHWAY (MOTORWAY SIDE)

Unit:km/h

	Motorway Design Speed 120	100
ADT > 10,000	40	40
5,000 < ADT < 10,000	40	40
5,000 > ADT	35	35

TABLE 6 JHPC'S RAMP DESIGN SPEEDS FOR MOTORWAY - HIGHWAY (HIGHWAY SIDE)

Unit:km/h

	Highway Design Speed 80	60	50	40
ADT > 10,000	40	35	35	30
5,000 < ADT < 10,000	40	35	35	30
5,000 > ADT	35	35	30	30