Figure11.2.2-10 Histogram of Vp (P-wave Velocity) Data of Each Borehole

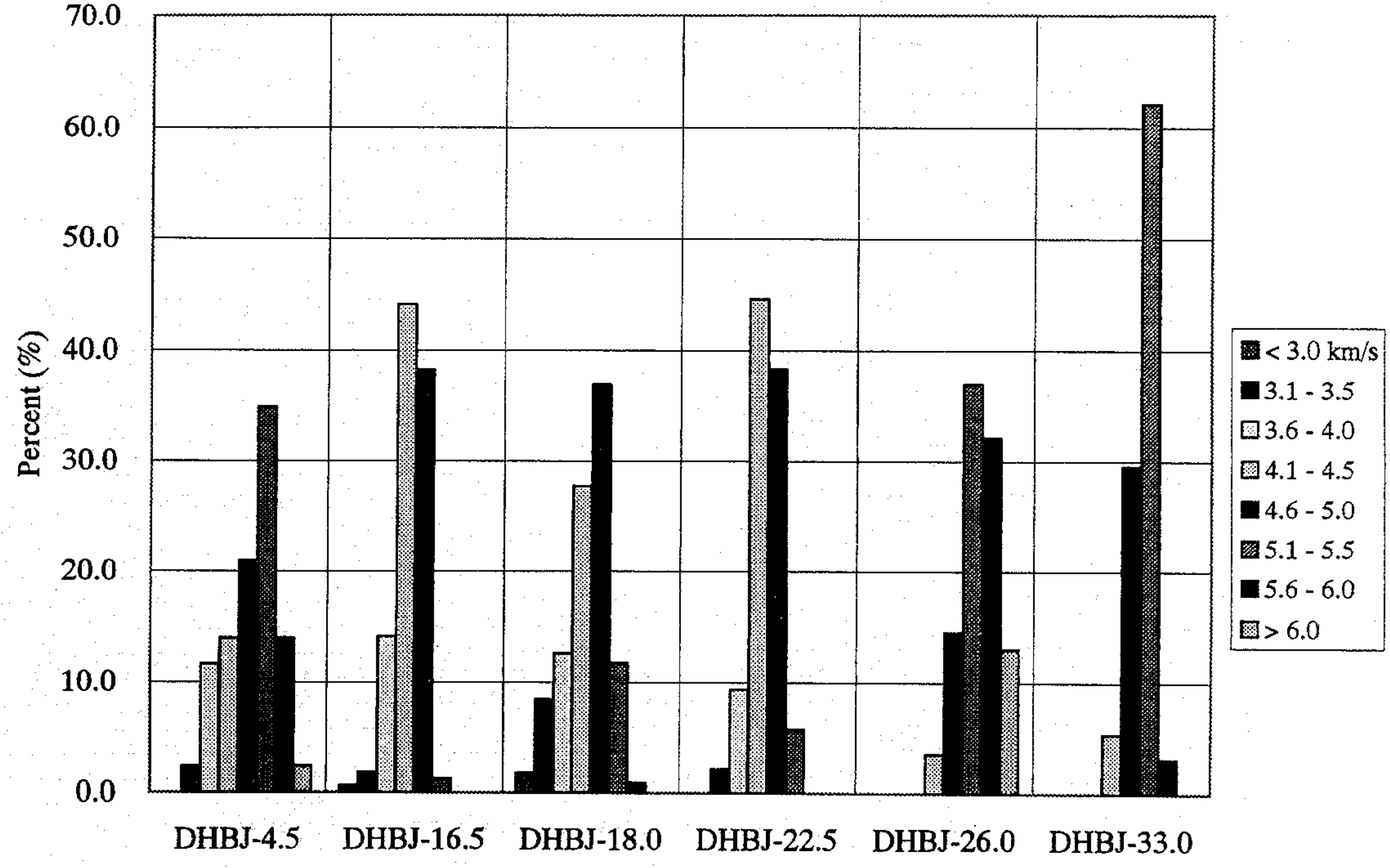


Figure11.2.2-11 Histogram of Vs (S-wave Velocity) of Each Borehole

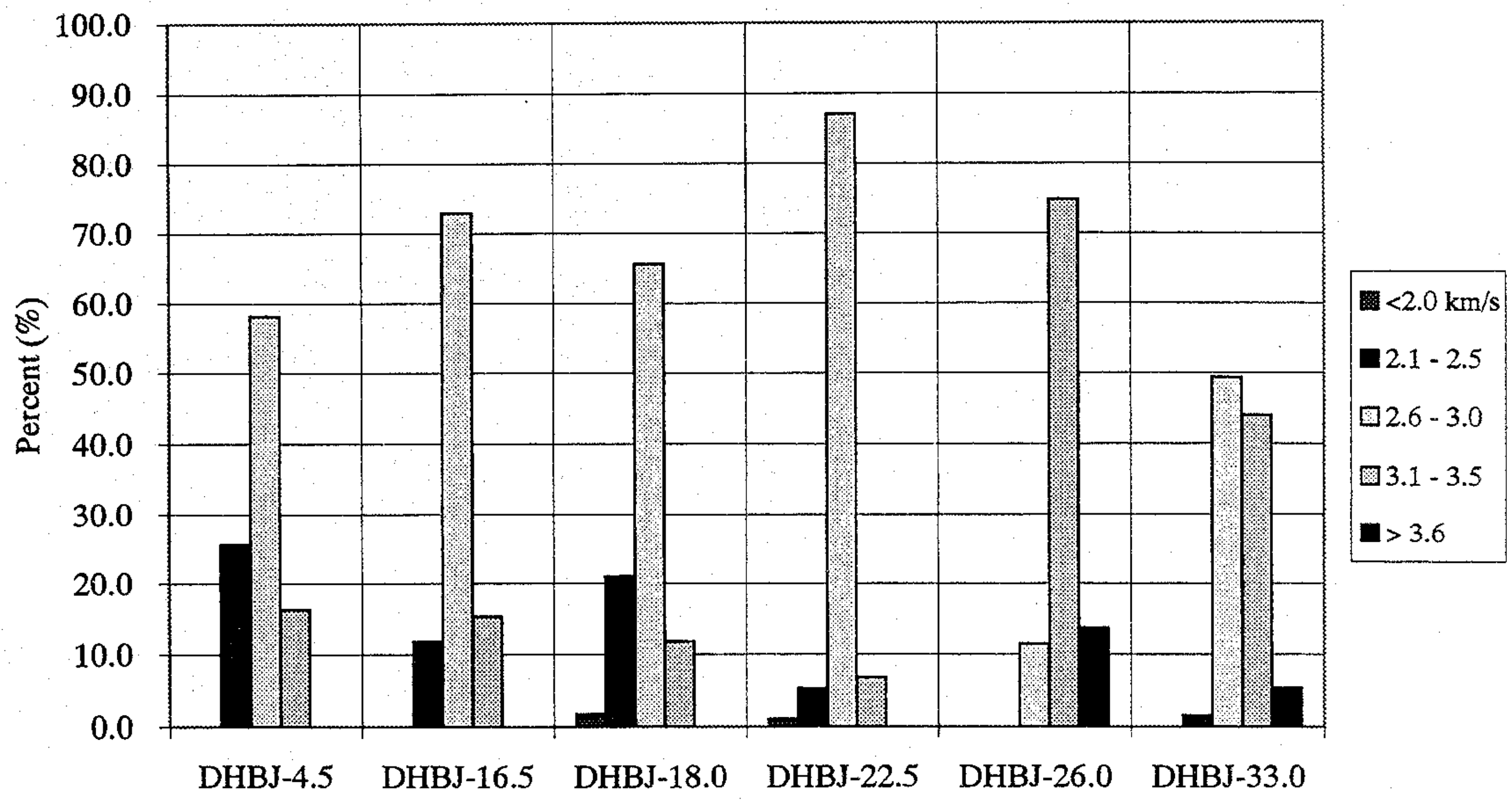


Figure 11.2.2-12 Histogram of Resistivity (Short Normal) Data of Each Borehole

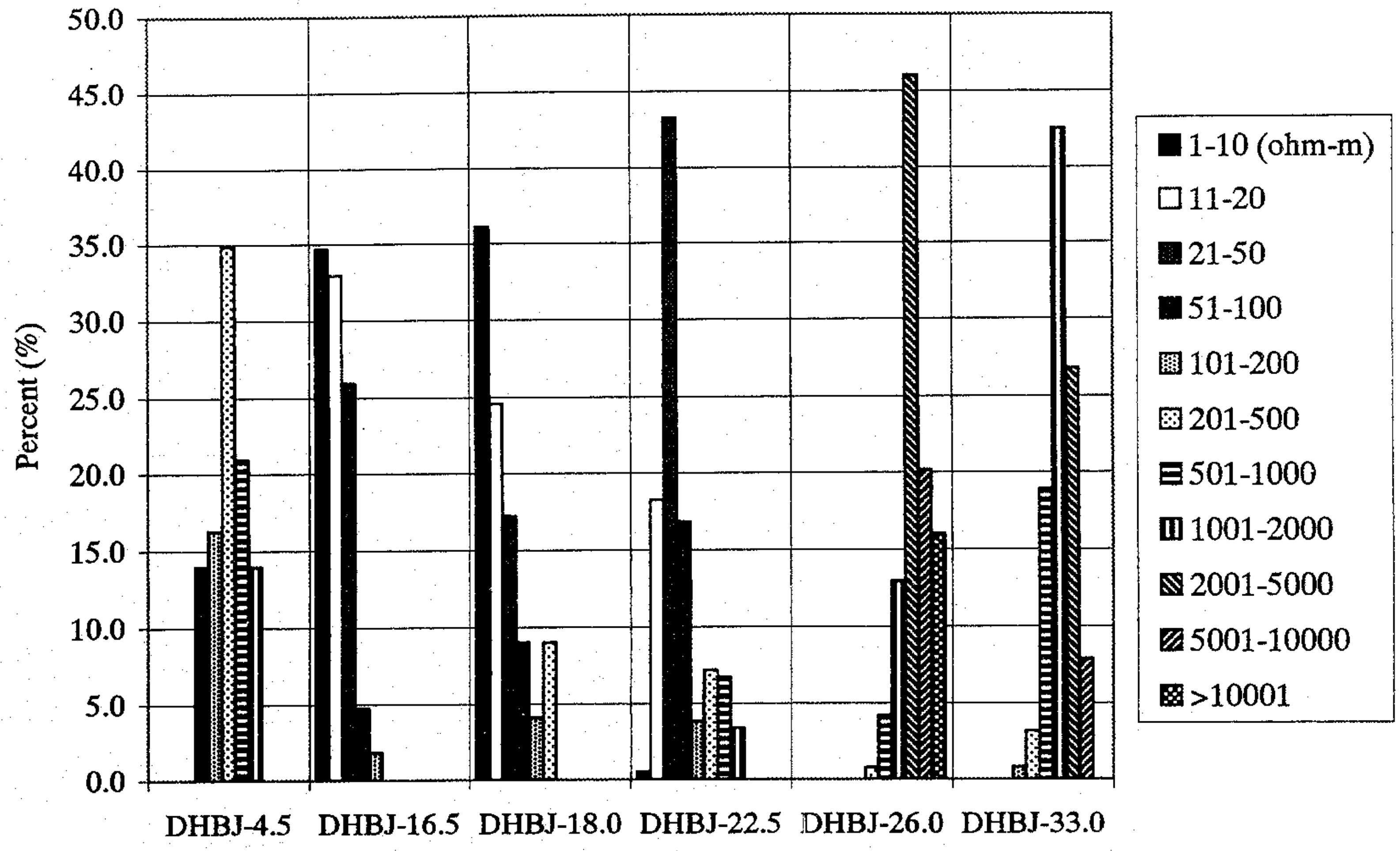


Figure 11.2.2-13 Histigram of Resistivity (Long Normal) Data of Each Borehole

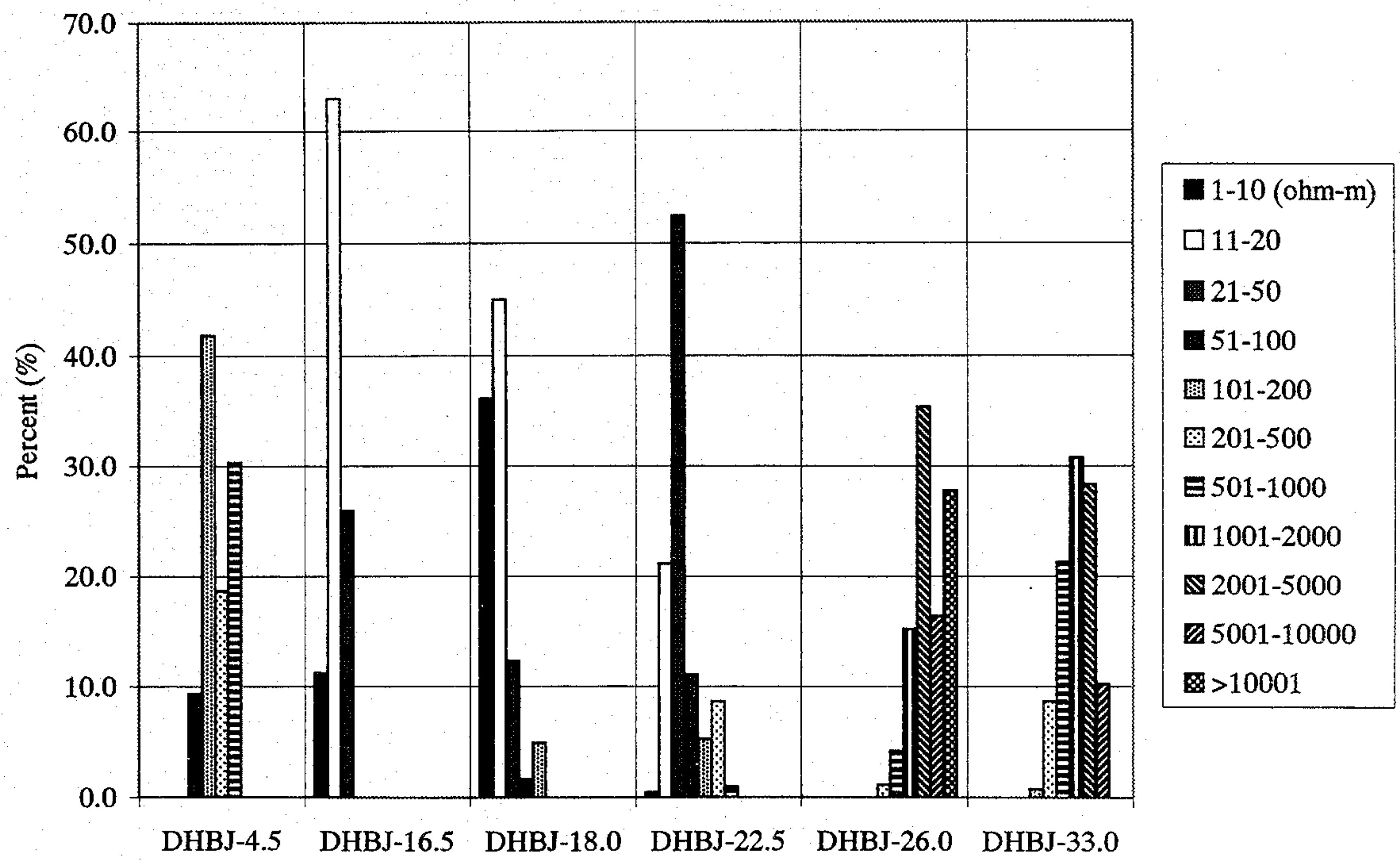


Table11.2.2-23 The Results of Laboratory Test (1)

Location	Borehole No.	Sampling Depth (m)	Unit Weight (g/cm^3)	Absorption Weight (%)	Ultra Sonic Velocity Vp(km/s)	Vs(km/s)	Young ratio (Gpa)	Poisson Ratio	U.C.S (kgf/cm^2)	Petrographic Examination	Boring Core Condition Form. Name	Geology	Rock Class.	Performed by
Kok-Ing No.1 tunnel	DHKBJT1-1SP	39.60 - 39.80	2.63	---	5.87	2.91	59.8	0.34	506.3	Granite	PTR	Granite	CM	Thai side
	DHKBJT1-1SP	63.00 - 63.30	2.75	---	5.73	2.81	51.2	0.37	937.4	---		Tuff	CH	Thai side
	DHKBJT1-1SP	66.60 - 66.90	2.70	---	5.00	3.20	63.7	0.18	367.7	(Micro)diorite		Diorite	CH	Thai side
Kok-Ing No.2 tunnel (B-J route)	DHKBJT2-1	37.10 - 37.40	2.62	---	6.48	2.95	65.6	0.37	953.5	(Meta)basalt	An	Basalt	CH	Thai side
	DHKBJT2-1	45.30 - 45.50	2.76	---	6.16	3.08	69.9	0.33	1,212.2	---		Basalt	CH	Thai side
	DHKBJT2-1	63.00 - 63.30	2.77	---	6.34	3.54	83.8	0.27	2,784.0	Dacite porphyry		Porphyry	CH	Thai side
Kok-Ing No.2 tunnel	DHKB1	50.05 - 50.25	2.72	---	6.34	3.06	66.0	0.35	445.0	Marble	P2	Marble	CM	Thai side
	DHKB2	30.00 - 30.60	2.79	---	6.29	3.35	81.6	0.30	836.9	Slate	PTR	Shale	CH-B	Thai side
	DHBJ4.5	132.60 - 133.30	2.71	0.42	5.52	3.14	67.1	0.26	32.1	Andesite	P3	Andesite	CM	JICA side
	DHBJ4.5	142.00 - 142.30	2.71	0.06	6.04	2.99	64.8	0.34	307.8	Andesite		Andesite	CM	JICA side
	DHBJ4.5	143.30 - 143.60	2.76	0.03	6.21	3.11	71.0	0.33	590.3	Andesite		Andesite	CM	JICA side
	DHBJ4.5	148.40 - 149.00	2.76	0.03	6.54	2.73	57.4	0.39	685.2	Andesite		Andesite	CM	JICA side
Ing-Yot No2. tunnel adit	DH3AD1	59.45 - 59.65	2.69	---	3.66	2.29	32.9	0.19	229.1	---	CPnb	Shale	CH	Thai side
	DH6AD1SP	95.50 - 96.00	2.63	---	4.75	2.64	44.1	0.30	566.4	(Meta-)sandstone	TRhf	Sandstone	CH	Thai side
	DH6AD1SP	114.55 - 114.80	2.72	---	4.50	2.57	45.4	0.26	---	---		Sandstone	CH	Thai side
	DH6AD1SP	119.55 - 120.00	2.73	---	5.41	2.92	60.0	0.29	1,983.4	---		Sandstone	B	Thai side
	DH7AD1	42.00 - 42.25	2.68	---	5.71	2.77	55.6	0.35	983.0	Meta-sandstone	TRhf	Sandstone	CM	Thai side
	DH7AD1	52.50 - 52.80	2.54	---	6.19	3.94	91.7	0.18	467.0	---		Sandstone	CH	Thai side
Ing-Yot No.2 tunnel	DHB0.6	48.50 - 48.80	2.55	---	4.08	2.27	33.5	0.28	228.1	---	TRpn	Sandstone	CM	Thai side
	DHB1SP	67.50 - 67.80	2.66	---	5.72	2.91	59.9	0.33	1,069.8	Granite porphyry	PTRgr	Granite porphyry	B	Thai side
	DHB8SP	109.75 - 110.00	2.71	---	5.08	2.09	33.1	0.40	418.0	Slate	CPnb	S.s.& shale alt.	CH	Thai side
	DHB8SP	126.50 - 126.65	2.70	---	3.12	1.89	23.7	0.22	247.2	Slate		S.s.& shale alt.	CM	Thai side
	DHBJ-16.5	45.10 - 45.35	2.73	---	3.35	1.76	22.1	0.31	248.0	---	CPnb	Shale	CH	Thai side
	DHBJ-16.5	45.40 - 45.60	2.72	---	3.42	1.75	22.0	0.32	47.8	---		Shale	CH	Thai side
	DHBJ-16.5	73.20 - 73.35	2.70	---	3.21	1.76	21.5	0.29	174.2	Slate		Slate	CM	Thai side
	DHBJ-16.5	160.20 - 160.80	2.74	0.35	4.00	2.04	30.1	0.32	65.8	Slate		Slate	CM	JICA side
	DHBJ-16.5	183.40 - 184.00	2.75	0.07	3.98	2.44	39.2	0.20	404.7	Slate		Slate	CH	JICA side
	DHBJ-16.5	188.10 - 188.60	2.76	0.19	4.95	2.81	54.9	0.26	123.8	Slate		S.s.& shale alt.	CM	JICA side
	DHBJ-18.0	157.30 - 157.50	2.69	---	5.30	2.32	40.0	0.38	65.3	Slate (with s.s.)	CPnb	S.s.& shale alt.	CM	Thai side
	DHBJ-18.0	165.60 - 166.00	2.67	0.04	5.67	3.13	66.9	0.28	287.2	Sandstone		Sandstone	CM	JICA side
	DHBJ-18.0	185.60 - 186.00	2.65	0.03	5.86	3.01	63.3	0.32	1,173.3	Sandstone		Sandstone	CH	JICA side
	DHBJ-18.0	196.30 - 197.00	2.68	0.04	5.70	2.62	50.3	0.37	678.8	Sandstone		Sandstone	CM	JICA side
	DHBJ-22.5	189.50 - 189.90	2.77	0.13	4.22	2.55	43.7	0.21	177.0	Slate	CPnb	S.s.& shale alt.	CH	JICA side
	DHBJ-22.5	190.40 - 191.00	2.73	0.06	5.33	2.36	42.0	0.38	101.4	Slate		S.s.& shale alt.	CH	JICA side
	DHBJ-22.5	194.00 - 194.60	2.73	0.10	4.30	2.48	42.0	0.25	406.4	Slate		Slate	CM	JICA side
	DHBJ-22.5	201.00 - 201.40	2.70	0.14	4.12	2.43	39.3	0.23	174.1	Sandstone		Sandstone	CH	JICA side

Table11.2.2-24 The Results of Laboratory Test (2)

Location	Borehole No.	Sampling Depth (m)	Unit Weight (g/cm^3)	Absorption Weight (%)	Ultra Sonic Velocity		Young ratio (Gpa)	Poisson Ratio	U.C.S (kgf/cm^2)	Petrographic Examination	Boring Core Condition			Performed by
					Vp(km/s)	Vs(km/s)					Form. Name	Geology	Rock Class.	
Ing-Yot No.2 tunnel	DHBJ-26.0	258.00 - 259.00	2.78	0.02	6.39	3.29	79.3	0.32	531.0	Dacite	PTRv	Dacite	CH-B	JICA side
	DHBJ-26.0	265.00 - 266.00	2.75	0.03	5.89	3.00	65.7	0.33	1,098.4	Tuff		Tuff	CH-B	JICA side
	DHBJ-26.0	270.00 - 271.00	2.80	0.04	5.11	3.14	66.1	0.20	566.4	Tuff		Tuff	CH	JICA side
	DHBJ-26.0	276.00 - 277.00	2.77	0.06	3.76	2.42	37.1	0.15	820.6	Tuff		Tuff	CH	JICA side
	DHBJ-33.0	181.50 - 181.80	2.71	—	4.25	2.73	48.4	0.15	888.1	Tuff(Marble)	TRhf	Tuff	CM	Thai side
	DHBJ-33.0	198.30 - 198.60	2.74	—	5.42	3.31	74.1	0.18	1,229.0	(Meta-)tuff		Tuff	CH	Thai side
	DHBJ-33.0	273.00 - 274.00	2.67	0.22	3.81	2.48	37.1	0.13	776.1	Tuff		Tuff	CH	JICA side
	DHBJ-33.0	289.00 - 290.00	2.72	0.04	5.36	2.59	49.2	0.35	650.5	Tuff		Tuff	CH	JICA side
	DHBJ-33.0	296.00 - 297.00	2.66	0.13	4.69	2.68	48.0	0.26	1,150.3	(Silicified) tuff		Tuff	CH	JICA side
	DHB46SP	57.20 - 57.50	2.72	—	6.49	2.56	50.2	0.41	2,007.8	—	TRpl	Limestone	CH	Thai side
	DHB46SP	71.50 - 71.75	2.69	—	6.51	3.42	82.5	0.31	1,101.5	Limestone		Limestone	CM	Thai side
	DHB46SP	89.25 - 89.50	2.72	—	6.53	2.58	51.2	0.41	772.2	—		Limestone	CM	Thai side
	DHB50SP	77.30 - 77.60	2.69	—	5.50	3.07	64.6	0.27	181.4	(Meta-)sandstone	TRhf	Sandstone	CM	Thai side
Ing-Yot No.2 tunnel ('97)	DHA-1	27.5	—	—	—	—	—	—	1,523.4	—	TRpn	Tuff	CH	Thai side
	DHB-7	52.0	—	—	—	—	—	—	1,978.3	—	TRpl	Limestone	B	Thai side
	DHB-8	48.0	—	—	—	—	—	—	1,267.9	—	TRhf	Tuff	CH	Thai side
Ing-Yot No.2 tunnel ('96) (south route)	DHC-1	29.5	—	—	—	—	—	—	1,032.0	—	TRpn	Siltstone	CH-B	Thai side
	DHC-2	64.5	—	—	—	—	—	—	271.3	—	ms3	Sandstone	CL	Thai side

* Unit weight (Bulk S.G.) = W(dry) / Volume
* Poisson's ratio, GPa = 1.0197×10^4 kgf/cm^2
* U.C.S. : Uniaxial compressive strength, in case of getting two data at the same sample, higher strength data is adopted.
* Tensile strength (by Brazillian test), DHBJ22.5 (194.0-194.6 m) : 97.9 kgf/cm^2, DHBJ26.0 (270.0-271.0 m) : 227.4 kgf/cm^2
* Point load strength (by point load test), DHBJ22.5 (194.0-194.6 m) : 18.5 kgf/cm^2, DHBJ26.0 (270.0-271.0 m) : 10.0 kgf/cm^2

Table11.2.2-25 Correlation of Results between Laboratory Test and In-situ Test (1)

Location	Borehole No.	Sampling Depth (m)	Laboratory Test: Ultra Sonic Velocity Vp(km/s)	Laboratory Test: Ultra Sonic Velocity Vs(km/s)	In-situ Test: Sonic Logging Vp(km/s)	In-situ Test: Sonic Logging Vs(km/s)	Short Resistivity (ohm/m)	Long Resistivity (ohm/m)	SP (mv)	Gamma (cps)	Boring Core Condition: Form. Name	Boring Core Condition: Geology	Boring Core Condition: Rock Class.
Kok-Ing No.1 tunnel	DHKBJT1-1SP	39.60 - 39.80	5.87	2.91	---	---	510	130	-135	38	PTR	Granite	CM
	DHKBJT1-1SP	63.00 - 63.30	5.73	2.81	---	---	885	>400	-180	19		Tuff	CH
	DHKBJT1-1SP	66.60 - 66.90	5.00	3.20	---	---	---	---	---	---		Diorite	CH
Kok-Ing No.2 tunnel (B-J route)	DHKBJT2-1	37.10 - 37.40	6.48	2.95	---	---	---	---	---	---	An	Basalt	CH
	DHKBJT2-1	45.30 - 45.50	6.16	3.08	---	---	---	---	---	---		Basalt	CH
	DHKBJT2-1	63.00 - 63.30	6.34	3.54	---	---	---	---	---	---		Porphyry	CH
Kok-Ing No.2 tunnel	DHKB1	50.05 - 50.25	6.34	3.06	---	---	---	---	---	---	P2	Marble	CM
	DHKB2	30.00 - 30.60	6.29	3.35	---	---	---	---	---	---	PTR	Shale	CH-B
	DHBJ4.5	132.60 - 133.30	5.52	3.14	3.68	2.96	400	380	380	55	P3	Andesite	CM
	DHBJ4.5	142.00 - 142.30	6.04	2.99	5.66	3.41	1550	780	300	15		Andesite	CM
	DHBJ4.5	143.30 - 143.60	6.21	3.11	6.12	3.28	1450	800	320	22		Andesite	CM
	DHBJ4.5	148.40 - 149.00	6.54	2.73	4.97	2.97	500	400	400	55		Andesite	CM
Ing-Yot No2. tunnel adit	DH3AD1	59.45 - 59.65	3.66	2.29	---	---	---	---	---	---	CPnb	Shale	CH
	DH6AD1SP	95.50 - 96.00	4.75	2.64	---	---	500	250	-115	38	TRhf	Sandstone	CH
	DH6AD1SP	114.55 - 114.80	4.50	2.57	---	---	620	320	-115	41		Sandstone	CH
	DH6AD1SP	119.55 - 120.00	5.41	2.92	---	---	>1000	>400	-75	35		Sandstone	B
	DH7AD1	42.00 - 42.25	5.71	2.77	---	---	---	---	---	---	TRhf	Sandstone	CM
	DH7AD1	52.50 - 52.80	6.19	3.94	---	---	---	---	---	---		Sandstone	CH
Ing-Yot No.2 tunnel	DHB0.6	48.50 - 48.80	4.08	2.27	---	---	---	---	---	---	TRpn	Sandstone	CM
	DHB1SP	67.50 - 67.80	5.72	2.91	---	---	1350	1250	-85	>60	PTRgr	Granite porphyry	B
	DHB8SP	109.75 - 110.00	5.08	2.09	---	---	20	30	107	60	CPnb	S.s.& shale alt.	CH
	DHB8SP	126.50 - 126.65	3.12	1.89	---	---	---	---	---	---		S.s.& shale alt.	CM
	DHBJ-16.5	45.10 - 45.35	3.35	1.76	---	---	25	30	-145	65	CPnb	Shale	CH
	DHBJ-16.5	45.40 - 45.60	3.42	1.75	---	---	23	25	-150	73		Shale	CH
	DHBJ-16.5	73.20 - 73.35	3.21	1.76	---	---	7	15	-100	75		Slate	CM
	DHBJ-16.5	160.20 - 160.80	4.00	2.04	4.36	2.83	10	12	-25	62		Slate	CM
	DHBJ-16.5	183.40 - 184.00	3.98	2.44	4.08	2.79	22	28	-10	66		Slate	CH
	DHBJ-16.5	188.10 - 188.60	4.95	2.81	4.71	2.68	10	15	12	63		S.s.& shale alt.	CM
	DHBJ-18.0	157.30 - 157.50	5.30	2.32	---	---	28	10	-25	55	CPnb	S.s.& shale alt.	CM
	DHBJ-18.0	165.60 - 166.00	5.67	3.13	4.62	3.07	25	10	-70	75		Sandstone	CM
	DHBJ-18.0	185.60 - 186.00	5.86	3.01	3.11	2.59	82	10	-190	45		Sandstone	CH
	DHBJ-18.0	196.30 - 197.00	5.70	2.62	4.79	2.84	40	8	-55	47		Sandstone	CM
	DHBJ-22.5	189.50 - 189.90	4.22	2.55	4.90	2.98	500	40	35	45	CPnb	S.s.& shale alt.	CH
	DHBJ-22.5	190.40 - 191.00	5.33	2.36	4.85	2.84	>1000	70	180	72		S.s.& shale alt.	CH
	DHBJ-22.5	194.00 - 194.60	4.30	2.48	4.71	2.95	70	50	-95	54		Slate	CM
	DHBJ-22.5	201.00 - 201.40	4.12	2.43	5.30	2.66	250	150	0	55		Sandstone	CH

Table11.2.2-26 Correlation of Results between Laboratory Test and In-situ Test (2)

Location	Borehole No.	Sampling Depth (m)	Laboratory Test Ultra Sonic Velocity Vp(km/s)	Laboratory Test Ultra Sonic Velocity Vs(km/s)	In-situ Test Sonic Logging Vp(km/s)	In-situ Test Sonic Logging Vs(km/s)	Short Resistivity (ohm/m)	Long Resistivity (ohm/m)	SP (mv)	Gamma (cps)	Boring Core Condition Form. Name	Boring Core Condition Geology	Boring Core Condition Rock Class.
Ing-Yot No.2 tunnel	DHBJ-26.0	258.00 - 259.00	6.39	3.29	6.08	3.18	>10000	>10000	100	37	PTRv	Dacite	CH-B
	DHBJ-26.0	265.00 - 266.00	5.89	3.00	5.99	3.31	9000	>10000	60	25		Tuff	CH-B
	DHBJ-26.0	270.00 - 271.00	5.11	3.14	5.40	3.20	3100	4000	35	50		Tuff	CH
	DHBJ-26.0	276.00 - 277.00	3.76	2.42	4.25	3.14	2000	1000	50	45		Tuff	CH
	DHBJ-33.0	181.50 - 181.80	4.25	2.73	---	---	1450	1500	-100	35	TRhf	Tuff	CM
	DHBJ-33.0	198.30 - 198.60	5.42	3.31	---	---	1700	1200	-70	38		Tuff	CH
	DHBJ-33.0	273.00 - 274.00	3.81	2.48	5.42	3.11	4000	>5000	165	32		Tuff	CH
	DHBJ-33.0	289.00 - 290.00	5.36	2.59	5.40	3.00	2000	2000	230	35		Tuff	CH
	DHBJ-33.0	296.00 - 297.00	4.69	2.68	5.32	3.13	3000	4000	400	23		Tuff	CH
	DHB46SP	57.20 - 57.50	6.49	2.56	---	---	2100	>600	50	11	TRpl	Limestone	CH
	DHB46SP	71.50 - 71.75	6.51	3.42	---	---	600	230	70	10		Limestone	CM
	DHB46SP	89.25 - 89.50	6.53	2.58	---	---	850	580	54	11		Limestone	CM
	DHB50SP	77.30 - 77.60	5.50	3.07	---	---	1050	800	10	36		Sandstone	CM

Table11.2.2-27 Correlation of P - wave Velocity by Different Measurement Method (1)

Location	Borehole No.	Sampling Depth (m)	Laboratory Test: Ultra Sonic Velocity Vp(km/s)	Laboratory Test: Ultra Sonic Velocity Vs(km/s)	In-situ Test: Sonic Logging Vp(km/s)	In-situ Test: Sonic Logging Vs(km/s)	Index for Cracking	Seismic Survey: RFR Vp(km/s)	Seismic Survey: RFL Vp(km/s)	Boring Core Condition: Form. Name	Boring Core Condition: Geology	Boring Core Condition: Rock Class.
Kok-Ing No.1 tunnel	DHKBJT1-1SP	39.60 - 39.80	5.87	2.91	---	---	---	---	>2.5	PTR	Granite	CM
	DHKBJT1-1SP	63.00 - 63.30	5.73	2.81	---	---	---	---	>2.5		Tuff	CH
	DHKBJT1-1SP	66.60 - 66.90	5.00	3.20	---	---	---	---	>2.5		Diorite	CH
Kok-Ing No.2 tunnel (B-J route)	DHKBJT2-1	37.10 - 37.40	6.48	2.95	---	---	---	---	---	An	Basalt	CH
	DHKBJT2-1	45.30 - 45.50	6.16	3.08	---	---	---	---	---		Basalt	CH
	DHKBJT2-1	63.00 - 63.30	6.34	3.54	---	---	---	---	---		Porphyry	CH
Kok-Ing No.2 tunnel	DHKB1	50.05 - 50.25	6.34	3.06	---	---	---	---	>2.3	P2	Marble	CM
	DHKB2	30.00 - 30.60	6.29	3.35	---	---	---	---	>2.3	PTR	Shale	CH-B
	DHBJ4.5	132.60 - 133.30	5.52	3.14	3.68	2.96	0.67	---	---	P3	Andesite	CM
	DHBJ4.5	142.00 - 142.30	6.04	2.99	5.66	3.41	0.94	---	---		Andesite	CM
	DHBJ4.5	143.30 - 143.60	6.21	3.11	6.12	3.28	0.99	---	---		Andesite	CM
	DHBJ4.5	148.40 - 149.00	6.54	2.73	4.97	2.97	0.76	---	---		Andesite	CM
Ing-Yot No2. tunnel adit	DH3AD1	59.45 - 59.65	3.66	2.29	---	---	---	(2.5)	>2.4	CPnb	Shale	CH
	DH6AD1SP	95.50 - 96.00	4.75	2.64	---	---	---	(2.7)	>2.8	TRhf	Sandstone	CH
	DH6AD1SP	114.55 - 114.80	4.50	2.57	---	---	---	(2.7)	>2.8		Sandstone	CH
	DH6AD1SP	119.55 - 120.00	5.41	2.92	---	---	---	(2.7)	>2.8		Sandstone	B
	DH7AD1	42.00 - 42.25	5.71	2.77	---	---	---	(4.6)	>2.1	TRhf	Sandstone	CM
	DH7AD1	52.50 - 52.80	6.19	3.94	---	---	---	(4.6)	>2.1		Sandstone	CH
Ing-Yot No.2 tunnel	DHB0.6	48.50 - 48.80	4.08	2.27	---	---	---	---	>2.9	TRpn	Sandstone	CM
	DHB1SP	67.50 - 67.80	5.72	2.91	---	---	---	(4.7)	>2.7	PTRgr	Granite porphyry	B
	DHB8SP	109.75 - 110.00	5.08	2.09	---	---	---	3.1	---	CPnb	S.s.& shale alt.	CH
	DHB8SP	126.50 - 126.65	3.12	1.89	---	---	---	3.2	---		S.s.& shale alt.	CM
	DHBJ-16.5	45.10 - 45.35	3.35	1.76	---	---	---	3.3	---	CPnb	Shale	CH
	DHBJ-16.5	45.40 - 45.60	3.42	1.75	---	---	---	3.3	---		Shale	CH
	DHBJ-16.5	73.20 - 73.35	3.21	1.76	---	---	---	3.4	---		Slate	CM
	DHBJ-16.5	160.20 - 160.80	4.00	2.04	4.36	2.83	1.09	3.7	---		Slate	CM
	DHBJ-16.5	183.40 - 184.00	3.98	2.44	4.08	2.79	1.03	3.8	---		Slate	CH
	DHBJ-16.5	188.10 - 188.60	4.95	2.81	4.71	2.68	0.95	3.8	---		S.s.& shale alt.	CM
	DHBJ-18.0	157.30 - 157.50	5.30	2.32	---	---	---	3.6	---	CPnb	S.s.& shale alt.	CM
	DHBJ-18.0	165.60 - 166.00	5.67	3.13	4.62	3.07	0.81	3.7	---		Sandstone	CM
	DHBJ-18.0	185.60 - 186.00	5.86	3.01	3.11	2.59	0.53	3.8	---		Sandstone	CH
	DHBJ-18.0	196.30 - 197.00	5.70	2.62	4.79	2.84	0.84	3.8	---		Sandstone	CM
	DHBJ-22.5	189.50 - 189.90	4.22	2.55	4.90	2.98	1.16	4.7	---	CPnb	S.s.& shale alt.	CH
	DHBJ-22.5	190.40 - 191.00	5.33	2.36	4.85	2.84	0.91	4.7	---		S.s.& shale alt.	CH
	DHBJ-22.5	194.00 - 194.60	4.30	2.48	4.71	2.95	1.10	4.8	---		Slate	CM
	DHBJ-22.5	201.00 - 201.40	4.12	2.43	5.30	2.66	1.29	4.8	---		Sandstone	CH

Table11.2.2-28 Correlation of P - wave Velocity by Different Measurement Method (2)

Location	Borehole No.	Sampling Depth (m)	Laboratory Test Ultra Sonic Velocity		In-situ Test Sonic Logging		Index for Cracking	Seismic Survey RFR	Seismic Survey RFL	Boring Core Condition		
			Vp(km/s)	Vs(km/s)	Vp(km/s)	Vs(km/s)		Vp(km/s)	Vp(km/s)	Form. Name	Geology	Rock Class.
Ing-Yot No.2 tunnel	DHBJ-26.0	258.00 - 259.00	6.39	3.29	6.08	3.18	0.95	---	---	PTRv	Dacite	CH-B
	DHBJ-26.0	265.00 - 266.00	5.89	3.00	5.99	3.31	1.02	---	---		Tuff	CH-B
	DHBJ-26.0	270.00 - 271.00	5.11	3.14	5.40	3.20	1.06	---	---		Tuff	CH
	DHBJ-26.0	276.00 - 277.00	3.76	2.42	4.25	3.14	1.13	---	---		Tuff	CH
	DHBJ-33.0	181.50 - 181.80	4.25	2.73	---	---	---	---	---	TRhf	Tuff	CM
	DHBJ-33.0	198.30 - 198.60	5.42	3.31	---	---	---	---	---		Tuff	CH
	DHBJ-33.0	273.00 - 274.00	3.81	2.48	5.42	3.11	1.42	---	---		Tuff	CH
	DHBJ-33.0	289.00 - 290.00	5.36	2.59	5.40	3.00	1.01	---	---		Tuff	CH
	DHBJ-33.0	296.00 - 297.00	4.69	2.68	5.32	3.13	1.13	---	---		Tuff	CH
	DHB46SP	57.20 - 57.50	6.49	2.56	---	---	---	4.5	>2.1	TRpl	Limestone	CH
	DHB46SP	71.50 - 71.75	6.51	3.42	---	---	---	4.5	>2.1		Limestone	CM
	DHB46SP	89.25 - 89.50	6.53	2.58	---	---	---	4.5	>2.1		Limestone	CM
	DHB50SP	77.30 - 77.60	5.50	3.07	---	---	---	---	>2.3		Sandstone	CM

* Index for cracking : Vp of field (or Vp of Logging) / Vp of core

* Seismic survey, RFL : Reflection seismic survey, RFR : Refraction seismic survey

* Vp in parentheses shows that of projected borehole on survey line.

Figure 11.2.2-14 Relationship between Unit Weight and Uniaxial Compressive Strength

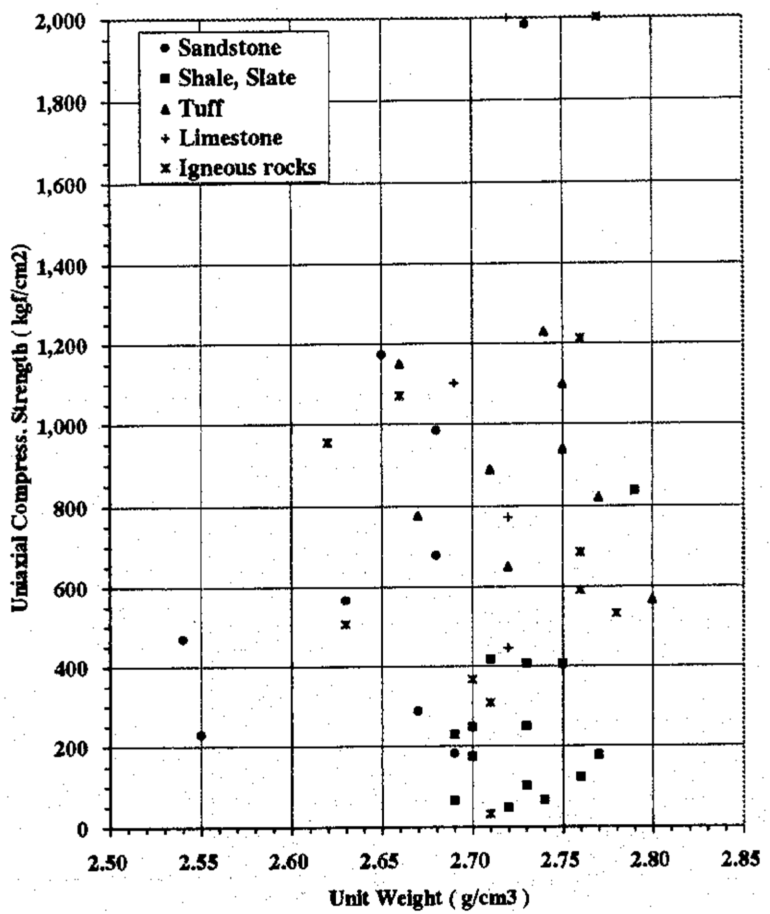


Figure 11.2.2-15 Relationship between Vp (Ultrasonic Velocity) and Uniaxial Compressive Strength

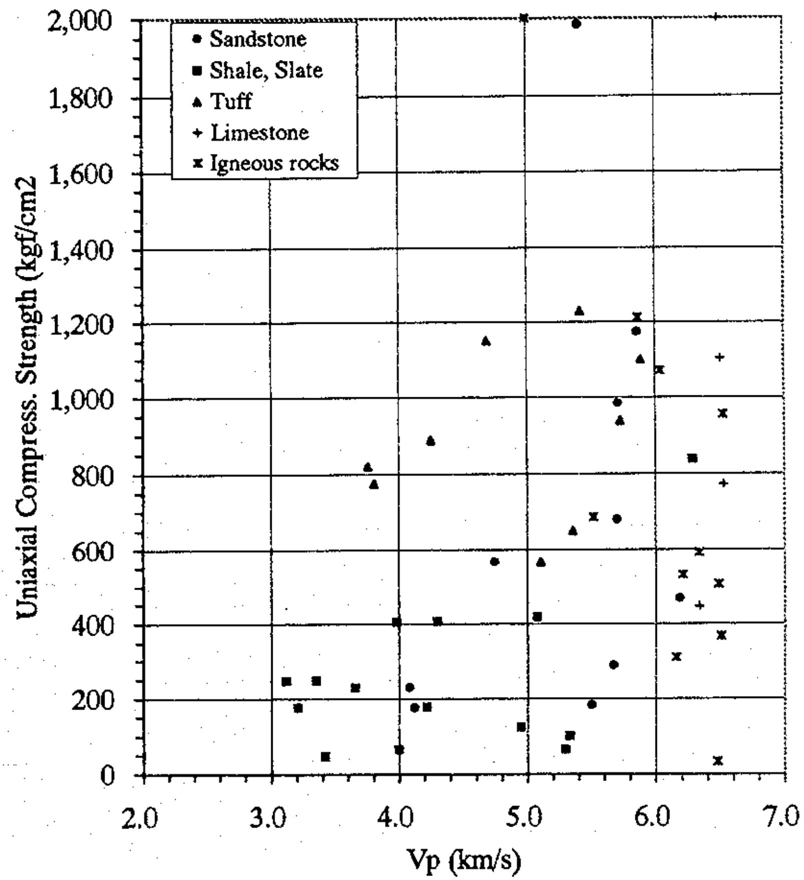


Figure 11.2.2-16 Relationship between Vp and Vs (Ultrasonic Velocity)

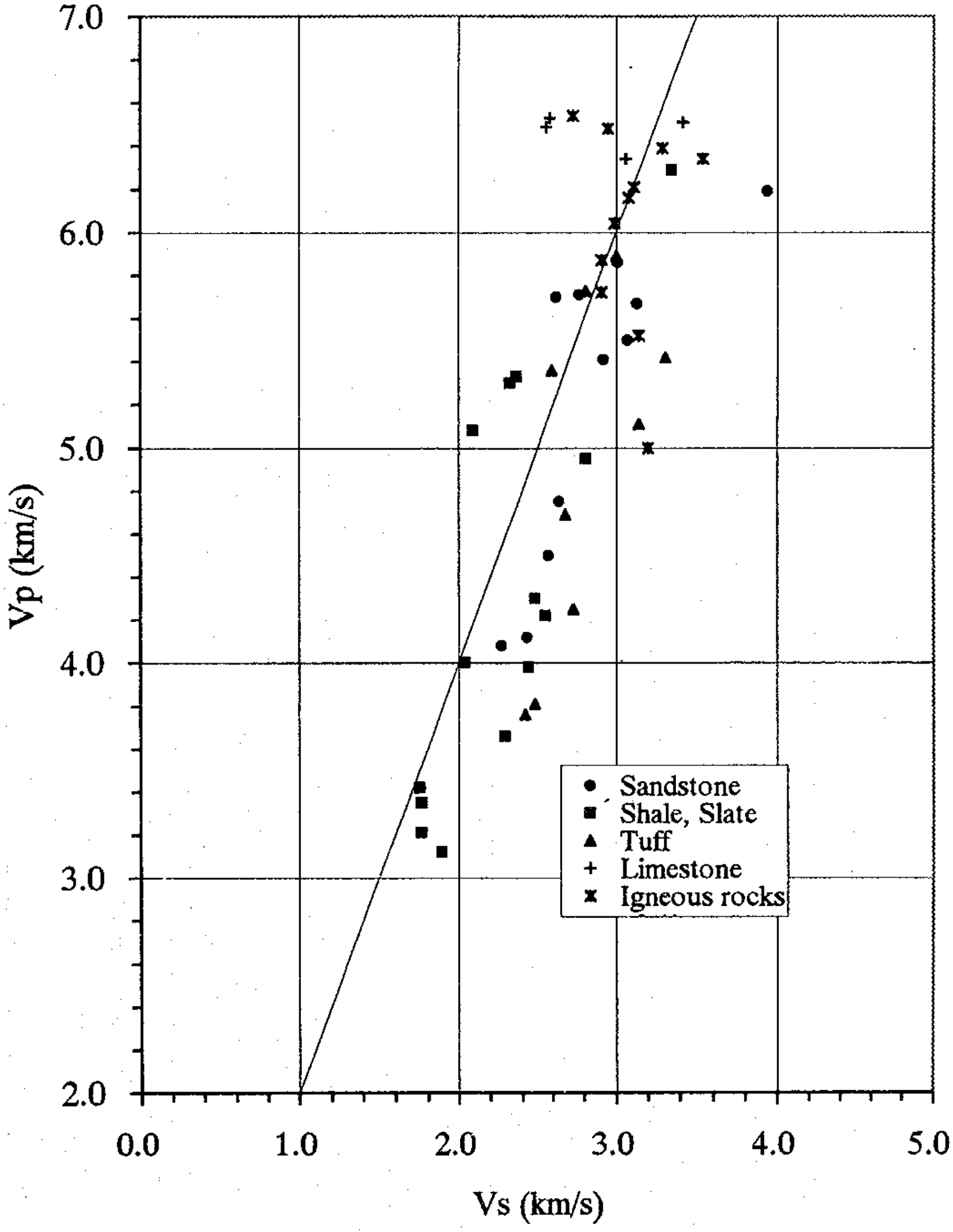


Figure 11.2.2-17 Relationship between Vp (Ultrasonic Velocity) and Vp (Sonic Logging)

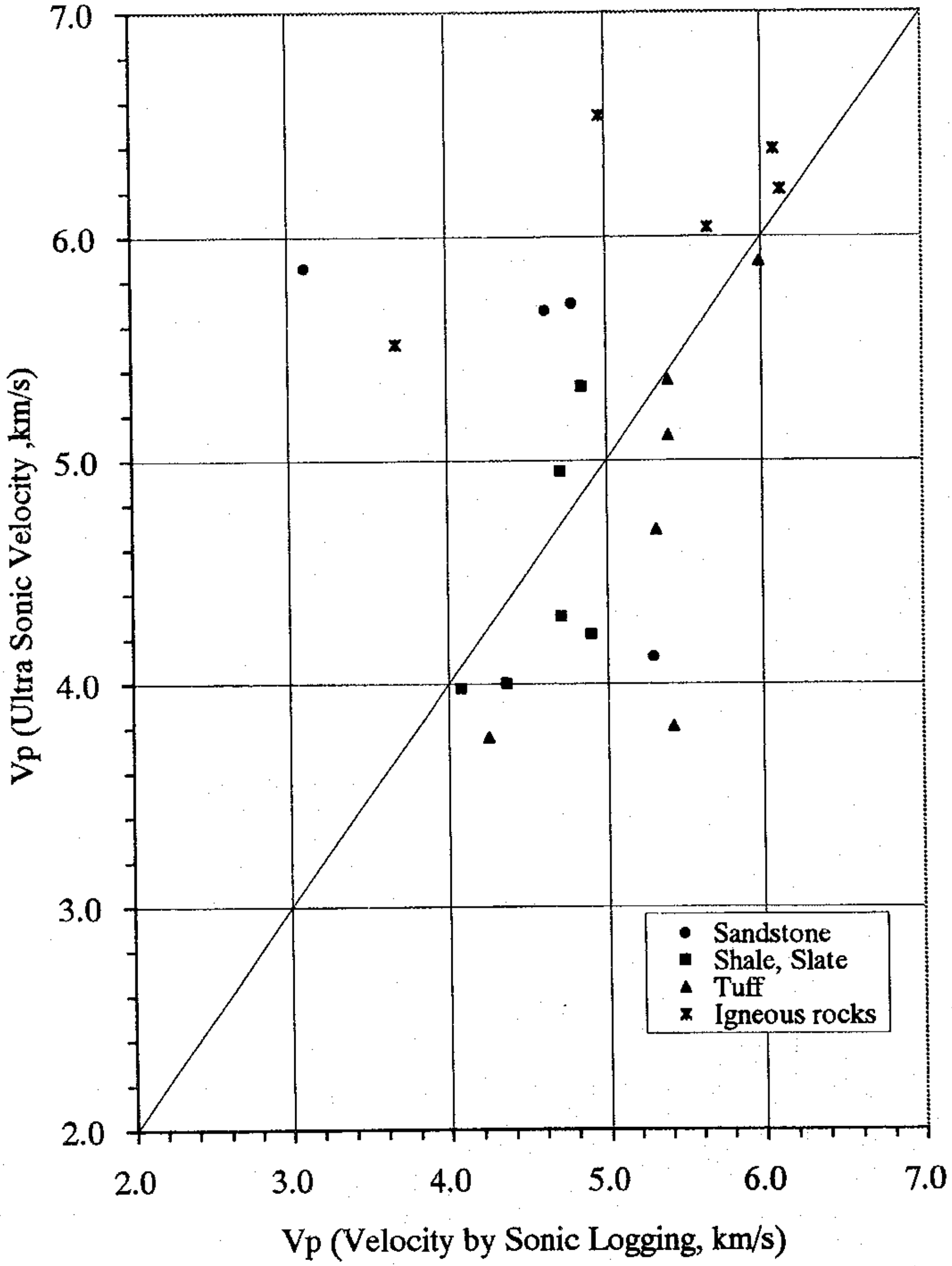


Table 11.2.2-29 Results of Refraction Prospecting Survey (P-wave Velocity)

Line Name	Location	Line Length (m)		Survey Line Number	Vp (P-wave velocity, km/sec)			Geological formation
					1st layer	2nd layer	3rd layer	
SKIT-1-1	Kok-Ing No.1 tunnel inlet (main)	400		A-1 to A-4	0.3 - 0.4	0.8 - 1.3	2.6 - 3.5	Qt, Jv
SKIT-1/1	Kok-Ing No.1 tunnel inlet (sub)	400		B-1 to B-4	0.3 - 0.4	1.3 - 1.9	2.4 - 3.7	Qt, Jv
SKIT-1-2	Kok-Ing No.1 tunnel outlet (main)	1,000		C-1 to C-9	0.3 - 0.4	0.6 - 1.3	2.1 - 3.7	Qt, PTR, Jv
SKIT-1/3	Kok-Ing No.1 tunnel outlet (sub)	300		D-1 to D-3	0.3 - 0.4	1.0 - 1.7	2.7 - 3.4	Qt, PTR, Jv
SKIT-1/4	Kok-Ing No.1 tunnel outlet (sub)	400		E-1 to E-4	0.3 - 0.4	1.1 - 1.5	2.4 - 3.9	Qt, PTR, Jv
SKI-1, SKIT-2	Kok-Ing No.2 tunnel inlet (main)	4,800						
(SKIT-2/1RR)			700	G-1 to G-6	0.4	0.7 - 0.8	1.1 - 1.4	Qt, P3
			360	G-7 to G-10	0.3 - 0.4	0.7 - 0.9	1.4 - 1.8	Qt, P3
			1,085	G-11 to G-20	0.3 - 0.4	1.1 - 1.5	2.2 - 2.8	Qt, P3
			435	G-21 to G-24	0.4	1.0 - 1.1	1.7	Qt, P3
			2,160	G-25 to G-44	0.3 - 0.5	1.1 - 1.9	2.2 - 4.4	Qt, P3, P2, Bs
SKIT-2/2RR	Kok-Ing No.2 tunnel inlet (sub)	500		SKITA-1 to AKITA-5	0.3 - 0.4	1.2 - 1.9	2.2 - 2.5	Qt, P3, P2, PTRgr
SKIT-3/1RR	Kok-Ing No.2 tunnel outlet (main)	800		F-1 to F-8	0.3 - 0.4	0.7 - 1.6	2.3 - 3.4	Qt, PTR, (Bs)
SKIT-3/2RR	Kok-Ing No.2 tunnel outlet (sub)	500		SKITB-1 to AKITB-5	0.3 - 0.4	1.2 - 1.5	2.3 - 2.9	Qt, PTR
Line IY	Ing-Yot No.1 tunnel (main)	1,925						
			1,155	LineIY-1 to LineIY-11	0.3 - 0.4	0.6 - 1.1	1.9 - 4.5	Qt, ms3, TRpn
			770	LineIY-12 to LineIY-18	0.3 - 0.5	3.3 - 4.8	-	Qt, ms3, TRpn
SB0(Main)	Ing-Yot No.2 tunnel inlet (main)	3,100		SB0-1 to SB0-28	0.3 - 0.5	0.5 - 1.0	1.7 - 3.4	TRpn, TRhf, PTRv, PTRgr
SB0(SubA)	Ing-Yot No.2 tunnel inlet (sub)	500		SB0-A1 to SB0-A5	0.4 - 0.5	0.7 - 1.2	2.2 - 3.0	TRpn
SB0(SubB)	Ing-Yot No.2 tunnel inlet (sub)	500		SB0-B1 to SB0-B5	0.3 - 0.4	0.9 - 1.2	2.3 - 3.1	PTRv
SB0(SubC)	Ing-Yot No.2 tunnel inlet (sub)	600		SB0-C1 to SB0-C6	0.3 - 0.4	0.7 - 1.1	2.5 - 4.1	TRhf, PTRv
S2B0(Main)	Ing-Yot No.2 tunnel inlet (main)	1,100		S2B0-1 to S2B0-11	0.4 - 0.5	0.7 - 1.2	2.0 - 4.0	TRpn, PTRv, PTRgr
S2B0(Sub)	Ing-Yot No.2 tunnel inlet (sub)	500		S2B0-A1 to S2B0-A5	0.3 - 0.4	0.7 - 0.9	2.7 - 4.3	TRpn, PTRv, PTRgr
SAd1(Main)	Ing-Yot No.2 tunnel Adit No.1(main)	1,000		SAd1-1 to SAd1-9	0.3 - 0.5	0.6 - 1.1	1.7 - 3.8	Qt, CPhk
SAd1(Sub)	Ing-Yot No.2 tunnel Adit No.1(sub)	500		SAd1-S1 to SAd-S5	0.4	0.6 - 0.8	1.8 - 3.5	Qt, CPhk
SAd2-RFR1	Ing-Yot No.2 tunnel Adit No.2(main)	400		SAd2-1 to SAd2-4	0.3 - 0.4	1.0 - 1.6	2.4 - 3.7	Qt, CPhk
SAd3-RFR1	Ing-Yot No.2 tunnel Adit No.3(main)	500		SAd3-A1 to SAd3-A5	0.3 - 0.4	0.8 - 1.3	2.1 - 2.4	Qt, CPnb
SAd3-RFR2	Ing-Yot No.2 tunnel Adit No.3(sub)	500		SAd3-B1 to SAd3-B5	0.3 - 0.4	0.9 - 1.3	2.3 - 2.4	Qt, CPnb
SAd4-RFR2	Ing-Yot No.2 tunnel Adit No.4(main)	600		SAd4-A1 to SAd4-A6	0.3 - 0.4	0.8 - 1.5	2.3 - 2.6	CPhk
SAd4-RFR1	Ing-Yot No.2 tunnel Adit No.4(sub)	650		SAd4-B1 to SAd4-B6	0.3 - 0.4	1.1 - 1.9	2.5 - 3.6	CPhk
SAd5-RFR1	Ing-Yot No.2 tunnel Adit No.5(main)	300		SAd5-A1 to SAd5-A3	0.3 - 0.4	1.2 - 1.4	2.4 - 3.0	TRhf
SAd5-RFR2	Ing-Yot No.2 tunnel Adit No.5(sub)	500		SAd5-B1 to SAd5-B5	0.3 - 0.4	0.9 - 1.5	2.4 - 3.9	TRhf

Table 11.2.2-30 Results of Refraction Prospecting Survey (P-wave Velocity)

Line name	Location	Line length (m)	Survey line number	Vp (P-wave velocity, km/sec) 1st layer	2nd layer	3rd layer	Geological formation
SAd6-RFR1	Ing-Yot No.2 tunnel Adit No.6(main)	500	SAd6-A1 to SAd6-A5	0.3 - 0.4	0.9 - 1.2	2.4 - 2.8	TRhf
SAd6-RFR2	Ing-Yot No.2 tunnel Adit No.6(sub)	500	SAd6-B1 to SAd6-B5	0.3 - 0.4	0.8 - 1.6	2.3 - 2.6	TRhf
SAd7-RFR1	Ing-Yot No.2 tunnel Adit No.7(main)	400	SAd7-A1 to SAd7-A4	0.3 - 0.4	1.1 - 1.4	2.1 - 3.1	Qt, TRhf, (TRpl)
SAd7-RFR2	Ing-Yot No.2 tunnel Adit No.7(sub)	500	SAd7-B1 to SAd7-B5	0.3 - 0.4	1.0 - 1.5	2.1 - 2.4	Qt, TRhf
SB49-RFR1	Ing-Yot No.2 tunnel outlet(main)	800	SB49-A1 to SB49-A7	0.3 - 0.4	1.1 - 1.7	2.3 - 3.9	Qt, TRpl, TRhf
SB49-RFR2	Ing-Yot No.2 tunnel outlet(sub)	600	SB49-B1 to SB49-B6	0.3	1.4 - 1.8	3.0 - 3.3	Qt, TRpl, TRhf
SKI-B20(Main)	Kok- Ing tunnel south route(main)	1,035	SKI-M1 to SKI-M9	0.3 - 0.4	1.6 - 1.9	2.7 - 3.5	Qa, Qt
SKI-B20(Sub)	Kok- Ing tunnel south route(sub)	345	SKI-S1 to SKI-S3	0.3 - 0.4	1.6 - 1.7	2.9 - 4.0	Qa, Qt
SB0(Main)	Ing-Yot No.1 tunnel (main)	990	SB0-M1 to SB0-M18	0.4 - 0.5	0.6 - 1.4	3.1 - 5.3	Qt, ms3, TRpn
SB0(Sub)	Ing-Yot No.1 tunnel (sub)	495	SB0-S1 to SB0-S9	0.4 - 0.5	1.0 - 1.6	3.1 - 5.6	Qt, ms3, TRpn
NY-A	Yao dam - dam axis	440	NY-A1 to NY-A8	0.3 - 0.4	0.7 - 1.2	2.4 - 3.3	TRhf
NY-B	Yao dam - left saddle	220	NY-B1 to NY-B4	0.3 - 0.4	0.5 - 1.3	2.6 - 3.4	TRhf
NY-C	Yao dam - cross section	385	NY-C1 to NY-C7	0.4 - 0.5	1.1 - 1.4	3.2 - 4.0	TRhf

* Dense colour area shows Vp (P-wave velocity) of 4.0 km/sec

* SKI-1 and SKIT-2 line correspond to a series of survey line. SKIT-2 line is located on the inlet of Kok-Ing No.2 tunnel, and survey line for Kok-Ing No.2 tunnel is called as SKIT-2/1RR line.

* SKIT-3/1RR line was called as SKIT-3 at the initial survey stage.

* SB0 (Main, SubA-C) line at the Ing-Yot tunnel inlet and SKI-B20 (Main, Sub) line at the south route are correspond to canceled route.

* Low velocity layers are found out following survey line.

SKIT-1/4 : width 5 m (survey point (sp.) 305-315)
Line IY : width 5 m (Vp=2.0 km/sec, sp.150-155), width 5 m (Vp=2.4 km/s, sp.925-930)
SB0 (Main) : width 5 m (sp. 2,550-2,555), width 15 m (sp. 2,580-2,590), width 10 m (sp. 3,015-3,025)
S2B0 (Main) : width 20 m (Vp=1.6 km/sec, sp.140-160)
SAd1 (Main) : width 10 m (Vp=1.1 km/sec, sp.50-60, width 10 m (Vp=1.3 km/sec, sp.270-280), width 5 m (Vp=1.3 km/sec, sp.790-795), width 10 m (Vp=2.3 km/sec, sp.905-915)
SAd1 (Sub) : width 5 m (Vp=1.1 km/sec, sp.L210-215), width 5 m (Vp=1.1 km/sec, sp.R135-140)
SAd4-RFR1 : width 10 m (sp.165-175)

* SAd1 (Sub), high speed layers (3rd layer) is found out line point R200-250 (Vp=3.5 km/sec). In case of the 3rd layer shows Vp=1.8-2.1 km/sec excluding the above high speed layer.
* SAd5 (Sub), the thickness of 1st layer at the right side shows 18.0 m.
* SB49 (Main), line point 0-40, 350-600 show 2-layer structure. High speed layer (3rd layer) is found out line point 220-330 (Vp=3.9 km/sec). In case of the above high speed layer, 3rd layer shows Vp=2.3-3.3 km/sec.
* SB0 (Main) by RID, line point 130-255, 375-495, 605-880 show 2-layer structure.
* SB0 (Sub) by RID, line point 90-205, 420-440 show 2-layer structure.
* NY-A by RID, line point 0-60, 155-285 show 2-layer structure.
* NY-B by RID, line point 80-125 shows 2-layer structure.
* NY-C by RID, line point 0-35, 170-235 show 2-layer structure.

Table11.2.2-31 Results of Reflection Prospecting Survey (Thckness of Velocity Layer)

Line Name	Location	Line Length (m)		Thickness of Each Layer (m)		Thickness from GL. (m)		Geological formation	Performed by
				1st layer	2nd layer	1st layer	2nd layer		
SKIT-1-1	Kok-Ing No.1 tunnel inlet (main)	400		0 - 3.7	4.0 - 15.0	0 - 3.7	4.9 - 18.0	Qt, Jv	Thai side
SKIT-1/1	Kok-Ing No.1 tunnel inlet (sub)	400		1.4 - 4.0	2.3 - 16.4	1.4 - 4.0	4.7 - 18.9	Qt, Jv	Thai side
SKIT-1-2	Kok-Ing No.1 tunnel outlet (main)	1,000		1.0 - 9.0	5.0 - 25.0	1.0 - 9.0	6.6 - 34.2	Qt, PTR, Jv	Thai side
SKIT-1/3	Kok-Ing No.1 tunnel outlet (sub)	300		1.2 - 5.3	3.3 - 18.0	1.2 - 5.3	7.7 - 20.3	Qt, PTR, Jv	Thai side
SKIT-1/4	Kok-Ing No.1 tunnel outlet (sub)	400		1.4 - 4.0	7.5 - 14.0	1.4 - 4.0	10.7 - 16.8	Qt, PTR, Jv	Thai side
SKI-1, SKIT-2	Kok-Ing No.2 tunnel inlet (main)	4,800							Thai side
(SKIT-2/1RR)			700	0.4 - 3.3	3.0 - 11.0	0.4 - 3.3	5.3 - 12.2	Qt, P3	Thai side
			360	0.5 - 2.3	3.5 - 9.3	0.5 - 2.3	4.7 - 10.7	Qt, P3	Thai side
			1,085	0.8 - 2.5	9.9 - 17.2	0.8 - 2.5	11.2 - 18.9	Qt, P3	Thai side
			435	0.2 - 1.4	4.3 - 6.8	0.2 - 1.4	5.1 - 7.7	Qt, P3	Thai side
			2,160	0.4 - 3.7	6.9 - 19.0	0.4 - 3.7	8.5 - 21.2	Qt, P3, P2, Bs	Thai side
SKIT-2/2RR	Kok-Ing No.2 tunnel inlet (sub)	500		1.0 - 5.0	3.5 - 19.0	1.0 - 5.0	6.5 - 20.0	Qt, P3, P2, PTRgr	Thai side
SKIT-3/1RR	Kok-Ing No.2 tunnel outlet (main)	800		1.3 - 7.0	9.8 - 25.2	1.3 - 7.0	13.0 - 28.0	Qt, PTR, (Bs)	Thai side
SKIT-3/2RR	Kok-Ing No.2 tunnel outlet (sub)	500		1.0 - 6.5	12.5 - 20.0	1.0 - 6.5	15.5 - 26.0	Qt, PTR	Thai side
Line IY	Ing-Yot No.1 tunnel (main)	1,925							Thai side
			1,155	0 - 4.3	0 - 11.5	0 - 4.3	1.4 - 13.7	Qt, ms3, TRpn	Thai side
			770	1.0 - 8.5	-	1.0 - 8.5	-	Qt, ms3, TRpn	Thai side
SB0(Main)	Ing-Yot No.2 tunnel inlet (main)	3,100		0 - 13.0	0 - 14.5	0 - 13.0	3.5 - 17.0	TRpn, TRhf, PTRv, PTRgr	Thai side
SB0(SubA)	Ing-Yot No.2 tunnel inlet (sub)	500		0 - 4.5	0 - 10.5	0 - 4.5	2.0 - 12.5	TRpn	Thai side
SB0(SubB)	Ing-Yot No.2 tunnel inlet (sub)	500		1.0 - 14.0	0 - 11.0	1.0 - 14.0	4.0 - 13.0	PTRv	Thai side
SB0(SubC)	Ing-Yot No.2 tunnel inlet (sub)	600		0 - 8.0	0 - 13.0	0 - 8.0	4.5 - 15.5	TRhf, PTRv	Thai side
S2B0(Main)	Ing-Yot No.2 tunnel inlet (main)	1,100		0 - 8.0	2.0 - 15.5	0 - 8.0	4.0 - 19.5	TRpn, PTRv, PTRgr	Thai side
S2B0(Sub)	Ing-Yot No.2 tunnel inlet (sub)	500		0 - 16.0	0 - 11.0	0 - 16.0	4.0 - 16.5	TRpn, PTRv, PTRgr	Thai side
SAd1(Main)	Ing-Yot No.2 tunnel Adit No.1(main)	1,000		0 - 4.0	4.0 - 17.0	0 - 4.0	5.0 - 17.0	Qt, CPhk	Thai side
SAd1(Sub)	Ing-Yot No.2 tunnel Adit No.1(sub)	500		0.5 - 5.0	3.0 - 12.0	0.5 - 5.0	5.0 - 12.5	Qt, CPhk	Thai side
SAd2-RFR1	Ing-Yot No.2 tunnel Adit No.2(main)	400		1.0 - 5.0	5.0 - 19.5	1.0 - 5.0	6.5 - 21.0	Qt, CPhk	Thai side
SAd3-RFR1	Ing-Yot No.2 tunnel Adit No.3(main)	500		0 - 4.5	9.0 - 16.5	0 - 4.5	11.5 - 18.5	Qt, CPnb	Thai side
SAd3-RFR2	Ing-Yot No.2 tunnel Adit No.3(sub)	500		0 - 4.0	6.0 - 21.0	0 - 4.0	9.0 - 23.0	Qt, CPnb	Thai side
SAd4-RFR2	Ing-Yot No.2 tunnel Adit No.4(main)	600		0 - 4.5	3.5 - 16.0	0 - 4.5	7.0 - 20.0	CPhk	Thai side
SAd4-RFR1	Ing-Yot No.2 tunnel Adit No.4(sub)	650		0 - 7.5	2.5 - 19.5	0 - 7.5	4.0 - 22.5	CPhk	Thai side
SAd5-RFR1	Ing-Yot No.2 tunnel Adit No.5(main)	300		0.5 - 5.0	4.0 - 19.0	0.5 - 5.0	5.5 - 22.0	TRhf	Thai side
SAd5-RFR2	Ing-Yot No.2 tunnel Adit No.5(sub)	500		0 - 18.0	1.0 - 20.5	0 - 18.0	2.0 - 34.0	TRhf	Thai side

Table11.2.2-32 Results of Reflection Prospecting Survey (Thckness of Velocity Layer)

Line Name	Location	Line Length (m)	Thickness of Each Layer (m)		Thickness from GL. (m)		Geological formation	Performed by
			1st layer	2nd layer	1st layer	2nd layer		
SAd6-RFR1	Ing-Yot No.2 tunnel Adit No.6(main)	500	0.5 - 4.5	2.0 - 19.0	0.5 - 4.5	3.5 - 20.5	TRhf	Thai side
SAd6-RFR2	Ing-Yot No.2 tunnel Adit No.6(sub)	500	0 - 8.5	5.0 - 18.0	0 - 8.5	5.0 - 23.0	TRhf	Thai side
SAd7-RFR1	Ing-Yot No.2 tunnel Adit No.7(main)	400	1.0 - 4.0	5.5 - 19.0	1.0 - 4.0	8.0 - 22.5	Qt, TRhf, (TRpl)	Thai side
SAd7-RFR2	Ing-Yot No.2 tunnel Adit No.7(sub)	500	0 - 7.5	8.5 - 24.0	0 - 7.5	8.5 - 26.0	Qt, TRhf	Thai side
SB49-RFR1	Ing-Yot No.2 tunnel outlet(main)	800	1.0 - 10.0	5.0 - 34.0	1.0 - 10.0	9.5 - 38.0	Qt, TRpl, TRhf	Thai side
SB49-RFR2	Ing-Yot No.2 tunnel outlet(sub)	600	0 - 24.0	0 - 23.5	0 - 24.0	3.5 - 29.0	Qt, TRpl, TRhf	Thai side
SKI-B20(Main)	Kok- Ing tunnel south route(main)	1,035	1.0 - 3.3	9.3 - 24.7	1.0 - 3.3	11.0 - 26.7	Qa, Qt	Thai side
SKI-B20(Sub)	Kok- Ing tunnel south route(sub)	345	0.7 - 2.3	18.0 - 25.5	0.7 - 2.3	19.0 - 27.7	Qa, Qt	Thai side
SB0(Main)	Ing-Yot No.1 tunnel (main)	990	0 - 6.0	0 - 10.7	0 - 6.0	3.0 - 15.3	Qt, ms3, TRpn	Thai side
SB0(Sub)	Ing-Yot No.1 tunnel (sub)	495	1.0 - 7.0	0 - 19.0	1.0 - 7.0	2.5 - 22.8	Qt, ms3, TRpn	Thai side
NY-A	Yao dam - dam axis	440	1.0 - 8.5	0 - 18.8	1.0 - 8.5	4.0 - 25.7	TRhf	Thai side
NY-B	Yao dam - left saddle	220	2.0 - 7.8	0 - 9.8	2.0 - 7.8	3.7 - 17.2	TRhf	Thai side
NY-C	Yao dam - cross section toward dam axi	385	0 - 5.6	0 - 10.8	0 - 5.6	0.6 - 13.2	TRhf	Thai side

* SKI-1 line, survey point (sp.) 1,060-1,130 has not data for existing of river flow.
* SKI-1 line, sp.0-700 is found out as 4-layer structure. The 4th layer shows Vp=2.3-2.5 km/sec, thickness of 3rd layer 11.6-19.8 m, thickness from GL. of 3rd layer 21.7-29.4 m
* SKI-1 line, high speed layers (3rd layer) are found out sp.3,060-3,170 (Vp=3.8 km/sec), 3,390-3,500 (Vp=3.7 km/sec), 3,500-3,610 (Vp=4.4 km/sec). In case of excluding the above high speed layer, 3rd layer shows Vp=2.2-2.9 km/sec.
* IY line, sp.325-450, 650-665, 1,155-1,925 show 2-layer structure. The 3rd layer shows Vp=3.0-4.8 km/sec excluding sp.0-155.
* SB0 (Main) line, sp.865-895, 2,075-2,170, 2,730-2,870 3,025-3,100 show 2-layer structure. The thickness of 1st layer of sp.2,075-2,170, 3,025-3,100 show 13.0 m, 5-10 m, respectively.
* SB0 (SubA), sp.L115-250, R15-45, 240-250 show 2-layer structure.
* SB0 (SubB), sp.L115-250, R70-250 show 2-layer structure. The thickness of !st layer at the right side shows 14.0 m.
* SB0 (SubC), sp.R65-300 shows 2-layer structure.
* S2B0 (Main), high speed layer (3rd layer) is found out sp.485-840 (Vp=3.8-4.0 km/sec).
* S2B0 (Sub), sp.150-250 shows 2-layer structure, high speed layer (3rd layer) is found out sp.R30-145 (Vp=4.1-4.3 km/sec). The thickness of 1st layer of sp.R150-250 shows
* SAd1 (Main), high speed layers (3rd layer) are found out sp.385-515 (Vp=3.5-3.6 km/sec), 855-1,000 (Vp=3.8 km/sec). In case of excluding the above high speed layer, the 3rd layer shows Vp=1.7-2.8 km/sec.

<Continued on the following page>

Table11.2.2-33 Results of Reflection Prospecting Survey (P-wave velocity)

Line Name	Length (m)	Vp along the Elevation 600 - 0 m Level (unit km/sec)							Vp at the Tunnel Invert Level (km/s)	Geology
		EL.600	EL.500	EL.400	EL.300	EL.200	EL.100	EL.0		
SKIT1-RFL1	1,200	-	-	3.8 - 4.1	4.0 - 4.3	4.1 - 4.8	-	-	3.8	Jv
SKIT2-RFL1	1,000	-	-	-	-	-	-	-	-	Bs, P3, PTR
SB0(Main)	4,500	-	3.0 - 4.2	3.1 - 4.4	3.3 - 4.6	3.4 - 4.8	4.0 - 4.9	4.6 - 5.1	3.2 - 4.5	CPhk
SB0(Sub)	900	3.2 - 3.6	3.3 - 3.8	3.5 - 4.1	3.9 - 4.5	4.1 - 4.8	-	-	4.3	CPhk
S2B0(Main)	1,600	-	-	3.8 - 4.4	4.1 - 5.1	4.5 - 6.3	5.0 - 7.3	5.6 - 7.7	4.0 - 4.7	TRhf, PTRv
S2B0(Sub)	900	-	4.8 - 5.8	5.6 - 6.6	6.3 - 7.1	6.0 - 7.3	-	-	6.7	TRhf
S2B0-RFL1	1,100	-	4.3 - 4.5	4.4 - 5.6	4.7 - 6.0	5.1 - 6.6	5.3 - 6.8	5.5 - 6.9	4.9	TRhf, (CPhk)
S2B0-RFL2	800	-	2.2 - 3.0	2.9 - 3.6	3.3 - 4.1	3.7 - 4.5	-	-	3.5	CPhk
SB8-RFL1	900	-	-	2.9 - 3.5	3.4 - 4.0	4.3 - 5.4	-	-	3.3	CPhk, CPnb, CPdm
SB10(Exit)	500	-	3.7 - 3.8	3.8 - 4.1	4.0 - 4.6	4.4 - 4.9	4.6 - 5.0	-	3.9 - 4.3	CPhk, CPnb
SB10(W)	600	-	3.2 - 3.9	3.6 - 4.4	4.1 - 4.9	5.2 - 5.6	5.6 - 5.9	-	3.8	CPnb
SB10(E.E)	900	-	3.4 - 3.5	3.8 - 4.0	4.1 - 4.8	4.5 - 5.4	-	-	4.2	CPnb
SAd2-RFL2	1,300	-	1.9 - 3.1	2.2 - 3.5	2.8 - 4.0	3.7 - 4.5	-	-	-	CPhk, TRpl, (Qt)
SB16(Main)	1,000	-	2.6 - 3.1	2.8 - 3.4	3.1 - 3.7	3.4 - 4.1	3.7 - 4.2	3.8 - 4.3	3.3	CPnb
SB16(Sub)	900	-	3.3 - 3.4	3.5 - 3.7	3.6 - 3.9	3.9 - 4.1	-	-	3.6	CPnb
SAd3-RFL1	900	-	2.3 - 2.8	2.5 - 3.2	3.2 - 3.6	3.6 - 3.9	-	-	-	CPnb
SB17(Main)	1,000	2.5 - 3.1	3.1 - 3.5	3.8 - 4.0	4.1 - 4.3	-	-	-	4.1	CPnb
SB17(Sub)	700	2.8 - 3.6	3.2 - 3.9	3.8 - 4.2	4.2 - 4.7	4.4 - 5.0	4.6 - 5.0	-	4.2	CPnb
SB21(Main)	1,100	-	4.2 - 4.5	4.5 - 4.7	4.9 - 5.0	5.1 - 5.6	5.3 - 5.7	-	4.8	CPnb
SB21(Sub)	700	-	3.4 - 3.6	3.8 - 4.2	4.2 - 5.2	5.0 - 5.4	-	-	-	CPnb
SB35(Main)	2,000	-	2.3 - 2.7	2.6 - 3.0	2.8 - 3.1	2.9 - 3.1	-	-	2.7 - 3.0	TRhf
SB35(Sub)	800	-	2.6 - 2.7	2.7 - 2.8	2.9 - 3.1	3.0 - 3.2	-	-	3	TRhf
SAd7-RFL1	1,600	-	-	3.6 - 4.5	3.9 - 4.9	4.4 - 5.2	4.6 - 5.6	4.9 - 5.6	-	TRhf, TRpl
SB46(Main)	900	-	-	3.2 - 4.6	3.5 - 4.9	3.9 - 5.2	4.2 - 5.4	4.4 - 5.5	4.5	TRhf, TRpl
SB48(Main)	1,100	-	-	3.1 - 3.8	3.9 - 4.6	4.5 - 5.4	-	-	3.6 - 4.3	TRhf
SB48(Sub)	800	-	-	3.1 - 4.7	3.5 - 5.0	4.0 - 5.5	4.6 - 5.8	-	4.9	TRhf, (TRpl)
SB49-RFL1	1,500	-	-	-	3.8 - 4.7	4.0 - 5.2	4.4 - 5.4	4.9 - 5.9	3.9	TRhf, TRpl

* Dense colour area shows Vp (P-wave velocity) of 5.0 km/sec or more.
* SKIT2-RFL1 survey line has not record as for velocity counter line.

Table11.2.2-33 Results of Reflection Prospecting Survey (P-wave velocity)

Line Name	Length (m)	Vp along the Elevation 600 - 0 m Level (unit km/sec)							Vp at the Tunnel Invert Level (km/s)	Geology
		EL.600	EL.500	EL.400	EL.300	EL.200	EL.100	EL.0		
SB46(Main)	900	-	-	3.2 - 4.6	3.5 - 4.9	3.9 - 5.2	4.2 - 5.4	4.4 - 5.5	4.5	TRhf, TRpl
Left side of survey point 150		-	-	3.2 - 3.5	3.5 - 3.9	3.9 - 4.4	4.2 - 4.7	4.4 - 4.9	-	TRhf
Right side of survey point 220		-	-	3.7 - 4.6	4.2 - 4.9	4.7 - 5.2	5.0 - 5.4	5.1 - 5.5	-	TRpl
SB48(Sub)	800	-	-	3.1 - 4.7	3.5 - 5.0	4.0 - 5.5	4.6 - 5.8	-	4.9	TRhf, (TRpl)
Left side of survey point 100		-	-	3.1 - 3.2	3.5 - 3.8	4.0 - 4.4	4.6 - 5.1	-	-	TRhf
Right side of survey point 220		-	-	4.6 - 4.7	4.9 - 5.0	5.4 - 5.5	5.6 - 5.8	-	-	TRpl

Table 11.2.2-34 Results of Reflection Prospecting Survey (Characteristics of Analyzed Section)

Line Name	Length (m)	General Description	Description around Tunnel Location
SKIT1-RFL1	1,200	Velocity contour lines show syncline feature around survey point (sp.) 440, and two clear discontinuities are found out at sp.300 (SSW-dip 70°) and sp.950 (NNE-dip 60°).	Tunnel location is situated on wing (NNE direction) of syncline feature as layer structures, and those around tunnel location show SSW-dip 40° .
SKIT1-RFL1	1,000	Clear anticline feature is found out at sp.320, and whole discontinuities shows SEE-dip with gradient 50-80°.	Tunnel location is situated at the area of dominant discontinuities with SEE-dip.
SB0(Main)	4,500	Velocity contour lines show both syncline feature around sp.980, sp.2,170 and sp.3,950 and anticline feature at sp. 4,300-4,500. Two clear discontinuities are found out at sp.2,200 (NNE-dip 60°) and sp.4,000 (SSW-dip 70°).	Layer structures along the tunnel line are flat or gentle gradient (less than 10° dip) for the most part, excluding existing of discontinuity (sp.2,100-2,600 (NNE-dip 10-15°)).
SB0(Sub)	900	Velocity contour lines show gentle syncline feature at sp.700-900. Feature of discontinuities can be classified NNW-dip at the NNW direction of survey line and SSE-dip at the SSE direction of that, respectively, and clear discontinuity is found out around sp.700 (SSE-dip 70-80°).	Tunnel location is situated in the distribution area of discontinuities, and layer structures around tunnel location show flat or gentle gradient.
S2B0(Main)	1,600	Velocity contour lines show syncline feature at sp.1,350-1,600. In this case, it is inferred that the range of TRhf shows high Vp in comparison with that of CPhk.	Layer structures along the tunnel line show flat or gentle gradient (less than 10° dip) for the most part, excluding distribution area of discontinuities.
S2B0(Sub)	900	Velocity contour lines show both syncline feature around sp.250 and gentle anticline feature around sp.670. Vp of this survey line are characterized by presence of high velocity in comparison with those of other survey line.	Layer structures at the tunnel location show gentle gradient with SSE-dip 5-10°.
S2B0-RFL1	1,100	Contour lines show high velocity at the south-direction of survey line, and clear discontinuity is found out around sp.450 (SEE-dip 65°).	Layer structures at the tunnel location show SSE-dip 15-20°.
S2B0-RFL2	800	Velocity contour lines show flat or gentle gradient for the most part, and clear discontinuity is found out around sp.450 (SSE-dip 60-65°).	Tunnel location is situated in the distribution area of discontinuities, which show SSE-dip 70° approximately.
SB8-RFL1	900	Velocity contour lines show both syncline feature from EL.400 to EL.300 at sp.0-200 and gentle anticline feature at sp.230-400.	Layer structures at the tunnel location show flat or gentle gradient (less than 10° dip).
SB10(Ext)	500	Velocity contour lines show anticline feature at sp.330-550, and clear discontinuity is found out at sp.50-150 (NWW-dip 65-70°).	Layer structures along the tunnel line show flat or gentle gradient (less than SEE-dip 5°).
SB10(W)	600	Velocity contour lines show anticline feature from EL.500 to EL.230 around sp.250. Feature of discontinuities can be classified N-dip at the S direction of survey line and S-dip at the N direction of that, respectively.	Layer structures at the tunnel location show S-dip 15° approximately.

* In the above table, the direction and dip as for discontinuity etc. mean apparent that.

Table 11.2.2-35 Results of Reflection Prospecting Survey (Characteristics of Analyzed Section)

Line Name	Length (m)	General Description	Description around Tunnel Location
SB10(E.E)	900	Syncline and anticline features on a large scale of velocity contour lines are hardly recognizable. Two clear discontinuities are found out at sp.E200 (SSW -dip 45°) and sp.E'300 (NNE-dip 60°).	Layer structures at the tunnel location show gentle gradient with NNE-dip 5-10°.
SAd2-RFL2	1,300	Velocity contour lines show syncline features, which is inferred to be ascribed to existing of thick diluvial deposits or weathered rock zone, at sp.400-1,200. Layer structures along the survey line show flat or gentle gradient with NNE-dip 5-10°. Especially, layer structures of sp.1,000-1,300 show monotonous feature.	—
SB16(Main)	1,000	Velocity contour lines show monotonous feature, and Vp of this survey line is characterized by presence of low velocity in comparison with those of other survey lines. Gradient of discontinuities shows steep gradient (70-90°).	Layer structures at the tunnel location show NW-dip 15-20°.
SB16(Sub)	900	Velocity contour lines show anticline feature around sp.480, and two clear discontinuities are found out at sp.0-200 (NNE-dip 45-60°) and sp.450-500 (SSW-dip 70°). Velocity of this survey line shows higher than those of SB16 (Main), suggesting existing of anisotropic characteristic in base rock.	Layer structures at the tunnel location show almost flat or gentle gradient.
SAd3-RFL1	900	Velocity contour lines show remarkable anticline feature, which is inferred to be ascribed to existing of base rock at the shallow depth, at sp.750-900. Layer structures along the survey line show flat or gentle gradient with NNE-dip 5-10°.	—
SB17(Main)	1,000	Velocity contour lines show monotonous feature, and two clear discontinuities are found out at/around sp.150-200 (NWW-dip 55°) and sp.700(SEE-dip 60-70°).	Layer structures at the tunnel location show NWW-dip 20-25°.
SB17(Sub)	700	Velocity contour lines have monotonous gentle gradient, which signify to rise toward SSW direction.	Layer structures at the tunnel location show flat or gentle gradient with SSE-dip 5°, and discontinuities (SSE-dip 60-70°) are recognized around tunnel
SB21(Main)	1,100	Velocity contour lines show monotonous feature, which signify almost flat or gentle gradient. Two clear discontinuities are found out at/around sp.250 (SEE-dip 80°) and sp.600-650 (NWW-dip 70°).	Tunnel location is situated between two discontinuities, and layer structures show steep gradient with NWW-dip 55-60°.
SB21(Sub)	700	Velocity contour lines show anticline feature at sp.350-400. Clear discontinuity is found out at sp.500-550 (SSW-dip 75°), and syncline feature as layer structure is recognized at the SSW direction of that.	—
SB35(Main)	2,000	Velocity contour lines show both syncline feature at sp.450-600 and anticline feature at sp.1,550-1,650. Vp of this survey line is characterized by presence of low velocity in comparison with that of other survey lines. Three clear discontinuities are found out around sp.400 (NW-dip 85°), sp.600 (SE-dip 60°) and sp.1,500 (SE-dip 70-75°).	Layer structures along the tunnel line show flat or gentle gradient (less then 20°), excluding around the above discontinuities, where shows steep gradient (dip 50- 70°, approximately).

Table 11.2.2-36 Results of Reflection Prospecting Survey (Characteristics of Analyzed Section)

Line Name	Length (m)	General Description	Description around Tunnel Location
SB35(Sub)	800	Velocity contour lines show monotonous feature, which signify almost flat or gentle gradient. Discontinuity is found out around sp.200 (SSW-dip 50°), and layer structures show NWW-dip at the deep portion (EL.400-200) of sp.400-800	Layer structures at the tunnel location show NEE-dip 20-30°.
SAd7-RFL1	1,600	Velocity contour lines show anticline feature at sp.250-350 and sp.950-1,300. Layer structures along the survey line show complex fold feature , which are remarkably recognized at/around sp.250-500 (N-dip 50-60°, sp.500-650 (S-dip 50-60°) and sp.1,100 (N-dip 55-60°), and these fold shapes are probably ascribed to the existing of discontinuities.	—
SB46(Main)	900	Velocity contour lines show high-speed feature at the NNE side from sp.220, which probably involve existing of limestone. A number of discontinuities (NNE-dip) are found out at sp.0-300.	Layer structures at the tunnel location show SSW-dip 15-20°.
SB48(Main)	1,100	Velocity contour lines show both syncline feature around sp.200 and anticline feature around sp.400.	Layer structures along the tunnel line show flat or gentle gradient, excluding at/around sp.120-250 (NW-dip 60°) and sp.800 (SE-dip 30-40°). Clear discontinuity is found out around sp.500 (NW-dip 55-60°).
SB48(Sub)	800	Velocity contour lines show high-speed feature at the SW side from sp.300-350, which probably involve existing of limestone. Clear discontinuities are found out at sp.50-150 (SW-dip 60°) and sp.300-450 (NE-dip 40°).	Layer structures at the tunnel location show gentle gradient (NE-dip 5-10°).
SB49-RFL1	1,500	Velocity contour lines show anticline feature at sp.100-200 and sp.700-850. A number of discontinuities, which are complex with a variety of gradient direction, are find out along the survey line.	Layer structures at the tunnel location show N-dip 20°, approximately.

Table 11.2.2-37 Summary of Drilling Results at the Yao Flood Control Dam (1)

DH - 1 (L = 50.0 m, G.L.(EL.) 321.5)			
Location: Right abutment along the dam axis			
Geological Condition		Rock Class. Condition	
Depth	Geology	Depth	Rock Class.
0 - 1.5 m	Soil	0 - 1.5 m	D
1.5 - 7.0 m	Shale interbedded with s.s.	1.5 - 5.0 m	CL
7.0 - 14.0 m	Shale	5.0 - 6.0 m	CL - CM
14.0 - 18.0 m	Sandstone	6.0 - 10.0 m	CL
18.0 - 50.0 m	Tuff	10.0 - 13.0 m	D - CL
		13.0 - 18.0 m	CL
N value, 1.0 m 16		18.0 - 20.0 m	CM
		20.0 - 22.0 m	CL - CM
		22.0 - 23.3 m	CM
		23.3 - 42.0 m	CM - CH
		42.0 - 43.0 m	CL - CM
		43.0 - 48.4 m	CM
		48.4 - 49.1 m	CL
		49.1 - 50.0 m	CM

DH - 2 (L=80.0 m, G.L.(EL.) 283.5)			
Location: River portion along the dam axis			
Geological Condition		Rock Class. Condition	
Depth	Geology	Depth	Rock Class.
0 - 6.1 m	Soil	0 - 6.1 m	D
6.1 - 52.0 m	Tuff	6.1 - 12.8 m	D - CL
52.0 - 55.0 m	Sandstone	12.8 - 13.0 m	CL
55.0 - 57.4 m	Shale	13.0 - 13.7 m	CL - CM
57.4 - 59.0 m	Sandstone	13.7 - 14.0 m	D - CL
59.0 - 80.0 m	Sandstone interbedded with sh.	14.0 - 22.0 m	CL
		22.0 - 23.0 m	CL - CM
		23.0 - 39.0 m	CL
		39.0 - 52.0 m	CM
		52.0 - 55.0 m	CM - CH
		55.0 - 57.4 m	CL - CM
		57.4 - 60.0 m	CM
		60.0 - 61.0 m	CL
		61.0 - 68.8 m	CM
		68.8 - 75.2 m	CL - CM
		75.2 - 79.0 m	CM
		79.0 - 80.0 m	CM - CH

DH - 3 (L=60.0 m, G.L.(EL) 295.8)			
Location: Left abutment along the dam axis			
Geological Condition		Rock Class. Condition	
Depth	Geology	Depth	Rock Class.
0 - 4.0 m	Soil	0 - 4.0 m	D
4.0 - 18.0 m	Shale	4.0 - 6.0 m	D - CL
18.0 - 44.0 m	Sandstone	6.0 - 7.7 m	CL
44.0 - 48.4 m	Shale	7.7 - 8.0 m	D - CL
48.4 - 51.0 m	Sandstone	8.0 - 8.2 m	CL
51.0 - 60.0 m	Sandstone interbedded with sh.	8.2 - 14.0 m	D - CL
		14.0 - 18.0 m	CL - CM
N value, 1.0 m - 20		18.0 - 21.0 m	CM
2.0 m - 21		21.0 - 22.2 m	CM - CH
3.0 m - 26		22.0 - 33.2 m	CL - CM
		33.2 - 35.6 m	CM
		35.6 - 36.6 m	CL
		36.6 - 44.3 m	CM - CH
		44.3 - 48.8 m	CL
		48.8 - 50.8 m	CM
		50.8 - 60.0 m	CL - CM

Table11.2.2-38 Summary of Drilling Results at the Yao Flood Control Dam (2)

DH - 4 (L=50.0 m, G.L.(EL) 330.8)			
Location: Left abutment along the dam axis			
Geological Condition		Rock Class. Condition	
Depth	Geology	Depth	Rock Class.
0 - 5.0 m	Soil	0 - 10.0 m	D
5.0 - 37.0 m	Shale	10.0 - 11.0 m	D - CL
37.0 - 50.0 m	Sandstone	11.0 - 13.0 m	D
N value, 1.0 m - 17 2.0 m - 24 3.0 m - 21 4.0 m - 33		13.0 - 15.5 m	D - CL
		15.5 - 34.0 m	D
		34.0 - 35.0 m	CL
		35.0 - 37.2 m	CM
		37.2 - 39.0 m	CL-CM
		39.0 - 39.5 m	CM
		39.5 - 43.2 m	CL - CM
		43.2 - 43.8 m	CM
		43.8 - 45.0 m	CL
		45.0 - 48.6 m	CM - CH
		48.6 - 50.0 m	CL - CM

DH - 5 (L=30.0 m, G.L.(EL) 328.4)			
Location: Left side mountain area			
Geological Condition		Rock Class. Condition	
Depth	Geology	Depth	Rock Class.
0 - 3.3 m	Soil	0 - 6.0 m	Soil
3.3 - 15.0 m	Shale	6.0 - 7.0 m	D - CL
15.0 - 16.0 m	Sandstone	7.0 - 9.0 m	D
16.0 - 30.0 m	Shale interbedded with s.s.	9.0 - 10.0 m	D - CL
N value, 1.0 m - 12 2.0 m - 14 3.0 m - 37		10.0 - 15.4 m	CL
		15.4 - 16.1 m	CL
		16.1 - 16.5 m	CM
		16.5 - 23.3 m	CL
		23.3 - 27.0 m	CM
		27.0 - 29.0 m	CL - CM
		29.0 - 30.0 m	CM - CH

DH - 6 (L=30.0 m, G.L.(EL) 315.9)			
Location: Left side mountain area			
Geological Condition		Rock Class. Condition	
Depth	Geology	Depth	Rock Class.
0 - 3.0 m	Soil	0 - 3.5 m	D
3.0 - 30.0 m	Sandstone	3.5 - 9.0 m	CL
N value, 1.0 m - 10 2.0 m - 14 3.0 m - 10/0		9.0 - 18.2 m	CL - CM
		18.2 - 20.5 m	CM
		20.5 - 23.1 m	CL - CM
		23.1 - 23.9 m	CM
		23.9 - 24.1 m	D
		24.1 - 25.5 m	CM - CH
		25.5 - 26.0 m	CL
		26.0 - 26.8 m	CM
		26.8 - 28.0 m	CL - CM
		28.0 - 28.3 m	CM - CH
		28.3 - 28.5 m	CL - CM
		28.5 - 29.0 m	CM - CH
		29.0 - 29.5 m	CL
		29.5 - 30.0 m	CM

Table 11.2.2-39 Results of Lugeon Test at the Yao Flood Control Dam (1)

DH-1 (EL.321.5)					
Testing Depth From	Testing Depth To	k (cm/sec)	Lu	Geology	Rock Class.
1.3	---	1.8×10^{-3}	141.5	Soil	D
1.5	3.0	6.8×10^{-5}	5.2	Shale	CL
3.0	6.0	1.7×10^{-3}	132.3	Shale	CL, CL-CM
6.0	9.0	1.2×10^{-3}	90.8	Shale	CL
9.0	12.0	1.7×10^{-3}	126.9	Shale	D-CL, CL
12.0	15.0	1.7×10^{-3}	13.2	Shale, S.s.	D-CL, CL
15.0	18.0	9.9×10^{-4}	76.1	Sandstone	CL
18.0	21.0	4.3×10^{-5}	5.6	Tuff	CL-CM, CM
21.0	24.0	4.3×10^{-4}	5.6	Tuff	CL-CM, CM, CM-CH
24.0	27.0	---	0.4	Tuff	CM-CH
27.0	30.0	---	0.0	Tuff	CM-CH
30.0	33.0	---	0.7	Tuff	CM-CH
33.0	36.0	---	1.4	Tuff	CM-CH
36.0	39.0	8.7×10^{-5}	6.7	Tuff	CM-CH
39.0	42.0	8.7×10^{-5}	6.7	Tuff	CM-CH
42.0	45.0	---	0.0	Tuff	CL-CM, CM
45.0	48.0	---	2.3	Tuff	CM
47.0	50.0	---	2.2	Tuff	CL, CM

* G.W.L.: GL.-17.8 m (26/6/98)
* k: coefficient of permeability, Lu: Lugeon value
* Lugeon value: thin figures show converted Lugeon value, dense figures show Lugeon value by Lugeon test.

DH-2 (EL.283.5)					
Testing Depth From	Testing Depth To	k (cm/sec)	Lu	Geology	Rock Class.
3.0	---	5.3×10^{-4}	40.8	Soil	D
4.0	---	2.0×10^{-2}	1,530.8	Soil	D
6.0	---	3.7×10^{-3}	286.9	Soil	D
7.0	---	3.7×10^{-3}	286.9	Tuff	D-CL
7.0	9.0	4.9×10^{-4}	37.8	Tuff	D-CL
9.0	10.0	2.7×10^{-5}	2.1	Tuff	D-CL
10.0	12.0	1.2×10^{-4}	9.5	Tuff	D-CL
12.0	13.0	8.1×10^{-4}	62.5	Tuff	D-CL, CL
13.0	15.0	1.2×10^{-3}	88.5	Tuff	D-CL, CL, CL-CM
15.0	16.0	1.4×10^{-3}	103.8	Tuff	CL
16.0	18.0	9.7×10^{-5}	7.5	Tuff	CL
18.0	21.0	2.1×10^{-5}	1.6	Tuff	CL
21.0	24.0	---	8.8	Tuff	CL, CL-CM
24.0	27.0	---	9.4	Tuff	CL
27.0	30.0	---	8.0	Tuff	CL
30.0	33.0	1.2×10^{-4}	9.3	Tuff	CL
33.0	36.0	6.0×10^{-5}	4.6	Tuff	CL
36.0	39.0	2.4×10^{-4}	18.5	Tuff	CL
39.0	42.0	6.0×10^{-5}	4.6	Tuff	CM
42.0	45.0	6.0×10^{-5}	4.6	Tuff	CM
45.0	48.0	6.0×10^{-5}	4.6	Tuff	CM
48.0	50.0	8.2×10^{-5}	6.3	Tuff	CM
50.0	54.0	2.9×10^{-4}	22.2	Tuff, S.s.	CM, CM-CH
54.0	57.0	---	2.2	S.s., Shale	CL-CM, CM-CH
57.0	60.0	3.6×10^{-4}	27.8	Shale, S.s.	CL-CM, CM
60.0	63.0	---	1.6	Sandstone	CL, CM
63.0	66.0	---	1.5	Sandstone	CM
66.0	69.0	---	1.5	Sandstone	CL-CM, CM
69.0	72.0	3.6×10^{-4}	27.8	Sandstone	CL-CM
72.0	75.0	4.8×10^{-4}	37.1	Sandstone	CL-CM
75.0	78.0	6.0×10^{-4}	46.4	Sandstone	CM
78.0	80.0	6.6×10^{-4}	50.5	Sandstone	CM, CM-CH

* G.W.L.: GL.-3.2 m (19/7/98)

DH-3 (EL.295.8)					
Testing Depth From	Testing Depth To	k (cm/sec)	Lu	Geology	Rock Class.
1.3	---	impervious		Soil	D
2.3	---	impervious		Soil	D
3.3	---	1.2×10^{-3}	92.3	Soil	D
4.0	---	9.9×10^{-4}	76.5	Soil	D
4.0	5.0	2.9×10^{-4}	22.2	Shale	D-CL
5.0	6.0	2.4×10^{-4}	18.2	Shale	D-CL
6.0	7.0	2.0×10^{-4}	15.4	Shale	CL
7.0	8.0	2.0×10^{-4}	15.5	Shale	D-CL, CL
8.0	9.0	2.6×10^{-4}	19.6	Shale	D-CL, CL
9.0	10.0	2.3×10^{-4}	17.5	Shale	D-CL
10.0	11.0	2.3×10^{-4}	17.5	Shale	D-CL
11.0	12.0	2.1×10^{-4}	15.9	Shale	D-CL
12.0	13.0	2.1×10^{-4}	16.0	Shale	D-CL
13.0	14.0	2.0×10^{-4}	15.4	Shale	D-CL
14.0	15.0	2.0×10^{-4}	15.4	Shale	CL-CM
15.0	16.0	2.0×10^{-4}	15.4	Shale	CL-CM
16.0	17.0	2.2×10^{-4}	16.7	Shale	CL-CM
17.0	18.0	2.2×10^{-4}	16.7	Shale	CL-CM
18.0	21.0	---	5.7	Sandstone	CM
21.0	24.0	---	6.5	Sandstone	CL-CM, CM-CH
24.0	27.0	---	2.5	Sandstone	CL-CM
27.0	30.0	---	2.2	Sandstone	CL-CM
30.0	33.0	---	2.7	Sandstone	CL-CM
33.0	36.0	---	3.0	Sandstone	CL, CL-CM, CM
36.0	39.0	---	4.5	Sandstone	CL, CM-CH
39.0	42.0	---	4.4	Sandstone	CM-CH
42.0	45.0	---	4.4	S.s., Shale	CL, CM-CH
45.0	48.0	---	5.3	Shale	CL
48.0	51.0	---	5.0	Shale, S.s.	CL, CL-CM, CM
51.0	54.0	---	5.9	Sandstone	CL-CM
54.0	57.0	---	6.6	Sandstone	CL-CM
57.0	60.0	---	6.6	Sandstone	CL-CM

* G.W.L.: GL.-13.0 m (24/7//98)

Table 11.2.2-40 Results of Lugeon Test at the Yao Flood Control Dam (2)

DH-4 (EL.330.8)					
Testing Depth		k (cm/sec)	Lu	Geology	Rock Class.
From	To				
1.3	---	3.1×10^{-3}	235.4	Soil	D
2.3	---	1.7×10^{-3}	133.1	Soil	D
3.3	---	1.2×10^{-3}	92.3	Soil	D
4.3	---	1.4×10^{-3}	106.9	Soil	D
5.0	---	1.2×10^{-3}	91.5	Soil	D
6.0	---	1.2×10^{-3}	91.5	Shale	D
7.0	---	1.0×10^{-3}	78.5	Shale	D
8.0	---	9.9×10^{-4}	76.5	Shale	D
9.0	---	8.8×10^{-4}	68.0	Shale	D
10.0	---	8.8×10^{-4}	67.3	Shale	D
11.0	---	8.0×10^{-4}	61.2	Shale	D-CL
12.0	---	7.3×10^{-4}	56.1	Shale	D
13.0	---	6.7×10^{-4}	51.8	Shale	D
14.0	---	6.5×10^{-4}	50.2	Shale	D-CL
15.0	---	6.1×10^{-4}	46.9	Shale	D-CL
16.0	---	5.7×10^{-4}	44.0	Shale	D
17.0	---	5.6×10^{-4}	43.2	Shale	D
18.0	---	5.7×10^{-4}	44.2	Shale	D
19.0	---	5.4×10^{-4}	41.8	Shale	D
20.0	---	4.6×10^{-4}	35.2	Shale	D
21.0	---	5.3×10^{-4}	40.8	Shale	D
22.0	---	4.7×10^{-4}	36.2	Shale	D
23.0	---	4.5×10^{-4}	34.6	Shale	D
24.0	---	3.8×10^{-4}	29.2	Shale	D
25.0	---	4.5×10^{-4}	34.6	Shale	D
26.0	---	5.2×10^{-4}	39.9	Shale	D
27.0	---	5.2×10^{-4}	39.9	Shale	D
28.0	---	1.0×10^{-3}	80.0	Shale	D
29.0	---	1.0×10^{-3}	80.0	Shale	D
30.0	---	1.0×10^{-3}	80.0	Shale	D
31.0	---	1.0×10^{-3}	80.0	Shale	D
32.0	---	1.1×10^{-3}	86.2	Shale	D
33.0	---	1.1×10^{-3}	86.2	Shale	D
34.0	---	1.1×10^{-3}	86.2	Shale	D
34.0	35.0	1.6×10^{-4}	12.3	Shale	CL
35.0	38.0	1.9×10^{-4}	14.2	Shale, S.s.	CL-CM, CM
38.0	41.0	1.9×10^{-4}	14.2	Sandstone	CL-CM, CM

<Continue to the left side sheet>

DH-5 (EL.328.4)					
Testing Depth		k (cm/sec)	Lu	Geology	Rock Class.
From	To				
2.3	---	1.2×10^{-4}	93.1	Soil	D
3.3	---	1.1×10^{-4}	83.1	Soil	D
4.0	---	9.9×10^{-4}	76.5	Shale	D
5.0	---	8.0×10^{-4}	61.2	Shale	D
6.0	---	1.2×10^{-3}	91.5	Shale	D
7.0	---	1.1×10^{-3}	87.7	Shale	D-CL
8.0	---	1.1×10^{-3}	83.8	Shale	D
9.0	---	9.7×10^{-4}	74.8	Shale	D
10.0	---	8.8×10^{-4}	67.3	Shale	D-CL
10.0	12.0	3.2×10^{-4}	24.2	Shale	CL
12.0	15.0	2.5×10^{-4}	19.3	Shale	CL
15.0	18.0	---	6.5	S.s., Shale	CL, CM
18.0	21.0	---	6.1	Shale	CL
21.0	24.0	---	2.3	Shale	CL, CM
24.0	27.0	---	2.0	Shale	CM
27.0	30.0	---	2.0	Shale	CL-CM, CM-CH

* G.W.L.: GL.-10.0 m (2/8//98)

41.0	44.0	2.4×10^{-4}	18.1	Sandstone	CL, CL-CM, CM
44.0	47.0	2.9×10^{-4}	22.6	Sandstone	CL, CM-CH
47.0	50.0	2.9×10^{-4}	22.6	Sandstone	CL-CM, CM-CH

* G.W.L.: GL.-23.0 m (24/6//98)

DH-6 (EL.315.9)					
Testing Depth		k (cm/sec)	Lu	Geology	Rock Class.
From	To				
1.3	---	impervious		Soil	D
2.3	---	impervious		Soil	D
3.0	---	8.0×10^{-4}	61.2	Soil	D
6.0	---	3.2×10^{-2}	2,446.0	Sandstone	CL
6.0	9.0	2.5×10^{-3}	193.1	Sandstone	CL
9.0	12.0	1.7×10^{-4}	13.4	Sandstone	CL-CM
12.0	14.0	1.3×10^{-4}	10.1	Sandstone	CL-CM
14.0	17.0	1.2×10^{-3}	89.2	Sandstone	CL-CM
17.0	20.0	---	4.9	Sandstone	CL-CM, CM
20.0	23.0	---	4.4	Sandstone	CL-CM, CM
23.0	26.0	---	4.2	Sandstone	D, CL, CM-CH
26.0	29.0	---	7.1	Sandstone	CL-CM, CM, CM-CH

* G.W.L.: GL.-2.0 m (10/7//98)

Figure11.2.2-18 Relationship between Depth and Lugeon Value at the Yao Flood Control Dam

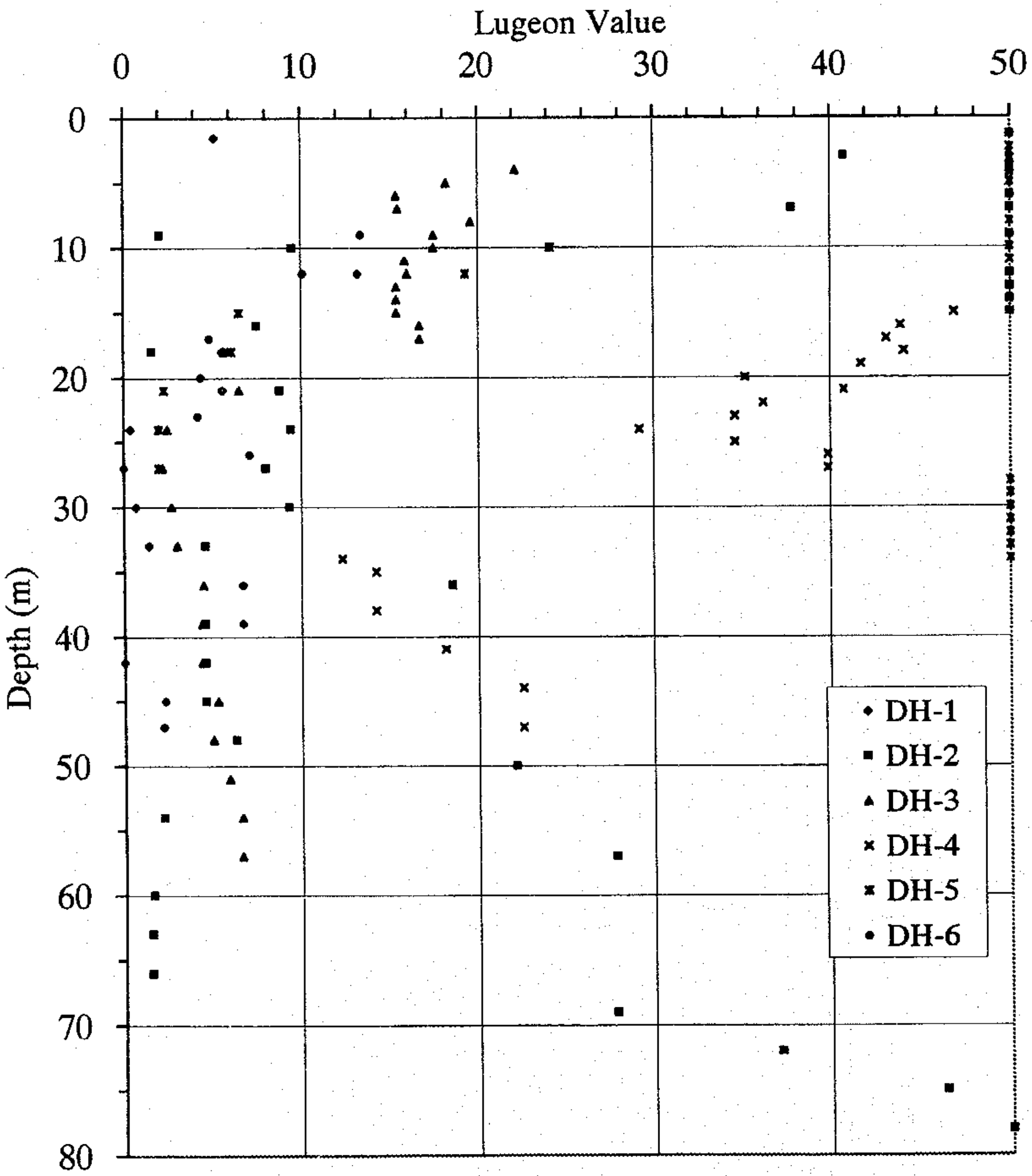


Table11.2.2-41 Results of Test Pitting and Augerhole Drilling at the Proposed Borrow Area

Pit No.	Depth (m)	USCS
TP.A1	0 - 4.0	ML
TP.A4	0 - 4.0	ML
TP.A5	0 - 2.0	ML
	2.0 - 4.0	GM
TP.A8	0 - 4.0	ML
TP.A11	0 - 2.0	GM
TP.A12	0 - 2.0	ML
TP.A15	0 - 4.0	ML
TP.A16	0 - 4.0	ML
TP.A17	0 - 4.0	ML
TP.A19	0 - 4.0	ML
TP.A22	0 - 4.0	ML
TP.A24	0 - 4.0	ML
TP.A27	0 - 4.0	ML
TP.A28	0 - 4.0	ML
TP.A30	0 - 4.0	ML
TP.A33	0 - 2.0	ML
	2.0 - 4.0	SM
TP.A36	0 - 4.0	ML
TP.A38	0 - 4.0	ML
TP.A41	0 - 4.0	SM
TP.A45	0 - 4.0	ML
TP.A47	0 - 4.0	ML
TP.A51	0 - 4.0	ML
TP.A53	0 - 4.0	SM
TP.A55	0 - 4.0	ML
TP.A57	0 - 1.5	ML
	1.5 - 4.0	GM

Pit No.	Depth (m)	USCS
A.1	0 - 2.5	ML
A.2	0 - 2.1	GM
A.3	0 - 2.5	ML
A.4	0 - 1.8	ML
A.5	0 - 1.5	ML
A.6	0 - 2.2	ML
A.7	0 - 4.0	ML
A.8	0 - 1.8	ML
A.9	0 - 2.0	ML
A.10	0 - 2.0	ML
A.11	0 - 1.7	GM
A.12	0 - 3.0	ML
A.13	0 - 2.3	ML
A.14	0 - 3.0	ML
A.15	0 - 2.5	ML
A.16	0 - 2.1	ML
A.17	0 - 3.0	ML
A.18	0 - 1.5	ML
A.19	0 - 2.3	ML
A.20	0 - 1.5	ML
A.21	0 - 2.5	ML
A.22	0 - 1.1	ML
A.23	0 - 3.0	ML
A.24	0 - 2.0	ML
A.25	0 - 1.0	ML
A.26	0 - 2.0	ML
A.27	0 - 2.5	ML
A.28	0 - 2.2	ML
A.29	0 - 2.1	ML
A.30	0 - 1.5	ML

Pit No.	Depth (m)	USCS
A.31	0 - 2.1	ML
A.32	0 - 2.1	ML
A.33	0 - 2.8	ML
A.34	0 - 2.3	ML
A.35	0 - 2.4	ML
A.36	0 - 1.8	ML
A.37	0 - 1.2	ML
A.38	0 - 2.7	ML
A.39	0 - 2.2	ML
A.40	0 - 2.0	ML
A.41	0 - 1.7	SM
A.42	0 - 2.1	ML
A.43	0 - 1.8	ML
A.44	0 - 2.3	ML
A.45	0 - 1.2	ML
A.46	0 - 2.1	ML
A.47	0 - 1.5	ML
A.48	0 - 2.2	ML
A.49	0 - 2.6	ML
A.50	0 - 1.5	ML
A.51	0 - 1.5	ML
A.52	0 - 1.5	ML
A.53	0 - 1.0	SM
A.54	0 - 2.1	ML
A.55	0 - 4.0	ML
A.56	0 - 2.0	ML
A.57	0 - 1.5	ML

* USCS: Unified soil classification system

* ML: Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts, with slight plasticity.

GM: Silty gravels, gravel-sand-clay mixtures.

SM: Silty sands, sand-silt mixtures.

Table 11.2.2-42 Results of Soil Test at the Proposed Borrow Area

Sample No.	Sampling Depth	Atterberg Limits (%)			Gradation (% Passing)					USCS Group
		LL.	PL.	PL.	#3/4	#4	#10	#40	#200	
TP.A5	2.0 - 4.0 m	30.2	27.3	2.9	100.0	58.4	43.3	24.4	19.1	GM
TP.A12	0 - 4.0 m	36.1	26.3	9.8	100.0	99.6	99.1	94.6	86.8	ML
TP.A16	0 - 4.0 m	38.9	32.8	6.1	100.0	87.9	84.5	83.2	81.8	ML
TP.A17	0 - 4.0 m	38.5	31.8	6.7	100.0	78.2	70.5	59.3	50.7	ML
TP.A28	0 - 4.0 m	41.8	30.0	11.8	100.0	92.1	85.4	80.1	77.1	ML
TP.A30	0 - 4.0 m	46.6	37.1	9.5	100.0	84.7	73.9	63.9	58.4	ML
TP.A33	0 - 2.0 m	48.3	30.4	17.9	---	---	100.0	96.5	89.8	ML
	2.0 - 4.0 m	29.9	26.0	3.9	100.0	91.7	84.5	66.9	44.3	SM
TP.A38	0 - 4.0 m	33.8	29.7	4.1	100.0	98.4	96.7	84.7	67.5	ML
TP.A41	0 - 4.0 m	29.3	27.1	2.2	100.0	90.8	78.6	55.0	37.1	SM
TP.A53	0 - 4.0 m	36.7	32.4	4.3	100.0	90.2	81.7	57.8	43.6	SM

* USCS: Unified soil classification system
* ML: Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts, with slight plasticity.
GM: Silty gravels, gravel-sand-clay mixtures.
SM: Silty sands, sand-silt mixtures.

Figure11.2.2-19 Grain Size Accumulation Curve of Soil Materials at the Borrow Area

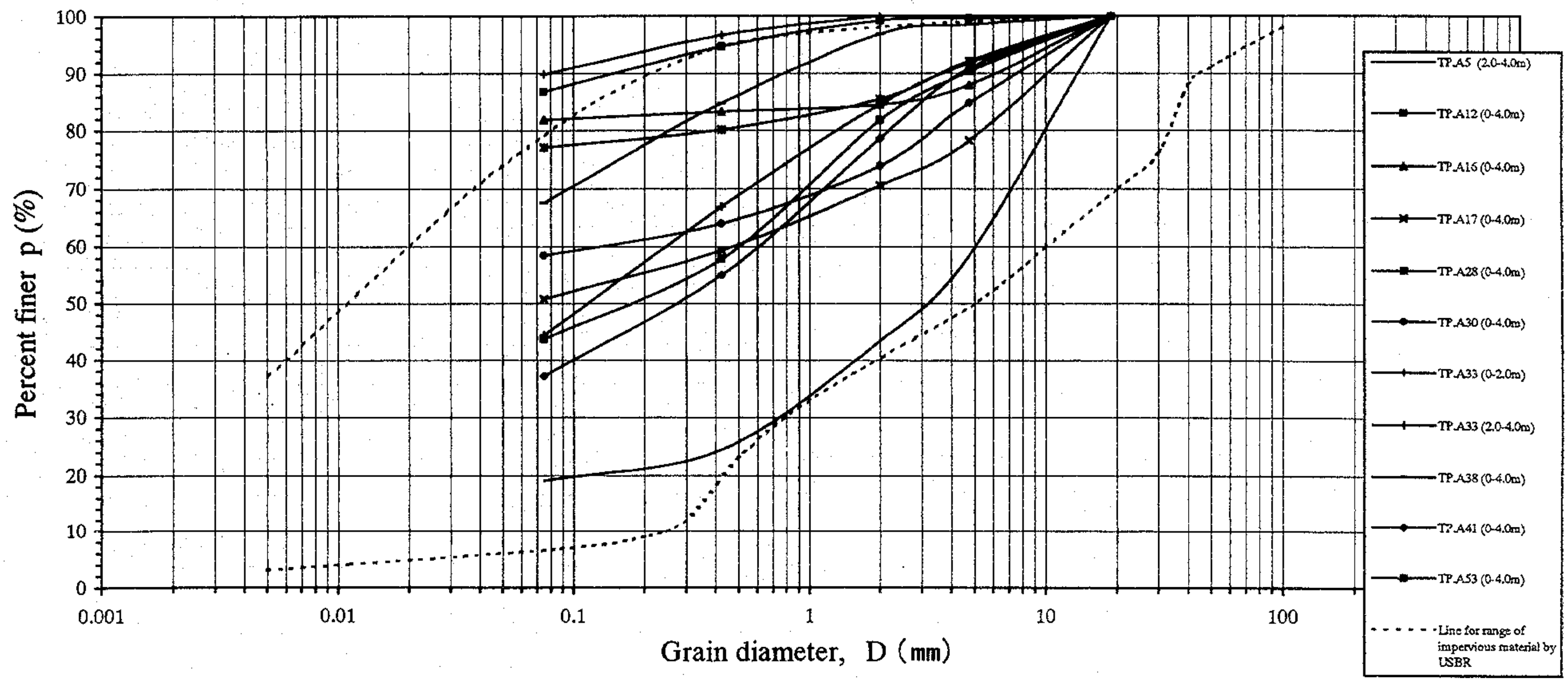


Table 11.2.2-43 Results of Water Quality Analysis

			ST.1		ST.2		ST.3		ST.4	
			DHBJ 26.0		Pangtham		Phusang waterfall		Phusang river	
		ppm---epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm
pH		---	7.6	---	7.7	---	7.6	---	7.4	---
Conductivity	micromho/cm	---	570.0	---	450.0	---	200.0	---	510.0	---
Temperature		---	---	---	22.2	---	27.5	---	24.5	---
Chloride	Cl^-	0.02820	1.9	0.05	1.1	0.03	0.7	0.02	0.7	0.02
Bicabonate Alkalinity	$CaCO_3$	0.01998	236.0	4.72	197.0	3.94	234.0	4.68	76.0	1.52
Sulfate	So_4^{2-}	0.02082	28.0	0.58	5.0	0.10	4.0	0.08	2.5	0.05
Nitrate	N	---	0.02 or less	---	0.7	---	0.0	---	0.3	---
Calcium	Ca^{2+}	0.04990	33.0	1.65	74.0	3.69	69.0	3.44	19.0	0.95
Magnesium	Mg^{2+}	0.08224	4.1	0.34	2.9	0.24	11.5	0.95	4.1	0.34
Potassium	K^+	0.02558	0.4	0.01	0.4	0.01	1.4	0.03	1.5	0.04
Sodium	Na^+	0.04350	84.0	3.65	2.9	0.13	7.0	0.31	6.8	0.30

* ppm : parts per milion (mg/liter), * epm : equivalent per million

* ST.1 (DHBJ 26.0) : aquifer water, ST.2 (Pangtham) : water from limestone cave,
ST.4 (Phusang river) : river water in front of waterfall

Geological Relationship between Tunnel and Phu Sang Waterfall

Geological condition of the section from STA.7+050 to STA.10+000 consists of the CPnb formation in Carboniferous-Permian age which is characterized by foliated dark gray slate interbedded with sandstone. Overburden condition shows 120 to 340 m in thickness and rock facies indicate medium hard to hard but somewhat breakable along bedding plain of the slate.

Geological condition from STA.7+050 to STA.10+000 consists of the CPnb formation characterized by foliated dark gray slate interbedded with sandstone. According to the drilling data, the geological condition shows sandstone and slate as follows.

Classification of Geological Condition of Borehole No. DHB-5

Drilling Depth	Soil	Sandstone	Shale, slate	Phyllite
120 m	7.0 m	56.9 m	54.6 m	1.5 m

The section from STA.10+000 to STA.11+200 is located on the northern part of the heated groundwater area (Phu Sang spring area). This spring has 27.5° C (river water is 24.5° C) water temperature and 498 micro-s/cm in conductivity.

The results of TEM prospecting reveal the existence of extremely low resistivity (5 to 10 ohm-m or less) from which it is inferred that cracks of basement rock at this area may be partly filled up by the above heated water.

These resistivity values may support the idea that geological condition of this area is derived from marine sediments.

Furthermore, their thermal origin is presumed to be related to the igneous rocks (granite or porphyry), which is continued for a great depth at a deeper portion, and some faults located around this section may be regarded as a passage of the heated groundwater.

In addition, this heated groundwater is characterized by rich in calcium according to the results of water quality analysis.

In accordance with the water pressure test at the drilling hole No.DHB5, the result shows the very low permeability from 1.3 to 1.8 Lugeon Value (Refer Table 11.2.2-13 Results of Lugeon Test (2) and following summary table), so that leakage of water during tunnel excavation will be judged to be small.

Results of Lugeon Test at Borehole No. DHB-5

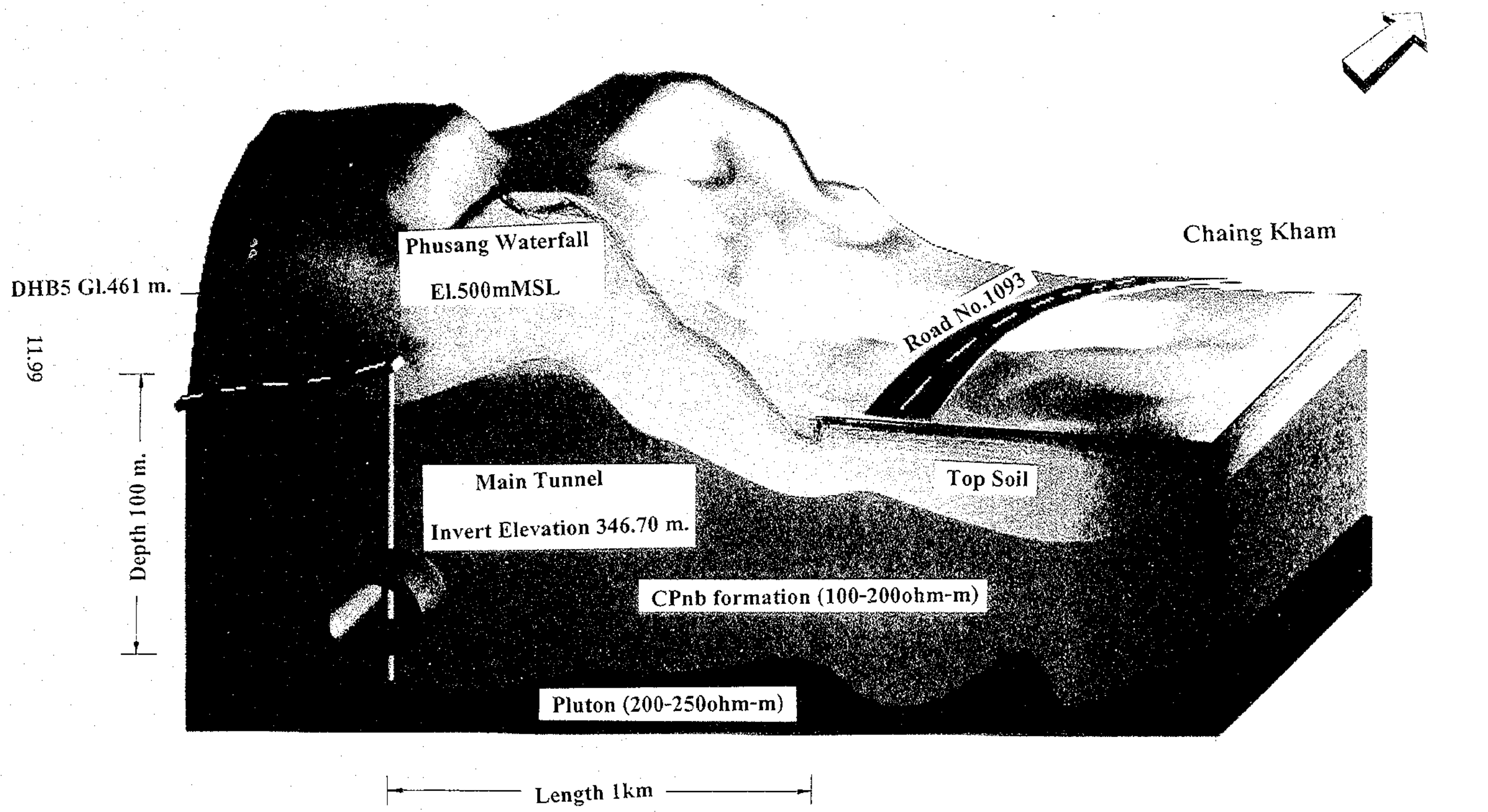
Elevation of Borehole	G.H.461 m		
Testing Depth from G.H.(m)	105 - 110	110 - 115	115 - 120
Testing Elevation	E.L.356 - 351	E.L.351 - 346	E.L.346 - 341
Max. Water Pressure (kgf/cm^2)	15.4		
Lugeon Value	**1.5**	**1.8**	**1.3**
Water Table (G.H.-m)	-3.2 m		
Testing Date	June 26, '96		
Geological Period	Paleozoic		
Geological Age	Carboniferous-Permian		
Name of Geological Formation	Nam Bong		

Boring Core Facies	Sandstone, Slate	Slate	Slate
Rock Class	CM, CL	CM	CH

Taking the whole geological information into consideration, it is inferred that tunnel alignment which passes around drilling hole No.DHB-5 location is situated on the outer area of the zone strongly affected by heated groundwater because that is located on the outside of remarkably low resistivity area.

The prospecting drawing around tunnel, drilling hole No.DHB-5 and the Phu Sang water fall are shown in Figure 11.2.2-20.

Figure 11.2.2-20 Prospecting at Phu Sang Waterfall



Comments for Additional Geological Investigation

For confirmation of geological conditions in detail at/along the sites of each project facility, the following additional geological investigations should be performed prior to the detail design stage. The required additional geological investigation items, investigation points and drilling depths (survey length) etc. are shown in Table 11.2.5-1 to 11.2.5-5 and Figure 11.2.5-1 respectively.

(1) Kok Intake

Along the Kok intake axis and on the cross section (apron portion), at least 4 drilling investigations with in-situ test (standard penetration test) are required to confirm the geological conditions (bearing capacity) of foundation.

(2) Kok-Ing Diversion Canal

Along the Kok-Ing diversion canal route, drilling investigation should be performed for confirmation of geological condition at points of 1,000 m interval at least. The in-situ test (standard penetration test) accompanied with drilling should be performed for confirmation of bearing capacity of foundation. Furthermore, the drilling investigation should be also performed at the planning locations of facility such as the highway bridge.

*Drilling investigation for foundation at the siphon facility have already been carried out up to this stage.

On the occasion of drilling investigation, if the geological condition of foundation is composed of thick sand layer or poor ground condition, in-situ test (the case of former is permeability test and that of the latter is lateral loading test (LLT)) should be performed together with drilling. Furthermore, laboratory test (physical test by grain size analysis, liquid limit test and plastic limit test etc.) by using of core sample should also be performed.

(3) Kok-Ing No.1 Tunnel

Along the Kok-Ing No.1 tunnel route, the following geological conditions in detail should be confirmed by the additional geological investigation, e.g. drilling investigation and geophysical prospecting survey (TEM, electromagnetic prospecting survey), prior to the detail design stage. Especially, electromagnetic prospecting survey is to be carried out along the whole section.

- Confirmation of geological conditions around the tunnel inlet and outlet

  These sections correspond to a shallow overburden condition and are necessary to confirm geological condition.

- Clarification of rock facies of Jv formation (rhyolite and tuff formation) and fault feature located around STA.1+260

  As for JV formation, there is no drilling data at present.

(4) Kok-Ing No.2 Tunnel

Along the Kok-Ing No.2 tunnel route, the following geological conditions should be confirmed by additional geological investigation such as drilling survey and geophysical prospecting survey (TEM, electromagnetic prospecting survey). Especially, electromagnetic prospecting survey is to be carried out along the whole section.

- Confirmation of geological condition around the tunnel inlet and outlet

  These sections show a shallow overburden condition and it is necessary to confirm geological condition. Especially, around the tunnel inlet, the existence of limestone has been clarified by the performed drilling survey.

- Clarification of fault condition at the middle section of tunnel

- Confirmation of geological condition in detail of basalt lava and intrusion

(5) Ing Diversion Weir

Along the axis of the Ing diversion weir and intake facility, at least 7 drilling investigations with in-situ test (standard penetration test) are required to confirm the geological conditions (bearing capacity) of foundation.

(6) Ing-Yot Diversion Canal

Along the Lao diversion canal route, drilling investigation should be performed for confirmation of geological condition at points of 1,000 m interval at least. The in-situ test (standard penetration test) accompanied with drilling should be performed for confirmation of bearing capacity of foundation. Furthermore, the drilling investigation should also be performed at the planning locations of facility such as the siphon facility etc. At present, there is no geological investigation data along the Lao diversion canal route.

On the occasion of drilling investigation, if the geological condition of foundation is composed of thick sand layer or poor ground condition, in-situ test (the case of former is permeability test and that of latter is lateral loading test (LLT)) should be performed together with drilling. Furthermore, laboratory test (physical test by sieving test and Atterberg test etc.) by using of core sample should be also performed.

(7) Ing-Yot No.1 Tunnel

Along the Ing-Yot No.1 tunnel route, drilling investigation, seismic survey (refraction prospecting survey) and geophysical prospecting survey (TEM, electromagnetic prospecting survey) are required in order to confirm the geological conditions and lithological characteristics. Especially, electromagnetic prospecting survey is to be carried out along the whole section. At present, there is no geological investigation data along the Ing-Yot No.1 tunnel route.

(8) Ing-Yot No.2 Tunnel

Along the Ing-Yot No.2 tunnel route, the following geological conditions need to be clearly confirmed by additional geological investigation such as drilling survey, including geophysical logging test, and geophysical prospecting survey (TEM and TDEM, electromagnetic prospecting survey). In addition, on the occasion of drilling survey at the fault zone, the inclined drilling is of great use in confirming the scale of fault or fracture zone.

- Confirmation of geological condition around tunnel inlet

  These sections show a shallow overburden condition and it is necessary to confirm geological condition.

- Clarification of lithological characteristics of basement rocks at the section between STA.0+800 and STA.3+250

  It is necessary to confirm rock facies at the contact between porphyry (granite porphry) and PTRv formation. In addition, the rock facies of the TRhf formation should also be clarified.

- Confirmation of geological condition and the scale of fault and fractured zone at the section from STA.3+140 to STA.3+250 section and around STA.7+000

  It is required to confirm the detail geological condition, including permeable characteristic, of the above fault and fractured zone because they show clear large-scale fault features and are likely to affect tunnel construction.

- Confirmation of hydrogeological mechanism of the heated groundwater around the Phu Sang spring area and proper assessment of the effects of tunnel construction

  The results of the electromagnetic prospecting survey (TEM) and drilling revealed that the thermal origin may be related to the igneous rocks (granite or porphyry), which are continued to a great depth in the deeper portion, and some faults located around this section may be regarded as the passage for the heated groundwater. However, clear identification and solution of these problems should be considered in detail based on the additional investigation from the hydrogeological viewpoint, for example drilling investigation and electromagnetic prospecting survey (TEM) by grid method as setting for investigation lines, including detailed groundwater quality tests etc. Furthermore, drilling holes for investigation should be use as observation well to monitor fluctuation of water level and quality both under natural condition and tunnel construction. In addition, in advance of tunnel construction, the preceding drilling (pilot drilling) will suppose to check the existence of heated groundwater discharge

- Checking of lithological condition of CPnb (Nam Bon) formation and CPhk (Huai Krai) formation

  These formations are recognized along the long section of 20 km or more in tunnel length and show uniform rock facies, as a whole, of foliated slate interbedded with sandstone. Additional drilling and electromagnetic prospecting survey (TEM) are required to confirm the situation of presumed fault and fractured zone at/around the major river course such as the Huai Sai, Huai Herak and Hai Bong.

- Problem of groundwater discharge from deeper depth in the PTRv formation around the existing drilling DHBJ26

  Drilling of DHBJ26 revealed the existence of excellent confined aquifers, which may be formed along fissure situated in PTRv formation (tuff and dacite formation), at the deeper depth from 276 m. Additional drilling and electromagnetic prospecting survey (TDEM) is required to confirm the geological condition and scale of fault and fractured zone related to groundwater discharge. Furthermore, in advance of tunnel construction, the preceding drilling (pilot drilling) will suppose to check groundwater discharge from deeper.

- Problem of groundwater discharge from the TRpl formation (limestone formation) of the Doi Pha Deang mountain around STA.28+500 to STA.30+100 section.

  At the limestone formation and adjacent PTRv and TRhf formation, supplemental electromagnetic prospecting survey (TDEM) and several drillings, including the inclined drillings, are required for confirmation of geological condition (rock facies of limestone and contact condition of formations) and the existence of limestone cave. In this case, the electromagnetic prospecting survey (TDEM) should be applied as point sounding method around tunnel alignment because of difficult line setting by the rugged topographical condition. Furthermore, in advance of tunnel construction, the preceding drilling (pilot drilling) can be used to check groundwater discharge from limestone cave.

- Confirmation of fault zone observed by TDEMB line 30.0

  Supplementary geophysical prospecting survey (TDEM survey) and several drillings are required for confirmation of geological condition, rock facies and fault zone at/around this area.

- Confirmation of geological condition of the TRhf (Huai Fak) formation

  This formation, which is composed of sandstone and tuff interbedded with shale, are recognized over a distance of approximately 16.0 km long along the tunnel alignment. Additional drilling is required for confirmation of geological condition and the existence of fault at/around the major river course such as the Yean river.

- Confirmation of geological condition around the highest mountain area (STA.38+000 to STA.45+000 section)

  The geophysical prospecting survey (TDEM survey) is required to confirm the boundary line between ms 5-3 formation and TRhf (Huai Fak) formation and the rock facies along the tunnel level. The check drilling is also required for correlation of results of geophysical prospecting survey. Required drilling depth of borehole should be reached at least 150 to 200 m in the fresh rock.

- Problem of groundwater discharge from the TRpl formation (limestone formation) around STA.46+000 to STA.47+100 section and STA.49+900 to STA.50+500 section.

  Additional geophysical prospecting survey (TEM survey) and drilling, including the inclined ones, are required for clarification of geological condition and the existence of limestone cave. Furthermore, in advance of tunnel construction, the preceding drilling (pilot drilling) is need to check groundwater discharge from limestone cave.

- Confirmation of geological condition around tunnel outlet

  These sections show a shallow overburden condition and it is necessary to confirm geological condition.

(9) Yao Flood Control Dam

At the Yao flood control dam, additional drilling investigations accompanying with lugeon test are required to confirm the geological condition in detail and permeable characteristics of dam foundation. At this site, the seismic survey (refraction prospecting survey) had already been performed in 1998. The required quantities for drilling arc as follows.

- Along the dam axis: 5 holes in total (hole location of the left abutment should be planned in a dense pattern.)
- At the upstream and downstream of dam base : 6 holes in total (3 holes at the upstream and downstream, respectively)
- Along the spillway axis : 4 holes in total
- Along the diversion tunnel axis : 3 holes in total
- At the thin ridge between spillway and diversion tunnel : 2 holes

At the left abutment of dam, geophysical prospecting survey (TEM, electromagnetic prospecting survey) should be also performed to clarify the geological condition because there is a possibility of the existence of a large-scale fault zone on.

Furthermore, for embankment material of dam, soil tests should be performed in detail. Required test items and quantities, including test pitting at the proposed borrow site, are as follows.

<table>
<tr><th>Material</th><th>Test Item</th><th>Sample</th><th>Remarks</th></tr>
<tr><td>Test pitting</td><td>---</td><td>30 pits</td><td>At the proposed borrow site</td></tr>
<tr><td rowspan="2">Impervious material</td><td>Physical test</td><td>20 samples</td><td></td></tr>
<tr><td>Dynamic test</td><td>10 samples</td><td></td></tr>
<tr><td rowspan="2">Semi-pervious material</td><td>Physical test</td><td>20 samples</td><td></td></tr>
<tr><td>Dynamic test</td><td>10 samples</td><td></td></tr>
<tr><td rowspan="3">Pervious material</td><td>Physical test and rock test</td><td>10 samples</td><td></td></tr>
<tr><td>Dynamic test</td><td>5 samples</td><td>Soil test for pervious material should be performed by large-scale testing using excavation material of tunnel</td></tr>
<tr><td>Rock test</td><td>10 samples</td><td></td></tr>
<tr><td rowspan="2">Filter material</td><td>Physical test</td><td>10 samples</td><td></td></tr>
<tr><td>Dynamic test</td><td>5 samples</td><td></td></tr>
</table>

In this case, testing items for physical, dynamic and rock test are as follows.

- Physical test : specific gravity of soil particle, field water content, grain size analysis, liquid limit, plastic limit etc.
- Dynamic test : compaction, permeability, consolidation, shear strength (by tri-axial compression test) etc.
- Rock test : specific gravity and water absorption, compressive strength, stability, abrasion resistance