APPENDIX – C

NAM LAN MINI HYDRO

Table C-1-1 Estimated Unit Consumption Demand (1/2)

Object	Accessibility ratio, %	Step		Watt	Simul-taneous use, %	Watt		Watt	Simul-taneous use, %	Watt
1. Household		1-1	a. 3 Lights	90	100		a. 3 Lights	90	15	
Shan South	87		b. Radio	10	30		b. Radio	10	15	
Shan North	84		c. TV (60w)	30	85		c. TV (60w)	30	15	
Kachin	93		Ownership ratio				Ownership ratio			
Total (Un-Ele	87		50%				50%			
ctrified)			Total	130	90%	118	Total	130	15%	20
Total (Electri-	92	1-2	1-1	130	90		1-1	130	15	
fied)			d. Rice Cooker	90	50		d. Rice Cooker	90	30	
Total	88		Ownership ratio				Ownership ratio			
			15%				15%			
			Total	220	70%	163	Total	220	20%	44
2. Public										
2.1 Street Light	100		1. 40w Tube 10/Place	50	100	2,000				0
2.2 Temple	100		1. Light 20wTubex30	600	67		1. Light 20wTubex30	600	0	
			2. TV 1x60w	60	50		2. TV 1x60w	60	0	
			3. Fan 4 x 60w	240	20		3. Fan 4 x 60w	240	50	
			4. Refrigerator(100w)	100	50		4. Refrigerator(100w)	100	100	
			5. A/C:1x1KW	1,000	0		5. A/C:1x1KW	1,000	50	
			Total	2,000	30%	528	Total	2,000	40%	720
2.3 Hospital	100		1. Outer light				1.Outer light			
			20w Tube x 1	20	100		20w Tube x 1	20	0	
			2. Inner light				2. Inner light			
			40w Tube x 5rooms	200	50		Night demand x 50%	200	25	
			3. Refrigerator				3. Refrigerator			
			130w x 1	130	100		130w x 1	130	100	
			Total	350	70%	250	Total	350	50%	180
2.4 Clinic	100		1. Outer light				1.Outer light	20	0	
			20w Tube x 1	20	100					
			2. Inner light				2. Inner light			
			40w Tube x 4rooms	160	50		Night demand x 50%	160	25	
			3. Refrigerator				3. Refrigerator			
			130w x 1	130	100		130w x 1	130	100	
			Total	310	70%	230	Total	310	50%	170
2.5 High School	100		1. Outer light	20			1.Outer light	20	0	
			20w Tube x 1							
			2. Inner light	5,760			2. Inner light	5,760	20	
			Class room (36)				For cloudy, rainy day			
			40w Tube x 4 x 36				use: 5,760x20% use			
			3. Head Master room				(50days/250days/year)			
			40w Tube x 1	40			3. Head Master room	40	20	
			4.Copy machine				4. Copy machine			
			300w x 10%	300			300w x 10%	300	10	
			5. Computer room				5. Computer room	80	100	
			40w x 2	80			40w x 2			
			Total	6,200	0%	0	Total	6,200	20%	1,270
2.6 Middle School	100		1. Outer light	20			1.Outer light	20	0	
			20w Tube x 1							
			2. Inner light	1,280			2. Inner light	1,280	20	
			Class room (8)				For cloudy, rainy day			
			40w Tube x 4 x 8				1.280x20%			
			3 Head Master room				(50days/250days/year)			
			40w Tube x 1	40			3. Head Master room	40	20	
			4 Copy machine	300			4. Copy machine	300	10	
			300w x 10%				300w x 10%			
			Total	1,640	0%	0	Total	1,640	20%	290

Source: The Study Team

Table C-1-2 Estimated Unit Consumption Demand (2/2)

Object	Accessibility ratio, %	Step	Watt	Simul-taneous use, %	Watt		Watt	Simul-taneous use, %	Watt
2.7 Primary	100	1. Outer light	20			1.Outer light	20	0	
School		20w Tube x 1				2. Inner light			
		2. Inner light	320			For cloudy, rainy day	320	20	
		Class room (8)				use:			
		40w Tube x 8				(50days/250days/year)			
		3 Head master room	40			3. Head Master room	40	0	
		40w Tube x 1							
		Total	380	0%	0	Total	380	20%	65
3. Business									
3.1 Restaurant		1. Inner light	160	100		1. Inner light	160	0	
		40w Tube x 4							
		2. 21" CTV (95w)	95	100		2. 21" CTV (95w)	95	100	
		3. Refrigerator				3. Refrigerator			
		130w x 1	130	100		130w x 1	130	100	
		4. Rice Cooker				4. Rice Cooker			
		600w x 2	1,200	30		600w x 2	1,200	30	
		5. Hot plate				5. Hot plate			
		800w x 2	1,600	20		800w x 2	1,600	20	
		Total	3,185	30%	1,070	Total	3,185	30%	905
3.2 Guest	100	1 Tube	4,400	50		1 Tube	4,400	20	
House		20w x 22 room				20w x 22 room			
		2. 20w x 2 Toilet	40	20		2. 20w x 2 Toilet	40	20	
		3. Refrigerator	130	100		3. Refrigerator	130	100	
		130 w x1				130 w x1			
		4 Fan 60w x 4	240	50		4 Fan 60w x 4	240	50	
		5 21"TV	95	100		5 21"TV	95	100	
		95w x 1				95w x 1			
		Total	4,905	50%	2,550	Total	4,905	30%	1,230
3.3 Hotel	100	All facilities for 22				All facilities for 22			
		rooms/Hotel	7,000	80%	5,600	rooms/Hotel	7,000	70%	4,900
4. Cottage or Household Industry									
4.1 Rice Mill			5,000	0%	0	1. Motor	5,000	80%	5,000
4.2 Oil Mill			7,000	0%	0	1. Motor	7,000	80%	7,000
4.3 Powder Mill			5,000	0%	0	1. Motor	5,000	80%	5,000
4.4 Sugarcane Processing			5,000	0%	0	1. Motor	5,000	80%	5,000
4.5 Saw Mill			5,000	0%	0	1. Motor	5,000	80%	5,000
4.6 Paper Mill			5,000	0%	0	1. Motor	5,000	80%	5,000
4.7 Tofu Manufacturing			4,000	0%	0	1. Motor	4,000	80%	4,000
4.8 Noodle Mill			7,000	0%	0	1. Motor	7,000	80%	7,000
4.9 Furniture Manufacturing			5,000	0%	0	1. Motor	5,000	80%	5,000
4.10 Iron Work (including car, Trawlergyi, boa			4,000	0%	0	1. Motor	4,000	80%	4,000
etc.repair shop)									
4.11 Battery Charge Station (BCS)			1,500	0%	0	1. Motor	1,500	80%	1,500
4.12 Weaving			5,000	0%	0	1. Motor	5,000	80%	5,000
4.13 Water Pump			200	0%	0	1. Motor	200	80%	200

Note: It is assumed 15% of household will have 600 W Rice Cooker certain years after electrification.
For Namlan Village, 2 Saw Mills have total 4 machines at 20kW

Source: The Study Team

Table C-1-3 Power Demand Forecast in Nam Lan Village

Customer	Number of Custo-mer	Step	Night						Daytime					
			Unit Con-sumption Watt	Sim-ulta-neous %	Unit Con-sumption Watt	Accessibility %	Estimat-ed Power Demand kW	Sub-total kW	Unit Con-sumption Watt	Sim-ulta-neous %	Unit Con-sumption Watt	Accessibility %	Estimat-ed Power Demand kW	Sub-total kW
1.Household	2,082	1-1	130	90%	120	93	232.4	232.4	130	15%	20	93	38.7	38.7
		1-2	220	70%	160	93	309.8	309.8	220	20%	50	93	96.8	96.8
2. Public														
2.1 Street Light	16		400	50%	200	100	3.2		400	0	0	100	0.0	
2.2 Temple & Pagoda	11		2,000	30%	600	100	6.6		2,000	40%	800	100	8.8	
2.3 Hospital	1		230	70%	160	100	0.2		230	50%	120	100	0.1	
2.4 Clinic	1		310	70%	220	100	0.2		310	50%	160	100	0.2	
2.5.1 H.School	1		6,200	0	0	100	0.0		6,200	20%	1,240	100	1.2	
2.5.2 M.School	0		1,640	0	0	100	0.0		1,640	20%	330	100	0.0	
2.5.3 P.School	9		380	0	0	100	0.0		380	20%	80	100	0.7	
Sub-total								10.2						11.0
3. Business														
3.1 Restaurant	3		3,185	30%	960	100	2.9		3,185	30%	960	100	2.9	
3.2 Guest House	2		4,905	50%	2,450	100	4.9		4,905	30%	1,470	100	2.9	
Sub-total								7.8						5.8
4. Industry														
4.1 Rice Mill	18		5,000	0	0	100	0.0		5,000	80%	4,000	100	72.0	
4.2 Oil Mill	6		5,000	0	0	100	0.0		5,000	80%	4,000	100	24.0	
4.3 Powder Mill	0		5,000	0	0	100	0.0		5,000	80%	4,000	100	0.0	
4.4 Sugarcane Processing	0		5,000	0	0	100	0.0		5,000	80%	4,000	100	0.0	
4.5 Saw Mill	2		10,000	0	0	100	0.0		10,000	80%	8,000	100	16.0	
4.6 Paper Mill	0		5,000	0	0	100	0.0		5,000	80%	4,000	100	0.0	
4.7 Tofu Mf'g	3		4,000	0	0	100	0.0		4,000	80%	3,200	100	9.6	
4.8 Noodle Mf'g	3		7,000	0	0	100	0.0		7,000	80%	5,600	100	16.8	
4.9 Furniture	5		5,000	0	0	100	0.0		5,000	80%	4,000	100	20.0	
4.10 Iron Work	5		4,000	0	0	100	0.0		4,000	80%	3,200	100	16.0	
4.11 BCS	2		1,500	0	0	100	0.0		1,500	80%	1,200	100	2.4	
4.12 Weaving	0		5,000	0	0	100	0.0		5,000	80%	4,000	100	0.0	
4.13 Water Pump	25		200	0	0	100	0.0		200	80%	160	100	4.0	
Sub-total								0.0						180.8
5. Total														
5.1 1-1+2,3,4								250.3						236.4
5.2 1-2+2,3,4								327.8						294.5
6. Gross Total														
6.1 1-1+2,3,4	Including 5% of transfer loss							270	Incl. 5% transfer loss					250
6.2 1-2+2,3,4	Including 5% of transfer loss							350	Incl. 5% transfer loss					310

Probable Flood

According to the absence of any flood data, maximum daily rainfall data at Hsipaw station were used as the main parameter in calculating the probable flood. Rational formula is used for the calculation.

Probable Rainfall

It was calculated rainfall data at Hsipaw station (1990 to 2001) as follows :

176 mm (Return Period : 100 year)

Probable Flood

The following parameters of the basins were used for the calculation of the probable flood.

	Hosant Chaung at Intake	Hosant Chaung at Power House
Catchment Area (km^2)	1.1	2.5
Average length of slopes (m)	317	485
Length of Stream (m)	1,500	3,100
Difference in elevation (m)	91	137

Finally probable floods at the proposed intake site and the proposed power house site were calculated as follows.

	Hosant Chaung at Intake	Hosant Chaung at Power House
Probable flood (m^3/s)	8.6	19.2

Flow Chart for Operation of Power Generation

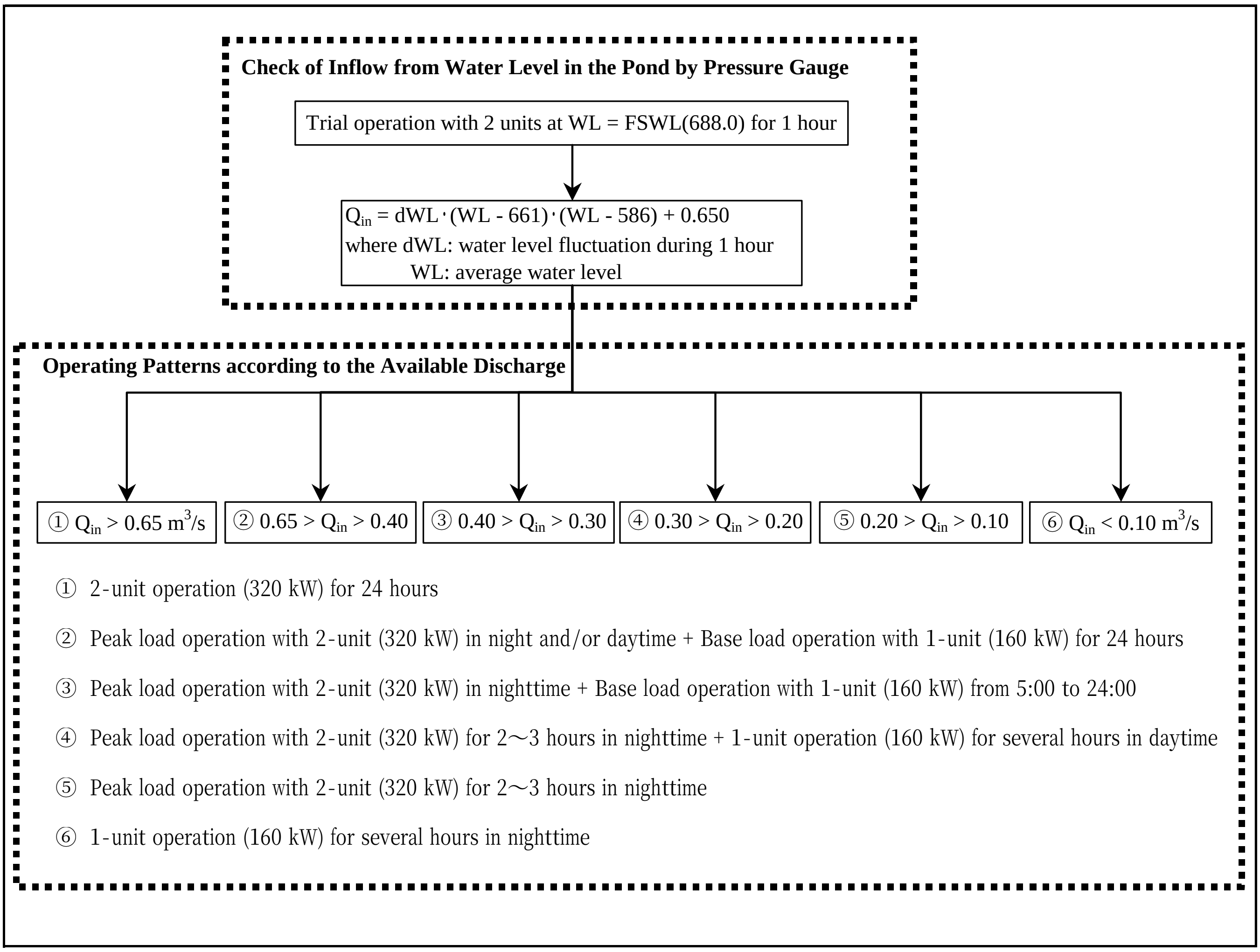


Table C-3-1 Calculation of Yearly Power Generation in Nam Lan Micro Hydro (1/3)

(1) Case - 1 : Hosang Chaung only (Phase-1)

Max. Discharge(m3/sec)	0.65	**Installed capacity for 2 units (kW)**	320
FSWL. at Pond (m)	688.00	**Installed capacity for 1unit (kW)**	160
TWL (m)	618.50	**Loss coefficient for 2-unit**	1.6177
Gross Head (m)	69.500	**Loss coefficient for 1-unit**	3.1570
Effective Head (m)	68.817		

Factor 0.95

0.00 0.00 1 Pond (m^3) 5,000

Month	River flow (m^3/sec)				Irrigation require. (m^3/sec)	Available discharge (m^3/sec)	Case - 1 : without regulation				Case - 2 : regulation with unrestricted pond					Case - 3 : regulation by rpond 5,000 m^3		
	Hosang	Nam Pankan	Kyutaw	Total			Q_{power} (m^3/sec)	Output (kW)	Operation (hr)	Energy (MWh)	Q_{power} (m^3/sec)	Output (kW)	Operation (hr)	Energy (MWh)	Pond (m^3)	Operation pattern	Output (kW)	Energy (MWh)
1	0.250	0.000	0.000	0.250	0.000	0.250	0.000	0	0.0	0.0	0.650	320	9.2	43.4	13,320	4	320/160	42.8
	0.250	0.000	0.000	0.250	0.000	0.250	0.000	0	0.0	0.0	0.650	320	9.2	43.4	13,320	4	320/160	42.8
2	0.250	0.000	0.000	0.250	0.000	0.250	0.000	0	0.0	0.0	0.650	320	9.2	39.2	13,320	4	320/160	38.6
	0.250	0.000	0.000	0.250	0.000	0.250	0.000	0	0.0	0.0	0.650	320	9.2	39.2	13,320	4	320/160	38.6
3	0.250	0.000	0.000	0.250	0.000	0.250	0.000	0	0.0	0.0	0.650	320	9.2	43.4	13,320	4	320/160	42.8
	0.250	0.000	0.000	0.250	0.000	0.250	0.000	0	0.0	0.0	0.650	320	9.2	43.4	13,320	4	320/160	42.8
4	0.250	0.000	0.000	0.250	0.000	0.250	0.000	0	0.0	0.0	0.650	320	9.2	42.0	13,320	4	320/160	41.4
	0.250	0.000	0.000	0.250	0.000	0.250	0.000	0	0.0	0.0	0.650	320	9.2	42.0	13,320	4	320/160	41.4
5	0.250	0.000	0.000	0.250	0.100	0.150	0.000	0	0.0	0.0	0.650	320	5.5	25.9	9,990	5	320/160	25.7
	0.300	0.000	0.000	0.300	0.100	0.200	0.000	0	0.0	0.0	0.650	320	7.4	34.9	11,952	4	320/160	34.2
6	0.350	0.000	0.000	0.350	0.100	0.250	0.000	0	0.0	0.0	0.650	320	9.2	42.0	13,320	4	320/160	41.4
	0.400	0.000	0.000	0.400	0.100	0.300	0.000	0	0.0	0.0	0.650	320	11.1	50.6	13,932	3	320/160	49.6
7	0.450	0.000	0.000	0.450	0.100	0.350	0.325	160	24.0	56.5	0.650	320	12.9	60.8	13,986	3	320/160	59.9
	0.500	0.000	0.000	0.500	0.100	0.400	0.325	160	24.0	56.5	0.650	320	14.8	69.7	13,248	2	320/160	68.4
8	0.500	0.000	0.000	0.500	0.075	0.425	0.325	160	24.0	56.5	0.650	320	15.7	74.0	12,699	2	320/160	72.7
	0.500	0.000	0.000	0.500	0.050	0.450	0.325	160	24.0	56.5	0.650	320	16.6	78.2	11,988	2	320/160	77.0
9	0.500	0.000	0.000	0.500	0.050	0.450	0.325	160	24.0	54.7	0.650	320	16.6	75.7	11,988	2	320/160	74.5
	0.450	0.000	0.000	0.450	0.050	0.400	0.325	160	24.0	54.7	0.650	320	14.8	67.5	13,248	2	320/160	66.2
10	0.450	0.000	0.000	0.450	0.050	0.400	0.325	160	24.0	56.5	0.650	320	14.8	69.7	13,248	2	320/160	68.4
	0.450	0.000	0.000	0.450	0.050	0.400	0.325	160	24.0	56.5	0.650	320	14.8	69.7	13,248	2	320/160	68.4
11	0.400	0.000	0.000	0.400	0.025	0.375	0.325	160	24.0	54.7	0.650	320	13.8	62.9	13,770	3	320/160	62.1
	0.350	0.000	0.000	0.350	0.000	0.350	0.325	160	24.0	54.7	0.650	320	12.9	58.8	13,986	3	320/160	57.9
12	0.300	0.000	0.000	0.300	0.000	0.300	0.000	0	0.0	0.0	0.650	320	11.1	52.3	13,932	3	320/160	51.3
	0.250	0.000	0.000	0.250	0.000	0.250	0.000	0	0.0	0.0	0.650	320	9.2	43.4	13,320	4	320/160	42.8
Total										558				1,272				1,251

Operation Patterns

1	Q > 0.65	2-unit operation (320 kW) for 24 hours
2	0.65 > Q > 0.40	Peak load operation with 2-unit (320 kW) in night and/or daytime + Base load operation with 1-unit (160 kW) for 24 hours
3	0.40 > Q > 0.30	Peak load operation with 2-unit (320 kW) in nighttime + Base load operation with 1-unit (160 kW) from 5:00 to 24:00
4	0.30 > Q > 0.20	Peak load operation with 2-unit (320 kW) for 2～3 hours in nighttime + 1-unit operation (160 kW) for several hours in daytime
5	0.20 > Q > 0.10	Peak load operation with 2-unit (320 kW) for 2～3 hours in nighttime
6	Q < 0.1	1-unit operation (160 kW) for several hours in nighttime

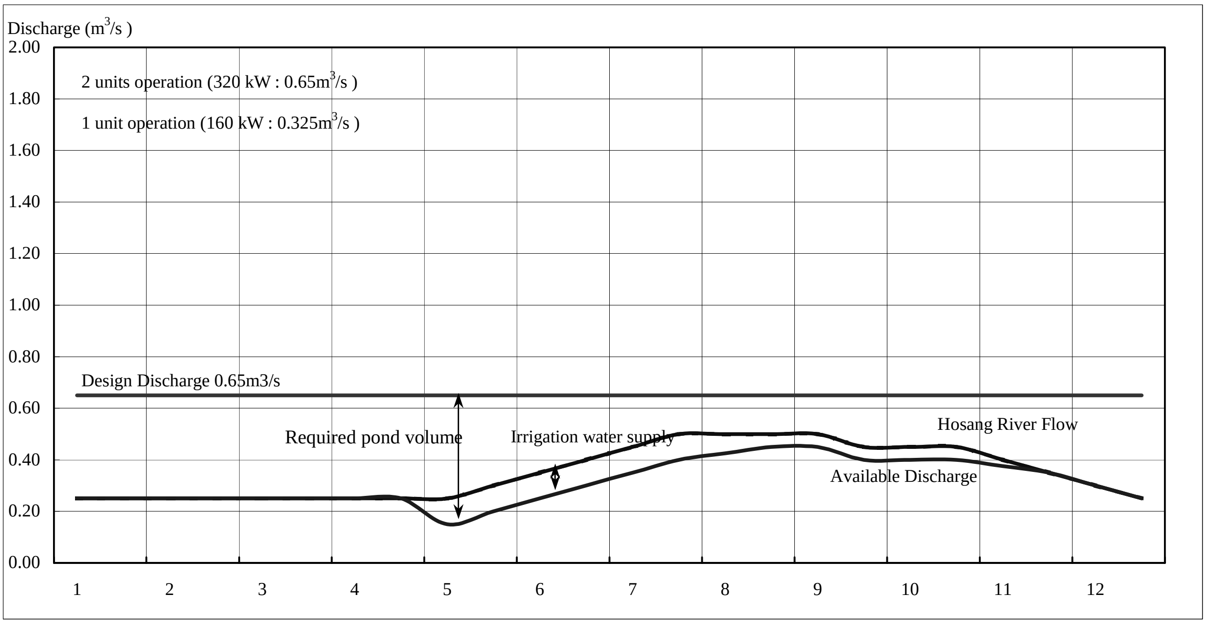


Table C-3-2 Calculation of Yearly Power Generation in Nam Lan Micro Hydro (2/3)

(2) Case - 2 : Hosang Chaung + Nam Pankan Chaung

Max. Discharge(m3/sec)	0.65	**Installed capacity for 2 units (kW)**	320
FSWL. at Pond (m)	688.00	**Installed capacity for 1unit (kW)**	160
TWL (m)	618.50	**Loss coefficient for 2-unit**	1.6177
Gross Head (m)	69.500	**Loss coefficient for 1-unit**	3.1570
Effective Head (m)	68.817		

1.00 0.00 2

Factor 0.95

Pond (m^3) 5,000

Month	River flow (m^3/sec)				Irrigation	Available	Case - 1 : without regulation				Case - 2 : regulation with unrestricted pond					Case - 3 : regulation by rpond 5,000 m^3		
	Hosang	Nam Pankan	Kyutaw	Total	require. (m^3/sec)	discharge (m^3/sec)	Q_{power} (m^3/sec)	Output (kW)	Operation (hr)	Energy (MWh)	Q_{power} (m^3/sec)	Output (kW)	Operation (hr)	Energy (MWh)	Pond (m^3)	Operation pattern	Output (kW)	Energy (MWh)
1	0.250	0.200	0.000	0.450	0.000	0.450	0.325	160	24.0	56.5	0.650	320	16.6	78.2	11,988	2	320/160	77.0
	0.250	0.200	0.000	0.450	0.000	0.450	0.325	160	24.0	56.5	0.650	320	16.6	78.2	11,988	2	320/160	77.0
2	0.250	0.200	0.000	0.450	0.000	0.450	0.325	160	24.0	51.1	0.650	320	16.6	70.6	11,988	2	320/160	69.5
	0.250	0.200	0.000	0.450	0.000	0.450	0.325	160	24.0	51.1	0.650	320	16.6	70.6	11,988	2	320/160	69.5
3	0.250	0.200	0.000	0.450	0.000	0.450	0.325	160	24.0	56.5	0.650	320	16.6	78.2	11,988	2	320/160	77.0
	0.250	0.200	0.000	0.450	0.000	0.450	0.325	160	24.0	56.5	0.650	320	16.6	78.2	11,988	2	320/160	77.0
4	0.250	0.200	0.000	0.450	0.000	0.450	0.325	160	24.0	54.7	0.650	320	16.6	75.7	11,988	2	320/160	74.5
	0.250	0.200	0.000	0.450	0.000	0.450	0.325	160	24.0	54.7	0.650	320	16.6	75.7	11,988	2	320/160	74.5
5	0.250	0.250	0.000	0.500	0.200	0.300	0.000	0	0.0	0.0	0.650	320	11.1	52.3	13,932	3	320/160	51.3
	0.300	0.300	0.000	0.600	0.200	0.400	0.325	160	24.0	56.5	0.650	320	14.8	69.7	13,248	2	320/160	68.4
6	0.350	0.350	0.000	0.700	0.200	0.500	0.325	160	24.0	54.7	0.650	320	18.5	84.4	9,900	2	320/160	82.7
	0.400	0.400	0.000	0.800	0.200	0.600	0.325	160	24.0	54.7	0.650	320	22.2	101.2	3,888	2	320/160	99.3
7	0.450	0.450	0.000	0.900	0.200	0.700	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
	0.500	0.500	0.000	1.000	0.200	0.800	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
8	0.500	0.500	0.000	1.000	0.150	0.850	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
	0.500	0.500	0.000	1.000	0.100	0.900	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
9	0.500	0.500	0.000	1.000	0.100	0.900	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
	0.450	0.450	0.000	0.900	0.100	0.800	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
10	0.450	0.450	0.000	0.900	0.100	0.800	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
	0.450	0.450	0.000	0.900	0.100	0.800	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
11	0.400	0.400	0.000	0.800	0.050	0.750	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
	0.350	0.350	0.000	0.700	0.000	0.700	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
12	0.300	0.300	0.000	0.600	0.000	0.600	0.325	160	24.0	56.5	0.650	320	22.2	104.6	3,888	2	320/160	102.6
	0.250	0.250	0.000	0.500	0.000	0.500	0.325	160	24.0	56.5	0.650	320	18.5	87.2	9,900	2	320/160	85.5
Total										1,833				2,221				2,202

Operation Patterns

1	Q > 0.65	2-unit operation (320 kW) for 24 hours
2	0.65 > Q > 0.40	Peak load operation with 2-unit (320 kW) in night and/or daytime + Base load operation with 1-unit (160 kW) for 24 hours
3	0.40 > Q > 0.30	Peak load operation with 2-unit (320 kW) in nighttime + Base load operation with 1-unit (160 kW) from 5:00 to 24:00
4	0.30 > Q > 0.20	Peak load operation with 2-unit (320 kW) for 2〜3 hours in nighttime + 1-unit operation (160 kW) for several hours in daytime
5	0.20 > Q > 0.10	Peak load operation with 2-unit (320 kW) for 2〜3 hours in nighttime
6	Q < 0.1	1-unit operation (160 kW) for several hours in nighttime

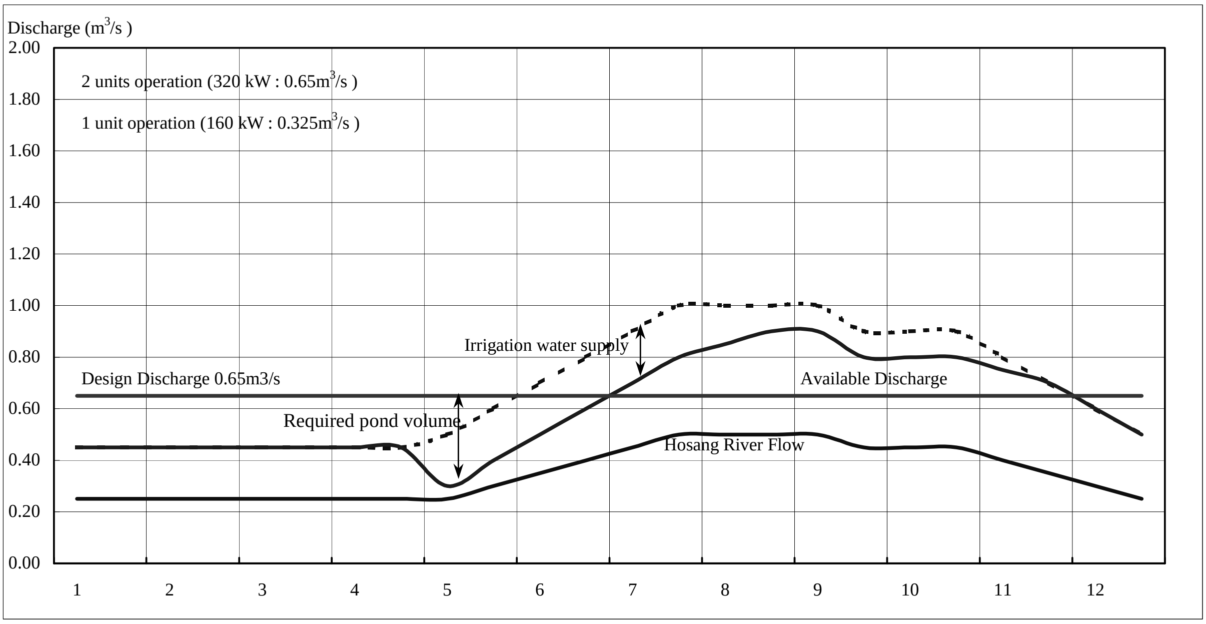


Table C-3-3 Calculation of Yearly Power Generation in Nam Lan Micro Hydro (3/3)

(3) Case - 3 : Hosang Chaung + Nam Pankan Chaung + Kyutaw Chaung

Max. Discharge(m3/sec)	0.65
FSWL. at Pond (m)	688.00
TWL (m)	618.50
Gross Head (m)	69.500
Effective Head (m)	68.817

Installed capacity for 2 units (kW)	320
Installed capacity for 1unit (kW)	160
Loss coefficient for 2-unit	1.6177
Loss coefficient for 1-unit	3.1570

Factor 0.95

1.00 1.00 3 Pond (m^3) 5,000

Month	River flow (m^3/sec) Hosang	Nam Pankan	Kyutaw	Total	Irrigation require. (m^3/sec)	Available discharge (m^3/sec)	Case - 1 : without regulation Q_{power} (m^3/sec)	Output (kW)	Operation (hr)	Energy (MWh)	Case - 2 : regulation with unrestricted pond Q_{power} (m^3/sec)	Output (kW)	Operation (hr)	Energy (MWh)	Pond (m^3)	Case - 3 : regulation by rpond 5,000 m^3 Operation pattern	Output (kW)	Energy (MWh)
1	0.250	0.200	0.200	0.650	0.000	0.650	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
	0.250	0.200	0.200	0.650	0.000	0.650	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
2	0.250	0.200	0.200	0.650	0.000	0.650	0.650	320	24.0	102.1	0.650	320	24.0	102.1	00	1	320	102.1
	0.250	0.200	0.200	0.650	0.000	0.650	0.650	320	24.0	102.1	0.650	320	24.0	102.1	00	1	320	102.1
3	0.250	0.200	0.200	0.650	0.000	0.650	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
	0.250	0.200	0.200	0.650	0.000	0.650	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
4	0.250	0.200	0.200	0.650	0.000	0.650	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
	0.250	0.200	0.200	0.650	0.000	0.650	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
5	0.250	0.250	0.250	0.750	0.300	0.450	0.325	160	24.0	56.5	0.650	320	16.6	78.2	11,988	2	320/160	77.0
	0.300	0.300	0.300	0.900	0.300	0.600	0.325	160	24.0	56.5	0.650	320	22.2	104.6	3,888	2	320/160	102.6
6	0.350	0.350	0.350	1.050	0.300	0.750	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
	0.400	0.400	0.400	1.200	0.300	0.900	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
7	0.450	0.450	0.450	1.350	0.300	1.050	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
	0.500	0.500	0.500	1.500	0.300	1.200	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
8	0.500	0.500	0.500	1.500	0.225	1.275	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
	0.500	0.500	0.500	1.500	0.150	1.350	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
9	0.500	0.500	0.500	1.500	0.150	1.350	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
	0.450	0.450	0.450	1.350	0.150	1.200	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
10	0.450	0.450	0.450	1.350	0.150	1.200	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
	0.450	0.450	0.450	1.350	0.150	1.200	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
11	0.400	0.400	0.400	1.200	0.075	1.125	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
	0.350	0.350	0.350	1.050	0.000	1.050	0.650	320	24.0	109.4	0.650	320	24.0	109.4	00	1	320	109.4
12	0.300	0.300	0.300	0.900	0.000	0.900	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
	0.250	0.250	0.250	0.750	0.000	0.750	0.650	320	24.0	113.1	0.650	320	24.0	113.1	00	1	320	113.1
Total										2,550				2,620				2,616

Operation Patterns

1	Q > 0.65	2-unit operation (320 kW) for 24 hours
2	0.65 > Q > 0.40	Peak load operation with 2-unit (320 kW) in night and/or daytime + Base load operation with 1-unit (160 kW) for 24 hours
3	0.40 > Q > 0.30	Peak load operation with 2-unit (320 kW) in nighttime + Base load operation with 1-unit (160 kW) from 5:00 to 24:00
4	0.30 > Q > 0.20	Peak load operation with 2-unit (320 kW) for 2～3 hours in nighttime + 1-unit operation (160 kW) for several hours in daytime
5	0.20 > Q > 0.10	Peak load operation with 2-unit (320 kW) for 2～3 hours in nighttime
6	Q < 0.1	1-unit operation (160 kW) for several hours in nighttime

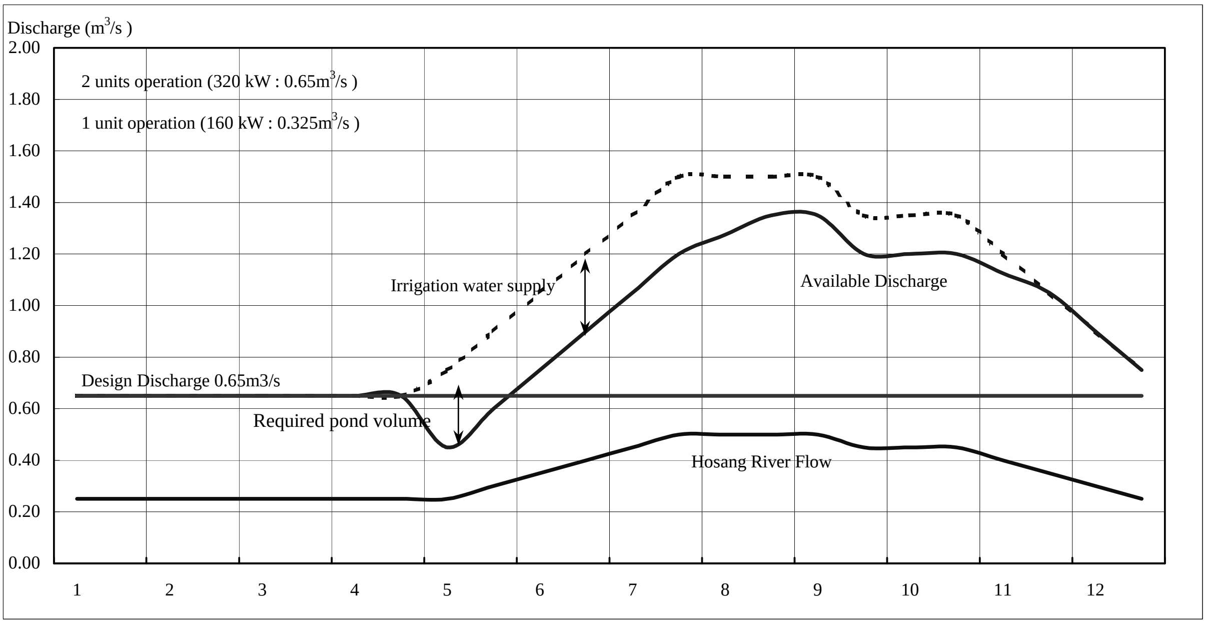
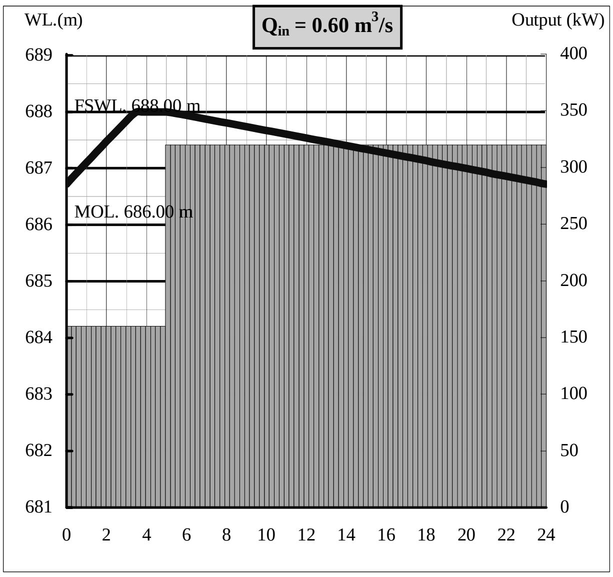
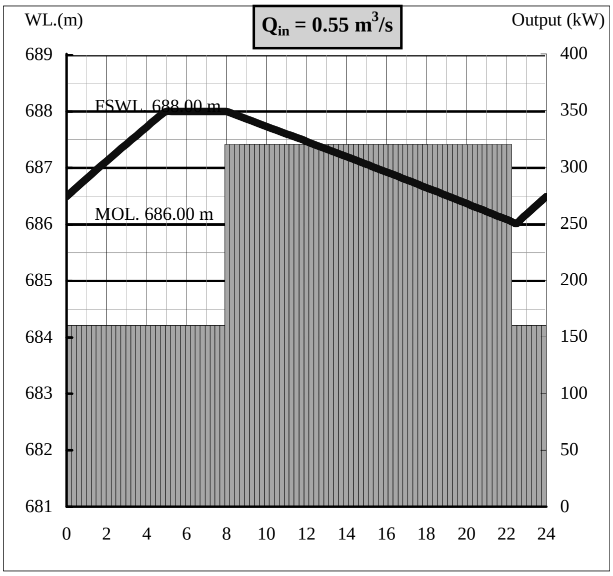
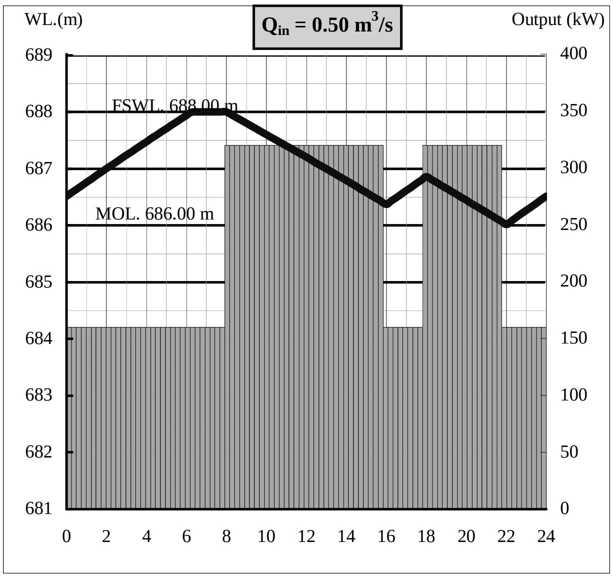
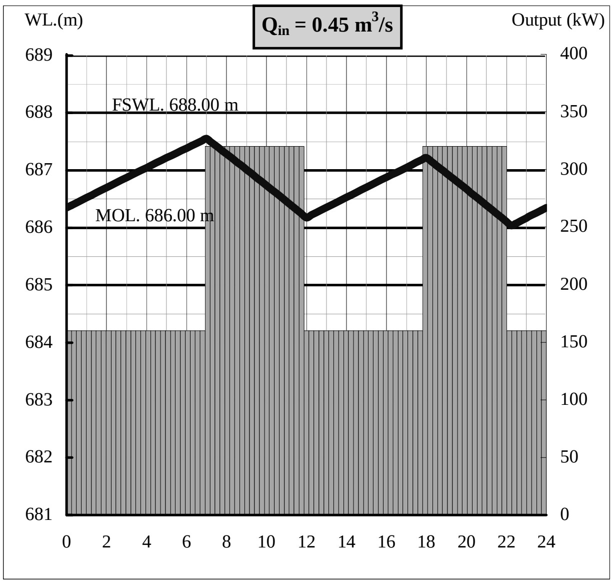


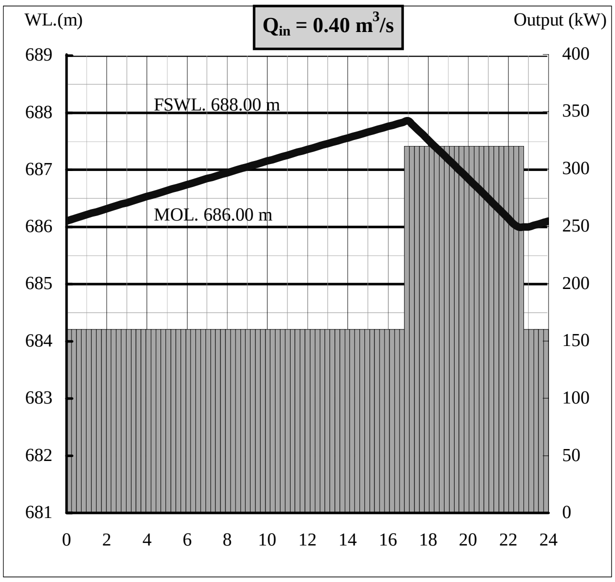
Table C-3-4 Calculation of Daily Power Generation in Nam Lan Micro Hydro (1/2)











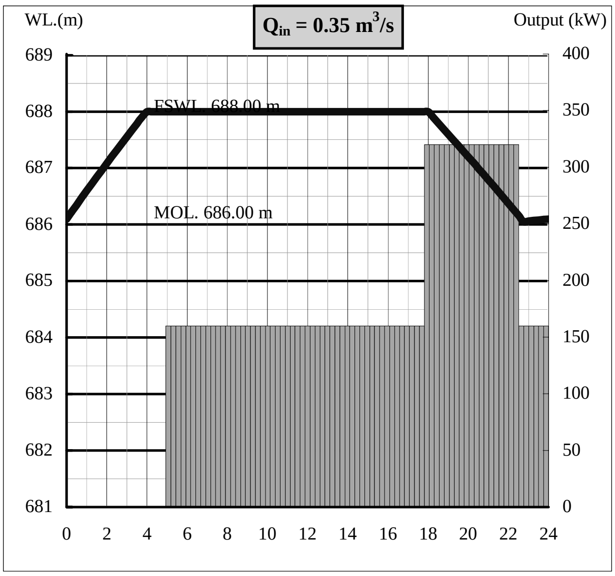
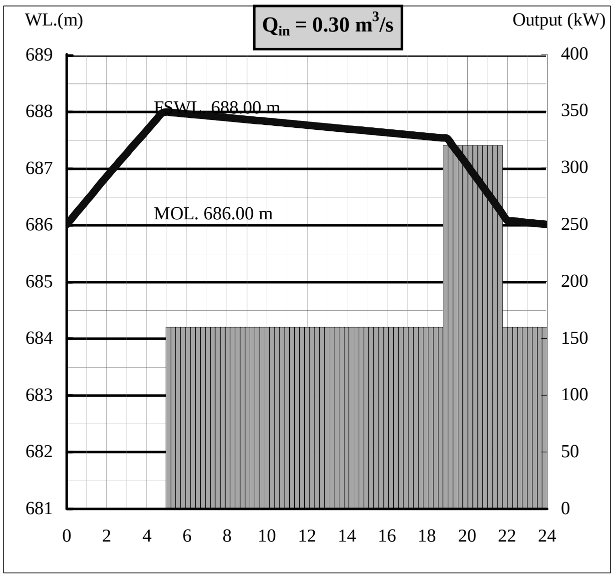
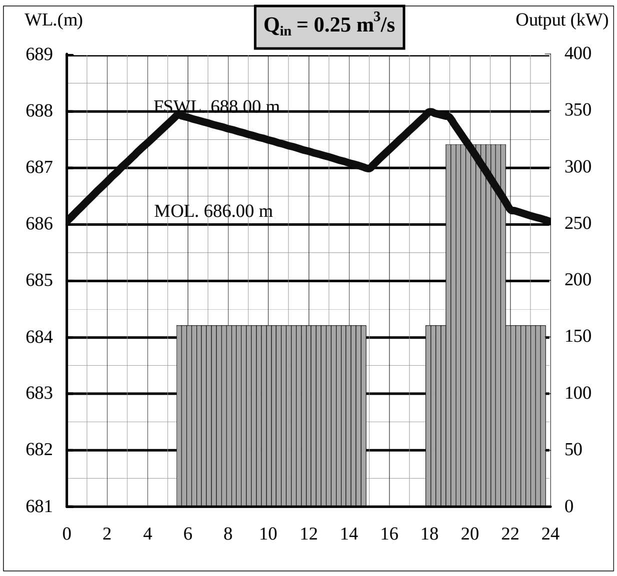
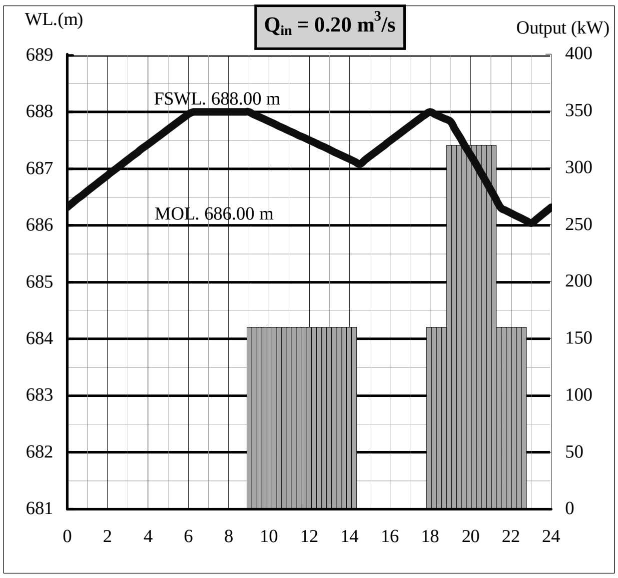
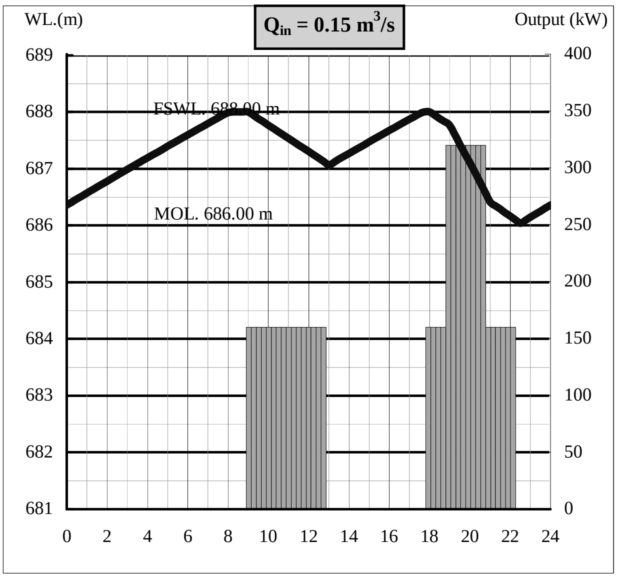


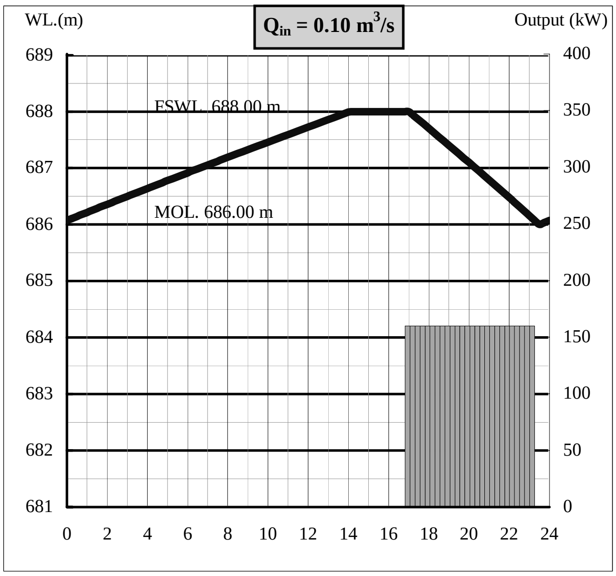
Table C-3-5 Calculation of Daily Power Generation in Nam Lan Micro Hydro (2/2)

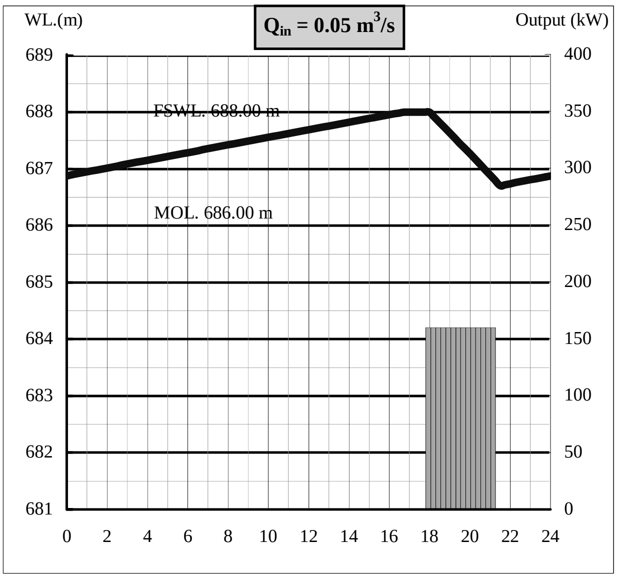










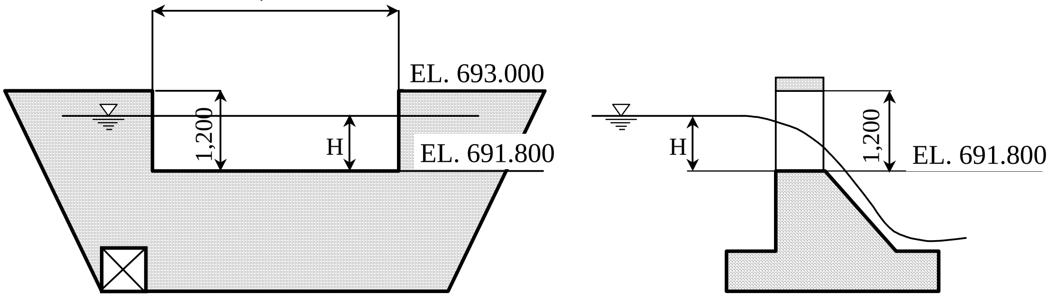


Hydraulic Calculations for Nam Lan Mini Hydro Scheme

1. Diversion Weir

(1) Overflow capacity during a flood

Excessive discharge during a flood will be released from the spillway of the diversion weir



The overflow discharge can be calculated by the following formula:

$$Q = 1.84 \cdot (B - 0.2 \cdot H) \cdot H^{1.5}$$

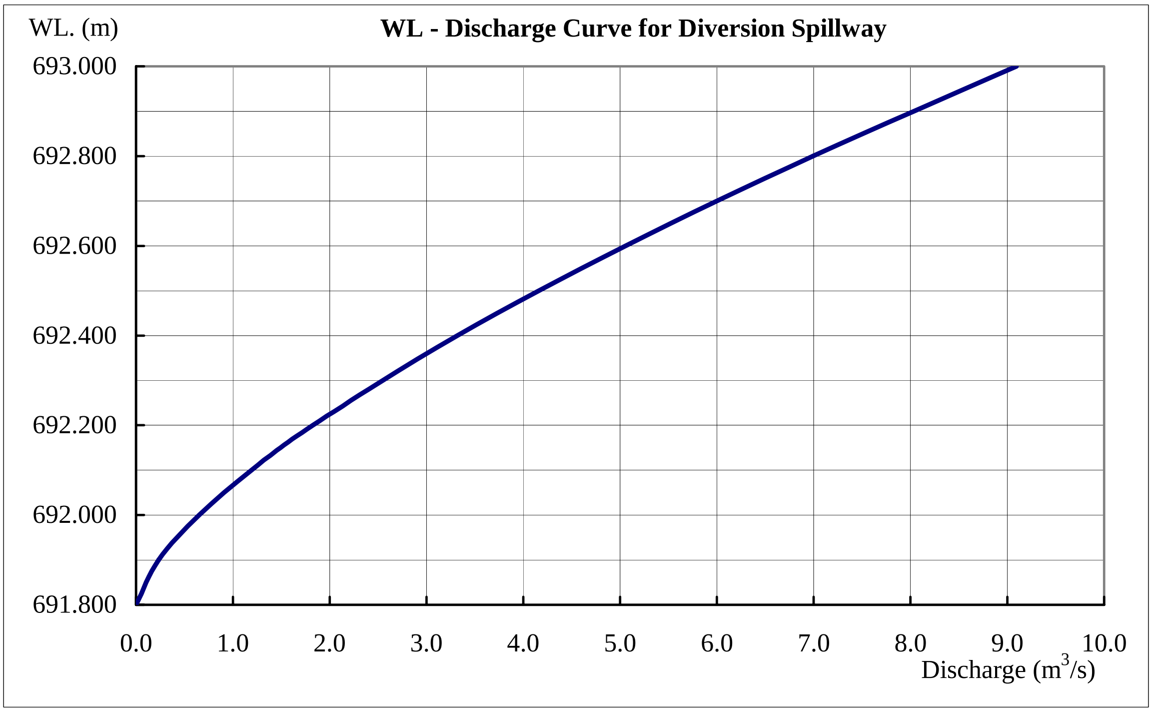
Where, Q : overflow discharge (m^3/s)
B : width of weir (= 4.0 m)
H : overflow depth (m)

Design Flood Discharge (100-year probable flood) = 8.6 m^3/sec

Flood Water Level   8.6 = 1.84 x (4.0 - 0.2 x 1.15) x $1.15^{1.5}$

FWL = 691.800 + 1.15 = 692.950

Overflow Capacity   Q = 1.84 x (4.0 - 0.2 x 1.2) x $1.2^{1.5}$ = 9.1 m^3/sec



(2) River Outlet

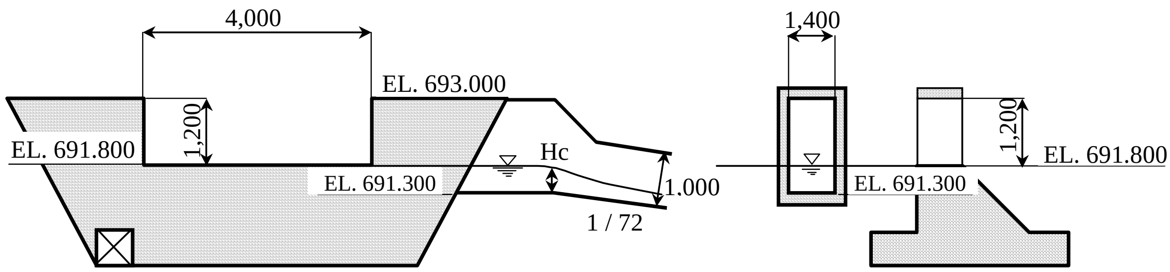
River Outet 1.0 m x 1.0 m, Center Elevation EL. 690.500

Discharge capacity at WL. 691.800

Discahrge Q = √ {2 x 9.8 x (691.800 - 690.500) / (1.0 + 0.2)} x (1.0 x 1.0) = 4.6 m^3/s

Velocity V = √ {2 x 9.8 x (691.800 - 690.500) / (1.0 + 0.5)} = 4.6 m/s

2. Diversion Channel



(1) Inflow into Diversion Channel

Critical depth occurs at BP. of the slope of the inlet, and the flow in the channel become supercritical, since the slope of the channel is 1/72 that is steeper than critical slope.

The inflow discharge can be calculated by the following formula:

$$Q = 1.84 \cdot (B - 0.2 \cdot H) \cdot H^{1.5}$$

Where, Q : overflow discharge (m^3/s)
B : width of inlet (= 1.4 m)
H : overflow depth (m)

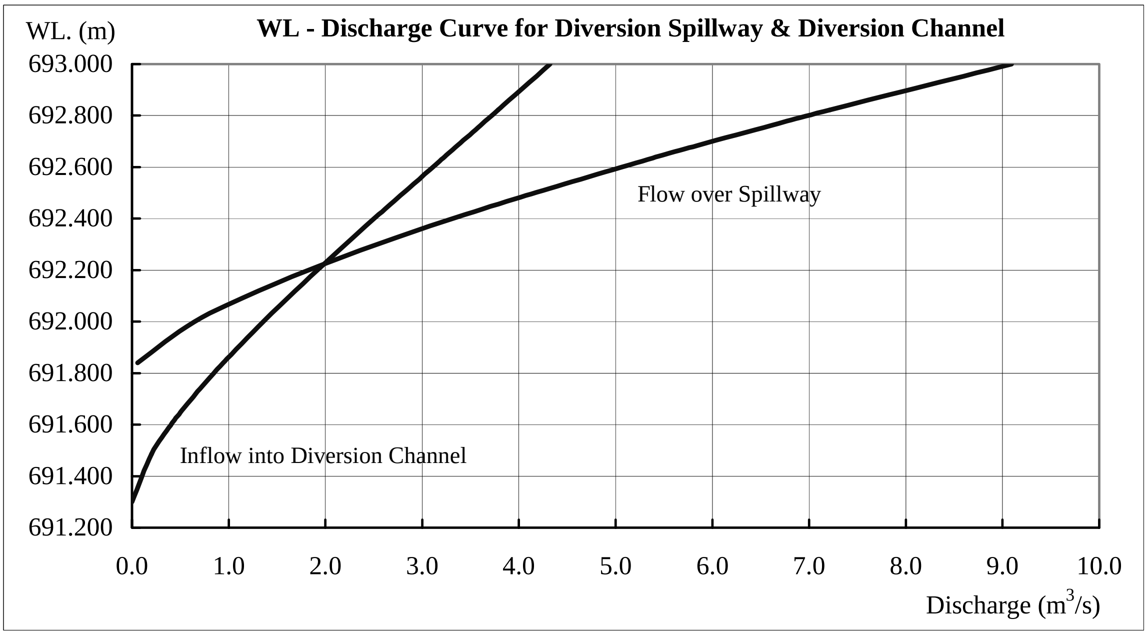
WL. < EL. 691.800 : whole river flow enters the diversion channel.

WL. > EL. 691.800 : river flow is divided into the weir and the channel

Flow into the channel Qin = 1.84 x { 1.40 - (WL - 691.300)} x (WL - 691.300)$^{1.5}$

Flow over the spillway Qspill = 1.84 x { 4.00 - (WL - 691.800)} x (WL - 691.800)$^{1.5}$

WL. 691.72	Qin = 0.65 m^3/s	Qspill = 0.00 m^3/s	Qriver = 0.65 m^3/s
WL. 691.80	Qin = 0.85 m^3/s	Qspill = 0.00 m^3/s	Qriver = 0.85 m^3/s
WL. 691.84	Qin = 0.94 m^3/s	Qspill = 0.06 m^3/s	Qriver = 1.00 m^3/s
WL. 692.12	Qin = 1.69 m^3/s	Qspill = 1.31 m^3/s	Qriver = 3.00 m^3/s
WL. 692.32	Qin = 2.28 m^3/s	Qspill = 2.72 m^3/s	Qriver = 5.00 m^3/s
WL. 692.64	Qin = 3.22 m^3/s	Qspill = 5.38 m^3/s	Qriver = 8.60 m^3/s (100-year flood)



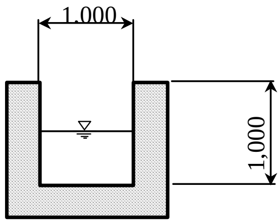
From the above analysis, the followings are sumarized:

1) River flow < 0.85 m^3/s the whole flow enters the diversion channel
2) River flow > 0.85 m^3/s the flow is divided into the weir and the channel
3) 100-year probable flood FWL = 692.68 Qin = 3.2 m^3/s Qspill = 5.4 m^3/s

(2) Uniform flow depth

Uniform flow depth in the diversion channel is callculated by the following formula:

$$Q = \frac{b \cdot h}{n} R^{2/3} I^{1/2}$$



Where, Q : discharge (m^3/s) n : roughness (= 0.015)
b : width (= 1.0 m) R : hydraulic radius (m)
h : depth of flow (m) I : slope (= 1 / 72)

Q (m^3/s)	Uniform depth (m)	Velocity (m/s)	Note
0.65	0.27	2.44	Max. design discharge
1.00	0.36	2.77	
2.00	0.60	3.31	
3.20	0.87	3.66	100-year probable flood

3. Head Pond

(1) Inflow Monitoring System

The inflow into the pond shall be monitored during the power generation by reading the water level in the pond through the pressure gauge equiped in the powerhouse.

$$\frac{dV}{dt} = \frac{dV}{dH} \cdot \frac{dH}{dt} = S(H) \cdot \frac{dH}{dt} = (Q_{in} - Q_{out})$$

$$\frac{dH}{dt} = \frac{(Q_{in} - Q_{out}) \cdot 3{,}600}{S(H)} = \frac{(Q_{in} - Q_{out}) \cdot 3{,}600}{\{25 + (H - 686)\} \cdot \{100 + (H - 686)\}} = \frac{(Q_{in} - Q_{out}) \cdot 3{,}600}{(H - 661) \cdot (H - 586)}$$

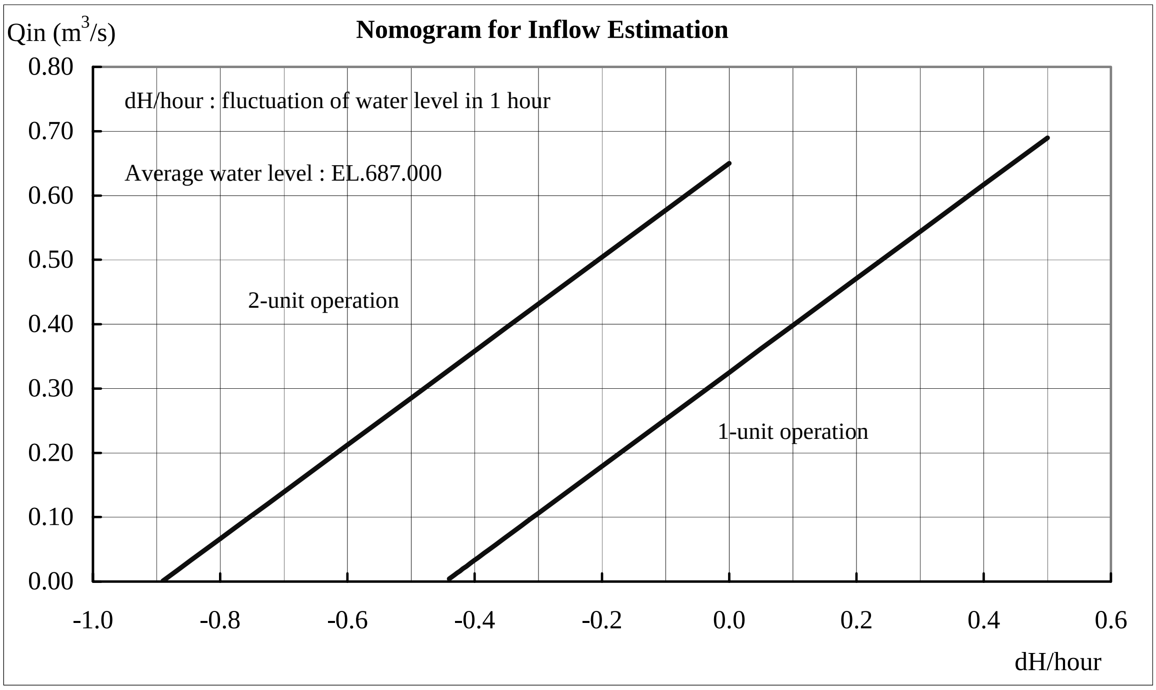
$$Q_{in} = \frac{dH}{dt} \cdot S(H) / 3{,}600 + Q_{out} = \frac{dH}{dt} \cdot (H - 661) \cdot (H - 586) / 3{,}600 + Q_{out}$$

where, dH/dt : fluctuation of water level in the pond during (dt) hours

H : water level in the pond (m)

Qin : inflow into the pond (m^3/s)

Qout : powr discharge (2-unit operation=0.65 m3/s, 1-unit operation=0.325 m3/s)



Procedures:

1) Power operation with 2-unit (320 kW, Qout=0.65 m^3/s))

2) Reading of water level in the pond by pressure gauge

3) When fluctuation of water level during 1.0 hour is -0.35m , and average water level is 687.000m under 2-unit operation

Qin = -0.35 x (687.000 - 661.000) x (687.000 - 586.000) / 3,600 + 0.65 = 0.395 m^3/s

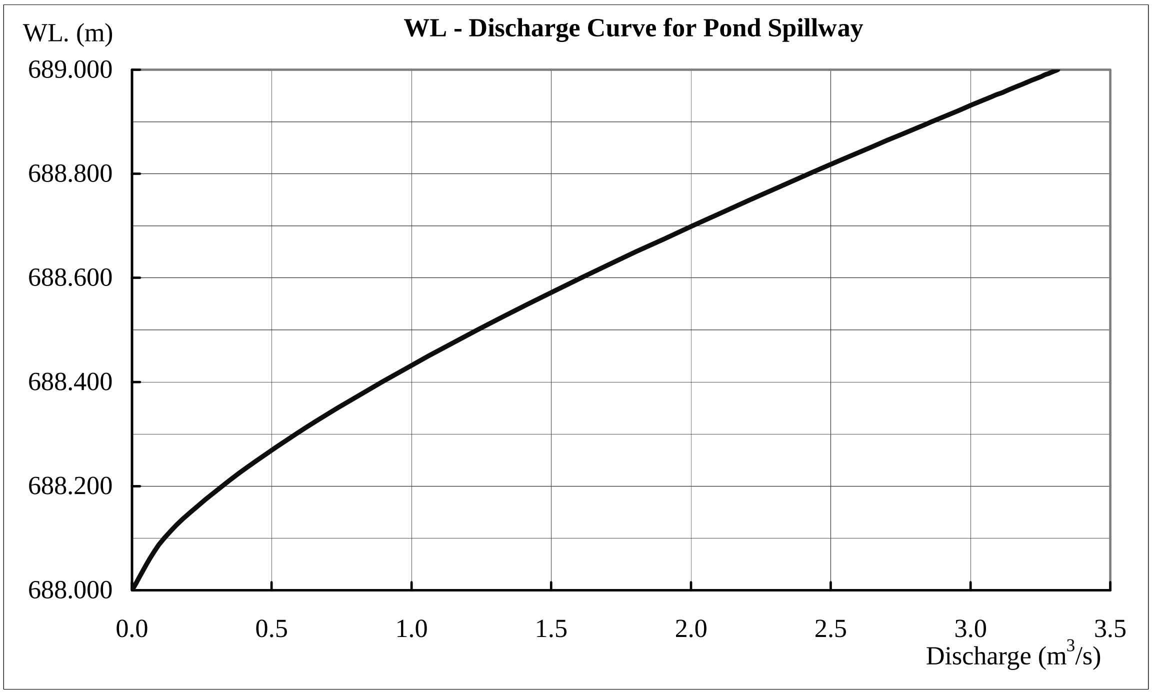
(2) Spillway of Head Pond

Spillway Crest EL. 688.000, Width = 2.0 m

$$Q = 1.84 \cdot (B - 0.2 \cdot H) \cdot H^{1.5}$$

Where, Q : overflow discharge (m^3/s)
B : width of weir (= 2.0 m)
H : overflow depth (m)

WL. 688.50	Qspill = 1.24 m^3/s
WL. 688.60	Qspill = 1.61 m^3/s
WL. 688.70	Qspill = 2.00 m^3/s
WL. 688.80	Qspill = 2.42 m^3/s
WL. 688.90	Qspill = 2.86 m^3/s
WL. 688.90	Qspill = 2.86 m^3/s
WL. 688.98	Qspill = 3.20 m^3/s
WL. 689.00	Qspill = 3.31 m^3/s



(3) Sand Drain of Head Pond

Outflow discharge through the sand drain gate can be calculated by the following formula:

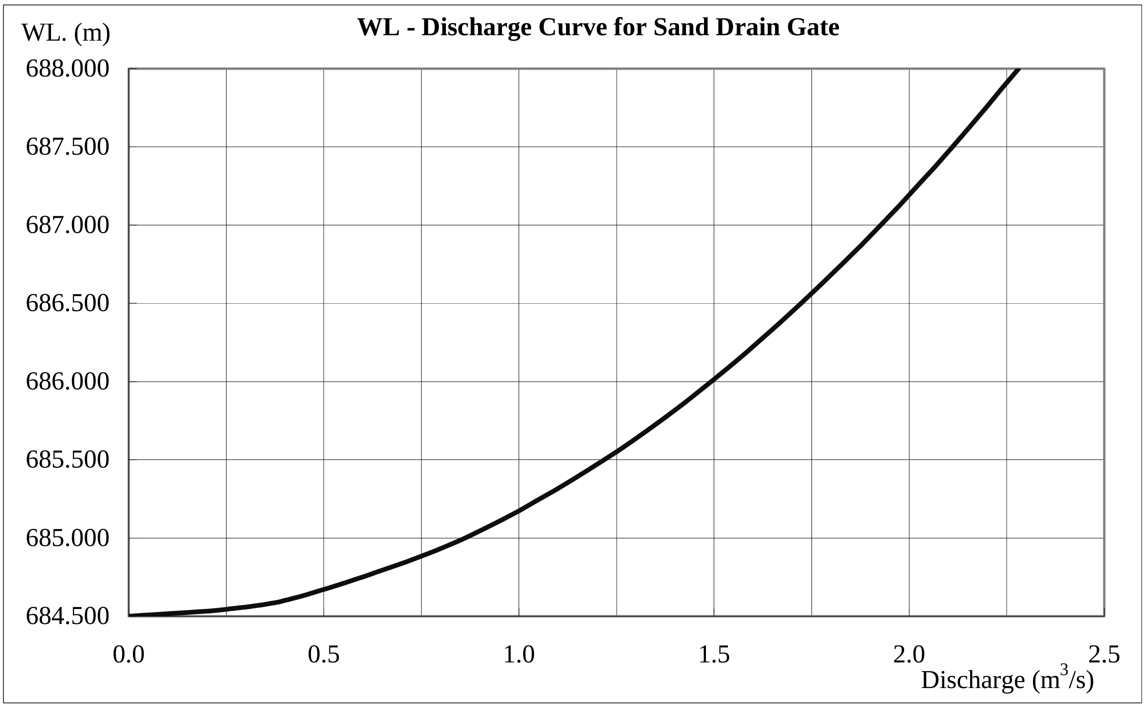
$$Q = A \cdot \sqrt{\frac{2 \cdot g \cdot H}{1 + f_e + f_b + f}}$$

Where, Q : discharge (m^3/s) A : area of gate (= 0.6 m x 0.6 m = 0.36 m^2)
H : head (= WL - 683.600 m) f_e : loss coefficient of inlet (= 0.2)
f_b : loss coefficient of bend = {0.131 + 0.1632 $(0.6/3.0)^{3.5}$} $(60/90)^{0.5}$ = 0.11
f : loss coefficient of friction = 12.7 x 9.8 x 0.012^2 x 11.2 / $0.6^{(4/3)}$ = 0.40

EL. of pipe outlet = EL. 683.60 m, Pipe length = 11.2 m, Pipe dia. = 0.60 m
Bend angle = 60 ° , Bend radius = 3.0 m

The relation between the water level in the pond and the outflow discharge under full opening of the sand drain gate is calculated as follows:

WL. 688.000 Qout = 2.28 m^3/s
WL. 687.500 Qout = 2.11 m^3/s
WL. 687.000 Qout = 1.93 m^3/s
WL. 686.500 Qout = 1.72 m^3/s
WL. 686.000 Qout = 1.49 m^3/s
WL. 685.500 Qout = 1.22 m^3/s
WL. 685.000 Qout = 0.86 m^3/s
WL. 684.500 Qout = 0.00 m^3/s



4. Penstock

For head loss calculations, refer to the following section.

5. Tailrace

Critical depth occurs at BP of tailrace channel, which can be calculated by the following formula.

$$Hc = \sqrt[3]{\frac{1.1 \cdot Q^2}{9.8 \cdot b^2}}$$

Where, Q : discharge (m^3/s)
Hc : Critical depth for rectangular section
b : width of channel (=1.5 m)

Critical depth Hc = 0.276 m, Velocity v = 1.569 m/s, Velocity head $v^2/2g$ = 0.126 m

Elevation of tailrace channel at BP

TWL - Hc - $v^2/2g$ = 618.500 - 0.276 - 0.126 = EL. 618.098 m ⇒ EL.618.100 m

Uniform flow depth for trapezoidal channel

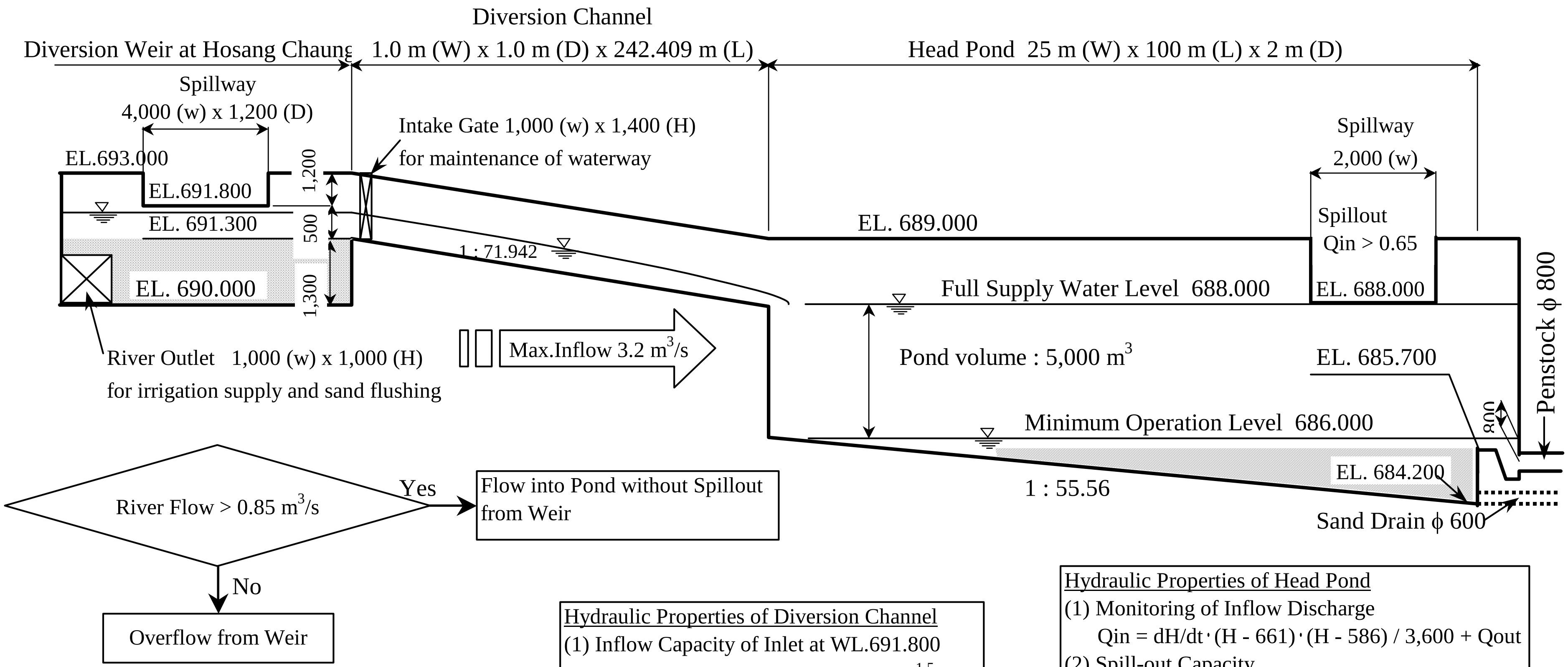
Depth = 0.16 m (Q = 0.65 m^3/s, n = 0.020, slope = 1 / 27, bottom width = 1.5 m, side slope 1 : 0.5)

Velocity = 2.55 m/s

Formation of the tailrace channel

STA. + 186.5 (BP. of tailrace channel)	FH = 618.100
STA. + 283.5 (BP. + 97.0 m)	FH = 614.500
Total length of tailrace channel	L = 97.0 m
Slope	1 / 26.944
Flood water level of the stream	EL. 615.900 (EL. 614.200 + 1.700 m)
Tail water level	EL. 618.500

HYDRAULIC FEATURES OF WATERWAY



<u>Hydraulic Properties of Diversion Weir</u>

(1) Overflow Capacity

$Q = 1.84 \times (4.0 - 0.2 \times 1.2) \times 1.2^{1.5} = 9.1\ m^3/s$

(2) Outflow Capacity of River Outlet

$Q = \sqrt{\{2 \times 9.8 \times 1.3 / (1.0 + 0.2)\}} \times (1.0 \times 1.0)$

$= 4.6\ m^3/s$

<u>Hydraulic Properties of Diversion Channel</u>

(1) Inflow Capacity of Inlet at WL.691.800

$Qin = 1.84 \times (1.40 - 0.2 \times 0.5) \times 0.5^{1.5}$

$= 0.85\ m^3/s > 0.65\ m^3/s$

(2) Inflow during 100-year flood ($Q = 8.6\ m^3/s$)

$Qin = 3.2\ m^3/s$

$Qspill = 5.4\ m^3/s$

(3) Uniform Depth of Channel

H = 0.27 m (b=1.0m, n=0.015, slope 1/72)

<u>Hydraulic Properties of Head Pond</u>

(1) Monitoring of Inflow Discharge

$Qin = dH/dt \cdot (H - 661) \cdot (H - 586) / 3,600 + Qout$

(2) Spill-out Capacity

$Q = 1.84 \times (2.0 - 0.2 \times 1.0) \times 1.0^{1.5} = 3.3\ m^3/s$

(3) Flow Capacity of Sand Drain

$Q = \sqrt{\{2 \times 9.8 \times 3.5 / (1.0 + 0.5)\}} \times (0.6 \times 0.6)$

$= 2.4\ m^3/s$ at FSWL

$Q = \sqrt{\{2 \times 9.8 \times 1.5 / (1.0 + 0.5)\}} \times (0.6 \times 0.6)$

$= 1.6\ m^3/s$ at MOL

Head Loss Calculation in Nam Lan Mini Hydro Scheme for 2 units Operation

FSWL at Regulating Pond	688.000
TWL at Tailrace	618.500
Discharge (m3/sec)	0.650
Combined Efficiency of Turbine & Generator	0.733
Units of Turbine & Generator	2

PENSTOCK

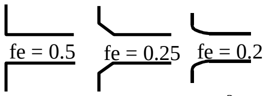
(1) Screen

$$h_{11} = f_r \cdot \frac{v_1^2}{2g} \qquad f_r = 2.34(\sin\theta)(\frac{t}{b})^{4/3}$$

B(m)	H(m)	f_r	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
3.00	0.30	0.97	0.722	0.0258	61,098.51

(2) Inlet

$$h_{12} = f_e \cdot \frac{v_2^2}{2g}$$



D (m)	f_e	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.80	0.20	1.293	0.0171	40,386.31

(3) Friction

$$h_{13} = \frac{124.5n^2}{D^{4/3}} L \frac{v^2}{2g}$$

$Q(m^3/s)$	n	D (m)	L (m)	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.65	0.0120	0.80	178.49	1.293	0.3676	870,063.87
0.33	0.0120	0.40	3.55	2.586	0.0738	174,573.35

(4) Bend

$$h_{14} = \{0.131 + 0.1632 \cdot (\frac{D}{R})^{3.5}\} \cdot (\frac{\theta}{90})^{0.5} \cdot \frac{v^2}{2g}$$

$Q(m^3/s)$	R	D(m)	θ (°)	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.65	2.400	0.80	23.77	1.293	0.0059	13,956.83
0.65	2.400	0.80	2.06	1.293	0.0017	4,108.71
0.65	2.400	0.80	9.04	1.293	0.0036	8,607.09
0.65	2.400	0.80	17.24	1.293	0.0050	11,886.14
0.33	1.200	0.40	30.00	2.586	0.0265	62,718.09

(5) Transition

$$h_{15} = f_{gc} \frac{v_2^2}{2g}$$

D_1(m)	D_2(m)	L(m)	$f_{transition}$	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2

(6) Branch

$$h_{16} = f_b \cdot \frac{v_0^2}{2g}$$

D_0(m)	f_b	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.80	0.500	1.293	0.0427	100,965.78

(7) Inlet valve

$$h_{17} = f_v \cdot \frac{v^2}{2g}$$

$Q(m^3/s)$	D(m)	f_{valve}	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.33	0.40	0.250	2.586	0.0853	201,931.57

		Head Loss (m)	Coefficient x 10^{-6} Q^2
(8) Others	Round-up	0.0050	11,833.92
Sub-total (1) - (8)		0.6600	1,562,130.18

TAILRACE

Discharge $Q(m^3/s)$: 0.33

(1) Friction in transition

$$h_{21} = \frac{2.37 \cdot n^2 Q^2 L}{D_2 - D_1} \cdot (\frac{1}{D_1^{13/3}} - \frac{1}{D_2^{13/3}})$$

n	D_1(m)	D_2(m)	L(m)	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2

(2) Enlargement

$$h_{21} = f_{ge}\{1 - (\frac{A_1}{A_2})\}^2 \cdot \frac{v_1^2}{2g}$$

D_1(m)	D_2(m)	f_{ge}	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2

(3) Exit

$$h_{23} = f_{exit} \cdot \frac{v^2}{2g}$$

D(m)	f_{exit}	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.80	1.000	0.647	0.0213	50,482.89

		Head Loss (m)	Coefficient x 10^{-6} Q^2
(4) Others	10%	0.0021	5,048.29
Sub-total		0.0235	55,531.18
Total of Head Loss		**0.6835**	**1,617,661.36**

Gross Head (m)	**69.500**
Effective Head (m)	**68.817**
Power Output (kW)	**320**

Head Loss Calculation in Nam Lan Mini Hydro Scheme for 1 unit Operation

FSWL at Regulating Pond	688.000
TWL at Tailrace	618.500
Discharge (m3/sec)	0.325
Combined Efficiency of Turbine & Generator	0.733
Units of Turbine & Generator	1

PENSTOCK

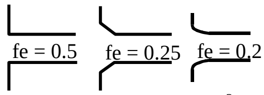
(1) Screen

$$h_{11} = f_r \cdot \frac{v_1^2}{2g} \qquad f_r = 2.34(\sin\theta)(\frac{t}{b})^{4/3}$$

B(m)	H(m)	f_r	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
3.00	0.30	0.97	0.361	0.0065	61,098.51

(2) Inlet

$$h_{12} = f_e \cdot \frac{v_2^2}{2g}$$



D (m)	f_e	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.80	0.20	0.647	0.0043	40,386.31

(3) Friction

$$h_{13} = \frac{124.5n^2}{D^{4/3}} L \frac{v^2}{2g}$$

Q(m^3/s)	n	D (m)	L (m)	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.33	0.0120	0.80	178.49	0.647	0.0919	870,063.87
0.33	0.0120	0.40	3.55	2.586	0.0738	698,293.39

(4) Bend

$$h_{14} = \{0.131 + 0.1632 \cdot (\frac{D}{R})^{3.5}\} \cdot (\frac{\theta}{90})^{0.5} \cdot \frac{v^2}{2g}$$

Q(m^3/s)	R	D(m)	θ (°)	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.33	2.400	0.80	23.77	0.647	0.0015	13,956.83
0.33	2.400	0.80	2.06	0.647	0.0004	4,108.71
0.33	2.400	0.80	9.04	0.647	0.0009	8,607.09
0.33	2.400	0.80	17.24	0.647	0.0013	11,886.14
0.33	1.200	0.40	30.00	2.586	0.0265	250,872.35

(5) Transition

$$h_{15} = f_{gc} \frac{v_2^2}{2g}$$

D_1(m)	D_2(m)	L(m)	$f_{transition}$	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2

(6) Branch

$$h_{16} = f_b \cdot \frac{v_0^2}{2g}$$

D_0(m)	f_b	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.80	0.500	0.647	0.0107	100,965.78

(7) Inlet valve

$$h_{17} = f_v \cdot \frac{v^2}{2g}$$

Q(m^3/s)	D(m)	f_{valve}	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.33	0.40	0.250	2.586	0.0853	807,726.27

		Head Loss (m)	Coefficient x 10^{-6} Q^2
(8) Others	Round-up	0.0071	66,945.98
Sub-total (1) - (8)		0.3100	2,934,911.24

TAILRACE

Discharge Q(m^3/s): 0.33

(1) Friction in transition

$$h_{21} = \frac{2.37 \cdot n^2 Q^2 L}{D_2 - D_1} \cdot (\frac{1}{D_1^{13/3}} - \frac{1}{D_2^{13/3}})$$

n	D_1(m)	D_2(m)	L(m)	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2

(2) Enlargement

$$h_{21} = f_{ge}\{1 - (\frac{A_1}{A_2})\}^2 \cdot \frac{v_1^2}{2g}$$

D_1(m)	D_2(m)	f_{ge}	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2

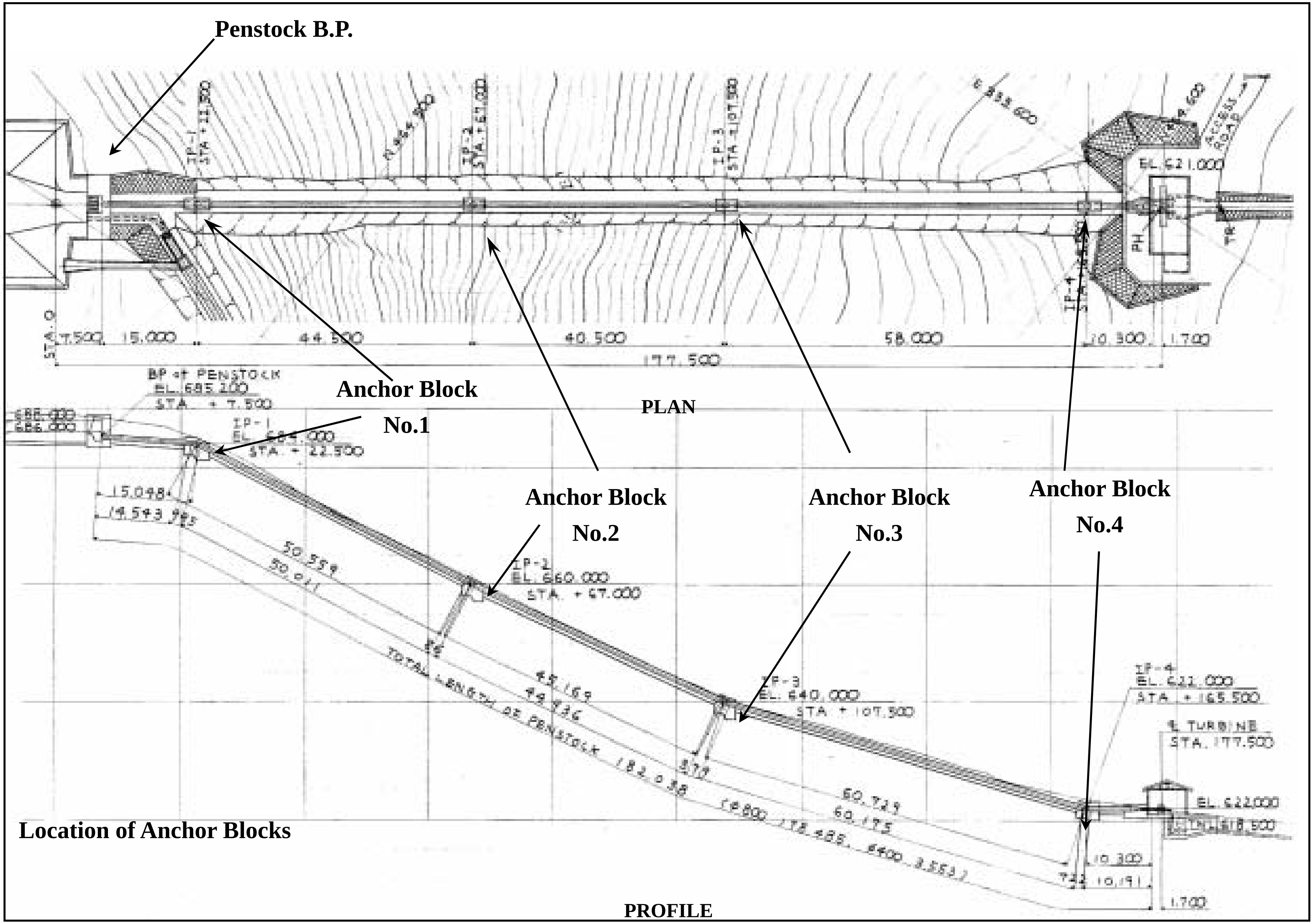
(3) Exit

$$h_{23} = f_{exit} \cdot \frac{v^2}{2g}$$

D(m)	f_{exit}	Velocity (m/s)	Head Loss (m)	Coefficient x 10^{-6} Q^2
0.80	1.000	0.647	0.0213	201,931.57

		Head Loss (m)	Coefficient x 10^{-6} Q^2
(4) Others	10%	0.0021	20,193.16
Sub-total		0.0235	222,124.72
Total of Head Loss		**0.3335**	**3,157,035.97**

Gross Head (m)	**69.500**
Effective Head (m)	**69.167**
Power Output (kW)	**160**


Penstock B.P.
Anchor Block No.1
Anchor Block No.2
Anchor Block No.3
Anchor Block No.4
PLAN
PROFILE
Location of Anchor Blocks
BP of PENSTOCK
EL. 685.200
STA. + 7.500
IP-1
EL. 684.000
STA. + 22.500
IP-2
EL. 660.000
STA. + 67.000
IP-3
EL. 640.000
STA. + 107.500
IP-4
EL. 621.000
STA. + 165.500
℄ TURBINE
STA. 177.500
EL. 622.000
EL. 621.000
177.500
15.000
44.500
40.500
58.000
10.300
1.700

Project: Namlan (REV3) **Anchor Block No.** 1

Item		unit	Input
Discharge	Q	m^3/s	0.65
Head	H	m	4.00
Dia. of Pipe (u/s)	ϕ_1	m	0.80
Dia. of Pipe (d/s)	ϕ_2	m	0.80
Thickness of pipe (u/s)	t_1	mm	6.00
Thickness of pipe (d/s)	t_2	mm	6.00
Distance to exp. jt. (u/s)	L_1	m	15.00
Distance to exp. jt. (d/s)	L_2	m	0.00
Distance to saddle (u/s)	l_1	m	6.00
Distance to saddle (d/s)	l_2	m	6.00
Pipe slope (u/s)	α_1	°	4.57
Pipe slope (d/s)	α_2	°	28.34
Center angle of bend	ψ	°	23.77
Width of Anchor	w	m	2.00
Fillet of anchor	b	m	0.30
Seismic coefficient	k_h	-	0.00
Unit weight of concrete	γ_c	t/m^3	2.30
Cohesion (concrete-foundation)	c	t/m^2	0.00
Friction coeff. (saddle)	f	-	0.50
Safety factor for sliding	F_s	-	1.50
Bearing stress of foundation	σ	t/m^2	100.00
滑動係数	ff	-	0.50

1. Anchor Block

No.	x(m)	y(m)
1	0.000	0.000
2	2.000	0.000
3	2.500	1.000
4	4.000	1.000
5	4.000	2.157
6	3.848	4.051
7	1.739	3.882
8	0.000	2.994
9	0.000	0.000
10		
11		
12		
13		
14		
15		

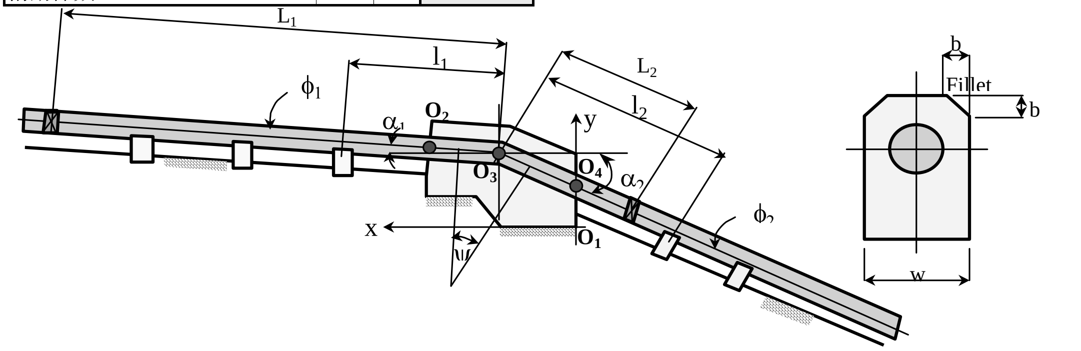
Max	4.000	
Min	0.000	
L	4.000	

2. Fillet

No.	x(m)	y(m)
1	3.848	4.051
2	1.739	3.882
3	0.000	2.994
4	0.000	2.603
5	1.826	3.588
6	3.872	3.752
7	3.848	4.051
8		
9		
10		
11		
12		
13		
14		
15		

Pipe Location

O_1	0.000	0.000
O_2	3.920	3.154
O_3	2.000	3.000
O_4	0.000	1.921



Force	Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr (t·m)	Mo (t·m)
(1) Penstock Pipe (u/s)	1.857	1.851	-0.148	2.000	3.000	4.146	
(2) Penstock Pipe (d/s)	1.640	1.443	-0.778	2.000	3.000	5.222	
(3) Axial Force of Penstock Pipe (u/s)	3.856	0.307	3.844	2.000	3.000	0.614	11.531
(4) Axial Force of Penstock Pipe (d/s)	0.000	0.000	0.000	2.000	3.000	0.000	0.000
(5) Friction (u/s)	0.016	0.001	0.016	2.000	3.000	0.003	0.048
(6) Friction (d/s)	0.000	0.000	0.000	2.000	3.000	0.000	0.000
(7) Centrifugal Force	0.035	-0.035	0.007	2.000	3.000		0.091
(8) Water Pressure at Bend	0.828	-0.810	0.171	2.000	3.000		2.132
(9) Reducer Bend	0.000	0.000	0.000	2.000	3.000	0.000	0.000
(10) Anchor Block	54.368	54.368	0.000	1.937	0.000	105.290	
(11) Seismic	0.000	0.000	0.000	0.000	1.959		0.000
Total		57.126	3.111			115.276	13.802
							101.473

Stability

	unit	unit	Result	Allowable Range	Judge
①	Safety factor for over turning	m	0.224	< 0.667	OK
②	Safety factor for sliding		11.017	> 1.200	OK
③	Bearing stress σ_1 (f=0.5)	t/m2	9.537	< 100.000	OK
④	Bearing stress σ_2 (f=0.5)	t/m2	4.745	< 100.000	OK

Stability Analysis of Anchor Block No.1

Project: Namlan (REV3) **Anchor Block No.** 2

Item		unit	Input
Discharge	Q	m^3/s	0.65
Head	H	m	28.00
Dia. of Pipe (u/s)	ϕ_1	m	0.80
Dia. of Pipe (d/s)	ϕ_2	m	0.80
Thickness of pipe (u/s)	t_1	mm	6.00
Thickness of pipe (d/s)	t_2	mm	6.00
Distance to exp. jt. (u/s)	L_1	m	50.00
Distance to exp. jt. (d/s)	L_2	m	0.00
Distance to saddle (u/s)	l_1	m	6.00
Distance to saddle (d/s)	l_2	m	6.00
Pipe slope (u/s)	α_1	°	28.34
Pipe slope (d/s)	α_2	°	26.28
Center angle of bend	ψ	°	2.06
Width of Anchor	w	m	2.00
Fillet of anchor	b	m	0.03
Seismic coefficient	k_h	-	0.00
Unit weight of concrete	γ_c	t/m^3	2.30
Cohesion (concrete-foundation)	c	t/m^2	0.00
Friction coeff. (saddle)	f	-	0.50
Safety factor for sliding	F_s	-	1.50
Bearing stress of foundation	σ	t/m^2	100.00
滑動係数	ff	-	0.50

1. Anchor Block

No.	x(m)	y(m)
1	0.000	0.000
2	1.500	0.000
3	2.000	1.000
4	4.000	1.000
5	4.000	2.942
6	3.098	4.615
7	1.587	3.800
8	0.000	3.016
9	0.000	0.000
10		
11		
12		
13		
14		
15		

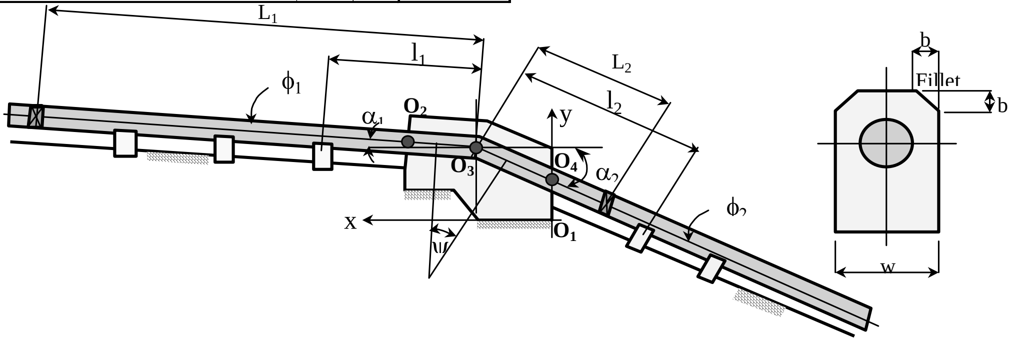
Max	4.000
Min	0.000
L	4.000

2. Fillet

No.	x(m)	y(m)
1	3.098	4.615
2	1.587	3.800
3	0.000	3.016
4	0.000	2.682
5	1.725	3.533
6	3.240	4.351
7	3.098	4.615
8		
9		
10		
11		
12		
13		
14		
15		

Pipe Location

O_1	0.000	0.000
O_2	3.525	3.823
O_3	2.000	3.000
O_4	0.000	2.012



Force	Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr (t·m)	Mo (t·m)
(1) Penstock Pipe (u/s)	1.640	1.443	-0.778	2.000	3.000	5.222	
(2) Penstock Pipe (d/s)	1.671	1.498	-0.740	2.000	3.000	5.215	
(3) Axial Force of Penstock Pipe (u/s)	15.655	7.431	13.779	2.000	3.000	14.862	41.336
(4) Axial Force of Penstock Pipe (d/s)	0.000	0.000	0.000	2.000	3.000	0.000	0.000
(5) Friction (u/s)	0.054	0.025	0.047	2.000	3.000	0.051	0.142
(6) Friction (d/s)	0.000	0.000	0.000	2.000	3.000	0.000	0.000
(7) Centrifugal Force	0.003	0.003	-0.000	2.000	3.000	0.006	
(8) Water Pressure at Bend	0.506	0.505	-0.009	2.000	3.000	1.038	
(9) Reducer Bend	0.000	0.000	0.000	2.000	3.000	0.000	0.000
(10) Anchor Block	54.795	54.795	0.000	1.951	0.000	106.897	
(11) Seismic	0.000	0.000	0.000	0.000	2.113		0.000
Total		65.701	12.299			133.290	41.477
							91.813

Stability

	unit	unit	Result	Allowable Range		Judge
①	Safety factor for over turning	m	0.603	<	0.667	OK
②	Safety factor for sliding		3.205	>	1.200	OK
③	Bearing stress σ_1 (f=0.5)	t/m2	15.636	<	100.000	OK
④	Bearing stress σ_2 (f=0.5)	t/m2	0.790	<	100.000	OK

Stability Analysis of Anchor Block No.2

Project: Namlan (REV3) **Anchor Block No.** 3

Item		unit	Input
Discharge	Q	m^3/s	0.65
Head	H	m	48.00
Dia. of Pipe (u/s)	ϕ_1	m	0.80
Dia. of Pipe (d/s)	ϕ_2	m	0.80
Thickness of pipe (u/s)	t_1	mm	6.00
Thickness of pipe (d/s)	t_2	mm	6.00
Distance to exp. jt. (u/s)	L_1	m	45.00
Distance to exp. jt. (d/s)	L_2	m	0.00
Distance to saddle (u/s)	l_1	m	6.00
Distance to saddle (d/s)	l_2	m	6.00
Pipe slope (u/s)	α_1	°	26.28
Pipe slope (d/s)	α_2	°	17.24
Center angle of bend	ψ	°	9.04
Width of Anchor	w	m	2.00
Fillet of anchor	b	m	0.30
Seismic coefficient	k_h	-	0.00
Unit weight of concrete	γ_c	t/m^3	2.30
Cohesion (concrete-foundation)	c	t/m^2	0.00
Friction coeff. (saddle)	f	-	0.50
Safety factor for sliding	F_s	-	1.50
Bearing stress of foundation	σ	t/m^2	100.00
滑動係数	ff	-	0.50

1. Anchor Block

No.	x(m)	y(m)
1	0.000	0.000
2	1.500	0.000
3	2.000	1.000
4	3.500	1.000
5	3.500	2.625
6	2.659	4.329
7	1.665	3.838
8	0.000	3.300
9	0.000	0.000
10		
11		
12		
13		
14		
15		

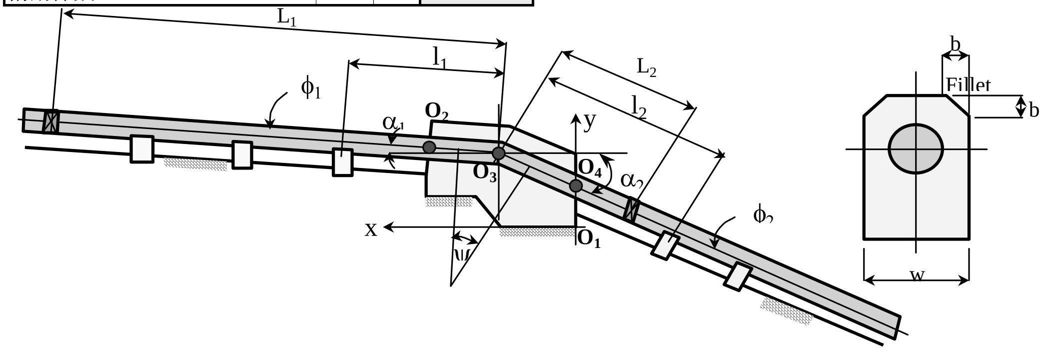
Max	3.500
Min	0.000
L	3.500

2. Fillet

No.	x(m)	y(m)
1	2.659	4.329
2	1.665	3.838
3	0.000	3.300
4	0.000	3.008
5	1.777	3.559
6	2.792	4.060
7		
8		
9		
10		
11		
12		
13		
14		
15		

Pipe Location

O_1	0.000	0.000
O_2	3.057	3.523
O_3	2.000	3.000
O_4	0.000	2.379



Force	Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr (t･m)	Mo (t･m)
(1) Penstock Pipe (u/s)	1.671	1.498	-0.740	2.000	3.000	5.215	
(2) Penstock Pipe (d/s)	1.779	1.699	-0.527	2.000	3.000	4.981	
(3) Axial Force of Penstock Pipe (u/s)	14.052	6.222	12.600	2.000	3.000	12.443	37.799
(4) Axial Force of Penstock Pipe (d/s)	0.000	0.000	0.000	2.000	3.000	0.000	0.000
(5) Friction (u/s)	0.048	0.021	0.043	2.000	3.000	0.043	0.130
(6) Friction (d/s)	0.000	0.000	0.000	2.000	3.000	0.000	0.000
(7) Centrifugal Force	0.014	0.013	-0.001	2.000	3.000	0.030	
(8) Water Pressure at Bend	3.803	3.791	-0.300	2.000	3.000	8.481	
(9) Reducer Bend	0.000	0.000	0.000	2.000	3.000	0.000	0.000
(10) Anchor Block	43.798	43.798	0.000	1.698	0.000	74.391	
(11) Seismic	0.000	0.000	0.000	0.000	2.283		0.000
Total		57.043	11.075			105.584	37.929
							67.655

Stability

	unit	unit	Result	Allowable Range	Judge
①	Safety factor for over turning	m	0.564	< 0.583	OK
②	Safety factor for sliding		3.090	> 1.200	OK
③	Bearing stress σ_1 (f=0.5)	t/m2	16.028	< 100.000	OK
④	Bearing stress σ_2 (f=0.5)	t/m2	0.270	< 100.000	OK

Stability Analysis of Anchor Block No.3

Project: Namlan (REV3) **Anchor Block No.** 4

Item		unit	Input
Discharge	Q	m^3/s	0.65
Head	H	m	66.00
Dia. of Pipe (u/s)	ϕ_1	m	0.80
Dia. of Pipe (d/s)	ϕ_2	m	0.80
Thickness of pipe (u/s)	t_1	mm	6.00
Thickness of pipe (d/s)	t_2	mm	6.00
Distance to exp. jt. (u/s)	L_1	m	60.00
Distance to exp. jt. (d/s)	L_2	m	0.00
Distance to saddle (u/s)	l_1	m	6.00
Distance to saddle (d/s)	l_2	m	6.00
Pipe slope (u/s)	α_1	°	17.24
Pipe slope (d/s)	α_2	°	0.00
Center angle of bend	ψ	°	17.24
Width of Anchor	w	m	2.00
Fillet of anchor	b	m	0.30
Seismic coefficient	k_h	-	0.00
Unit weight of concrete	γ_c	t/m^3	2.30
Cohesion (concrete-foundation)	c	t/m^2	0.00
Friction coeff. (saddle)	f	-	0.50
Safety factor for sliding	F_s	-	1.50
Bearing stress of foundation	σ	t/m^2	100.00
滑動係数	ff	-	0.50

1. Anchor Block

No.	x(m)	y(m)
1	0.000	0.000
2	1.750	0.000
3	2.000	0.500
4	3.500	0.500
5	3.500	1.418
6	2.937	3.233
7	1.864	2.900
8	0.000	2.900
9	0.000	0.000
10		
11		
12		
13		
14		
15		

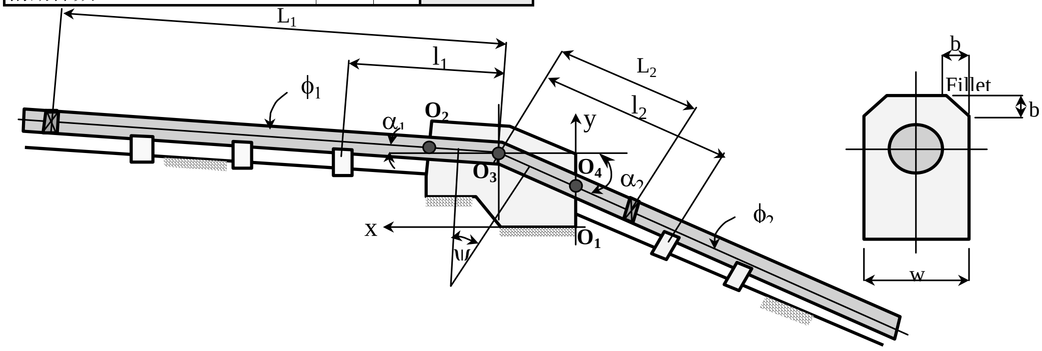
Max	3.500
Min	0.000
L	3.500

2. Fillet

No.	x(m)	y(m)
1	2.937	3.233
2	1.864	2.900
3	0.000	2.900
4	0.000	2.600
5	1.909	2.600
6	3.026	2.947
7	2.937	3.233
8		
9		
10		
11		
12		
13		
14		
15		

Pipe Location

	x	y
O_1	0.000	0.000
O_2	3.204	2.374
O_3	2.000	2.000
O_4	0.000	2.000



Force	Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr (t·m)	Mo (t·m)
(1) Penstock Pipe (u/s)	1.779	1.699	-0.527	2.000	2.000	4.454	
(2) Penstock Pipe (d/s)	1.863	1.863	0.000	2.000	2.000	3.726	
(3) Axial Force of Penstock Pipe (u/s)	19.009	5.634	18.155	2.000	2.000	11.268	36.310
(4) Axial Force of Penstock Pipe (d/s)	0.000	0.000	0.000	2.000	2.000	0.000	0.000
(5) Friction (u/s)	0.064	0.019	0.061	2.000	2.000	0.038	0.123
(6) Friction (d/s)	0.000	0.000	0.000	2.000	2.000	0.000	0.000
(7) Centrifugal Force	0.026	0.025	-0.004	2.000	2.000	0.059	
(8) Water Pressure at Bend	9.945	9.833	-1.491	2.000	2.000	22.647	
(9) Reducer Bend	0.000	0.000	0.000	2.000	2.000	0.000	0.000
(10) Anchor Block	37.889	37.889	0.000	1.629	0.000	61.729	
(11) Seismic	0.000	0.000	0.000	0.000	1.473		0.000
Total		56.963	16.195			103.921	36.433
							67.488

Stability

	unit	unit	Result	Allowable Range	Judge
①	Safety factor for over turning	m	0.565	< 0.583	OK
②	Safety factor for sliding		2.110	> 1.200	OK
③	Bearing stress σ_1 (f=0.5)	t/m2	16.023	< 100.000	OK
④	Bearing stress σ_2 (f=0.5)	t/m2	0.253	< 100.000	OK

Stability Analysis of Anchor Block No.4

Project: Namlan (REV5) **Section** A

Item		unit	Input
Discharge	Q	m^3/s	0.65
Dia. of pipe	ϕ	m	0.80
Thickness of pipe	t	mm	6.00
Distance between saddles	l	m	6.00
Pipe slope	α	°	4.57
Width of saddle	w	m	1.20
Fillet of saddle	b	m	0.60
Seismic coefficient	k_h	-	0.12
Unit weight of concrete	γ_c	t/m^3	2.30
Cohesion (concrete-foundation)	c	t/m^2	0.00
Friction coeff. (saddle)	f	-	0.50
Safety factor for sliding	F_s	-	1.50
Bearing stress of foundation	σ	t/m^2	100.00
滑動係数	ff	-	0.50

1. Anchor Block

No.	x(m)	y(m)
1	0.000	0.000
2	0.622	0.000
3	0.495	1.586
4	0.000	1.546
5	0.000	0.000
6		
7		
8		
9		
10		

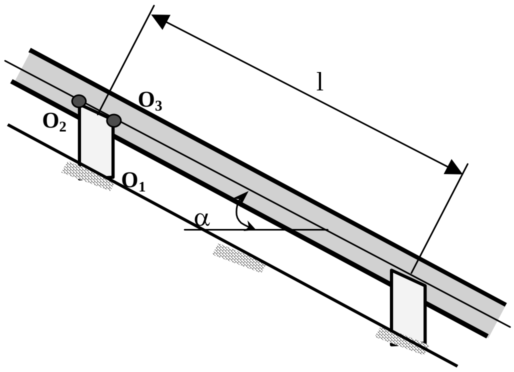
Max	0.622
Min	0.000
L	0.622

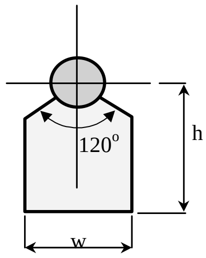
2. Fillet

No.	x(m)	y(m)
1	0.495	1.586
2	0.000	1.546
3	0.000	1.200
4	0.522	1.242
5	0.495	1.586
6		
7		
8		
9		
10		

Pipe Location

O_1	0.000	0.000
O_2	0.495	1.586
O_3	0.000	1.546





Force	Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr (t･m)	Mo (t･m)
(1) Penstock Pipe	3.714	3.703	-0.296	0.248	1.566	1.380	
(2) Axial Force due to Friction	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(3) Axial Force due to Penstock Pipe	0.057	0.005	0.056	0.248	1.566	0.001	0.088
(4) Friction of Water	0.006	0.001	0.006	0.248	1.566	0.000	0.010
(5) Saddle	1.983	1.983	0.000	0.288	0.000	0.572	
(6) Seismic	0.238	0.000	0.238	0.000	0.565		0.134
Total		5.691	0.005			1.953	0.233
							1.720

Stability

	unit	unit	Result	Allowable Range	Judge
①	Safety factor for over turning	m	0.009	< 0.104	OK
②	Safety factor for sliding		2.845	> 0.005	OK
③	Bearing stress σ_1 (f=0.5)	t/m2	8.265	< 100.000	OK
④	Bearing stress σ_2 (f=0.5)	t/m2	6.984	< 100.000	OK

Stability Analysis of Saddle Type A (Penstock B.P. ~ Anchor Block No.1)

Project: Namlan (REV5) **Section** B

Item		unit	Input
Discharge	Q	m^3/s	0.65
Dia. of pipe	φ	m	0.80
Thickness of pipe	t	mm	6.00
Distance between saddles	l	m	6.00
Pipe slope	α	°	28.34
Width of saddle	w	m	1.20
Fillet of saddle	b	m	0.60
Seismic coefficient	k_h	-	0.12
Unit weight of concrete	γ_c	t/m^3	2.30
Cohesion (concrete-foundation)	c	t/m^2	0.00
Friction coeff. (saddle)	f	-	0.50
Safety factor for sliding	F_s	-	1.50
Bearing stress of foundation	σ	t/m^2	100.00
滑動係数	ff	-	0.50

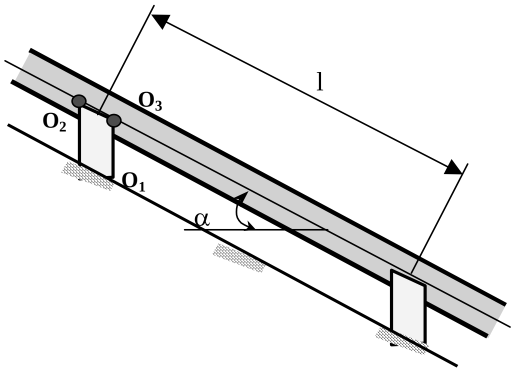
1. Anchor Block		
No.	x(m)	y(m)
1	0.000	0.000
2	1.000	0.000
3	1.000	0.699
4	0.421	1.773
5	0.000	1.546
6	0.000	0.000
7		
8		
9		
10		

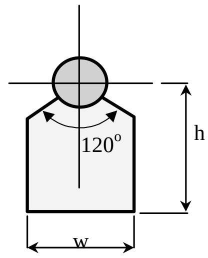
Max	1.000
Min	0.000
L	1.000

2. Fillet		
No.	x(m)	y(m)
1	0.421	1.773
2	0.000	1.546
3	0.000	1.200
4	0.565	1.505
5	0.421	1.773
6		
7		
8		
9		
10		

Pipe Location

O_1	0.000	0.000
O_2	0.421	1.773
O_3	0.000	1.546





Force	Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr (t·m)	Mo (t·m)
(1) Penstock Pipe	3.280	2.887	-1.557	0.211	1.660	3.191	
(2) Axial Force due to Friction	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(3) Axial Force due to Penstock Pipe	0.337	0.160	0.297	0.211	1.660	0.034	0.492
(4) Friction of Water	0.006	0.003	0.006	0.211	1.660	0.001	0.009
(5) Saddle	3.484	3.484	0.000	0.470	0.000	1.639	
(6) Seismic	0.418	0.000	0.418	0.000	0.623		0.261
Total		6.533	-0.836			4.864	0.762
							4.102

Stability

	unit	unit	Result	Allowable Range	Judge
①	Safety factor for over turning	m	-0.128	< 0.167	OK
②	Safety factor for sliding		3.267	> 0.836	OK
③	Bearing stress σ_1 (f=0.5)	t/m2	1.271	< 100.000	OK
④	Bearing stress σ_2 (f=0.5)	t/m2	9.619	< 100.000	OK

Stability Analysis of Saddle Type B (Anchor Block No.1 ~ No.2)

Project: Namlan (REV5) **Section** C

Item		unit	Input
Discharge	Q	m^3/s	0.65
Dia. of pipe	ϕ	m	0.80
Thickness of pipe	t	mm	6.00
Distance between saddles	l	m	6.00
Pipe slope	α	°	26.28
Width of saddle	w	m	1.20
Fillet of saddle	b	m	0.60
Seismic coefficient	k_h	-	0.12
Unit weight of concrete	γ_c	t/m^3	2.30
Cohesion (concrete-foundation)	c	t/m^2	0.00
Friction coeff. (saddle)	f	-	0.50
Safety factor for sliding	F_s	-	1.50
Bearing stress of foundation	σ	t/m^2	100.00
滑動係数	ff	-	0.50

1. Anchor Block

No.	x(m)	y(m)
1	0.000	0.000
2	1.000	0.000
3	1.000	0.804
4	0.509	1.798
5	0.000	1.546
6	0.000	0.000
7		
8		
9		
10		

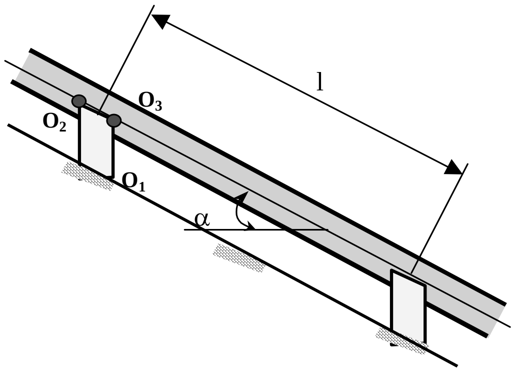
Max	1.000
Min	0.000
L	1.000

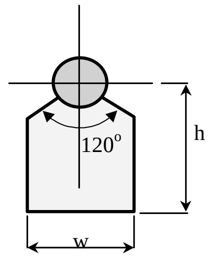
2. Fillet

No.	x(m)	y(m)
1	0.509	1.798
2	0.000	1.546
3	0.000	1.200
4	0.647	1.519
5	0.509	1.798
6		
7		
8		
9		
10		

Pipe Location

O_1	0.000	0.000
O_2	0.509	1.798
O_3	0.000	1.546





Force	Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr (t･m)	Mo (t･m)
(1) Penstock Pipe	3.341	2.996	-1.479	0.255	1.672	3.236	
(2) Axial Force due to Friction	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(3) Axial Force due to Penstock Pipe	0.314	0.139	0.282	0.255	1.672	0.035	0.471
(4) Friction of Water	0.006	0.003	0.006	0.255	1.672	0.001	0.010
(5) Saddle	3.617	3.617	0.000	0.484	0.000	1.752	
(6) Seismic	0.434	0.000	0.434	0.000	0.637		0.276
Total		6.754	-0.758			5.024	0.758
							4.266

Stability

	unit	unit	Result	Allowable Range	Judge
①	Safety factor for over turning	m	-0.132	< 0.167	OK
②	Safety factor for sliding		3.377	> 0.758	OK
③	Bearing stress σ_1 (f=0.5)	t/m2	1.183	< 100.000	OK
④	Bearing stress σ_2 (f=0.5)	t/m2	10.074	< 100.000	OK

Stability Analysis of Saddle Type C (Anchor Block No.2 ~ No.3)

Project: Namlan (REV5) **Section** D

Item		unit	Input
Discharge	Q	m^3/s	0.65
Dia. of pipe	ϕ	m	0.80
Thickness of pipe	t	mm	6.00
Distance between saddles	l	m	6.00
Pipe slope	α	°	17.24
Width of saddle	w	m	1.20
Fillet of saddle	b	m	0.60
Seismic coefficient	k_h	-	0.12
Unit weight of concrete	γ_c	t/m^3	2.30
Cohesion (concrete-foundation)	c	t/m^2	0.00
Friction coeff. (saddle)	f	-	0.50
Safety factor for sliding	F_s	-	1.50
Bearing stress of foundation	σ	t/m^2	100.00
滑動係数	ff	-	0.50

1. Anchor Block

No.	x(m)	y(m)
1	0.000	0.000
2	0.900	0.000
3	0.900	0.287
4	0.464	1.691
5	0.000	1.500
6	0.000	0.000
7		
8		
9		
10		

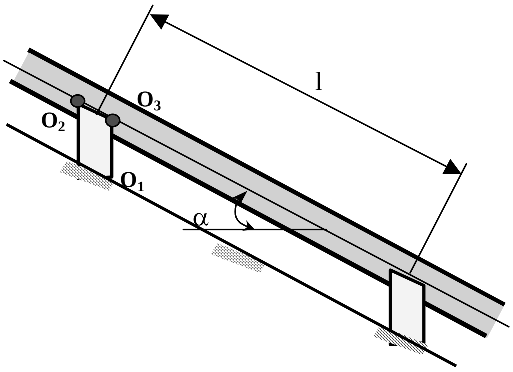
Max	0.900
Min	0.000
L	0.900

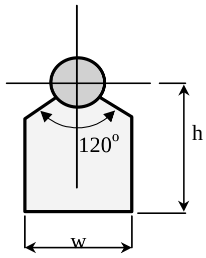
2. Fillet

No.	x(m)	y(m)
1	0.464	1.691
2	0.000	1.500
3	0.000	1.200
4	0.562	1.375
5	0.464	1.691
6		
7		
8		
9		
10		

Pipe Location

O_1	0.000	0.000
O_2	0.464	1.691
O_3	0.000	1.500





Force	Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr (t･m)	Mo (t･m)
(1) Penstock Pipe	3.559	3.399	-1.055	0.232	1.596	2.471	
(2) Axial Force due to Friction	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(3) Axial Force due to Penstock Pipe	0.211	0.062	0.201	0.232	1.596	0.014	0.321
(4) Friction of Water	0.006	0.002	0.006	0.232	1.596	0.000	0.010
(5) Saddle	2.810	2.810	0.000	0.402	0.000	1.128	
(6) Seismic	0.337	0.000	0.337	0.000	0.575		0.194
Total		6.273	-0.510			3.614	0.524
							3.090

Stability

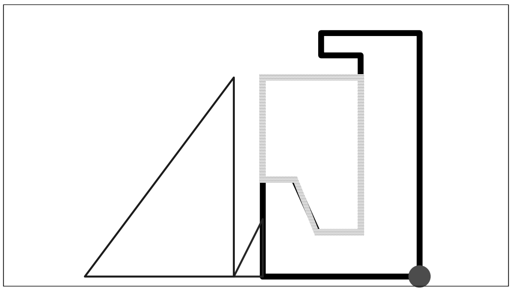
	unit	unit	Result	Allowable Range	Judge
①	Safety factor for over turning	m	-0.043	< 0.150	OK
②	Safety factor for sliding		3.136	> 0.510	OK
③	Bearing stress σ_1 (f=0.5)	t/m2	4.158	< 100.000	OK
④	Bearing stress σ_2 (f=0.5)	t/m2	7.459	< 100.000	OK

Stability Analysis of Saddle Type D (Anchor Block No.3 ~ No.4)

Project: Namlan

Input			
Height	H	5.50	m
Margin Height	h_0	1.00	m
Water depth (U/S)	h_2	4.50	m
Water depth (D/S)	h_1	0.00	m
Sediment depth	h_s	1.30	m
Slope (U/S)	1:n	0.00	
Slope (D/S)	1:m	0.00	
Unit weight of water	w_o	1.00	t/m3
Unit weight of concrete	w_c	2.30	t/m3
Unit weight of earth (below water)	w_s	1.13	t/m3
Uplift coefficient	ζ	1.00	
Coefficient of earth pressure	C_e	0.50	
Seismic coefficient (Full)	κ_1	0.10	
Seismic coefficient (Empty)	κ_2	0.05	

Concrete			Water		
No.	x (m)	y (m)	No.	x (m)	y (m)
1	0.000	0.000	1	0.000	2.200
2	0.000	2.200	2	0.800	2.200
3	0.800	2.200	3	1.400	1.000
4	1.400	1.000	4	2.500	1.000
5	2.500	1.000	5	2.500	4.500
6	2.500	5.000	6	0.000	4.500
7	1.491	5.000	7	0.000	2.200
8	1.491	5.500	8		
9	4.000	5.500	9		
10	4.000	0.000	10		
11	0.000	0.000	11		
12			12		
13			13		
14			14		
15			15		



Max	4.000
Min	0.000
L	4.000

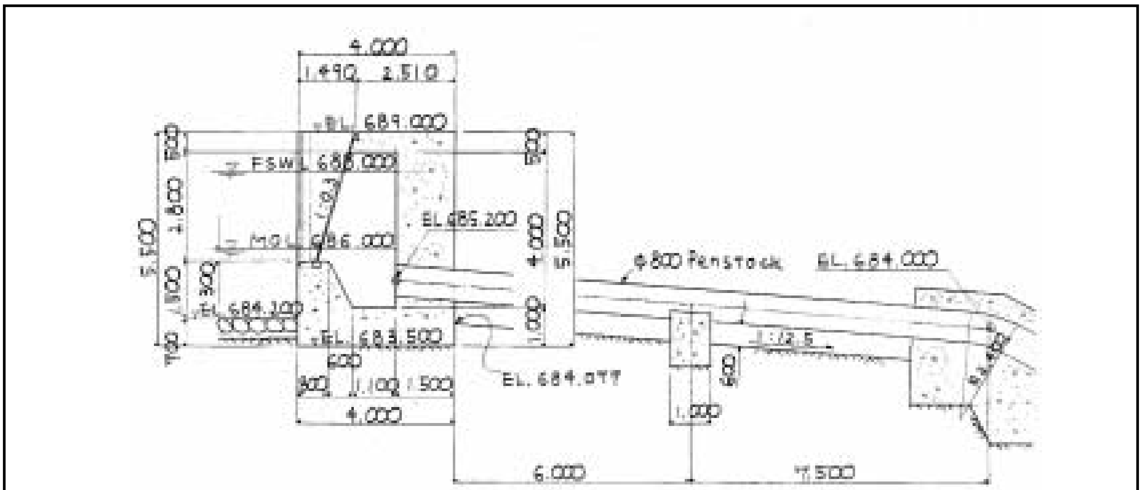
	Weir Full + Seismic D/S Direction		Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr(tm)	Mo (tm)
(1)	Self Weight	W_1	28.921	28.921	0.000	1.480	0.000	42.802	
(2)	Seismic	F_1	2.892	0.000	2.892	0.000	2.277		6.584
(3)	Static Water Pressure (U/S)	Pw1	10.125	0.000	10.125	0.000	1.500		15.188
(4)	Static Water Pressure (D/S)	Pw2	n.a	n.a	n.a	n.a	n.a		
(5)	Earth Pressure due to Sediment	Ps	0.479	0.000	0.479	0.000	0.433		0.207
(6)	Active Water Pressure (U/S)	Pd	0.131	0.000	0.131	0.000	1.800		0.236
(7)	Uplift	Wu	-9.000	-9.000	0.000	2.667	0.000		24.000
(8)	Water (U/S)	Ww	7.430	7.430	0.000	2.628	0.000	19.527	0.000
(9)	Water (D/S)	Ws	n.a	n.a	n.a	n.a	n.a		
	Total			27.351	13.627			62.329	46.215
								ΣM=	16.114

Stability (Weir Full +Seismic D/S Direction)

		unit	Result		Allowable Range	Judge
①	Safety factor for over turning	m	1.411	<	0.667	NG
②	Safety factor for sliding		1.204	>	1.200	OK
③	Bearing stress s1 (f=0.5)	t/m2	21.309	<	100.000	OK
④	Bearing stress s2 (f=0.5)	t/m2	-7.633	<	100.000	NG

neglect overturning	
$\Sigma M_r/\Sigma M_o$=	1.35

Stability Analysis of Power Intake

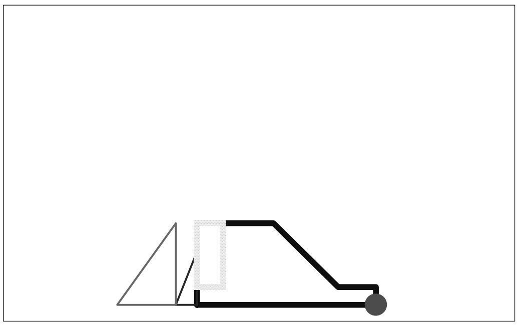


Project: Namlan (FSWL)

Input			
Weir Height	H	2.30	m
Margin Height	h_0	0.00	m
Water depth (U/S)	h_2	2.30	m
Water depth (D/S)	h_1	0.00	m
Sediment depth	h_s	1.50	m
Slope (U/S)	1:n	0.00	
Slope (D/S)	1:m	0.70	
Unit weight of water	w_o	1.00	t/m3
Unit weight of concrete	w_c	2.30	t/m3
Unit weight of earth (submerged)	w_s	1.10	t/m3
Uplift coefficient	ζ	1.00	
Coefficient of earth pressure	C_e	0.50	
Seismic coefficient (Full)	κ_1	0.00	
Seismic coefficient (Empty)	κ_2	0.00	

Weir Coordinates			Water Upstream Coordinates		
No.	x (m)	y (m)	No.	x (m)	y (m)
1	0.000	0.000	1	0.000	0.500
2	0.000	0.500	2	0.000	2.300
3	0.500	0.500	3	0.500	2.300
4	0.500	2.300	4	0.500	0.500
5	1.500	2.300	5	0.000	0.500
6	2.760	0.500	6		
7	3.500	0.500	7		
8	3.500	0.000	8		
9	0.000	0.000	9		
10			10		
11			11		
12			12		
13			13		
14			14		
15			15		

Max	3.500
Min	0.000
L	3.500

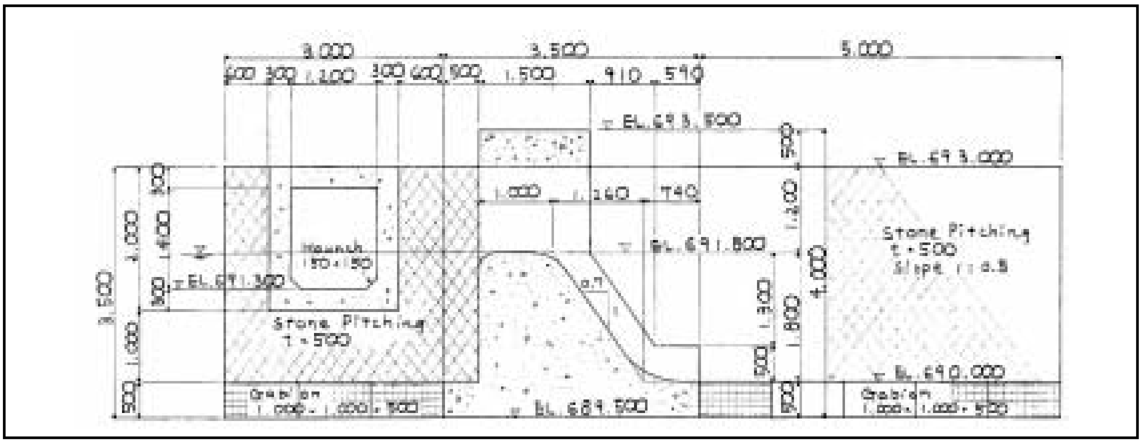


	Weir Full		Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr (tm)	Mo (tm)
(1)	Self Weight	W_1	10.773	10.773		1.997		21.515	
(2)	Seismic	F_1	0.000		0.000		0.898		0.000
(3)	Static Water Pressure (U/S)	Pw1	2.645		2.645		0.767		2.028
(4)	Static Water Pressure (D/S)	Pw2	0.000		0.000		0.000	0.000	
(5)	Earth Pressure due to Sediment	Ps	0.619		0.619		0.500		0.309
(6)	Active Water Pressure (U/S)	Pd	0.000		0.000		0.920		0.000
(7)	Uplift	Wu	-4.025	-4.025		2.333			9.392
(8)	Water (U/S)	Ww1	0.900	0.900		3.250		2.925	
(9)	Water (D/S)	Ww2	0.000	0.000		3.500		0.000	
(10)	Concentrated Load of Bridge	Wb	2.300	2.300		2.5		5.750	
(11)	Sediment(U/S)	Ws	0.550	0.550		3.250		1.788	
	Total			10.498	3.264			31.977	11.729
								ΣM=	20.248

Stability (Weir Full)

		unit	Result		Allowable Range	Judge	
①	Safety factor for over turning	m	0.179	<	0.583	OK	
②	Safety factor for sliding		1.930	>	1.5	OK	f=0.6
③	Bearing stress s1 (f=0.5)	t/m2	3.919	<	100.000	OK	
④	Bearing stress s2 (f=0.5)	t/m2	2.080	<	100.000	OK	

Stability Analysis of Intake Weir (Full Supply Water Level)

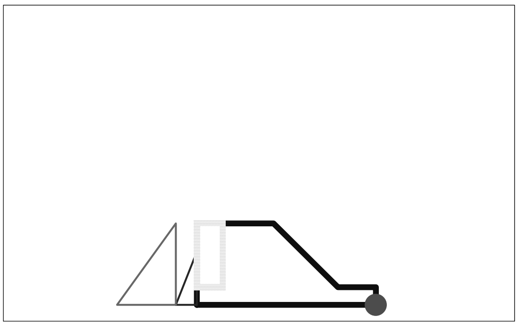


Project: <u>Namlan (FSWL + Seismic Downstream)</u>

Input			
Weir Height	H	2.30	m
Margin Height	h_0	0.00	m
Water depth (U/S)	h_2	2.30	m
Water depth (D/S)	h_1	0.00	m
Sediment depth	h_s	1.50	m
Slope (U/S)	1:n	0.00	
Slope (D/S)	1:m	0.70	
Unit weight of water	w_o	1.00	t/m3
Unit weight of concrete	w_c	2.30	t/m3
Unit weight of earth (below water)	w_s	1.10	t/m3
Uplift coefficient	ζ	1.00	
Coefficient of earth pressure	C_e	0.50	
Seismic coefficient (Full)	κ_1	0.10	
Seismic coefficient (Empty)	κ_2	0.05	

Weir Coordinates			Water Upstream Coordinates		
No.	x (m)	y (m)	No.	x (m)	y (m)
1	0.000	0.000	1	0.000	0.500
2	0.000	0.500	2	0.000	2.300
3	0.500	0.500	3	0.500	2.300
4	0.500	2.300	4	0.500	0.500
5	1.500	2.300	5	0.000	0.500
6	2.760	0.500	6		
7	3.500	0.500	7		
8	3.500	0.000	8		
9	0.000	0.000	9		
10			10		
11			11		
12			12		
13			13		
14			14		
15			15		

Max	3.500
Min	0.000
L	3.500



	Weir Full + Seismic D/S Direction		Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr (tm)	Mo (tm)
(1)	Self Weight	W_1	10.773	10.773		1.997		21.515	
(2)	Seismic	F_1	1.077		1.077		0.898		0.967
(3)	Static Water Pressure (U/S)	Pw1	2.645		2.645		0.767		2.028
(4)	Static Water Pressure (D/S)	Pw2	0.000		0.000		0.000	0.000	
(5)	Earth Pressure due to Sediment	Ps	0.619		0.619		0.500		0.309
(6)	Active Water Pressure (U/S)	Pd	0.067		0.067		0.920		0.062
(7)	Uplift	Wu	-4.025	-4.025		2.333			9.392
(8)	Water (U/S)	Ww1	0.900	0.900		3.250		2.925	
(9)	Water (D/S)	Ww2	0.000	0.000		3.500		0.000	
(10)	Concentrated Load of Bridge	Wb	2.300	2.300		2.5		5.750	
(11)	Sediment(U/S)	Ws	0.550	0.550		3.250		1.788	
	Total			10.498	4.408			31.977	12.758
								ΣM=	19.219

Stability (Weir Full +Seismic D/S Direction)

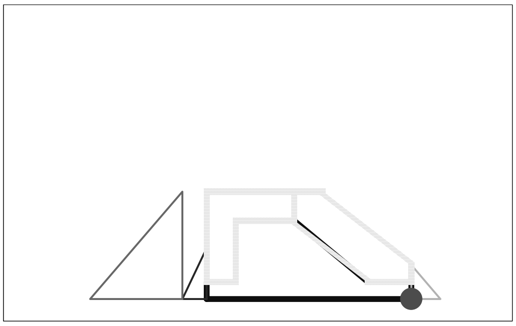
		unit	Result		Allowable Range	Judge
①	Safety factor for over turning	m	-0.081	<	0.583	OK
②	Safety factor for sliding		1.429	>	1.2	OK
③	Bearing stress s1 (f=0.5)	t/m2	2.584	<	100.000	OK
④	Bearing stress s2 (f=0.5)	t/m2	3.415	<	100.000	OK

f=0.6

Stability of Intake Weir (Full Supply Water Level; Seismic)

Project: Namlan (Flood Condition)

Input			
Weir Height	H	2.30	m
Margin Height	h_0	0.00	m
Water depth (U/S)	h_2	3.16	m
Water depth (D/S)	h_1	1.00	m
Sediment depth	h_s	1.50	m
Slope (U/S)	1:n	0.00	
Slope (D/S)	1:m	0.70	
Unit weight of water	w_o	1.00	t/m3
Unit weight of concrete	w_c	2.30	t/m3
Unit weight of earth (below water)	w_s	1.10	t/m3
Uplift coefficient	ζ	1.00	
Coefficient of earth pressure	C_e	0.50	
Seismic coefficient (Full)	κ_1	0.00	
Seismic coefficient (Empty)	κ_2	0.00	



Weir Coordinates		
No.	x (m)	y (m)
1	0.000	0.000
2	0.000	0.500
3	0.500	0.500
4	0.500	2.300
5	1.500	2.300
6	2.760	0.500
7	3.500	0.500
8	3.500	0.000
9	0.000	0.000
10		
11		
12		
13		
14		
15		

Max	3.500
Min	0.000
L	3.500

Water Upstream Coordinates		
No.	x (m)	y (m)
1	0.000	0.500
2	0.000	3.160
3	1.500	3.160
4	1.500	2.300
5	0.500	2.300
6	0.500	0.500
7	0.000	0.500
8		
9		
10		
11		

Water Downstream Coordinates		
No.	x (m)	y (m)
1	1.500	2.300
2	1.500	3.160
3	1.988	3.160
4	3.500	1.000
5	3.500	0.500
6	2.760	0.500
7	1.500	2.300
8		
9		
10		

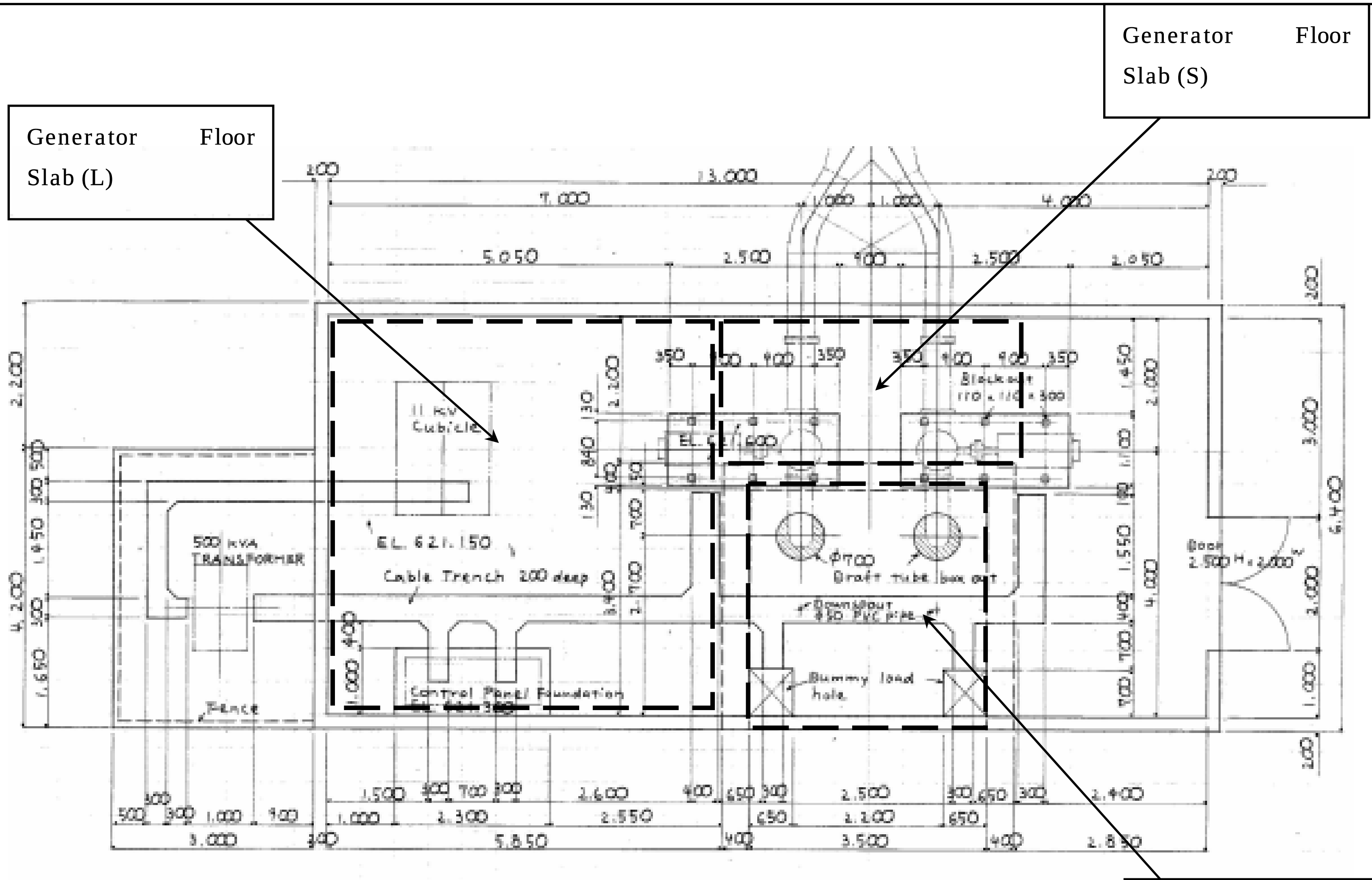
	Flood Condition		Magnitude (ton)	V (ton)	H (ton)	x (m)	y (m)	Mr (tm)	Mo (tm)
(1)	Self Weight	W_1	10.773	10.773		1.997		21.515	
(2)	Seismic	F_1	0.000		0.000		0.898		
(3)	Static Water Pressure (U/S)	Pw1	4.993		4.993		1.053		5.259
(4)	Static Water Pressure (D/S)	Pw2	-0.500		-0.500		0.333	0.167	
(5)	Earth Pressure due to Sediment	Ps	0.619		0.619		0.500		0.309
(6)	Active Water Pressure (U/S)	Pd	0.000		0.000		0.920		
(7)	Uplift	Wu	-7.280	-7.280		2.053			14.945
(8)	Water (U/S)	Ww1	2.190	2.190		2.955		6.473	
(9)	Water (D/S)	Ww2	2.553	2.553		1.060		2.705	
(10)	Concentrated Load of Bridge	Wb	2.300	2.300		2.5		5.750	
(11)	Sediment(U/S)	Ws	0.550	0.550		3.250		1.788	
	Total			11.086	5.112			38.397	20.513
								ΣM=	17.883

Stability (Flood Condition)

		unit	Result		Allowable Range	Judge
①	Safety factor for over turning	m	0.137	<	0.583	OK
②	Safety factor for sliding		1.301	>	1.2	OK
③	Bearing stress s1 (f=0.5)	t/m2	3.911	<	100.000	OK
④	Bearing stress s2 (f=0.5)	t/m2	2.424	<	100.000	OK

f=0.6

Stability Analysis of Weir (Flood Water Level)



Powerhouse Slab and Draft Tube Pit Upper Slab

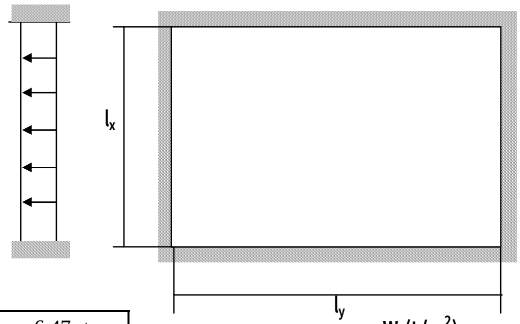
EL. 617.500 Draft Tube Pit Bottom Slab <Uniform Load / 4 Fixed Edges (ν=0)>

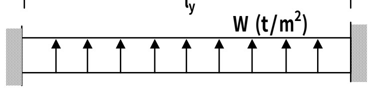
Short span	l_x	3.50 m
Long span	l_y	3.60 m
Span ratio	l_y/l_x	1.03

Unit weight of concret	w_c	2.3 t/m^3
Unit weight of water	w_w	1.0 t/m^3

Dead Load	W_c	-0.9 t/m^2
Reaction	P_l	7.6 t/m^2
Uplift	P_u	3.5 t/m^2

Load Combination	$W = W_c+P_l+P_u$	10.2 t/m^2

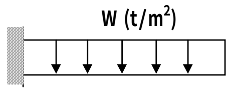




Moment	M_{x1}	-0.052 x W x l_x^2	-6.47 t･m
	M_{x2}	0.018 x W x l_x^2	2.24 t･m
	M_{y1}	-0.052 x W x l_x^2	-6.47 t･m
	M_{y2}	0.018 x W x l_x^2	2.24 t･m
Shear	Q_x	0.44 x W x l_x	15.63 t
	Q_y	0.44 x W x l_x	15.63 t

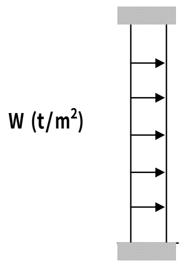
Moment and Shear of Draft Tube Pit Bottom Slab (EL 617.500)

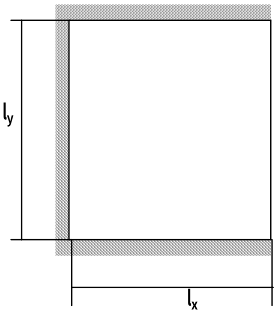
EL. 621.150 Draft Tube Pit Top Slab
<Uniform Load / 3 Fixed Edges (ν=0) / Long Span Free>



Short span	l_x	3.40 m
Long span	l_y	3.50 m
Span ratio	l_y/l_x	1.03

Unit weight of concret	w_c	2.3 t/m^3
Unit weight of water	w_w	1.0 t/m^3





Dead load	W_c	1.3 t/m^2
Live load	P_l	1.0 t/m^2

Load Combination	$W = W_c+P_l$	2.3 t/m^2

Moment	M_{x1}	-0.058 x W x l_x^2	-1.52 t･m
	M_{x2}	0.012 x W x l_x^2	0.31 t･m
	M_{y1}	-0.085 x W x l_x^2	-2.23 t･m
	M_{y2}	0.040 x W x l_x^2	1.05 t･m
Shear	Q_x	0.40 x W x l_x	3.08 t
	Q_y	0.58 x W x l_x	4.47 t

Moment and Shear of Draft Tube Pit Upper Slab (EL 621.150)

Draft Tube Pit Wall <Trapezoid Load on Short Span / 4 Fixed Edges (ν=0)>

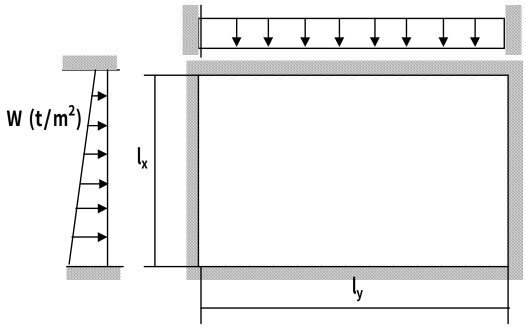
Short span	l_x	3.10 m
Long span	l_y	3.50 m
Span ratio	l_y/l_x	1.13

Unit weight of concret	w_c	2.3 t/m^3
Unit weight of water	w_w	1.0 t/m^3

Water pressure	P_w	3.1 t/m^2
Horizontal earth pressure	P_H	1.7 t/m^2
Horiz earth pressure due to live load	P_{Hq}	0.5 t/m^2

Load Combination	$W = P_w+P_H+P_{Hq}$	5.3 t/m^2

Moment	M_{x1}	-0.038 x W x l_x^2	-1.94 t･m
	M_{x2}	0.013 x W x l_x^2	0.66 t･m
	M_{x3}	-0.022 x W x l_x^2	-1.12 t･m
	M_{y1}	-0.028 x W x l_x^2	-1.43 t･m
	M_{y2}	0.008 x W x l_x^2	0.41 t･m
Shear	Q_{x1}	0.34 x W x l_x	5.60 t
	Q_{x3}	0.14 x W x l_x	2.30 t
	Q_{y1}	0.24 x W x l_x	3.95 t



Moment and Shear of Draft Tube Pit Wall

EL. 621.150 Generator Floor Slab <Uniform Load / 4 Edges Pin (ν=0)>

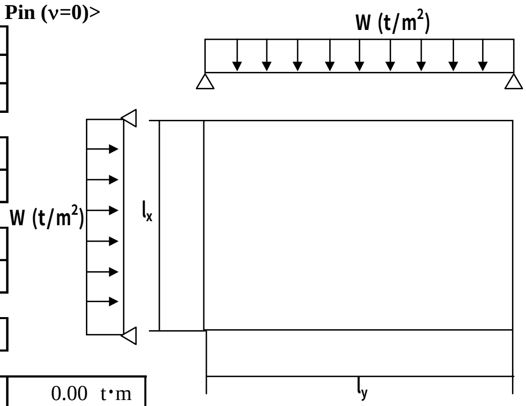
Short span	l_x	5.85 m
Long span	l_y	6.00 m
Span ratio	l_y/l_x	1.03

Unit weight of concret	w_c	2.3 t/m^3
Unit weight of water	w_w	1.0 t/m^3

Dead load	W_c	1.3 t/m^2
Live load	P_l	1.0 t/m^2

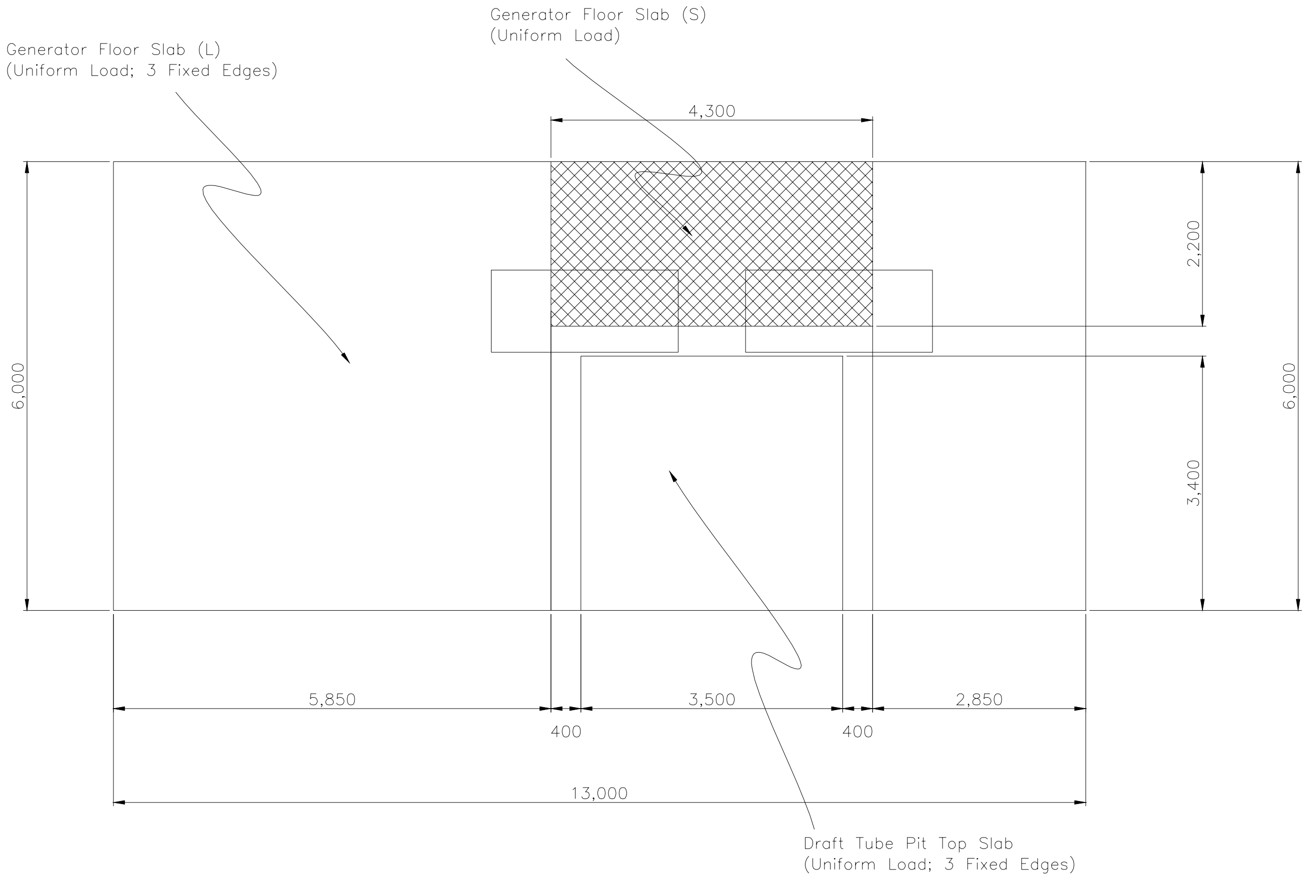
Load Combination	$W = W_c+P_l$	2.3 t/m^2

Moment	M_{x1}	0.000 x W x l_x^2	0.00 t･m
	M_{x2}	0.038 x W x l_x^2	2.95 t･m
	M_{y1}	0.000 x W x l_x^2	0.00 t･m
	M_{y2}	0.038 x W x l_x^2	2.95 t･m
Shear	Q_x	0.46 x W x l_x	6.10 t
	Q_y	0.46 x W x l_x	6.10 t

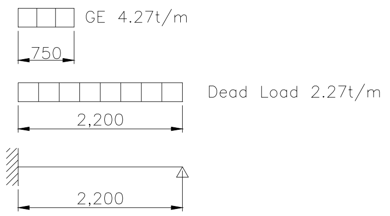


Moment and Shear of Generator Floor Slab (L) (EL 621.150)

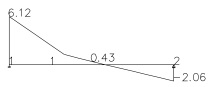
Moment and Shear of Generator Floor Slab (S) (EL 621.150)



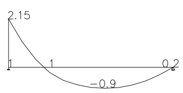
Powerhouse Plan (EL 621.150)



Skelton and Loading Diagram
of Generator Floor Slab (S)



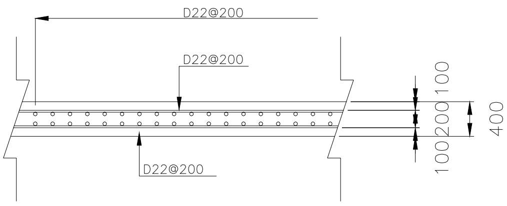
Shear (t)



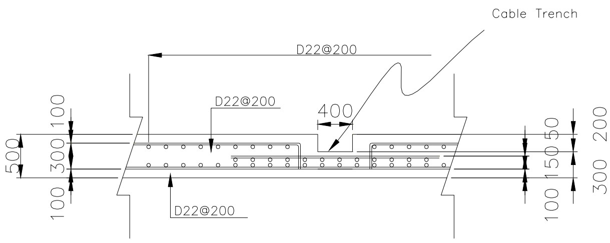
Moment (tm)

STRESS CALCULATION FOR REINFORCED CONCRETE
Powerhouse Slab and Draft Tube Pit Slab and Wall

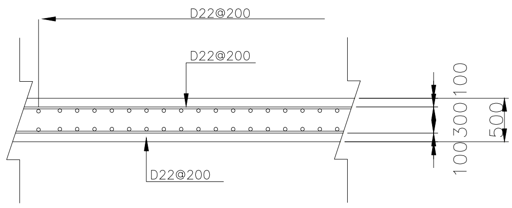
Structure / Member			1 Draft Tube Pit Bottom Slab	2a Draft Tube Pit Top Slab	2b Draft Tube Pit Top Slab (Trench)	3a Generator Floor Slab (L)	3b Generator Floor Slab (L) (Trench)	4 Generator Floor Slab (S)	5 Draft Tube Pit Wall
Moment	M	(t.m)	6.47	2.23	2.23	2.95	2.95	2.15	1.94
Shear	S	(t)	15.63	4.47	4.47	6.10	6.10	6.12	5.60
Axial Force	N	(t)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Width	B	(cm)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Height	H	(cm)	40.00	50.00	30.00	50.00	30.00	50.00	40.00
Effective Height	d	(cm)	30.00	40.00	25.00	40.00	25.00	40.00	30.00
Cover for comp.	d'	(cm)							
Re-bar (tension)	As	(cm2)	19.40	19.40	19.40	19.40	19.40	19.40	19.40
Re-bar arrange			D22@200	D22@200	D22@200	D22@200	D22@200	D22@200	D22@200
Re-bar (comp.)	As'	(cm2)							
Re-bar arrange									
Compression	σ_c	(kg/cm2)	46.05	9.87	21.51	13.06	28.45	9.52	13.81
		(kg/cm2)							
Tension	σ_s	(kg/cm2)	1,260.42	321.15	526.47	424.84	696.45	309.63	377.93
		(kg/cm2)							
Shear	τ	(kg/cm2)	5.91	1.25	2.05	1.70	2.79	1.71	2.12
Allowable stress	σ_{ca}	(kg/cm2)	60.00	60.00	60.00	60.00	60.00	60.00	60.00
	σ_{sa}	(kg/cm2)	1,600.00	1,600.00	1,600.00	1,600.00	1,600.00	1,600.00	1600.00
	τ_a	(kg/cm2)	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Note									



Draft Tube Pit Bottom Slab

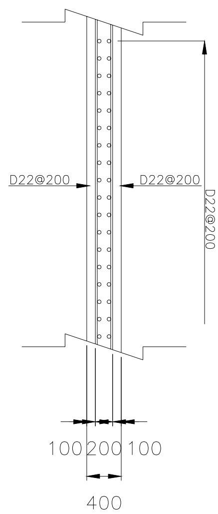


Generator Floor Slab (L) and Draft Tube Pit Upper Slab



Generator Floor Slab (S)

Re-bar Arrangement of Powerhouse Slab and
Draft Tube Pit Slab and Wall



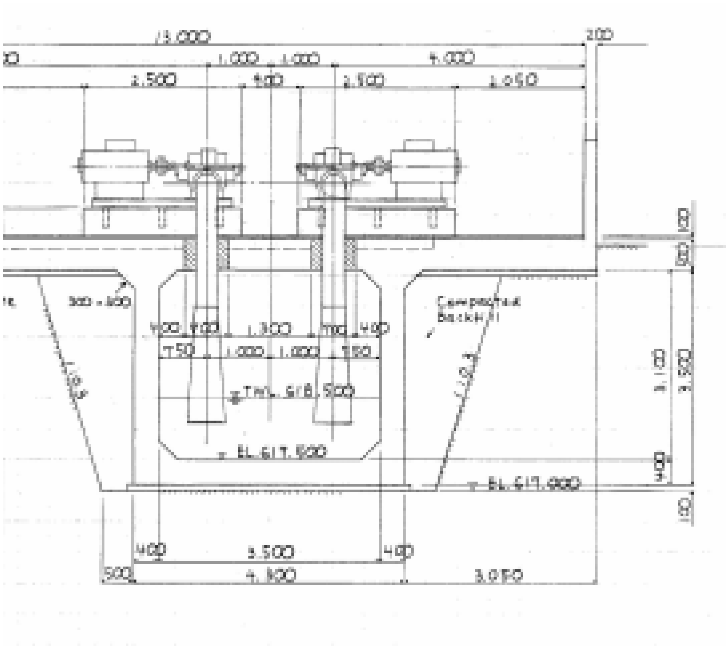
Draft Tube Pit Wall

STRESS CALCULATION FOR REINFORCED CONCRETE

Namlan Tailrace Culvert (Large Section)

Structure Member			1 Top Slab	2 Side Wall	3 Side Wall	4 Bottom Slab
Moment	M	(t.m)	3.07	5.16	5.16	3.70
Shear	S	(t)	4.19	9.60	9.60	5.69
Axial Force	N	(t)	4.56	7.46	7.46	0.00
Width	B	(cm)	100.00	100.00	100.00	100.00
Height	H	(cm)	40.00	40.00	40.00	40.00
Effective Height	d	(cm)	30.00	30.00	30.00	30.00
Cover for comp.	d'	(cm)				
Re-bar (tension)	As	(cm2)	14.30	14.30	14.30	14.30
Re-bar arrange			D19@200	D19@200	D19@200	D19@200
Re-bar (comp.)	As'	(cm2)				
Re-bar arrange						
Compression	σc	(kg/cm2)	24.18	40.65	40.65	29.30
		(kg/cm2)				
Tension	σs	(kg/cm2)	618.52	1,047.47	1,047.47	963.06
		(kg/cm2)				
Shear	τ	(kg/cm2)	1.59	3.65	3.65	2.12
Allowable stress	σca	(kg/cm2)	60.00	60.00	60.00	60.00
	σsa	(kg/cm2)	1,600.00	1,600.00	1,600.00	1,600.00
	τa	(kg/cm2)	8.00	8.00	8.00	8.00
Note						

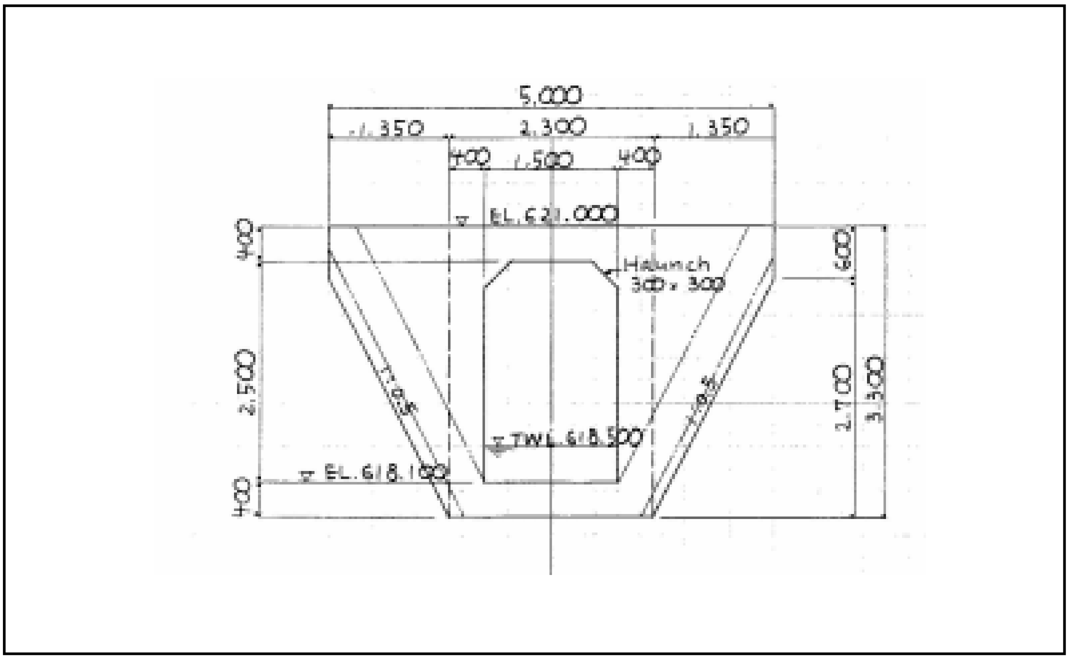
Re-bar Arrangement of Tailrace Culvert (Large Section)

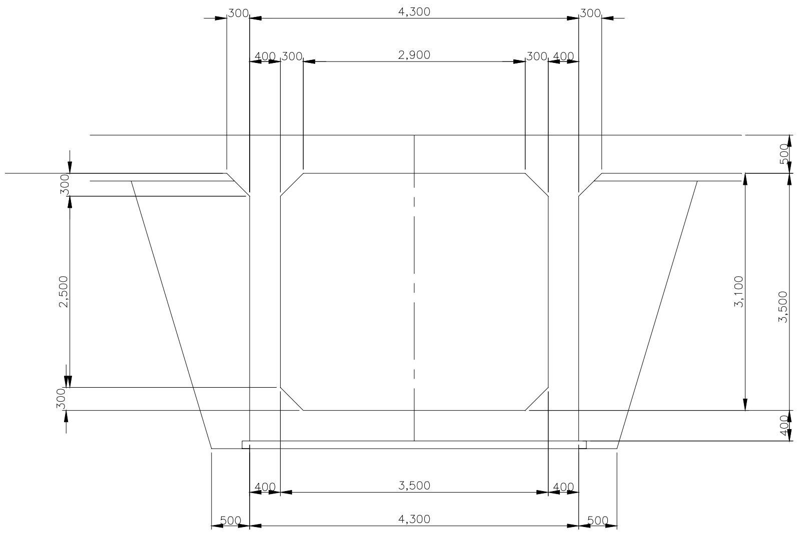


STRESS CALCULATION FOR REINFORCED CONCRETE
Namlan Tailrace Culvert (Small Section)

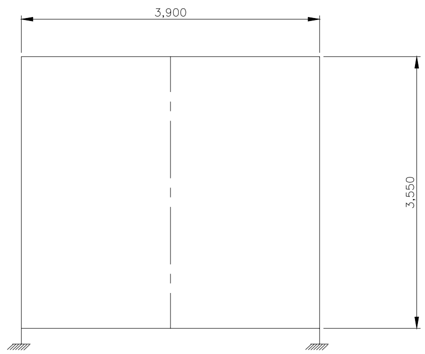
Structure Member			1 Top Slab	2 Side Wall	3 Side Wall	4 Bottom Slab
Moment	M	(t.m)	1.08	2.76	2.76	2.05
Shear	S	(t)	1.82	6.01	6.01	6.48
Axial Force	N	(t)	2.57	4.49	4.49	0.00
Width	B	(cm)	100.00	100.00	100.00	100.00
Height	H	(cm)	40.00	40.00	40.00	40.00
Effective Height	d	(cm)	30.00	30.00	30.00	30.00
Cover for comp.	d'	(cm)				
Re-bar (tension)	As	(cm2)	14.30	14.30	14.30	14.30
Re-bar arrange			D19@200	D19@200	D19@200	D19@200
Re-bar (comp.)	As'	(cm2)				
Re-bar arrange						
Compression	σc	(kg/cm2)	8.39	21.70	21.70	16.23
		(kg/cm2)				
Tension	σs	(kg/cm2)	181.26	541.10	541.10	533.59
		(kg/cm2)				
Shear	τ	(kg/cm2)	0.70	2.29	2.29	2.41
Allowable stress	σca	(kg/cm2)	60.00	60.00	60.00	60.00
	σsa	(kg/cm2)	1,600.00	1,600.00	1,600.00	1,600.00
	τa	(kg/cm2)	8.00	8.00	8.00	8.00
Note						

Re-bar Arrangement of Tailrace Culvert (Small Section)

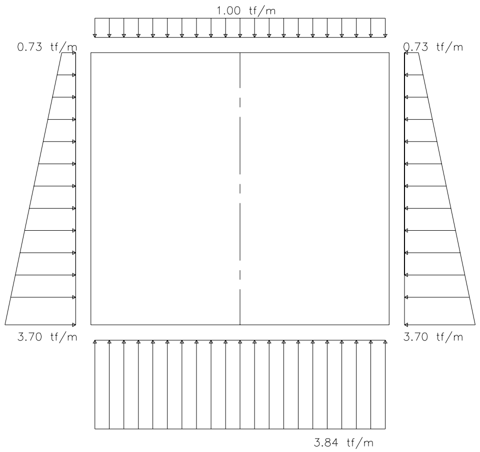




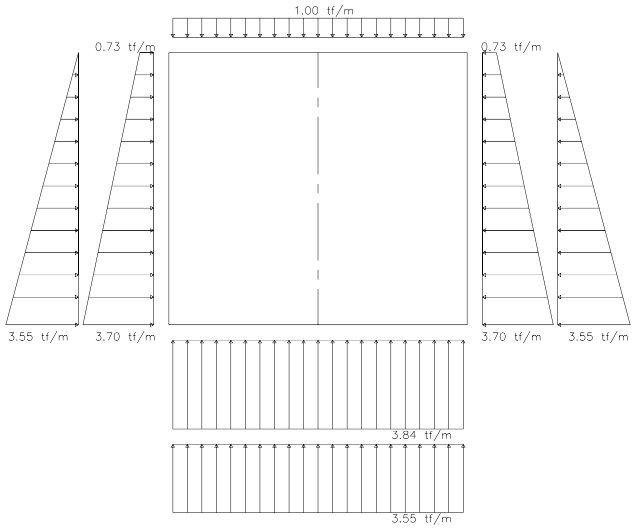
Typical Section



Skelton Diagram

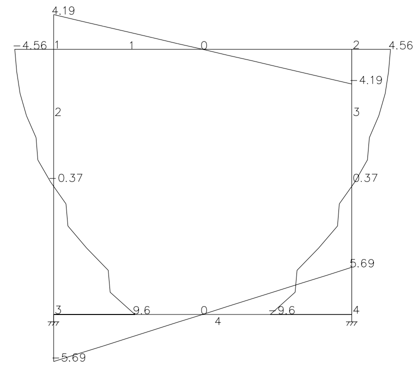


Normal Condition

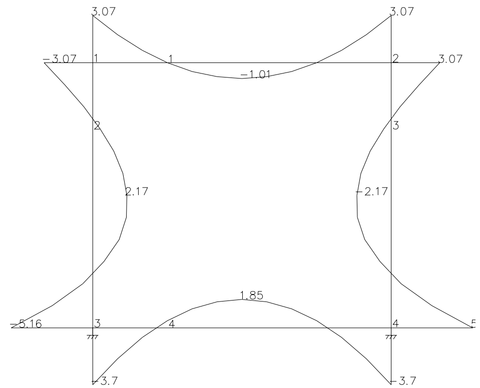


With Groundwater

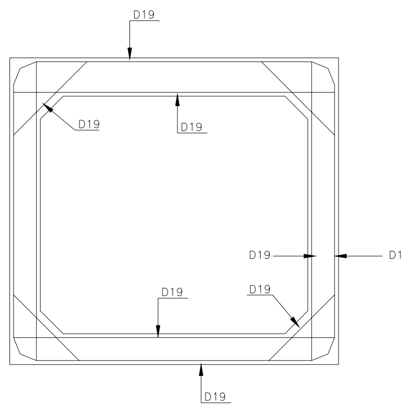
Loading Diagram



Shear (with groundwater)

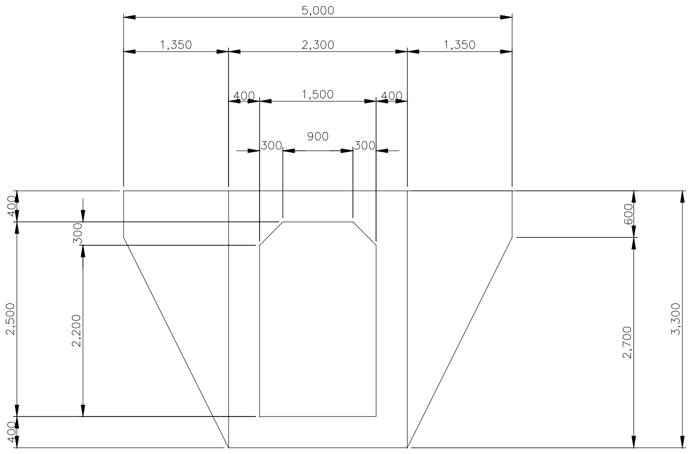


Moment (with groundwater)

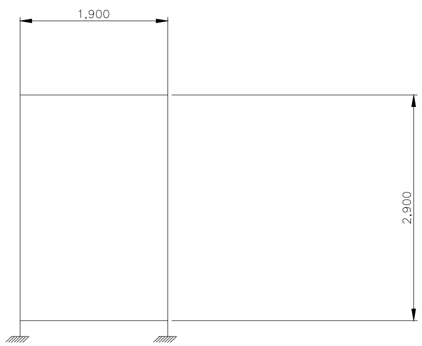


Reinforcement Bar
Arrangement @200

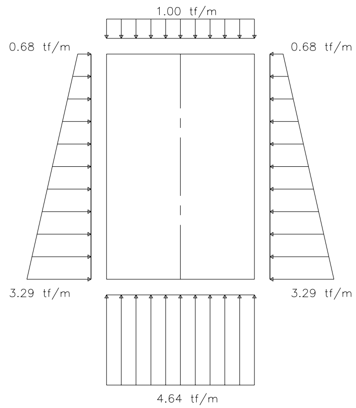
Tailrace Culvert (Large Section) Section, Skeleton Diagram, Loading Diagram, Shear, Moment and Re-bar Arrangement



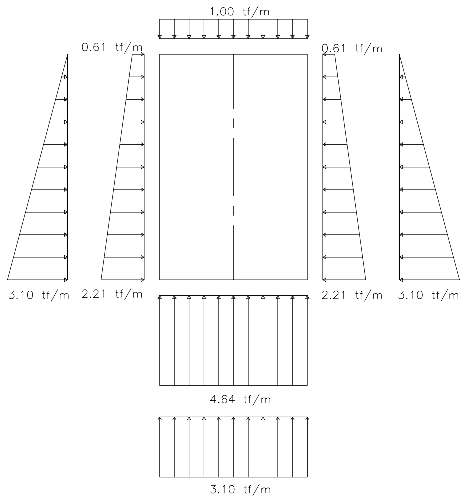
Typical Section



Skelton Diagram

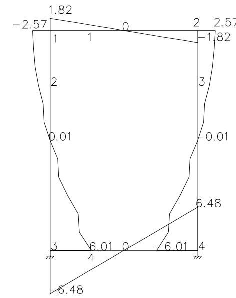


Normal Condition

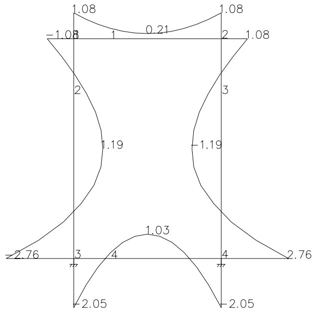


With Groundwater

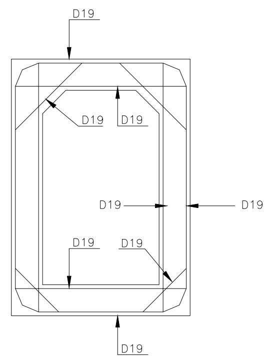
Loading Diagram



Shear (with groundwater)



Moment (with groundwater)



Reinforcement Bar Arrangement @200

Tailrace Culvert (Small Section) Section, Skeleton Diagram, Loading Diagram, Shear, Moment and Re-bar Arrangement

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LOG OF TEST PIT OR AUGER HOLE

FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature SURGE TANK SITE Project NAMLAN HYDROPOWER PROJECT Hole No. TP-1

Area Designation----------------------------- Coordinates------------------------- Ground Elevation------------------- Depth to Ground Water Level NIL

Method of Excavation Manual Approx;Dimension of Hole 4' x6' x15' Dates of Excavation 24/25-May-01 Hole Logged By S.Lwin

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART UNIFIED SOIL CLASSIFICATION GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATION)	PERCENTAGE OF COBBLES AND BOULDERS** VOLUME OF HOLES SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5 INCH SAMPLE (POUNDS)	PERCENTAGE BY VOLUME OF 3 TO 5 INCH	WEIGHT OF PLUS 5 INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF PLUS TO 5 INCH
		5' 10		0-2 ft. Top soil. black silty clay with scattered shell and rocks 2-3ft Tufa mixed with soil 2.25 loose yellowish yellowish grey tufa and from 2.5 to 3ft is black soil layer. 3-5ft Tufa yellowish grey poorly consolidated tufa with some hollows from which solid tufa pieces fall out or solution holes.Easy in excavation. 5-15ft tufa yellowish brown with iron staining,medium dense, with bedding like layers dipping towards the cliff side indicating the water flow direction.					

REMARKS

NOTES Record water test and density test data, if applicable, under remarks
*Record after water has reached its natural level, give date of reading adjacent to graphic symbol or in remarks
**Applicable only to borrow pits and to foundations which are potential sources of construction materials

*** (lbs of rock sampled)100

(bulk specific gravity of rock)62.4 (Cubic feet hole sampled)

Figure C-5-1 Log of Test Pit No.1

NAM LAN SCHEME

TEST PIT No. 1
PONDAGE

AUNG PYI TUN CONSTRUCTION LTD.

Figure C-5-2 Photograph of Test Pit No.1 (1/2)

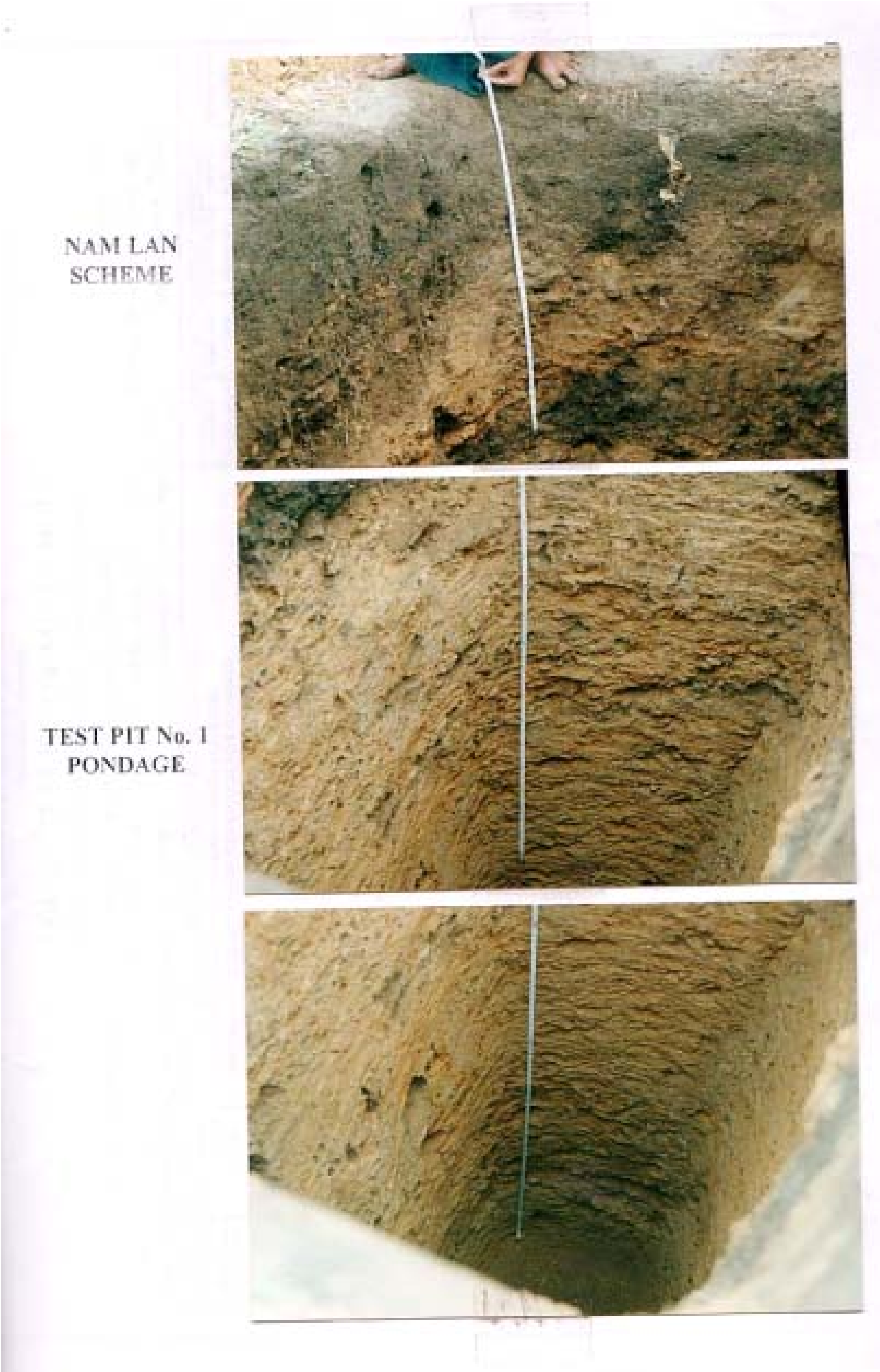

Figure C-5-3 Photograph of Test Pit No.1 (2/2)

Figure C-5-4 Log of Test Pit No.2

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LOG OF TEST PIT OR AUGER HOLE

FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature ANCHOR BLOCK Project NAMLAN HYDROPOWER PROJECT Hole No. TP-2

Area Designation---------------------------- Coordinates------------------------- Ground Elevation-------------------- Depth to Ground Water Level NIL

Method of Excavation Manual Approx;Dimension of Hole 4'X 6'X15' Dates of Excavation 24/25-May-01 Hole Logged By S.Lwin

CLASSIFICATION SYMBOL – LETTER	CLASSIFICATION SYMBOL – GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART UNIFIED SOIL CLASSIFICATION GIVE GEOLOGIC AND IN-PLACE DESCRIPTIONFOR FOUNDATION INVESTIGATION)	PERCENTAGE OF COBBLES AND BOULDERS** – VOLUME OF HOLES SAMPLED (CUIC FEET)	WEIGHT OF 3 TO 5 INCH SAMPLED(LBS)	PERCENTAGE BY VOLUME OF 3 TO 5 INCH	WEIGHT OF PLUS 5 INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF PLUS TO 5 INCH
				0-1.5ft. Top soil. Black silty clay with pieces of tufa anf roots					
				1.5-2.5ft Tufa Whitish grey loose tufa					
CL				2.5-5.5ft Clay, Yellowish brown and purplish stiff clay; developed from completely weathered shale.					
H-W		5		5.5-7.0ft Shale, highly weathered purplish shale, thinly bedded and highly jointed,can crushed between fingers.Easy in excavation. Foundation class C_L					
H-W or M-W		10		7.5-15 Shale.Highly to moderately weathered purple shale. Hard in excavation. Broken into flat pieces;closely jointed. Foundation class C_{M-L}.					
		15'							

REMARKS shale do not break down after soaking in water. Some are sandy.

NOTES Record water test and density test data, if applicable, under remarks
*Record after water has reached its natural level, gaive date of reading adjacent to graphic symbol or in remarks
**Applicable nly to borrow pits and to foundations which are potential sources of construction materials

*** (lbs of rock sampled)400

(bulk specific gravity of rock)624 (Cubic feet hole sampled)
Record bulk specific gravity in remarks,stating how obtained (measured or estimated)

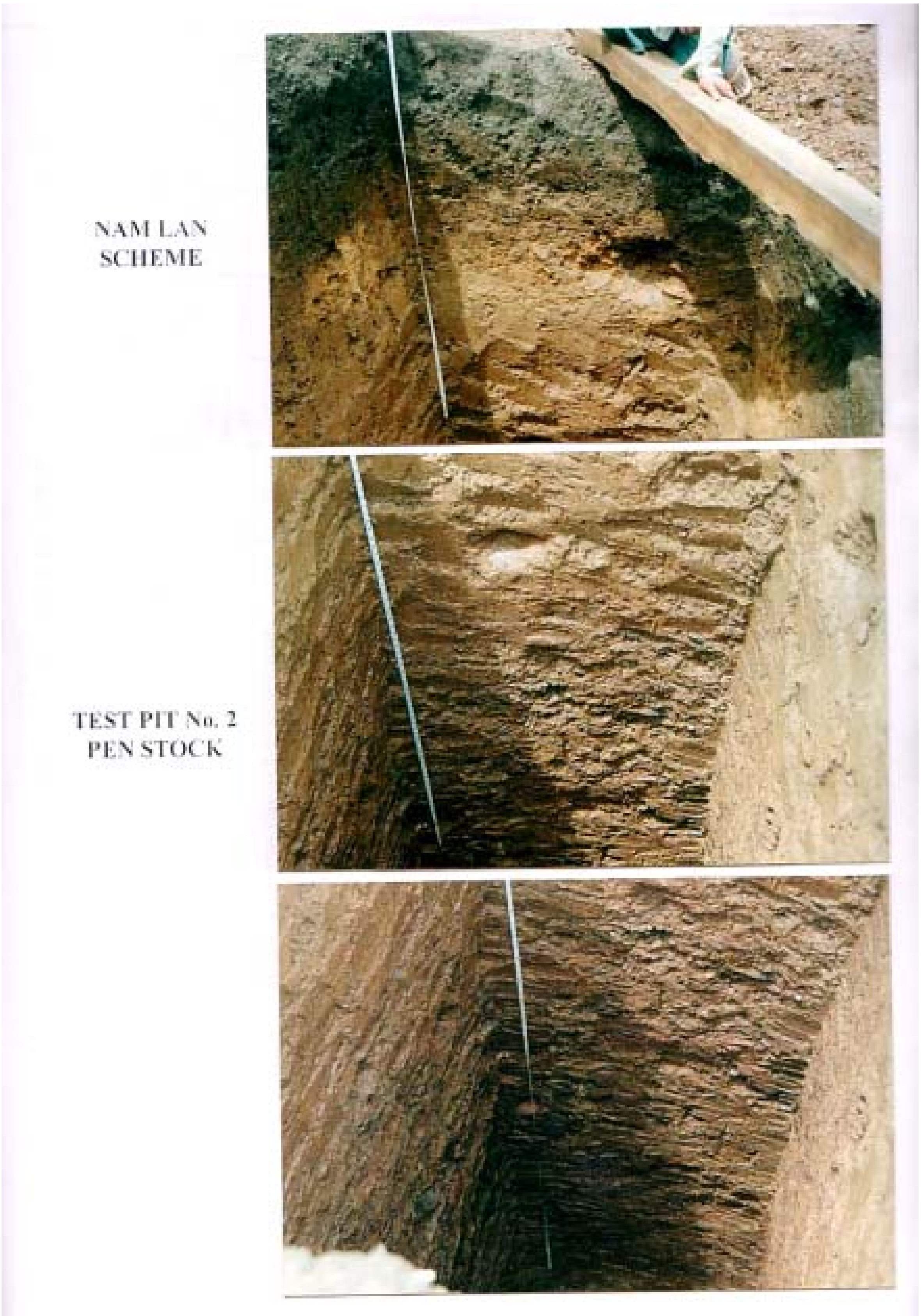

Figure C-5-5 Photograph of Test Pit No.2

Figure C-5-6 Log of Test Pit No.3

GEODYNAMICS CO.,LTD.

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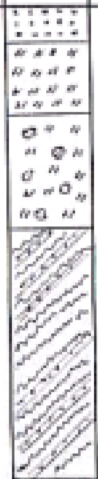
LOG OF TEST PIT OR AUGER HOLE

FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature POWER STATION SITE Project NAMLAN HYDROPOWER PROJECT Hole No. TP-3

Area Designation---------------------------- Coordinates------------------------ Ground Elevation-------------------- Depth to Ground Water Level 9.3ft

Method of Excavation Manual Approx;Dimension of Hole 4' X6'X15' Dates of Excavation 25/26-May-01 Hole Logged By S.Lwin

CLASSIFICATION SYMBOL: LETTER	CLASSIFICATION SYMBOL: GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART UNIFIED SOIL CLASSIFICATION GIVE GEOLOGIC AND IN-PLACE DESCRIPTIONFOR FOUNDATION INVESTIGATION)	PERCENTAGE OF COBBLES AND BOULDERS**: VOLUME OF HOLES SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5 INCH SAMPLED(LBS)	PERCENTAGE BY VOLUME OF 3 TO 5 INCH	WEIGHT OF PLUS 5 INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF PLUS TO 5 INCH
		5 10 15		0-1.3ft. Top soil. Black silty clay with vegetable roots. 1.3-3.5ft Shale. Completely weathered yellowish brown with patches of purple spots, stiff.Easy in excavation. 3.5-7.0ft Boulders in weathered shales;boulders are hard sandstone . 7.0-15ft Shale.Moderately weathered purple shale, thin bedded, interbedded with thin sandy shale layers.Hard in excavation. Foundation class C_M ground water at 9.3ft.					

REMARKS

NOTES.Record water test and density test data, if applicable, under remarks
*Record after water has reached its natural level, gvive date of reading adjacent to graphic symbol or in remarks
**Applicable oly to borrow pits and to foundations which are potential sources of construction materials

*** (lbs of rock sampled)100
(bulk specific gravity of rock)624 (Cubic feet hole sampled)
Record bulk specific gravity in remarks,stating how obtained (measured or estimated)

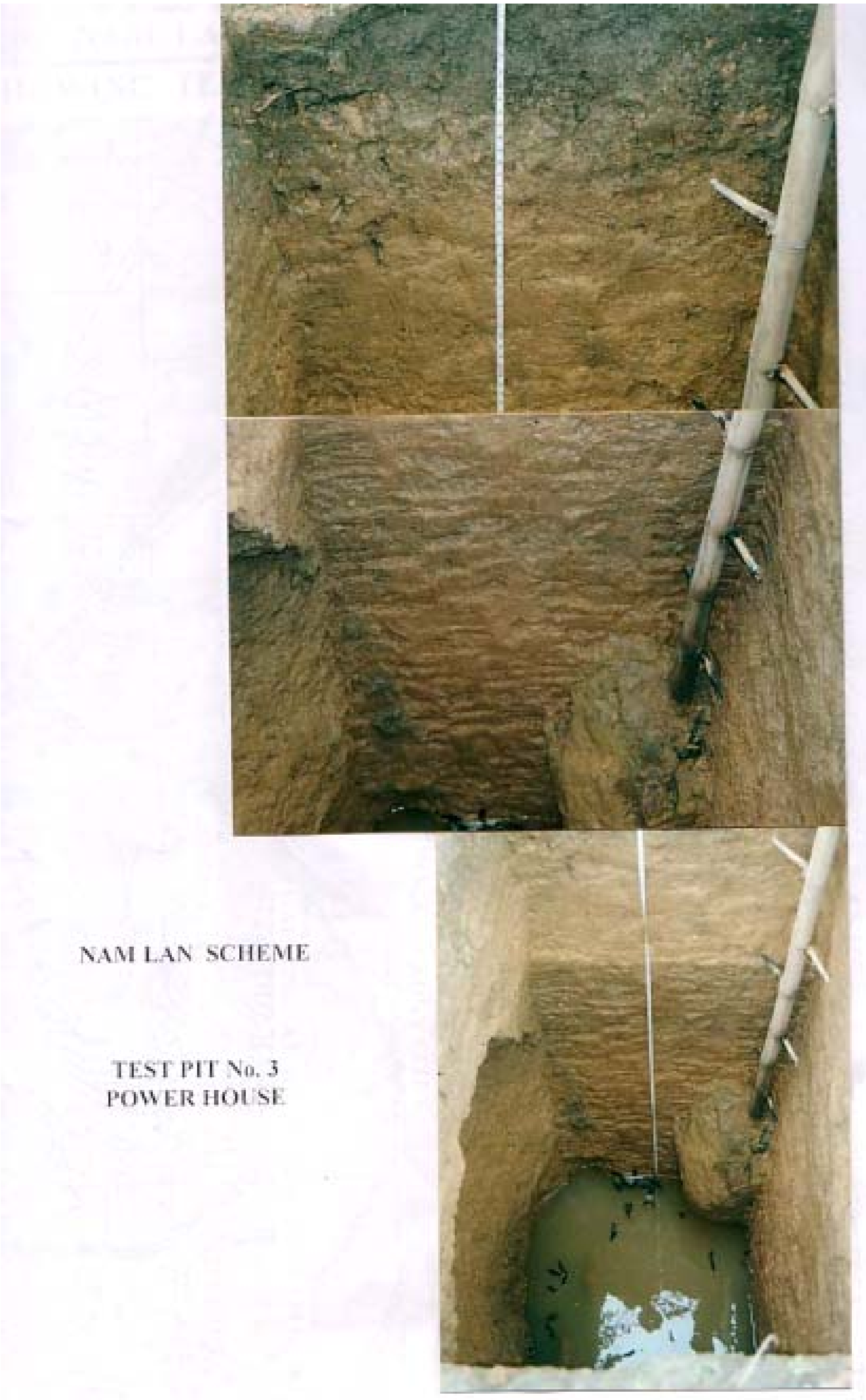


Figure C-5-7 Photograph of Test Pit No.3