Table A-6-10 Geologic Column of CP-3

INSTITUTO COSTARRICENSE DE ELECTRICIDAD
DEPARTAMENTO DE INGENIERIA GEOTECNICA
DESCRIPCION DE POZOS DE EXPLORACION
TRINCHERAS Y PERFORACIONES

PROYECTO: P.H. PIRRIS	POZO: C P - 3
UBICACION: Margen derecha, Río San Rafael	ELEVACION:
COORDENADAS N: E:	FONDO:
FECHA INICIO: 8/2/91	NIVEL FREATICO: No hay
FECHA FINALIZACION: 12/2/91	
METODO EXCAVACION: Manual	

PRO-FUN-DIDAD (m)	ESTRA-TIGRA-FIA	DESCRIPCION TIPO SUELO, COLOR, CONSISTENCIA, ESTRUCTURA, CONTENIDA HUMEDAD, PLASTICIDAD	CLASI-FICA-CION SUCS	% HUME-DAD NATURAL	GRAVE-DAD ES-PECIFI-CA (GS)
		Orgánico			
1.0		Material arenoso limoso color café con bloques. T máx ≃ 12 plg. Los bloques presentan diferentes estados de meteorización. Se estima que por volumen, el 80 % de los bloques es menor que 3 plg.	SM	23	2.70
2.0		Material similar tramo anterior, se estima que por volumen el 70 % de los bloques que contiene son de diámetro menor a las las 3 plg. T máx ≃ 22 plg.	SM	75	2.67
3.0		Arena limosa similar tramo anterior, contiene bloques de T máx 13 pulgadas, de buena condición física-mecánica. Se estima que por volumen posee un 60 % retenido en 3 pulgadas.	SM	-	-
4.0		Material similar tramo anterior, los bloques son un poco más alargados. Posee bloques hasta de 4 pulgadas, y se estima que el retenido en 3 pulgadas es del orden del 95 %.	GM	-	-
5.0					

OBSERVACIONES:

INSPECTOR: A. Torres	FECHA: Febrero 1991
DESCRITO POR: Ing. M. Valverde/ A. Torres	APROBADO POR:

Table A-6-11 Data Sheets of Triaxial Compression Test of CP-1 (P3' = 2.0)

C A L C U L O D E T R I A X I A L E S   T I P O C U

Proyecto : P.H. PIRRIS
Sitio : PRESTAMO
Localizacion: C . P. 1
Profundidad : INTEGRAL
Fecha : 21-6-91

Lo (mm) :	206.1	Ao (cm2) :	79.49	eo :	1.00
Do (mm) :	100.6	Vo (cm3) :	1638.19	So (%) :	79.30
Wto (g) :	2882	&to (k/m3) :	1759.26	w (%) :	29.18
Wt (g) :	3006	&tf (k/m3) :	1888.21	ef :	0.95
Ws (g) :	2231	&do (k/m3) :	1361.87	Sf (%) :	100.00
Gs :	2.73	&df (k/m3) :	1401.53	wf (%) :	34.72
A.carga :	1.11	PCT(k/cm2) :	3.9	Lc (mm):	204.75
&Vcelda :	32.1	PCE(k/cm2) :	2	Ac(cm2):	78.45
V (mm/''):	0.15	CP (k/cm2) :	1.9	Vc(cm3):	1606.09
&Vcontrapr	214.3	V.aire cm3 :	169.972	&V(cm3):	32.1

DEF	DIV. DIAL	U kN/m2		DEF (%)	CARGA kg	ESF k/cm2	U k/cm2	P1 kg/cm2	P1' k/cm2	P3' kg/cm2	P1'/P3'	E k/cm2	E. EF. k/cm2
0	0	191	*	0.00	0.00	0.00	0.00	---	---	---	---	---	0
50	10	198	*	0.24	11.10	0.14	0.07	2.18	2.11	1.97	1.07	57.8	0.07
100	15	200	*	0.49	16.65	0.21	0.09	2.25	2.16	1.95	1.11	43.2	0.119
150	25	203	*	0.73	27.75	0.35	0.12	2.39	2.27	1.92	1.18	47.9	0.229
200	55	217	*	0.98	61.05	0.77	0.27	2.81	2.54	1.77	1.43	78.9	0.506
250	101	233	*	1.22	112.11	1.41	0.43	3.45	3.02	1.61	1.88	115.6	0.984
300	130	249	*	1.47	144.30	1.81	0.59	3.85	3.26	1.45	2.25	123.7	1.221
400	164	268	*	1.95	182.04	2.28	0.78	4.31	3.53	1.25	2.81	116.5	1.49
500	182	280	*	2.44	202.02	2.51	0.91	4.55	3.64	1.13	3.22	102.9	1.605
600	192	290	*	2.93	213.12	2.64	1.01	4.68	3.67	1.03	3.56	90.0	1.628
700	197	296	*	3.42	218.67	2.69	1.07	4.73	3.66	0.97	3.78	78.7	1.622
800	202	298	*	3.91	224.22	2.75	1.09	4.79	3.69	0.95	3.90	70.3	1.656
900	205	299	*	4.40	227.55	2.77	1.10	4.81	3.71	0.94	3.96	63.1	1.672
1000	208	299	*	4.88	230.88	2.80	1.10	4.84	3.74	0.94	3.99	57.3	1.698
1100	211	299	*	5.37	234.21	2.83	1.10	4.86	3.76	0.94	4.01	52.6	1.724
1200	214	298	*	5.86	237.54	2.85	1.09	4.89	3.80	0.95	4.01	48.6	1.76
1300	217	298	*	6.35	240.87	2.88	1.09	4.91	3.82	0.95	4.03	45.3	1.785
1400	220	297	*	6.84	244.20	2.90	1.08	4.94	3.86	0.96	4.03	42.4	1.82
1500	222	295	*	7.33	246.42	2.91	1.06	4.95	3.89	0.98	3.97	39.7	1.851
1600	225	295	*	7.81	249.75	2.93	1.06	4.97	3.91	0.98	4.00	37.6	1.875
1700	228	292	*	8.30	253.08	2.96	1.03	5.00	3.97	1.01	3.93	35.6	1.929
1800	230	292	*	8.79	255.30	2.97	1.03	5.01	3.98	1.01	3.94	33.8	1.939
1900	233	292	*	9.28	258.63	2.99	1.03	5.03	4.00	1.01	3.96	32.2	1.961
2000	236	290	*	9.77	261.96	3.01	1.01	5.05	4.04	1.03	3.93	30.8	2.004
2100	240	290	*	10.26	266.40	3.05	1.01	5.09	4.08	1.03	3.96	29.7	2.038
2200	243	288	*	10.74	269.73	3.07	0.99	5.11	4.12	1.05	3.92	28.6	2.08
2300	246	288	*	11.23	273.06	3.09	0.99	5.13	4.14	1.05	3.94	27.5	2.101
2400	249	288	*	11.72	276.39	3.11	0.99	5.15	4.16	1.05	3.96	26.5	2.122
2500	251	288	*	12.21	278.61	3.12	0.99	5.16	4.17	1.05	3.97	25.5	2.129
2600	254	286	*	12.70	281.94	3.14	0.97	5.18	4.21	1.07	3.93	24.7	2.169
2700	256	284	*	13.19	284.16	3.14	0.95	5.18	4.24	1.09	3.88	23.8	2.197
2800	258	282	*	13.67	286.38	3.15	0.93	5.19	4.26	1.11	3.84	23.0	2.224
2900	260	280	*	14.16	288.60	3.16	0.91	5.20	4.29	1.13	3.79	22.3	2.251
3000	262	278	*	14.65	290.82	3.16	0.89	5.20	4.32	1.15	3.75	21.6	2.277

Table A-6-12 Data Sheets of Triaxial Compression Test of CP-1 (P3' =4.0)

CALCULO DE TRIAXIALES TIPO CU

Proyecto : P.H. PIRRIS
Sitio : PRESTAMO
Localizacion: C . P. 1
Profundidad : INTEGRAL
Fecha : 21-6-91

						*	*	*
Lo (mm) :	206.1	Ao (cm2) :	79.17	eo :	0.99	*	*	*
Do (mm) :	100.4	Vo (cm3) :	1631.68	So (%) :	79.60	*	*	*
Wto (g) :	2885	&to (k/m3) :	1768.12	u (%) :	28.85	*	*	*
Wt (g) :	2995	&tf (k/m3) :	1900.2	ef :	0.92	*	*	*
Ws (g) :	2239	&do (k/m3) :	1372.2	Sf (%) :	100.00	*	*	*
Gs :	2.73	&df (k/m3) :	1420.55	uf (%) :	33.77	*	*	*
A.carga :	1.11	PCT(k/cm2) :	5.9	Lc (mm):	204.29	*	*	*
&V (cm3):	43.1	PCE(k/cm2) :	4	Ac(cm2):	77.78	*	*	*
V (mm/''):	0.12	CP (k/cm2) :	1.9	Vc(cm3):	1588.58	*	*	*
&Vcontrapr	223.6	V.aire cm3 :	165.535	&V(cm3):	43.1	*	*	*

DEF	DIV. DIAL	U kN/m2		DEF (%)	CARGA kg	ESF k/cm2	U Kg/cm/	P1 kg/cm2	P1' k/cm2	P3' kg/cm2	P1'/P3'	E k/cm2	E. EF. k/cm2
0	0	194	*	0.00	0.00	0.00	---	---	---	---	---	---	0
50	15	205	*	0.24	16.65	0.21	0.11	4.29	4.14	3.97	1.04	87.3	0.101
100	82	220	*	0.49	91.02	1.16	0.27	5.24	4.94	3.81	1.30	237.9	0.9
150	131	250	*	0.73	145.41	1.86	0.57	5.93	5.33	3.51	1.52	252.8	1.285
200	170	281	*	0.98	188.70	2.40	0.89	6.48	5.57	3.19	1.75	245.4	1.516
250	213	307	*	1.22	236.43	3.00	1.15	7.08	5.91	2.93	2.02	245.4	1.851
300	230	330	*	1.47	255.30	3.23	1.39	7.31	5.91	2.69	2.20	220.2	1.848
400	267	370	*	1.96	296.37	3.74	1.79	7.81	6.01	2.28	2.63	190.8	1.942
500	291	397	*	2.45	323.01	4.05	2.07	8.13	6.06	2.01	3.02	165.5	1.982
600	306	410	*	2.94	339.66	4.24	2.20	8.32	6.12	1.88	3.26	144.3	2.037
700	317	422	*	3.43	351.87	4.37	2.32	8.45	6.13	1.75	3.49	127.5	2.045
800	324	428	*	3.92	359.64	4.44	2.39	8.52	6.14	1.69	3.63	113.5	2.058
900	329	433	*	4.41	365.19	4.49	2.44	8.57	6.14	1.64	3.74	101.9	2.052
1000	334	435	*	4.90	370.74	4.53	2.46	8.61	6.16	1.62	3.80	92.6	2.077
1100	338	437	*	5.38	375.18	4.56	2.48	8.64	6.17	1.60	3.86	84.8	2.087
1200	342	437	*	5.87	379.62	4.59	2.48	8.67	6.20	1.60	3.88	78.2	2.117
1300	345	437	*	6.36	382.95	4.61	2.48	8.69	6.22	1.60	3.89	72.5	2.133
1400	348	433	*	6.85	386.28	4.63	2.44	8.70	6.27	1.64	3.82	67.5	2.19
1500	352	431	*	7.34	390.72	4.65	2.42	8.73	6.32	1.66	3.81	63.4	2.239
1600	355	428	*	7.83	394.05	4.67	2.39	8.75	6.37	1.69	3.76	59.6	2.284
1700	358	428	*	8.32	397.38	4.68	2.39	8.76	6.38	1.69	3.77	56.3	2.299
1800	362	428	*	8.81	401.82	4.71	2.39	8.79	6.41	1.69	3.79	53.5	2.326
1900	365	426	*	9.30	405.15	4.72	2.36	8.80	6.44	1.71	3.76	50.8	2.36
2000	368	425	*	9.79	408.48	4.74	2.35	8.82	6.47	1.72	3.75	48.4	2.383
2100	372	425	*	10.28	412.92	4.76	2.35	8.84	6.49	1.72	3.77	46.3	2.409
2200	375	425	*	10.77	416.25	4.78	2.35	8.85	6.50	1.72	3.77	44.3	2.421
2300	378	425	*	11.26	419.58	4.79	2.35	8.86	6.51	1.72	3.78	42.5	2.433
2400	381	424	*	11.75	422.91	4.80	2.34	8.88	6.54	1.73	3.77	40.3	2.454
2500	384	424	*	12.24	426.24	4.81	2.34	8.89	6.55	1.73	3.78	39.3	2.465
2600	386	422	*	12.73	428.46	4.81	2.32	8.89	6.57	1.75	3.74	37.8	2.484
2700	389	420	*	13.22	431.79	4.82	2.30	8.90	6.60	1.77	3.72	36.5	2.514
2800	391	418	*	13.71	434.01	4.82	2.28	8.89	6.61	1.79	3.69	35.1	2.532
2900	394	416	*	14.20	437.34	4.82	2.26	8.90	6.64	1.81	3.66	34.0	2.562
3000	396	414	*	14.69	439.56	4.82	2.24	8.90	6.66	1.83	3.63	32.8	2.579

Table A-6-13 Data Sheets of Triaxial Compression Test of CP-1 (P3' =8.0)

C A L C U L O   D E   T R I A X I A L E S   T I P O   C U

Proyecto : P.H. PIRRIS
Sitio : PRESTAMO
Localizacion: C . P. 1
Profundidad : INTEGRAL
Fecha : 21-6-91

						*	*	*
Lo (mm) :	206.3	Ao (cm2) :	79.33	eo :	0.97	*	*	*
Do (mm) :	100.5	Vo (cm3) :	1636.52	So (%) :	86.61	*	*	*
Wto (g) :	2964	&to (k/m3) :	1811.16	w (%) :	30.84	*	*	*
Wt (g) :	2980	&tf (k/m3) :	1929.45	ef :	0.86	*	*	*
Ws (g) :	2265	&do (k/m3) :	1384.22	Sf (%) :	100.00	*	*	*
Gs :	2.73	&df (k/m3) :	1466.71	wf (%) :	31.55	*	*	*
A.carga :	1.11	PCT(k/cm2) :	9.9	Lc (mm):	202.03	*	*	*
&V (cm3):	101.5	PCE(k/cm2) :	8	Ac(cm2):	76.05	*	*	*
V (mm/'):	0.12	CP (k/cm2) :	1.9	Vc(cm3):	1535.02	*	*	*
&Vcontrapr	230.7	V.aire cm3 :	108.039	&V(cm3):	101.5	*	*	*

DEF	DIV. DIAL	U kN/m2		DEF (%)	CARGA kg	ESF k/cm2	U Kg/cm/	P1 kg/cm2	P1' k/cm2	P3' kg/cm2	P1'/P3'	E k/cm2	E. EF. Kg/cm/
0	0	191	*	0.00	0.00	0.00	---	---	---	---	---	---	0
50	30	220	*	0.25	33.30	0.44	0.30	8.59	8.29	7.86	1.06	176.5	0.141
100	88	236	*	0.49	97.68	1.28	0.46	9.43	8.97	7.70	1.17	258.2	0.819
150	201	275	*	0.74	223.11	2.91	0.86	11.07	10.22	7.30	1.40	392.2	2.056
200	268	317	*	0.99	297.48	3.87	1.28	12.03	10.76	6.87	1.57	391.2	2.589
250	325	363	*	1.24	360.75	4.69	1.75	12.84	11.11	6.40	1.74	378.6	2.932
300	375	420	*	1.48	416.25	5.39	2.33	13.55	11.25	5.82	1.93	363.1	3.058
400	451	482	*	1.98	500.61	6.45	2.97	14.61	11.69	5.19	2.25	325.9	3.486
500	502	543	*	2.47	557.22	7.15	3.59	15.30	11.77	4.57	2.58	288.7	3.558
600	534	593	*	2.97	592.74	7.56	4.10	15.72	11.69	4.06	2.88	254.7	3.465
700	554	611	*	3.46	614.94	7.81	4.28	15.96	11.75	3.87	3.03	225.3	3.525
800	567	636	*	3.96	629.37	7.95	4.54	16.10	11.64	3.62	3.22	200.7	3.412
900	577	645	*	4.45	640.47	8.05	4.63	16.20	11.65	3.53	3.30	180.6	3.419
1000	584	655	*	4.95	648.24	8.10	4.73	16.26	11.61	3.43	3.39	163.7	3.372
1100	590	665	*	5.44	654.90	8.14	4.83	16.30	11.55	3.32	3.47	149.6	3.311
1200	595	667	*	5.94	660.45	8.17	4.85	16.32	11.55	3.30	3.50	137.5	3.317
1300	600	670	*	6.43	666.00	8.19	4.88	16.35	11.55	3.27	3.53	127.3	3.311
1400	604	672	*	6.93	670.44	8.21	4.90	16.36	11.54	3.25	3.55	118.4	3.302
1500	607	673	*	7.42	673.77	8.20	4.91	16.36	11.53	3.24	3.56	110.5	3.289
1600	611	674	*	7.92	678.21	8.21	4.92	16.37	11.53	3.23	3.57	103.7	3.288
1700	614	674	*	8.41	681.54	8.21	4.92	16.36	11.52	3.23	3.57	97.5	3.284
1800	618	674	*	8.91	685.99	8.22	4.92	16.37	11.53	3.23	3.57	92.2	3.293
1900	621	674	*	9.40	689.31	8.21	4.92	16.37	11.53	3.23	3.57	87.3	3.288
2000	624	674	*	9.90	692.64	3.21	4.92	16.36	11.52	3.23	3.57	82.9	3.283
2100	626	674	*	10.39	694.86	8.19	4.92	16.34	11.50	3.23	3.56	78.8	3.264
2200	628	674	*	10.89	697.08	9.17	4.92	16.32	11.48	3.23	3.55	75.0	3.245
2300	629	670	*	11.38	698.19	8.14	4.88	16.29	11.49	3.27	3.51	71.5	3.253
2400	630	667	*	11.88	699.30	3.10	4.85	16.26	11.49	3.30	3.48	68.2	3.251
2500	632	661	*	12.37	701.52	8.08	4.79	16.24	11.53	3.36	3.43	65.3	3.292
2600	633	658	*	12.87	702.63	8.05	4.76	16.21	11.53	3.39	3.40	62.6	3.29

Table A-6-14 Data Sheets of Triaxial Compression Test of CP-2 (P3' =2.0)

C A L C U L O   D E   T R I A X I A L E S   T I P O   C U

Proyecto : P.H. PIRRIS
Sitio : PRESTAMO
Localizacion: C.P.2
Profundidad : INTEGRAL 0-5m
Fecha : 26 / 7 / 91

						*	*	*
Lo (mm) :	206.4	Ao (cm2) :	79.17	eo :	0.66	*	*	*
Do (mm) :	100.4	Vo (cm3) :	1634.06	So (%) :	85.62	*	*	*
Wto (g) :	3195	&to (k/m3) :	1955.26	w (%) :	21.07	*	*	*
Wt (g) :	3260	&tf (k/m3) :	2030.27	ef :	0.63	*	*	*
Ws (g) :	2639	&do (k/m3) :	1615	Sf (%) :	100.00	*	*	*
Gs :	2.68	&df (k/m3) :	1643.52	wf (%) :	23.53	*	*	*
A.carga :	1.11	PCT(k/cm2) :	3.4	Lc (mm):	204.04	*	*	*
&Vcelda :	56.1	PCE(k/cm2) :	2	Ac(cm2):	77.36	*	*	*
V (mm/'):	0.15	CP (k/cm2) :	1.4	Vc(cm3):	1577.96	*	*	*
&Vcontrapr	115	V.aire cm3 :	93.3547	&V(cm3):	56.1	*	*	*

DEF	DIV. DIAL	U kN/m2		DEF (%)	CARGA kg	ESF k/cm2	U k/cm2	P1 kg/cm2	P1' k/cm2	P3' kg/cm2	P1'/P3'	E k/cm2	E. EF. k/cm2
0	0	140	*	0,00	0,00	0,00	0,00	---	---	---	---	---	0
50	13	145	*	0,25	14,43	0,19	0,05	2,22	2.17	1,99	1,09	75,9	0.135
100	90	165	*	0,49	99,90	1,29	0,25	3,32	3.07	1,78	1,72	262,2	1.03
150	142	188	*	0,74	157,62	2,02	0,49	4,06	3.57	1,55	2,31	275,1	1,533
200	184	197	*	0,98	204,24	2,61	0,58	4,65	4,07	1,46	2,79	266,7	2,033
250	217	205	*	1,23	240,87	3,08	0,66	5,11	4,45	1,38	3,23	251,0	2,413
300	239	208	*	1,47	265,29	3,38	0,69	5,42	4,72	1,35	3,51	229,8	2,686
400	264	211	*	1,96	293,04	3,71	0,72	5,75	5,03	1,31	3,82	189,4	2,99
500	278	211	*	2,45	308,58	3,89	0,72	5,93	5,21	1,31	3,96	158,8	3,168
600	287	211	*	2,94	318,57	4,00	0,72	6,04	5,31	1,31	4,04	135,9	3,273
700	295	210	*	3,43	327,45	4,09	0,71	6,13	5,41	1,33	4,08	119,2	3,374
800	301	209	*	3,92	334,11	4,15	0,70	6,19	5,49	1,34	4,11	105,8	3,446
900	308	208	*	4,41	341,88	4,22	0,69	6,26	5,57	1,35	4,14	95,8	3,531
1000	315	206	*	4,90	349,65	4,30	0,67	6,34	5,66	1,37	4,15	87,7	3,626
1100	321	204	*	5,39	356,31	4,36	0,65	6,40	5,74	1,39	4,14	80,8	3,705
1200	324	202	*	5,88	359,64	4,38	0,63	6,41	5,78	1,41	4,11	74,4	3,744
1300	329	200	*	6,37	365,19	4,42	0,61	6,46	5,85	1,43	4,10	69,4	3,808
1400	334	198	*	6,86	370,74	4,46	0,59	6,50	5,91	1,45	4,08	65,1	3,872
1500	339	197	*	7,35	376,29	4,51	0,58	6,55	5,96	1,46	4,09	61,3	3,926
1600	344	195	*	7,84	381,84	4,55	0,56	6,59	6,03	1,48	4,08	58,0	3,988
1700	348	192	*	8,33	386,28	4,59	0,53	6,62	6,09	1,51	4,03	54,9	4,047
1800	352	188	*	8,82	390,72	4,61	0,49	6,64	6,15	1,55	3,97	52,2	4,116
1900	356	185	*	9,31	395,16	4,63	0,46	6,67	6,21	1,58	3,93	49,7	4,174
2000	359	185	*	9,80	398,49	4,65	0,46	6,69	6,23	1,58	3,94	47,4	4,198
2100	363	185	*	10,29	402,93	4,67	0,46	6,71	6,25	1,58	3,96	45,4	4,214
2200	367	183	*	10,78	407,37	4,70	0,44	6,74	6,30	1,60	3,94	43,6	4,26
2300	372	180	*	11,27	412,92	4,74	0,41	6,77	6,37	1,63	3,90	42,0	4,328
2400	376	180	*	11,76	417,36	4,76	0,41	6,80	6,39	1,63	3,92	40,5	4,353
2500	379	178	*	12,25	420,69	4,77	0,39	6,81	6,42	1,65	3,89	38,9	4,385
2600	382	176	*	12,74	424,02	4,78	0,37	6,82	6,45	1,67	3,86	37,5	4,416
2700	386	175	*	13,23	428,46	4,81	0,36	6,84	6,49	1,69	3,86	36,3	4,449
2900	391	173	*	13,72	434,01	4,84	0,34	6,88	6,54	1,70	3,84	35,3	4,504
2900	395	173	*	14,21	438,45	4,86	0,34	6,90	6,56	1,70	3,86	34,2	4,526
3000	398	172	*	14,70	441,78	4,87	0,33	6,91	6,58	1,71	3,84	33,1	4,545

Table A-6-15 Data Sheets of Triaxial Compression Test of CP-2 (P3' =4.0)

C A L C U L O   D E   T R I A X I A L E S   T I P O   C U

Proyecto : P.H. PIRRIS
Sitio : PRESTAMO
Localizacion: C.P.2
Profundidad : INTEGRAL 0-5m
Fecha : 26 / 7 / 91

Lo (mm) :	206.4	Ao (cm2) :	79.17	eo :	0.65
Do (mm) :	100.4	Vo (cm3) :	1634.96	So (%) :	81.29
Wto (g) :	3179	ɣto (k/m3) :	1944.85	w (%) :	19.70
Wt (g) :	3236	ɣtf (k/m3) :	2059.95	ef :	0.59
Ws (g) :	2655	ɣdo (k/m3) :	1624.79	Sf (%) :	100.00
Gs :	2.68	ɣdf (k/m3) :	1689.28	wf (%) :	21.88
A.carga :	1.11	PCT(k/cm2) :	5.4	Lc (mm):	203.47
ΔV (cm3):	69.7	PCE(k/cm2) :	4	Ac(cm2):	76.92
V (mm/'):	0.15	CP (k/cm2) :	1.4	Vc(cm3):	1564.36
ΔVcontrapr	108.5	V.aire cm3 :	120.385	ΔV(cm3):	69.7

DEF	DIV. DIAL	U kN/m2		DEF (%)	CARGA kg	ESF k/cm2	U Kg/cm²	P1 kg/cm2	P1' k/cm2	P3' kg/cm2	P1'/P3'	E k/cm2	E. EF. k/cm2
0	0	143	*	0.00	0.00	0.00	---	---	---	---	---	---	0
50	19	146	*	0.25	21.09	0.27	0.03	4.35	4.29	4.05	1.06	111.3	0.243
100	27	149	*	0.49	29.97	0.39	0.06	4.47	4.38	4.02	1.09	78.9	0.327
150	36	152	*	0.74	39.96	0.52	0.09	4.59	4.47	3.99	1.12	69.9	0.424
200	119	173	*	0.98	132.09	1.70	0.31	5.78	5.45	3.77	1.44	173.0	1.395
250	199	190	*	1.23	220.89	2.84	0.48	6.91	6.41	3.60	1.78	230.8	2.357
300	259	205	*	1.47	287.49	3.68	0.63	7.76	7.11	3.45	2.06	249.8	3.05
400	338	243	*	1.97	375.18	4.79	1.07	8.86	7.83	3.06	2.56	243.2	3.762
500	383	271	*	2.46	425.13	5.39	1.30	9.47	8.16	2.77	2.94	219.4	4.086
600	408	296	*	2.95	452.88	5.71	1.56	9.79	8.23	2.52	3.27	193.8	4.155
700	423	313	*	3.44	469.53	5.89	1.73	9.97	8.24	2.34	3.52	171.3	4.161
800	432	325	*	3.93	479.52	5.99	1.86	10.07	8.22	2.22	3.70	152.3	4.134
900	440	330	*	4.42	488.40	6.07	1.91	10.15	8.25	2.17	3.80	137.2	4.163
1000	446	332	*	4.91	495.06	6.12	1.93	10.20	8.28	2.15	3.85	124.5	4.193
1100	449	330	*	5.41	498.39	6.13	1.91	10.21	8.31	2.17	3.83	113.4	4.223
1200	454	330	*	5.90	503.94	6.17	1.91	10.24	8.34	2.17	3.84	104.5	4.259
1300	459	330	*	6.39	509.49	6.20	1.91	10.28	8.38	2.17	3.86	97.0	4.294
1400	464	330	*	6.88	515.04	6.24	1.91	10.31	8.41	2.17	3.87	90.6	4.329
1500	467	330	*	7.37	518.37	6.24	1.91	10.32	8.42	2.17	3.88	84.7	4.336
1600	471	330	*	7.86	522.81	6.26	1.91	10.34	8.44	2.17	3.89	79.6	4.356
1700	476	330	*	8.36	528.36	6.30	1.91	10.37	8.47	2.17	3.90	75.3	4.389
1800	480	330	*	8.85	532.80	6.31	1.91	10.39	8.49	2.17	3.91	71.4	4.408
1900	484	330	*	9.34	537.24	6.33	1.91	10.41	8.51	2.17	3.92	67.8	4.426
2000	488	330	*	9.83	541.68	6.35	1.91	10.43	8.53	2.17	3.93	64.6	4.444
2100	492	330	*	10.32	546.12	6.37	1.91	10.44	8.54	2.17	3.94	61.7	4.461
2200	496	328	*	10.81	550.56	6.38	1.89	10.46	8.58	2.19	3.92	59.0	4.498
2300	501	325	*	11.30	556.11	6.41	1.86	10.49	8.64	2.22	3.89	56.7	4.557
2400	505	325	*	11.80	560.55	6.43	1.86	10.51	8.66	2.22	3.89	54.5	4.573
2500	510	320	*	12.29	566.10	6.46	1.80	10.53	8.73	2.27	3.84	52.5	4.651
2600	515	320	*	12.78	571.65	6.48	1.80	10.56	8.75	2.27	3.85	50.7	4.678
2700	519	320	*	13.27	576.09	6.50	1.80	10.57	8.77	2.27	3.86	49.0	4.691
2900	522	315	*	13.76	579.42	6.50	1.75	10.57	8.82	2.32	3.80	47.2	4.743
2900	526	315	*	14.25	583.86	6.51	1.75	10.59	8.84	2.32	3.80	45.7	4.755
3000	531	315	*	14.74	589.41	6.53	1.75	10.61	8.86	2.32	3.81	44.3	4.79

Table A-6-16 Data Sheets of Triaxial Compression Test of CP-2 (P3' =8.0)

C A L C U L O   D E   T R I A X I A L E S   T I P O   C U

Proyecto : P.H. PIRRIS
Sitio : PRESTAMO
Localizacion: C.P.2
Profundidad : *INTEGRAL 0-5m*
Facha : 26 / 7 / 91

Lo (mm) :	206,2	Ao (cm2) :	79,17	eo :	0,65
Do (mm) :	100,4	Vo (cm3) :	1632,47	So (%) :	97,21
Wto (g) :	3210	δto (k/m3) :	1966,34	w (%) :	21,72
Wt (g) :	3229	δtf (k/m3) :	2057,92	ef :	0,59
Ws (g) :	2646	δdo (k/m3) :	1622,08	Sf (%) :	100,00
Gs :	2,68	δdf (k/m3) :	1687,63	wf (%) :	21,94
A.carga :	1,11	PCT(k/cm2) :	9,4	Lc (mm):	202,03
δV (cm3):	99,1	PCE(k/cm2) :	8	Ac(cm2):	75,97
V (mm/'):	0,15	CP (k/cm2) :	1,4	Vc(cm3):	1533,37
δVcontrapr	90,1	V.aire cm3 :	82,4132	δV(cm3):	99,1

DEF	DIV. DIAL	U kN/m2		DEF (%)	CARGA kg	ESF k/cm2	U Kg/cm²	P1 kg/cm2	P1' k/cm2	P3' kg/cm2	P1'/P3'	E k/cm2	E. EF. Kg/cm²
0	0	141	*	0,00	0,00	0,00	---	---	---	---	---	---	0
50	33	163	*	0,25	36,63	0,48	0,22	8,64	8,41	7,93	1,06	194,4	0,257
100	48	176	*	0,49	53,28	0,70	0,36	8,85	8,49	7,80	1,09	141,0	0,341
150	62	189	*	0,74	68,82	0,90	0,49	9,05	8,56	7,67	1,12	121,1	0,41
200	75	213	*	0,99	83,25	1,09	0,73	9,24	8,51	7,42	1,15	109,6	0,351
250	134	236	*	1,24	148,74	1,93	0,97	10,09	9,13	7,19	1,27	156,3	0,965
300	278	283	*	1,48	308,58	4,00	1,45	12,16	10,73	6,71	1,60	269,5	2,554
400	446	386	*	1,98	495,06	6,39	2,50	14,54	12,08	5,66	2,14	322,6	3,89
500	546	479	*	2,47	606,06	7,78	3,45	15,94	12,55	4,71	2,66	314,4	4,335
600	603	516	*	2,97	669,33	8,55	3,82	16,70	12,94	4,33	2,99	287,9	4,727
700	639	566	*	3,46	708,18	9,00	4,33	17,15	12,89	3,82	3,37	259,7	4,667
800	660	591	*	3,96	732,60	9,26	4,59	17,42	12,91	3,57	3,62	233,9	4,675
900	679	608	*	4,45	752,58	9,47	4,76	17,62	12,94	3,39	3,91	212,5	4,705
1000	691	610	*	4,95	767,01	9,60	4,78	17,75	13,05	3,37	3,87	193,9	4,816
1100	703	615	*	5,44	780,33	9,71	4,83	17,97	13,12	3,32	3,95	178,4	4,981
1200	715	619	*	5,94	793,65	9,83	4,87	17,98	13,19	3,28	4,02	165,4	4,954
1300	726	619	*	6,43	805,86	9,93	4,87	18,08	13,29	3,28	4,05	154,3	5,053
1400	736	618	*	6,93	816,96	10,01	4,86	18,16	13,38	3,29	4,06	144,4	5,147
1500	746	614	*	7,42	828,06	10,09	4,82	18,25	13,51	3,33	4,05	135,9	5,27
1600	756	612	*	7,92	839,16	10,17	4,80	18,33	13,61	3,35	4,06	128,4	5,371
1700	764	612	*	8,41	848,04	10,22	4,80	18,38	13,66	3,35	4,07	121,5	5,423
1800	773	609	*	8,91	858,03	10,29	4,77	18,44	13,75	3,38	4,06	115,5	5,518
1900	782	605	*	9,40	868,02	10,35	4,73	18,51	13,86	3,43	4,05	110,1	5,622
2000	791	603	*	9,90	878,01	10,41	4,71	18,57	13,94	3,45	4,05	105,2	5,704
2100	800	603	*	10,39	888,00	10,47	4,71	18,63	14,00	3,45	4,06	100,8	5,765
2200	808	600	*	10,89	896,88	10,52	4,69	18,68	14,08	3,48	4,05	96,6	5,842
2300	815	600	*	11,38	904,65	10,55	4,68	18,71	14,11	3,48	4,06	92,7	5,874
2400	821	597	*	11,88	911,31	10,57	4,65	18,73	14,16	3,51	4,04	89,0	5,923
2500	828	595	*	12,37	919,08	10,60	4,63	18,76	14,21	3,53	4,03	85,7	5,974
2600	834	592	*	12,87	925,74	10,62	4,60	18,77	14,25	3,56	4,01	82,5	6,021
2700	840	587	*	13,36	932,40	10,63	4,55	18,79	14,32	3,61	3,97	79,6	6,087
2800	846	582	*	13,86	939,06	10,65	4,50	18,80	14,38	3,66	3,93	76,8	6,153
2900	851	575	*	14,35	944,61	10,65	4,47	18,80	14,45	3,73	3,87	74,2	6,226
3000	856	570	*	14,85	950,16	10,65	4,37	18,81	14,51	3,78	3,84	71,7	6,277

Table A-6-17 Data Sheets of Triaxial Compression Test of CP-3 (P3' =2.0)

C A L C U L O D E T R I A X I A L E S   T I P O C U

Proyecto : P.H. PIRRIS
Sitio : *PRESTAMO*
Localizacion: C.P.3
Profundidad : INTEGRAL 0-5m
Fecha : 4 / 7 / 91

						*	*	*
Lo (mm) :	206.4	Ao (cm2) :	79.54	eo :	0.65	*	*	*
Do (mm) :	100	Vo (cm3) :	1621.06	So (%) :	85.86	*	*	*
Wto (g) :	3194	γto (k/m3) :	1970.31	w (%) :	20.66	*	*	*
Wt (g) :	3270	γff (k/m3) :	2034.83	ef :	0.63	*	*	*
Ws (g) :	2647	γdo (k/m3) :	1632.88	Sf (%) :	100.00	*	*	*
Gs :	2.69	γdf (k/m3) :	1647.15	wf (%) :	23.54	*	*	*
A.carga :	1.11	PCT(k/cm2) :	3.9	Lc (mm):	203.59	*	*	*
ΔVcelda :	66.1	PCE(k/cm2) :	2	Ac(cm2):	76.40	*	*	*
V (mm/'):	0.15	CP (k/cm2) :	1.9	Vc(cm3):	1554.96	*	*	*
ΔVcontrapr	115	V.aire cm3 :	90.0469	ΔV(cm3):	66.1	*	*	*

DEF	DIV. DIAL	U kN/m2		DEF (%)	CARGA kg	ESF k/cm2	U k/cm2	P1 kg/cm2	P1' k/cm2	P3' kg/cm2	P1'/P3'	E k/cm2	E. EF. k/cm2
0	0	193	*	0.00	0.00	0.00	0.00	---	---	---	---	---	0
50	13	200	*	0.25	14.43	0.19	0.07	2.23	2.16	1.97	1.10	76.7	0.117
100	18	205	*	0.49	19.98	0.26	0.12	2.30	2.18	1.92	1.14	53.0	0.138
150	22	208	*	0.74	24.42	0.32	0.15	2.36	2.20	1.89	1.17	43.1	0.164
200	25	210	*	0.98	27.75	0.36	0.17	2.40	2.23	1.87	1.19	36.6	0.186
250	84	231	*	1.23	93.24	1.21	0.39	3.24	2.86	1.65	1.73	98.2	0.818
300	134	250	*	1.47	148.74	1.92	0.58	3.96	3.38	1.46	2.32	130.2	1.337
400	203	272	*	1.96	225.33	2.89	0.81	4.93	4.12	1.23	3.34	147.2	2.086
500	242	279	*	2.46	268.62	3.43	0.88	5.47	4.59	1.16	3.95	139.6	2.553
600	265	280	*	2.95	294.15	3.74	0.89	5.78	4.89	1.15	4.24	126.8	2.85
700	278	277	*	3.44	308.58	3.90	0.86	5.94	5.08	1.18	4.30	113.4	3.044
900	290	273	*	3.93	321.90	4.05	0.82	6.09	5.27	1.22	4.31	103.0	3.232
900	299	270	*	4.42	330.78	4.14	0.78	6.18	5.39	1.25	4.30	93.6	3.353
1000	305	266	*	4.91	338.55	4.21	0.74	6.25	5.51	1.29	4.25	85.8	3.459
1100	310	263	*	5.40	344.10	4.26	0.71	6.30	5.59	1.33	4.21	78.9	3.547
1200	314	260	*	5.89	348.54	4.29	0.68	6.33	5.65	1.36	4.17	72.8	3.61
1300	319	257	*	6.39	354.09	4.34	0.65	6.38	5.72	1.39	4.13	67.9	3.686
1400	322	254	*	6.88	357.42	4.36	0.62	6.40	5.77	1.42	4.07	63.4	3.734
1500	326	251	*	7.37	361.86	4.39	0.59	6.43	5.83	1.45	4.03	59.5	3.796
1600	330	249	*	7.86	366.30	4.42	0.57	6.46	5.89	1.47	4.01	56.2	3.847
1700	333	248	*	9.35	369.63	4.43	0.56	6.47	5.91	1.48	4.00	53.1	3.873
1800	336	246	*	8.84	372.96	4.45	0.54	6.49	5.95	1.50	3.97	50.3	3.91
1900	338	244	*	9.33	375.18	4.45	0.52	6.49	5.97	1.52	3.93	47.7	3.932
2000	340	242	*	9.82	377.40	4.45	0.50	6.49	5.99	1.54	3.89	45.3	3.955
2100	342	240	*	10.31	379.62	4.46	0.48	6.49	6.02	1.56	3.86	43.2	3.977
2200	343	238	*	10.81	380.73	4.44	0.46	6.48	6.02	1.58	3.81	41.1	3.986
2300	344	236	*	11.30	381.84	4.43	0.44	6.47	6.03	1.60	3.77	39.2	3.995
2400	345	234	*	11.79	382.95	4.42	0.42	6.46	6.04	1.62	3.73	37.5	4.003
2500	346	233	*	12.28	384.06	4.41	0.41	6.45	6.04	1.63	3.70	35.9	4.002
2600	346	232	*	12.77	384.06	4.38	0.40	6.42	6.03	1.64	3.67	34.3	3.987
2700	348	232	*	13.26	386.28	4.39	0.40	6.42	6.03	1.64	3.67	33.1	3.988
2800	349	231	*	13.75	387.39	4.37	0.39	6.41	6.02	1.65	3.65	31.8	3.986
2900	350	230	*	14.24	388.50	4.36	0.38	6.40	6.02	1.66	3.62	30.6	3.983
3000	350	229	*	14.74	389.50	4.34	0.37	6.37	6.01	1.67	3.59	29.4	3.969

Table A-6-18 Data Sheets of Triaxial Compression Test of CP-3 (P3' =4.0)

C A L C U L O   D E   T R I A X I A L E S   T I P O   C U

Proyecto : P.H. PIRRIS
Sitio : PRESTAMO
Localizacion: C.P.3
Profundidad : INTEGRAL 0-5m
Fecha : 4 / 7 / 91

						*		*	*
Lo (mm) :	206,2	Ao (cm2) :	79,01	eo :	0,66	*		*	*
Do (mm) :	100,3	Vo (cm3) :	1629,22	So (%) :	84,75	*		*	*
Wto (g) :	3189	γto (k/m3) :	1957,38	w (%) :	20,80	*		*	*
Wt (g) :	3245	γtf (k/m3) :	2045,5	ef :	0,62	*		*	*
Ws (g) :	2640	γdo (k/m3) :	1620,4	Sf (%) :	100,00	*		*	*
Gs :	2,69	γdf (k/m3) :	1664,13	wf (%) :	22,92	*		*	*
A.carga :	1,11	PCT(k/cm2) :	5,9	Lc (mm):	204,38	*		*	*
ΔV (cm3):	65,4	PCE(k/cm2) :	4	Ac(cm2):	77,62	*		*	*
V (mm/'):	0,15	CP (k/cm2) :	1,9	Vc(cm3):	1586,12	*		*	*
ΔVcontrapr	107,1	V.aire cm3 :	98,8099	ΔV(cm3):	43,1	*		*	*

DEF	DIV. DIAL	U kN/m2		DEF (%)	CARGA kg	ESF k/cm2	U Kg/cm²	P1 kg/cm2	P1' k/cm2	P3' kg/cm2	P1'/P3'	E k/cm2	E. EF. k/cm2
0	0	192	*	0,00	0,00	0,00	---	---	---	---	---	---	0
50	20	215	*	0,24	22,20	0,29	0,23	4,36	4,11	3,84	1,07	116,6	0,051
100	29	226	*	0,49	32,19	0,41	0,35	4,49	4,13	3,73	1,11	84,3	0,066
150	36	235	*	0,73	39,96	0,51	0,44	4,59	4,14	3,64	1,14	69,6	0,073
200	149	268	*	0,98	165,39	2,11	0,77	6,19	5,41	3,30	1,64	215,6	1,335
250	225	305	*	1,22	249,75	3,18	1,15	7,26	6,11	2,93	2,09	259,8	2,026
300	276	345	*	1,47	306,36	3,89	1,56	7,97	6,42	2,52	2,55	265,0	2,329
400	338	383	*	1,96	375,18	4,74	1,95	8,82	6,89	2,13	3,23	242,1	2,792
500	370	412	*	2,45	410,70	5,16	2,24	9,24	7,02	1,83	3,83	211,0	2,919
600	389	418	*	2,94	431,79	5,40	2,30	9,48	7,20	1,77	4,06	183,9	3,096
700	401	420	*	3,42	445,11	5,54	2,32	9,62	7,32	1,75	4,17	161,7	3,214
800	411	420	*	3,91	456,21	5,65	2,32	9,73	7,43	1,75	4,23	144,3	3,323
900	419	420	*	4,40	465,09	5,73	2,32	9,81	7,51	1,75	4,28	130,1	3,404
1000	425	417	*	4,89	471,75	5,78	2,29	9,86	7,59	1,78	4,25	118,1	3,497
1100	431	417	*	5,38	477,86	5,83	2,29	9,90	7,63	1,78	4,28	108,2	3,532
1200	435	414	*	5,87	482,85	5,86	2,26	9,93	7,69	1,81	4,24	99,7	3,593
1300	440	412	*	6,36	487,85	5,89	2,24	9,96	7,74	1,83	4,22	92,5	3,643
1400	444	411	*	6,85	492,29	5,91	2,23	9,99	7,78	1,85	4,21	86,2	3,676
1500	448	407	*	7,34	497,29	5,94	2,19	10,01	7,84	1,89	4,16	80,9	3,745
1600	451	403	*	7,83	500,61	5,94	2,15	10,02	7,89	1,93	4,10	75,9	3,794
1700	454	401	*	8,32	503,94	5,95	2,13	10,03	7,92	1,95	4,07	71,6	3,822
1800	456	399	*	8,81	506,16	5,95	2,11	10,02	7,93	1,97	4,03	67,5	3,837
1900	458	396	*	9,30	508,38	5,94	2,08	10,02	7,94	2,00	3,98	63,9	3,861
2000	459	394	*	9,79	509,49	5,92	2,06	10,00	7,96	2,02	3,94	60,5	3,863
2100	461	392	*	10,27	511,71	5,92	2,04	9,99	7,97	2,04	3,91	57,6	3,877
2200	463	389	*	10,76	513,93	5,91	2,01	9,99	8,00	2,07	3,86	54,9	3,9
2300	465	386	*	11,25	516,15	5,90	1,98	9,99	8,02	2,10	3,82	52,4	3,924
2400	466	384	*	11,74	517,26	5,88	1,96	9,96	8,02	2,12	3,78	50,1	3,924
2500	466	383	*	12,23	517,26	5,85	1,95	9,93	8,00	2,13	3,75	47,8	3,902
2600	467	382	*	12,72	518,37	5,83	1,94	9,91	7,99	2,14	3,73	45,8	3,892
2700	467	382	*	13,21	518,37	5,80	1,94	9,87	7,95	2,14	3,72	43,9	3,859
2800	468	380	*	13,70	519,48	5,78	1,92	9,85	7,95	2,16	3,68	42,2	3,859
2900	468	380	*	14,19	519,48	5,74	1,92	9,82	7,92	2,16	3,67	40,5	3,827
3000	467	378	*	14,68	518,37	5,70	1,90	9,78	7,90	2,18	3,62	38,8	3,802

Table A-6-19 Data Sheets of Triaxial Compression Test of CP-3 (P3' = 8.0)

C A L C U L O   D E   T R I A X I A L E S   T I P O   C U

Proyecto : P.H. PIRRIS
Sitio : PRESTAMO
Localizacion: C.P.3
Profundidad : INTEGRAL 0-5m
Fecha : 4 / 7 / 91

Lo (mm) :	206.4	Ao (cm2) :	79.17	eo :	0.67
Do (mm) :	100.4	Vo (cm3) :	1634.06	So (%) :	81.78
Wto (g) :	3164	&to (k/m3) :	1936.29	w (%) :	20.49
Wt (g) :	3208	&tf (k/m3) :	2058.77	ef :	0.60
Ws (g) :	2626	&do (k/m3) :	1607.04	Sf (%) :	100.00
Gs :	2.69	&df (k/m3) :	1685.27	wf (%) :	22.16
A.carga :	1.11	PCT(k/cm2) :	9.9	Lc (mm):	202.13
&V (cm3):	96.8	PCE(k/cm2) :	8	Ac(cm2):	75.89
V (mm/'):	0.1	CP (k/cm2) :	1.9	Vc(cm3):	1532.56
&Vcontrapr	196.8	V.aire cm3 :	119.848	&V(cm3):	101.5

DEF	DIV. DIAL	U kN/m2		DEF (%)	CARGA kg	ESF k/cm2	U Kg/cm2	P1 kg/cm2	P1' k/cm2	P3' kg/cm2	P1'/P3'	E k/cm2	E. EF. Kg/cm2
0	0	193	*	0.00	0.00	0.00	---	---	---	---	---	---	0
50	30	213	*	0.25	33.30	0.44	0.20	8.59	8.36	7.95	1.05	176.9	0.234
100	42	225	*	0.49	46.67	0.61	0.33	8.77	8.47	7.83	1.08	123.6	0.285
150	54	236	*	0.74	59.94	0.78	0.44	8.94	8.48	7.72	1.10	105.6	0.346
200	65	246	*	0.99	72.15	0.94	0.54	9.10	8.54	7.61	1.12	95.1	0.401
250	205	287	*	1.24	227.55	2.96	0.91	11.12	10.20	7.75	1.41	239.4	2.054
300	299	319	*	1.48	331.89	4.31	1.28	12.46	11.17	6.87	1.63	290.3	3.024
400	427	405	*	1.98	473.97	6.12	2.16	14.28	12.13	5.99	2.02	309.3	3.961
500	514	495	*	2.47	570.54	7.33	3.08	15.49	12.44	5.08	2.45	296.4	4.253
600	567	555	*	2.97	629.37	8.05	3.69	16.20	12.55	4.46	2.81	271.1	4.357
700	597	605	*	3.46	662.67	8.43	4.20	16.58	12.43	3.96	3.14	243.4	4.23
800	614	635	*	3.96	681.54	8.63	4.51	16.78	12.33	3.65	3.38	217.9	4.119
900	628	651	*	4.45	697.08	8.78	4.67	16.93	12.32	3.49	3.53	197.1	4.108
1000	637	658	*	4.95	707.07	8.86	4.74	17.01	12.33	3.41	3.61	179.0	4.116
1100	645	670	*	5.44	715.95	8.92	4.86	17.08	12.28	3.29	3.73	163.9	4.058
1200	653	678	*	5.94	724.83	8.98	4.94	17.14	12.26	3.21	3.82	151.3	4.04
1300	658	684	*	6.43	730.38	9.01	5.01	17.16	12.22	3.15	3.88	140.0	4
1400	665	686	*	6.93	738.15	9.05	5.03	17.21	12.25	3.13	3.91	130.7	4.027
1500	670	696	*	7.42	743.70	9.07	5.03	17.23	12.27	3.13	3.92	122.3	4.047
1600	675	684	*	7.92	749.25	9.09	5.01	17.25	12.31	3.15	3.91	114.8	4.086
1700	680	684	*	8.41	754.80	9.11	5.01	17.26	12.32	3.15	3.91	108.3	4.104
1800	685	682	*	8.91	760.35	9.13	4.98	17.28	12.36	3.17	3.90	102.5	4.142
1900	690	682	*	9.40	765.90	9.14	4.98	17.30	12.39	3.17	3.90	97.3	4.159
2000	695	680	*	9.89	771.45	9.16	4.96	17.31	12.41	3.19	3.89	92.6	4.195
2100	700	680	*	10.39	777.00	9.17	4.96	17.33	12.43	3.19	3.90	88.3	4.21
2200	705	680	*	10.88	782.55	9.19	4.96	17.34	12.44	3.19	3.90	84.4	4.225
2300	709	680	*	11.38	786.99	9.19	4.96	17.34	12.44	3.19	3.90	80.8	4.226
2400	713	678	*	11.87	791.43	9.19	4.94	17.35	12.47	3.21	3.88	77.4	4.246
2500	719	678	*	12.37	798.09	9.20	4.94	17.36	12.49	3.21	3.89	74.4	4.259
2600	722	675	*	12.86	801.42	9.20	4.91	17.36	12.51	3.24	3.86	71.5	4.298

APPENDIX A-7 FEASIBILITY DESIGN

APPENDIX A-7 FEASIBILITY DESIGN

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APPENDIX A-7 FEASIBILITY DESIGN

A-7-1 Hydraulic Calculation

(1) Calculation of Optimum Inner Diameter for Diversion Tunnel

(i) Basic Condition

Design flood (Q)	:	560 m^3/s (10 year return period flood)
Flow condition	:	Piping flow
Shape of cross-section	:	Horse shoe with concrete lining
Length of tunnel (L)	:	330 m
Inlet sill elevation	:	1,086 m
Outlet sill elevation	:	1,078 m

(ii) Calculation of Discahrge

In case of the piping flow for the diversion tunnel, relation between the river water level and the tunnel discharge is estimated with the following formulas:

$$H_1 = \frac{V^2}{2g}(1+f) + H_2$$

$$H_0 = H_1 - h' - 1,080 = H_2 + \frac{1+f}{2g}\left(\frac{Q}{A}\right)^2 + h' - 1080$$

where,

H_1	:	River water level at the inlet
v	:	Average velocity in the tunnel
H_2	:	River water level at the outlet

f : Coefficient of loss

$$f = fe + f_f$$

fe : Coefficient of loss at the inlet in this case fe is applied 0.2 with circular bell mouth

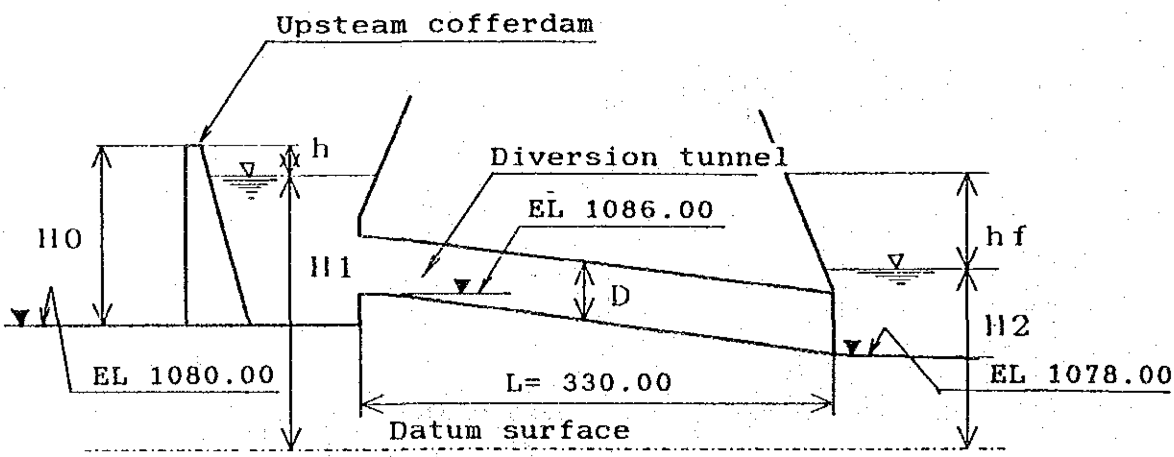
f_f : Friction loss
Friction loss will be calculated with the flowing formula:

$$f_f = \frac{2gn^2 \cdot L}{D^{\frac{4}{3}}} = \frac{1,152}{D^{\frac{4}{3}}}$$

H_o : Required height of the cofferdam

h' : Free board = 1.0 m

A : Inner cross-section area = 3.317 $(\frac{D}{2})^2$



(iii) Result of Calculation

Construction costs of the tunnel and upstream cofferdam were estimated, varying the tunnel diameter and cofferdam height case by case.

Result of the calculation shows that the optimum diameter for the diversion tunnel was judged as 6.50 m by the below Fig. A-7-1.

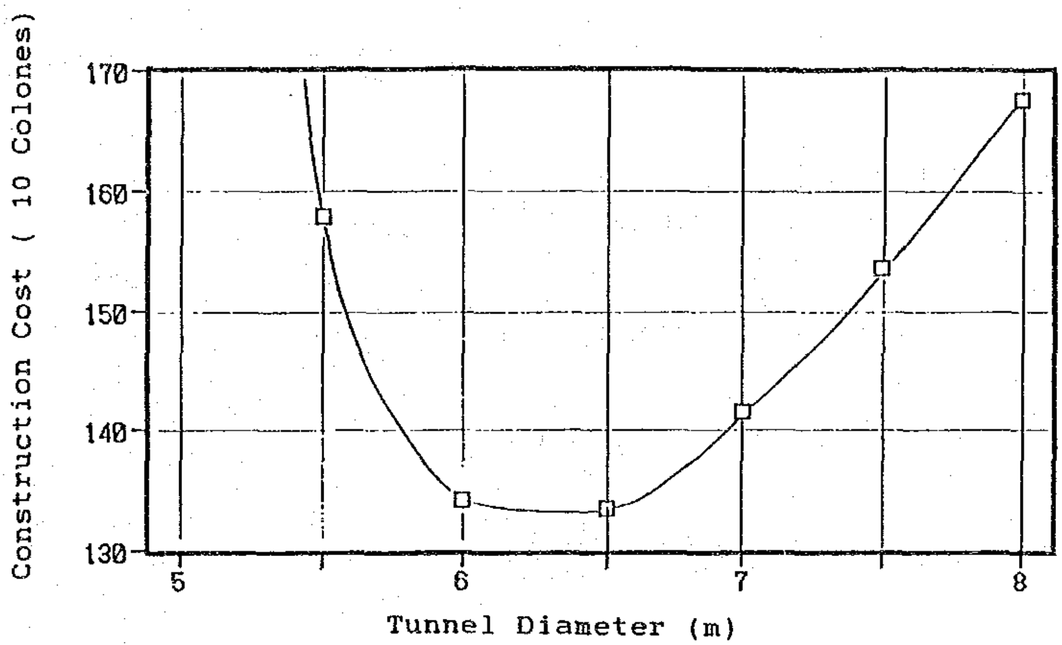


Fig. A-7-1 Relation Curve between Construction Cost and Tunnel Diameter

(2) Calculation of Discharge Capacity of Spillway

(i) Basic Condition

Design flood (Q_f)	:	1,670 m^3/sec (P.M.F)
Reservoir water level	:	1,195.00 m (H.W.L)

(ii) Calculation of Discharge Capacity of Spillway

The discharge capacity is given by the following equations:

$$Q_f = nc' BH^{3/2}$$

$$C' = C\{1-Md\ (\frac{H}{Hd})^{1.5}\}$$

$$Cd = 2.200 - 0.0416\ (\frac{Hd}{W})^{0.990}$$

$$C = 1.60 \times \frac{1 + 2a\ (H/Hd)}{1 + a\ (H/Hd)}$$

In case of $n \geq 2$, $\frac{b}{S'} \geq 0.8$

$$Md = 0.0756\ (\frac{Hd}{B})^{0.5}$$

In case of $n \geq 2$, $\frac{b}{S'} \leq 0.8$

$$Md = 0.0756\ (\frac{Hd}{B})^{0.5} \times \{\frac{1}{n} + 1.465 \times \frac{n-1}{n} \times (\frac{b}{S'})^{1.7}\}$$

where,

Q	:	Discharge (m^3/sec)
n	:	Number of chute
B	:	Width of chute (m)
H	:	Water depth from reservoir water level to weir crest (m)
C'	:	Coefficient of discharge with pier effect considered

C : Coefficient of discharge without pier effect
Md : Reduction ratio of discharge coefficient due to piers
Hd : Water depth from design reservoir water level to weir crest (m)
W : Height of crest (m)
Cd : Value of C when H is equal to Hd
a : Constant
s' : Distance from crest to pier head (m)
b : Thickness of pier (m)

(iii) Study of Number and Dimensions of Spillway Gate

Relation of the number of gate (n), water depth (H) and chute width (B) was calculated based on the conditions that the pier thickness (b) is 3.0 m and the distance (s') is 0.28 Hd. The result is shown in the following Table:

n	H (m)	B (m)	n·B + b (m)
2	9.00	15.00	33.00
	10.00	12.90	28.80
	11.00*	11.30	25.60
	12.00	10.00	23.00
3	8.00	12.00	42.00
	9.00	10.20	36.60
	10.00	8.80	32.40
	11.00	7.70	29.10

As a result, the dimension of spillway gate is determined as H = 11.0 m, B = 11.5 m and n = 2.

(iv) Discharge Capacity of Spillway

Spillway capacity was calculated at various reservoir water level as shown in Fig. A-7-2.

Result of the calculation, the spillway has enough capacity for the design flood at the reservoir water level 1,195.0 m.

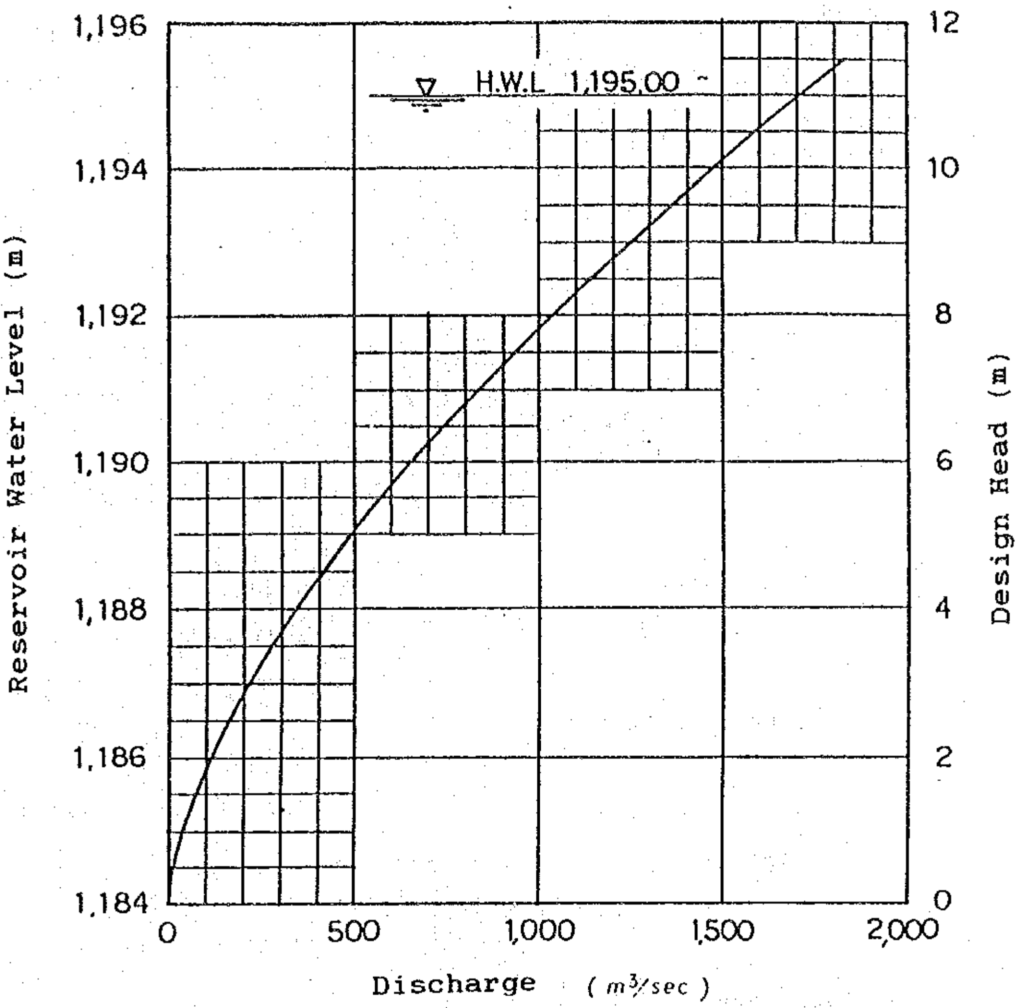


Fig. A-7-2 Discharge Capacity of Spillway

(3) Calculation of Discharge Capacity of Dam Outlet

(i) Basic Condition

As a result of discussion with ICE dated on December 5, 1991, the basic design conditions of the dam outlet works was agreed to modify some items as follows:

- Center elevation of the inlet : 1,135.00 m
- Diameter of the conduit with gate: 2.0 - 3.0 m

Result of the study, the outlet works facilities such as inlet, conduit pipe and gate are designed as below;

- Conduit pipe

  Type : Girder type

Cross section	(width)	(Height)
Inlet	2.55 m	3.16 m
Outlet	1.70 m	1.55 m

  Length : 36.0 m

- Main gate (Outlet gate)

  Type : High pressure radial gate

  Size : 1.70 wide x 2.50 high

- Auxiliary gate (Inlet gate)

  Type : Steel box type stop logs

  Size : 2.55 m wide x 0.70 m high x 5 pieces

(ii) Calculation of Discharge Capacity of Outlet

Discharge capacity is calculated with the following formula:

$$Q = A_o \sqrt{\frac{2g(H+Z_o)}{1+\eta}}$$

where,

H = Static head (m)

= Reservoir water level - 1,135.00

Z_o = Differential head between center of inlet and outlet

= 1,135.00 - 1,132.00 = 3.00 m

η = Coefficient of head loss in the conduit pipe

a) Calculation of head loss coefficient

- Entrance loss coefficient

  fe = 0.200 (with rectangular bell mouth)

- Friction loss coefficient

$$f_f = \frac{2gn^2}{R^{\frac{4}{3}}} \times L$$

where,

n = Kutter friction coefficient

R = Hydraulic radius (m)

$= \frac{A_o}{P}$

A_o = Cross-sectional area (m^2)

P = Wetted perimeter (m)

No.	Distance (m)	A_o (m^2)	P (m)	R (m)	Rm	f_f
0	0	8.068	11.428	0.706	-	-
1	1.7	3.797	7.342	0.517	0.612	0.009234
2	5.3	3.008	6.414	0.469	0.493	0.038409
3	13.0	3.008	6.414	0.469	0.469	0.100693
4	16.0	2.498	5.814	0.430	0.450	0.130959
Total	36.0					0.279295

- Bend loss coefficient

  $fb = fb_1 \times b_2 \fallingdotseq 0.020$

where,

$fb_1 \cdot fb_2$ = Loss coefficient for ratio of radius of bend curvature to pipe diameter (ρ/D) and to the angle of inter sector.

- Gradual contraction loss coefficient

  $fg \fallingdotseq 0$

- Total

  Entrance = 0.200

  Friction = 0.279

  Bend = 0.020

  Total 0.499 ≒ 0.50

b) Calculation of discharge

Result of the calculation, it is possible to release 70 m^3/sec at high water level of 1,195.00 m and 37 m^3/sec at low water level as shown below;

$$Q = 2.498 \times \sqrt{\frac{2 \times 9.8 \times (H + Z_o)}{1 + 0.50}}$$

W.L.	$H + Z_o$ (m)	Q (m^3/sec)
1.195	63.0	71.67
1.190	58.0	68.77
1,180	48.0	62.56
1.170	38.0	55.66
1.160	28.0	47.78
1.150	18.0	38.31
1,149	17.0	37.23

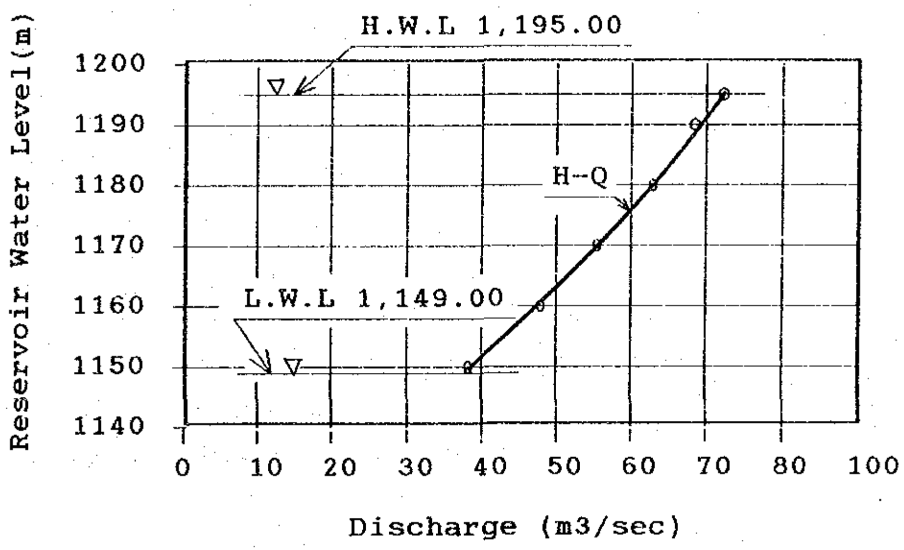


Fig. A-7-3 Discharge Capacity of Outlet

(4) Freeboard

(i) General

The elevation of dam crest is determined enough high not to be lower than reservoir water level adding wave heights and allowances.

(ii) Basic Formula

Ht ≥ max (H.W.L. + hw + he + ha, max. W.L. + hw)

where,

Ht : Elevation of dam crest
hw : Height of wave due to wind
he : " earthquake
ha : Allowance considering delayed gate operation

$hw = 0.00086\ V^{1.1}\ F^{0.45}$ .... SMB method

V : Design wind velocity (average for 10 minutes)
= 30 m/s

F : Fetch = 1,000 m

$$he = \frac{1}{2} \times \frac{k\tau}{\pi}\sqrt{g\ Ho}$$

k : Seismic coefficient = 0.15
τ : Earthquake period = 1 sec
g : Acceleration of gravity = 9.8 m/s^2
Ho : Height from reservoir level to foundation rock
= 115.00 m

(iii) Calculation

$$hw = 0.00086\ V^{1.1}\ F^{0.45}$$

$$= 0.00086 \times 30^{1.1} \times 1{,}000^{0.45}$$

$$= 0.81\ m$$

$$he = \frac{1}{2} \times \frac{k\tau}{\pi}\sqrt{g\ Ht}$$

$$= \frac{1}{2} \times \frac{0.15 \times 1}{\pi}\sqrt{9.8 \times 115.00}$$

$$= 0.80\ m$$

$$ha = 0.50\ m$$

H.W.L + hw + he + ha = 1,195.00 + 0.81 + 0.80 + 0.50 = 1,197.21

Therefore, elevation of dam top was decided 1,197.50.

(5) Calculation of Surging

(i) Design Conditions

(a) Reservoir Water Level

H.W.L.	:	1,195.00 m
L.W.L.	:	1,149.00 m

(b) Headrace Tunnel

Shape of tunnel	:	Circular
Diameter	:	2.80 m
Length	:	8,695.05 m
Coefficient of loss	:	1.694
Cross-sectional area	:	6.158 m^2

(c) Discharge

Qmax.	:	18.00 m^3/sec

(d) Surge Tank

Type of surge tank	:	Restricted orifice type
Dimension of surge tank	:	

Item	Upper Chamber	Shaft
Section	Circular	Circular
Diameter	10.00 m	5.00 m
Cross-Sectional Area	19.635 m^2	78.540 m^2

Dimension of orifice

Diameter	:	1.20 m
Coefficiency of loss		
Up-sursing	:	0.80
Down-sursing	:	0.70

(ii) Calculation Cases

Calculation of the surging is performed for two cases: rapid load rejection and rapid load increase from 1-unit operation to 2-unit operation.

- In case of full load rejection

Discharge	:	Q = 18.00 m^3/sec → 0 m^3/sec
Closing time	:	T_1 = 0 sec
Reservoir water level	:	1,195.00 m
Coefficient of head loss for head race	:	Eup = 1.694

- In case of half load increase

Discharge	:	Q = 9.00 m^3/sec → 18.00 m^3/sec
Opining time	:	T_1 = 15 sec
Reservoir water level	:	1,149.00 m

(iii) Calculation of Surging

Surging of the surge tank is computed using (particulars) properties shown in Fig. A-7-4.

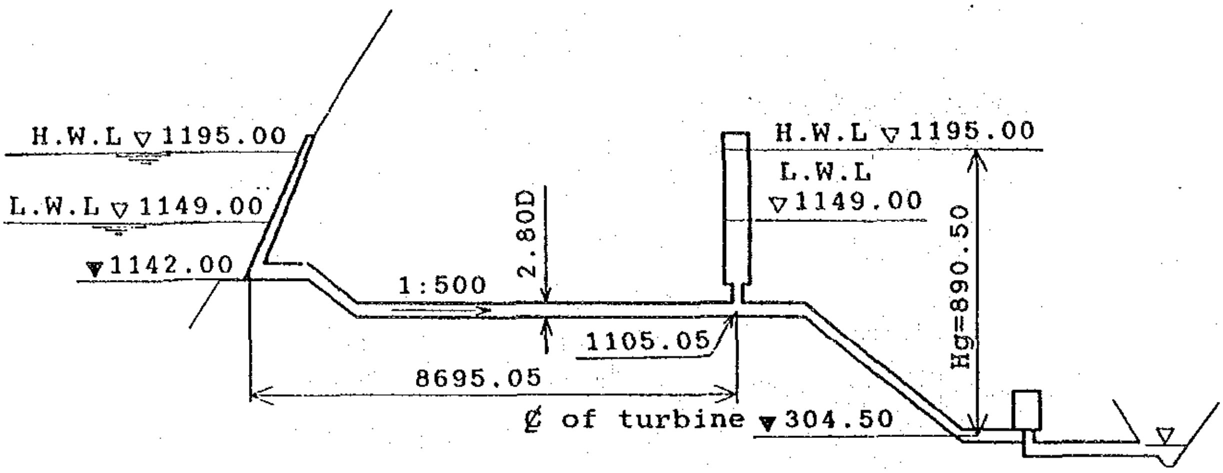


Fig. A-7-4 Profile of Waterway

Surging can be computed using the following formula:

$$\frac{d_v}{d_t} = \frac{Z - \epsilon \cdot |V| \cdot V - K}{L/g}$$

$$\frac{d_z}{d_t} = \frac{Q - f \cdot V}{F}$$

$$K = \phi \cdot |Q| \cdot Q$$

where,

Z : Water level in the surge tank
(Reservoir water level is 0)
V : Velocity in headrace tunnel (m/sec)
f : Cross-sectional area of the tunnel (m^2)
L : Length of the tunnel (m^2)
F : Cross-sectional area of shaft (m^2)
∈ : Coefficient of head loss for the tunnel

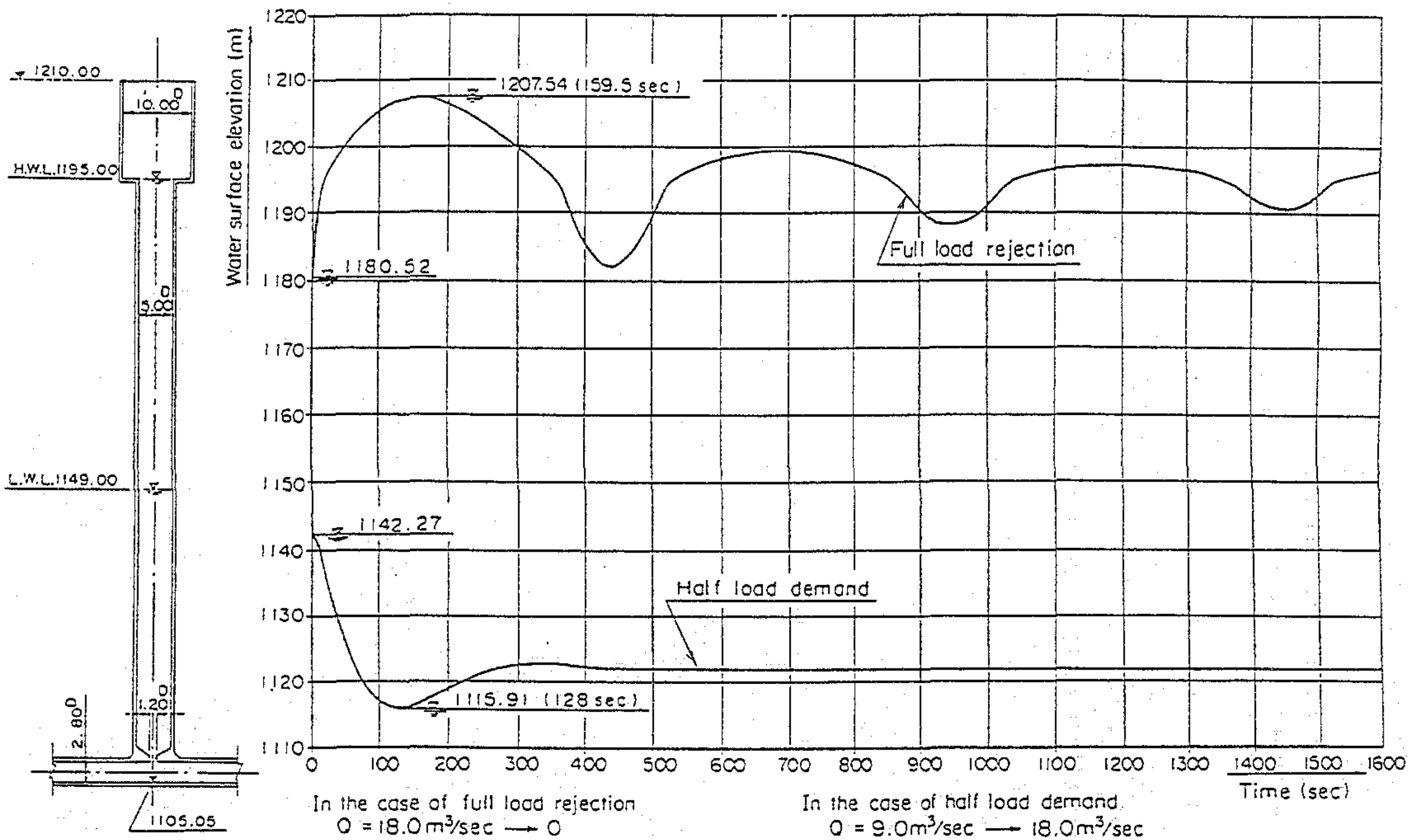
Q : Discharge at the below of the tank (m^3/sec)

K : Resistance at orifice

ϕ : Coefficient of orifice loss

Surging curves of water level were calculated with the numerical computation.

The calculation revealed that maximum rising water level is 1,207.54 m at 159.5 sec after load rejection, and the maximum drawdown of the sursing is 1,115.91 m occurred at 128 sec after load increasing as shown in Fig. A-7-5.



In the case of full load rejection
$Q = 18.0 m^3/sec \longrightarrow 0$
$n = 0.011$
$\varepsilon_{up} = 1.694$
Reservoir water surface = $1195.^{m}00$

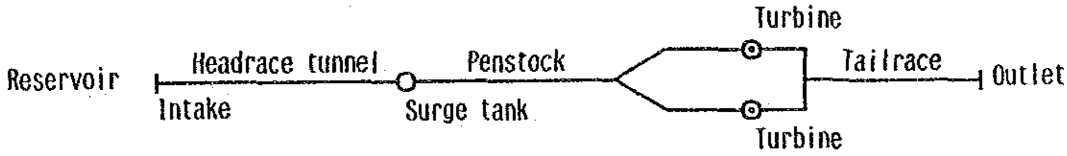
In the case of half load demand
$Q = 9.0 m^3/sec \longrightarrow 18.0 m^3/sec$
$n = 0.015$
$\varepsilon_{down} = 3.149$
Reservoir water surface = $1149.^{m}00$

Fig. 11-5 Surging Curve

(6) Calculation of Water Hammer Pressure

Penstock is installed basically on the ground surface except partial tunnel portions. The tunnels are provided both at connecting section with the bottom of surge tank and beginning of the penstock, and at the middle section of penstock.

One line steel penstock is installed from end of the surge tank to just before of the power station, and after that it bifurcates to connect No. 1 and No. 2 turbines as shown below:



(i) Calculation Conditions

Headrace Tunnel

Length	: 8,686.32 m
Cross-sectional area	: 6.16 m^2 (D = 2.8 m)

Surge tank

Height of upper chamber sill	: EL 1,195.00 m
Cross-sectional area of upper chamber	: 78.54 m^2 (D = 10.0 m)
Height of basement of shaft	: EL 1,106.45 m
Cross-sectional area of shaft	: 19.63 m^2 (D = 5.0 m)

Penstock

Length

from surge tank to bifurcater	: 2,601.43 m
from bifurcater to No.1 turbine	: 31.91 m
from bifurcater to No.2 turbine	: 31.91 m

Equivalent cross-sectional area

from surge tank to bifurcater	:	$4.12\ m^2$ (D = 2.29 m)
from bifurcater to No.1 turbine	:	$0.79\ m^2$ (D = 1.0 m)
from bifurcater to No.2 turbine	:	$0.79\ m^2$ (D = 1.0 m)

Turbine

Maximum discharge	:	$9\ m^2/sec$ x 2 units = $18.0\ m^3/sec$
Number of unit	:	2
Height of turbine center	:	EL 304.50 m
Closing time	:	30 sec

Reservoir

High water level	:	W.L 1,195.00 m

Outlet

Outlet water level	:	W.L 304.50 m (as same as center of turbine)

Pressure propagation velocity : 1,000 m/sec

(ii) Calculation Formula and Boundary Conditions

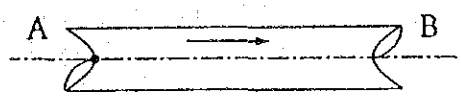
(a) Calculation Formula

$$HA,(t) \pm S \cdot QA,(t) = HB,(t-\frac{L}{a}) \pm S \cdot QB,(t-\frac{L}{a})$$

where,

HA,(t)	:	Pressure of point A at time (t)
QA,(t)	:	Discharge of point A at time (t)
$HB,(t-\frac{L}{a})$	:	Pressure of point B at time $(t-\frac{L}{a})$
$QB,(t-\frac{L}{a})$	:	Discharge of point B at time $(t-\frac{L}{a})$
S	:	Constant = a/g.A

a	:	Pressure propagation velocity
g	:	Acceleration due to gravity
A	:	Cross-sectional area of penstock
L	:	Length of penstock



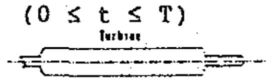
(b) Boundary Conditions

- Boundary condition at closure

In case of linearity closing, the boundary condition is formed as follows:

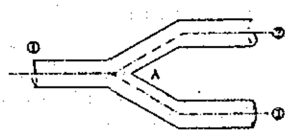
$$QA,(t) = (1 - \frac{t}{T}) \cdot \sqrt{HA,(t) - HB,(t)}$$

T	:	Closing time
t	:	Random time in the closing time ($0 \leq t \leq T$)



- Boundary condition at branch

$\{Q\ 1,(t) = Q\ 2,(t) + Q\ (3),(t)\}$



- Boundary condition at intake (reservoir)

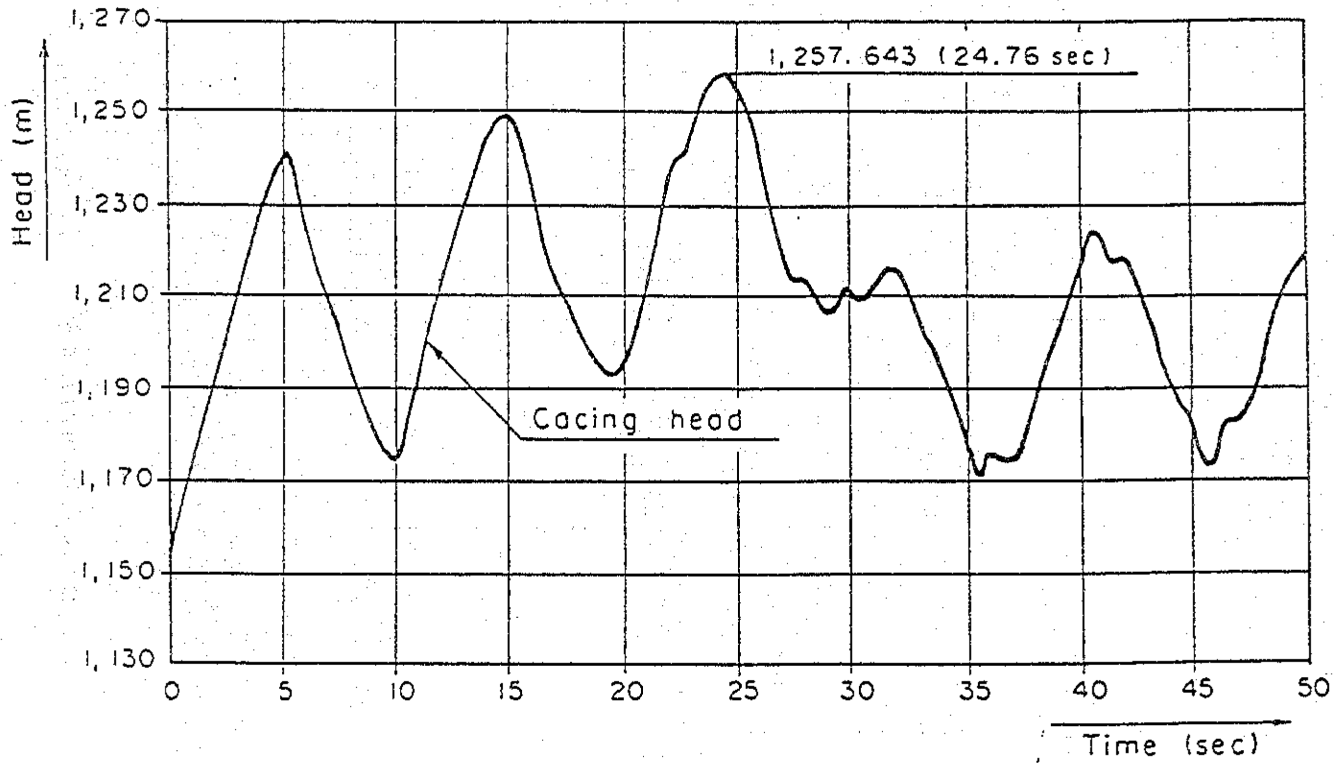
$HA,(t) = HA,\ 0$

(iii) Result of Calculation

Calculation is performed by electronic computer per 0.01 second.

Results is as shown in Fig. A-7-6, the maximum water hammer is estimated 10.7% of the static water pressure.

$$\frac{HA,\ (24.76\ \text{sec})}{HA,\ (0\ \text{sec})} = \frac{1{,}257.64 - 304.50}{1{,}195.00 - 304.50} = 1.070$$

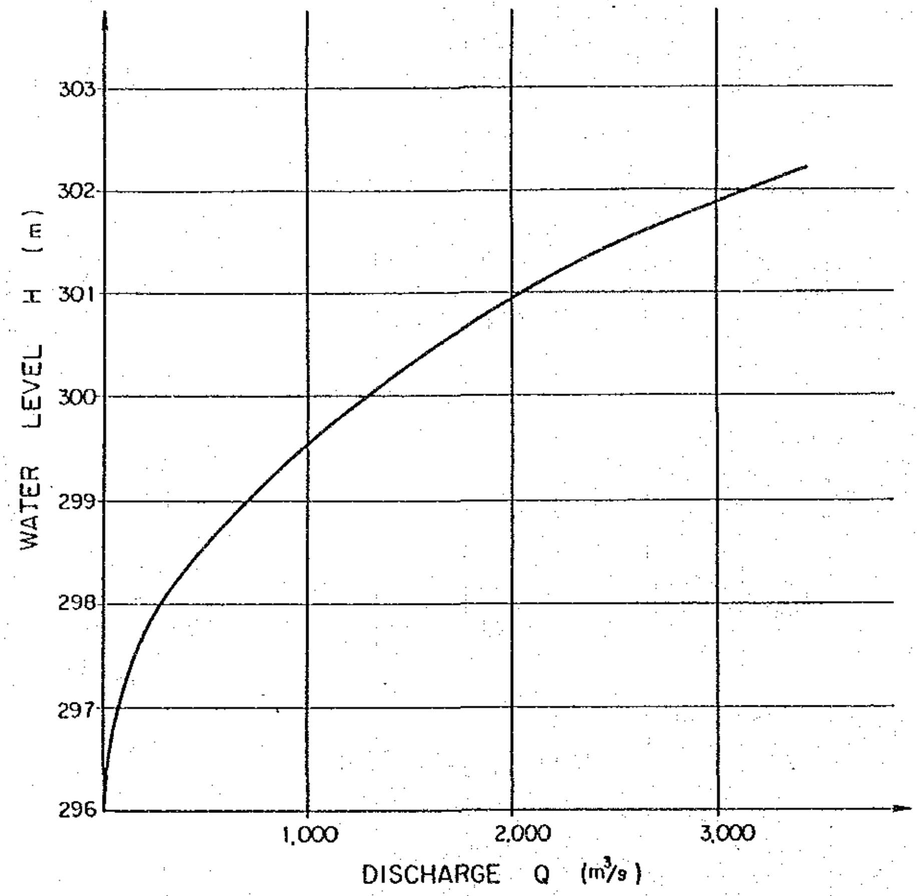


Reservoir Water Surface elevation	:	1,195.00 m
Tailrace Water Surface elevation	:	301. 30 m
Maximum discharge	:	9.00 x 2 = 18.00 m^3/sec
Number of generator	:	2 Units
Closing time	:	30 sec
Pressure wave Propagation velocity	:	1,000 m/sec

Fig. A-7-6 Water Hammer Pressure Curve

(7) Rating Curve at Power Plant Site

Rating curve at power plant site was calculated by manning formula because there laked actual observation data.



※ Rating Curve was calculated at the site of Power Plant by Manning Formula

Fig. A-7-7 Rating Curve at Power Plant Site

(8) Calculation of Effective Head

(i) Calculation of Head Loss

a) Intake Head Loss (h1)

a)-1 Trashrack Loss (Screen)

$$h_{1-1}=\beta\cdot\sin\theta\cdot\left(\frac{t}{b}\right)^{\frac{4}{3}}\cdot\frac{V^2}{2g}$$

where,

h_{1-1}: Trashrack loss (m)

ß : Coefficient for the sectional shape of screen bars (=1.60)

θ : Angle of the screen (=60° .4349)

t : Thickness of screen bars (=10 mm)

b : Size of screen mesh (=40 mm)

V : Flow velocity at face of screen (m/sec)

A : Flow area at face of screen (=7.00 mm x 4.50 mm = 31.50 m^2)

Q : Discharge (m^3/sec)

$$h_{1-1} = 1.60 \times \sin60°4349 \times \left(\frac{10}{40}\right)^{\frac{4}{3}} \times \frac{1}{2g} \times \left(\frac{Q}{31.50}\right)^2$$
$$= 11.59 \times 10^{-6} \times Q^2$$

a)-2 Entrance Loss

$$h_{1-2} = f_1\cdot\frac{V^2}{2g}$$

where,

h_{1-2} : Entrance Loss (m)

f_1 : Coefficient of entrance loss (=0.20)

V : Flow velocity after entrance $(=\frac{Q}{A})$

A : Flow area after entrance

$$(=\frac{\pi \times 2.80^2}{4} = 6.158\ m^2)$$

$$h_{1-2} = 0.20 \times \frac{1}{2g} \times (\frac{Q}{6.158})^2$$
$$= 269.09 \times 10^{-6} \times Q^2$$

a)-3 Total loss at Intake

$$h_1 = h_{1-1} + h_{1-2} = (11.59 + 268.09) \times 10^{-6} \times Q^2$$
$$= 280.68 \times Q^2$$

b) Headrace Tunnel Head Loss

b)-1 Friction loss

$$h_{2-1} = \frac{124.5 \cdot n^2}{D^{\frac{4}{3}}} \cdot L \cdot \frac{V^2}{2g}$$

where,

h_{2-1} : Friction loss (m)

n : Kutter friction coefficient (=0.013)

D : Tunnel inner diameter (=2.80 m)

L : Length of headrace tunnel (=8,695.05 m)

V : Flow velocity $(=\frac{Q}{A}\ m/sec)$

A : Cross-sectional area of tunnel (=6.158 m^2)

$$h_{2-1} = \frac{124.5x0.013^2}{2.80^{\frac{4}{3}}} x\ 8{,}695.05\ x\ \frac{1}{2g}\ x\ (\frac{Q}{6.158})^2$$

$$= 62{,}370.90\ x\ 10^{-6}\ x\ Q^2$$

where,

h_{3-1} : Friction loss (m)

n : Kutter friction coefficient (=0.0115)

D : Penstock inner diameter (m)

L : Length of penstock (m)

V : Average velocity $(=\frac{Q}{A}\ m/sec)$

Q : Discharge (m^3/sec)

A : Cross-sectional area of tunnel (m^2)

b)-2 Bend Loss

$$h_{2-2} = f_{b1} \cdot f_{b2} \cdot \frac{V^2}{2g}$$

where,

h_{2-2} : Bend Loss (m)

fb_1, fb_2 : Loss coefficient for ratio of radius of bend curveture to tunnel diameter $(\frac{\rho}{D})$, and to the angle of intersector

V : Average velocity $(\frac{Q}{A}\ m/sec)$

Q : Discharge (m^3/sec)

A : Cross sectional area of tunnel (= 6.158 m^2)

Intersection Point	Intersector Angle	ρ	f_{b1}	f_{b2}	h_{2-2}
VIP.1	48°00'	15.00	0.075	0.72	$72.65 \times 10^{-6} \times Q^2$
VIP.2	48°00'	15.00	0.075	0.72	$72.65 \times 10^{-6} \times Q^2$
HIP.1	36°30'	100.00	0.075	0.59	$59.54 \times 10^{-6} \times Q^2$
HIP.2	17°45'	100.00	0.075	0.33	$33.30 \times 10^{-6} \times Q^2$
Total					$238.14 \times 10^{-6} \times Q^2$

b)-3 Total of Headrace tunnel head loss

$$h_2 = h_{2-1} + h_{2-2} = (62,370.90 + 238.14) \times 10^{-6} \times Q^2$$
$$= 62,609.04 \times 10^{-6} \times Q^2$$

c) Penstock Head Loss

c)-1 Friction loss

$$h_{3-1} = \frac{124.5 \cdot n^2}{D^{\frac{4}{3}}} \cdot L \cdot \frac{V^2}{2g}$$

where,

h_{3-1} : Friction loss (m)

n : Kutter friction coefficient (=0.0115)

D : Penstock inner diameter (m)

L : Length of penstock (m)

V : Average velocity $(\frac{Q}{A}$ m/sec)

Q : Discharge (m^3/sec)

A : Cross-sectional area of penstock (m^2)

D	$D^{4/3}$	L	A	h_{3-1}
2.80	3.946	366.75	6.158	$1,058.93 \times 10^{-6} \times Q^2$
2.80 - 2.30	3.393	10.35	4.909	$106.34 \times 10^{-6} \times Q^2$
2.30	3.036	550.09	4.155	$8,816.58 \times 10^{-6} \times Q^2$
2.30 - 2.20	2.948	5.47	3.976	$98.60 \times 10^{-6} \times Q^2$
2.20	2.861	1,238.58	3,801	$2,517.18 \times 10^{-6} \times Q^2$
2.20 - 2.10	2.775	15.56	3.631	$357.28 \times 10^{-6} \times Q^2$
2.10	2.689	424.63	3.464	$11,055.40 \times 10^{-6} \times Q^2$
1.00	1.000	32.91	0.785	$44,863.95 \times 10^{-6} \times (\frac{Q^2}{2})$ $(11,215.99 \times 10^{-6} \times Q^2)$
Total (h_{3-1})				$58,881.30 \times 10^{-6} \times Q^2$

c)-2 Bend loss

$$h_{2-2} = fb_1 \cdot fb_2 \cdot \frac{V^2}{2g}$$

where,

h_{2-2} : Bend loss (m)

fb_1, fb_2: Loss coefficient for ratio of radius of bend curvature to tunnel diameter $(\frac{\rho}{D})$, and to the angle of intersector

V : Average velocity $(\frac{Q}{A}\ m/sec)$

Q : Discharge (m^3)

A : Cross sectional area of tunnel ($=6.158\ m^2$)

Inter-section Point	Inter-sector Angle	ρ	D	fb_1	fb_2	h_{3-2}
1	23°43'	25.00	2.80-2.30	0.075	0.40	$58.69 \times 10^6 \times Q^2$
2	7°50'	25.00	2.30	0.075	0.11	$24.38 \times 10^6 \times Q^2$
3	10°37'	25.00	2.30	0.075	0.21	$46.55 \times 10^6 \times Q^2$
4	22°50'	25.00	2.30	0.075	0.42	$93.09 \times 10^6 \times Q^2$
5	12°31'	25.00	2.30-2.20	0.075	0.22	$53.25 \times 10^6 \times Q^2$
6	7°08'	25.00	2.20	0.075	0.11	$29.13 \times 10^6 \times Q^2$
7	9°46'	25.00	2.20	0.075	0.20	$52.97 \times 10^6 \times Q^2$
8	42°28'	25.00	2.20	0.075	0.66	$174.80 \times 10^6 \times Q^2$
9	8°42'	25.00	2.20	0.075	0.15	$39.73 \times 10^6 \times Q^2$
10	7°08'	20.00	2.20	0.075	0.11	$29.13 \times 10^6 \times Q^2$
11	12°06'	20.00	2.20	0.075	0.22	$58.27 \times 10^6 \times Q^2$
12	24°34'	20.00	2.20	0.075	0.45	$119.19 \times 10^6 \times Q^2$
13	44°34'	20.00	2.20-2.10	0.075	0.68	$197.36 \times 10^6 \times Q^2$
14	15°09'	20.00	2.10	0.075	0.27	$86.10 \times 10^6 \times Q^2$
15	14°03'	20.00	2.10	0.075	0.24	$76.54 \times 10^6 \times Q^2$
16	43°32'	15.00	2.10	0.075	0.67	$214.66 \times 10^6 \times Q^2$
17	35°00'	15.00	1.00	0.075	0.58	$3{,}601.59 \times 10^6 \times (\frac{Q}{2})^2$ ($900.40 \times 10^6 \times Q^2$)
Total (h_{3-2})						$2{,}253.24 \times 10^6 \times Q^2$)

c)-3 Branch Loss

$$h_{2-3} = fb \cdot \frac{V^2}{2g}$$

where,

h_{3-3} : Branch loss (m)

fb : Coefficient of branch loss (=0.25)

V : Velocity of before entrance $(=\frac{Q}{A})$

Q : Discharge (m^3/sec)

A : Cross sectional area of penstock (=3.464 m^2)

$$h_{3-3} = 0.25 \times \frac{1}{2g} \times (\frac{Q}{3.464})^2$$
$$= 1,069.99 \times 10^{-6} \times Q^2$$

c)-4 Butterfly valve Loss

$$h_{3-4} = fv \cdot \frac{V^2}{2g}$$

where,

h_{3-4} : Butterfly valve loss (m)

fv : Valve loss coefficient $(=\frac{t}{D})$

V : Velocity of before entrance $(=\frac{Q}{A})$

t : Thickness of valve disc (≒0.80 m)

D : Penstock inner diameter (=2.80 m)

$$h_{3-4} = \frac{0.80}{2.80} \times \frac{1}{2g} \times (\frac{Q}{6.158})^2$$
$$= 384.37 \times 10^{-6} \times Q^2$$

c)-5 Total of Penstock loss

$$h_3 = h_{3-2} + h_{3-2} = h_{3-3} + h_{3-4}$$
$$= (58,881.30 + 2,253.24 + 1,062.99 + 384.37) \times 10^{-6} \times Q^2$$
$$= 62,581.90 \times 10^{-6} \times Q^2$$

d) Total of Head Loss

Location		Coefficient of Head Loss ($x10^{-6}xQ^2$)	Head Loss Q = 18.00 m^3/sec (m)
Intake	Trashrack	11.59	0.038
	Entrance	269.09	0.087
	Others	182.28	0.025
	Sub-Total	462.96	0.150
Headrace Tunnel	Friction	62,370.90	20.209
	Bend	238.14	0.077
	Others	2,205.77	0.715
	Sub-Total	2,205.77	0.715
Penstock	Friction	58,88.30	19.078
	Bend	2,253.24	0.730
	Branch	1,062.99	0.344
	Valve	384.37	0.125
	Others	2,617.28	0.848
	Sub-Total	65,581.90	21.125
	Total		42.275
	Allowance		2.225
	Ground Total		44.500

(ii) Calculation of Effective Head

Standard intake water level 1,179.70 m
Turbine Center Level 304.50 m

Gross Head H = 1,178.70 - 304.50 = 875.20 m
Head Loss h = 44.50 m

Effective Head He = H - h
= 875.20 - 44.50
= 830.70 m

A-7-2 Structural Calculation

(1) Stability Analysis of Dam

(i) General

Stability analysis of the Pirris dam was executed according to load partition method under flood and earthquake conditions. Design loads were considered to act onto the dambody under two stages of construction as shown below;

1st stage first impounding/before joint grouting

2nd stage final impounding/after joint grouting

(ii) Design Conditions

- Properties of dam

Elevation of crest	EL. 1197.50 m
Height	120.00 mm
Crest length	225.00 m
Arch angle	64°27'30"
Slope (Downstream slope)	1 : 0.60
Unit weight of concrete	γc = 2.30 tf/m^3
Elastic modulus of concrete	Ec = 2.0 x 10^6 tf/m^2
Poisson's ratio of concrete	νc = 0.2

- Properties of foundation rock

Elastic modulus of rock	Er = 3.8 x 10^5 tf/m^2
Poisson's ratio of rock	νr = 0.2
Angle of internal friction	ϕ = 4.50°
Shear strength	τ = 250 tf/m^2

- Reservoir

Reservoir water level

First stage	EL.1184.00 m (Spillway crest)

Second stage	EL.1195.00 m (H.W.L)
Wave height (considered for second stage only)	
Flood condition	hw = 0.90 m
Earthquake condition	hw + hs = 1.70 m
Downstream water level	
Flood condition	EL. 1087.73 m
Earthquake condition	EL. 1081.00 m

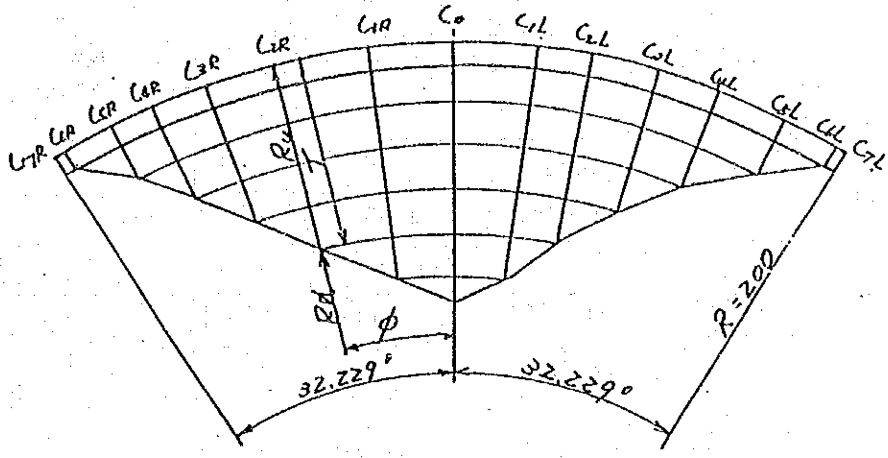
· Sediment

Sedimentation surface	EL. 1149.00 m
Unit weight	γs = 1.10 tf/m^3
Coefficient of sediment pressure	Cs = 0.50

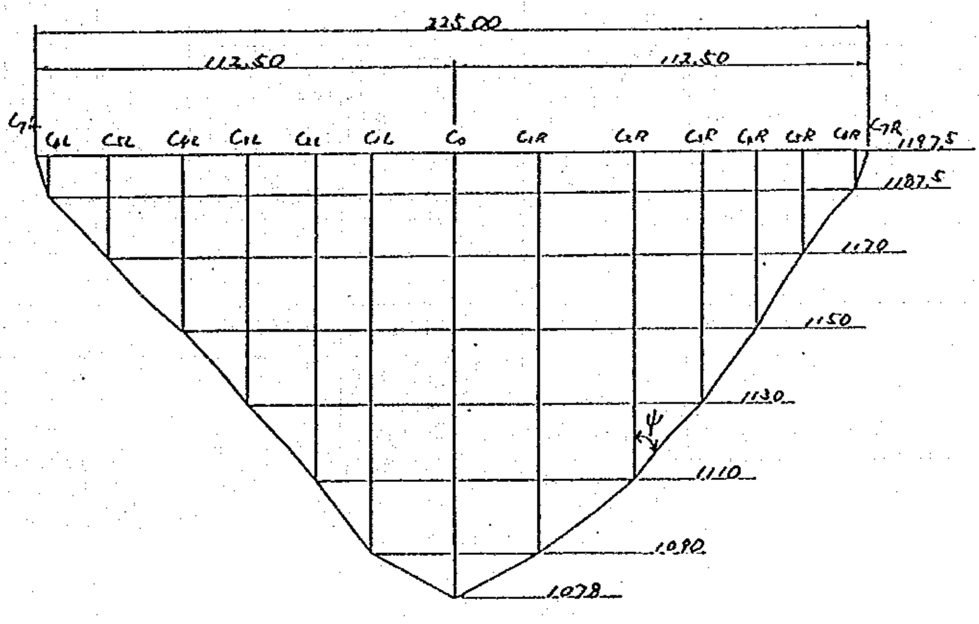
· Earthquake

Seismic coefficient	k = 0.15
Direction	Horizontal

Dimension of dam are shown in Fig. A-7-8 and Table A-7-1.



Plan



Elevation

Fig. A-7-8 Dam Configuration

Table A-7-1 Dimensions of Dam

Right Bank

EL (m)	Ru (m)	Rd (m)	Raxis (m)	T (m)	ø (deg)	ø (deg)
1,197.50	200.00	194.00	200.00	6.00	32.229	19.0
1,187.50	200.00	194.00	200.00	6.00	31.226	19.0
1,170.00	200.00	183.50	200.00	16.50	27.215	37.9
1,150.00	200.00	171.50	200.00	28.50	23.635	30.5
1,130.00	200.00	159.50	200.00	40.50	19.337	34.4
1,110.00	200.00	147.50	200.00	52.50	13.894	40.0
1,090.00	200.00	135.50	200.00	64.50	6.446	48.0
1,078.00	200.00	128.30	200.00	71.70	0.000	57.3

Left Bank

EL (m)	Ru (m)	Rd (m)	Raxis (m)	T (m)	ø (deg)	ø (deg)
1,197.50	200.00	194.00	200.00	6.00	32.229	19.0
1,187.50	200.00	194.00	200.00	6.00	31.226	19.0
1,170.00	200.00	183.50	200.00	16.50	26.643	41.6
1,150.00	200.00	171.50	200.00	28.50	20.913	43.3
1,130.00	200.00	159.50	200.00	40.50	16.043	37.8
1,110.00	200.00	147.50	200.00	52.50	10.743	39.3
1,090.00	200.00	135.50	200.00	64.50	6.446	32.6
1,078.00	200.00	128.30	200.00	71.70	0.000	57.3

iii) Calculation Cases

The analysis is to be mode under conditions shown in Table-2.

Table A-7-2 Calculation Cases

Construction Stage	*1st Stage*	*2nd Stage*	
Normal/Earthquake	Normal	Normal	Earthquake
Reservoir Water Level	EL. 1184	EL. 1195	
Dead load	o		
Seismic load			o
Hydrostatic pressure	o	o (differential)	o (differential)
Hydrodynamic pressure			o
Uplift	o	o (differential)	o (differential)
Sediment pressure		o	o
Decrement of temperature		o	o
Section Forces	N_1, Q_1, M_1	N_2, Q_2, M_2	N_2', Q_2', M_2'
Stresses	σ_{e1}, σ_{t1}, τ_1	σ_{e2}, σ_{t2}, τ_2	σ_{e2}', σ_{t2}', τ_2'
Cumulative Section Forces	N_1 Q_1 M_1	$N_1 + N_2$ $Q_1 + Q_2$ $M_1 + M_2$	$N_1 + N_2'$ $Q_1 + Q_2'$ $M_1 + M_2'$
Cumulative Stresses	σ_{e1} σ_{t1} τ_1	$\sigma_{e1} + \sigma_{e2}$ $\sigma_{t1} + \sigma_{t2}$ $\tau_1 + \tau_2$	$\sigma_{e1} + \sigma_e'{}_2$ $\sigma_{t1} + \sigma_t'{}_2$ $\tau_1 + \tau_2'$
Design Loads Beared by	Vertical section (cantilever beam element) only	Both the vertical section (cantilever beam element) and horizontal section (arch element)	

iv) Design Loads

· Dead Load (W)

$$W = \gamma c \cdot A$$

where,

W : dead load (tf/m)

γc: unit weight of concrete (=2.30 tf/m^3)

A : cross-sectional area (m^2)

· Hydrostatic Pressure (Pw)

$Pw = \gamma w \cdot h$

where,

Pw: hydrostatic pressure (tf/m^2)
γw: unit weight of water (=1.00 ft/m^3)
h : water depth from reservoir surface adding wave height (m)

· Sediment Pressure (Ps)

$Ps = Cs \cdot \gamma s \cdot hs$

where,

Ps: sediment pressure (tf/m^2)
Cs: coefficient of sediment pressure (=0.5)
γs: unit weight of sediment (=1.10 ft/m^3)
hs: depth from sediment at an optional point (m)

· Hydrodynamic Pressure (Pd)

$Pd = 7/8 \cdot \gamma w \cdot k \cdot \sqrt{H \cdot h} \cdot \cos \phi$ ..... Westergaard's formula

where,

Pd: hydrodynamic pressure (tf/m^2)
γw: unit weight of water (=1.00 ft/m^3)
k : seismic coefficient (=0.15)
H : water depth from H.W.L. to foundation rock surface (=1195.00-1078.00=117.00m)
h : water depth from H.W.L.to objective point (m)

· Seismic Pressure (Pe)

$$Pe = k \cdot \gamma c \cdot t \cdot r'/r \cdot \cos \phi$$

where,

- Pe: seismic pressure (tf/m^2)
- k : seismic coefficient (=0.15)
- γc: unit weight of concrete (=2.30 ft/m^3)
- t : thickness of dam in radial direction (m)
- r : radius of arch (=220 m)
- r': radius of arch in the center of horizontal section (=r-t/2)
- h : water depth from reservoir surface adding wave height (m)

· Uplift (U)

The uplift pressure is to be act on the dam base to vary linearly as shown in Fig. A-7-9.

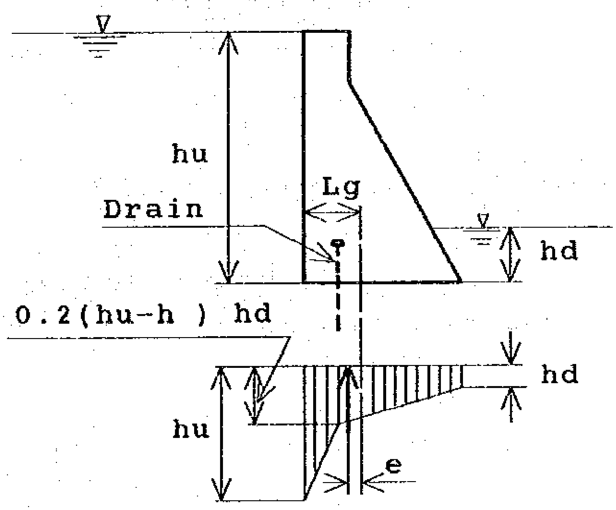


Fig. A-7-9 Diagram of Uplift Pressure

where,

U : uplift (tf/m)

hu: upstream water depth (m)

hd: downstream water depth (m)

γw: unit weight of water (=1.00 tf/m^3)

lg: distance between upstream face to centroid of base (m)

e : eccentricity between working point of uplift and the centroid of base (m)

· Stress due to decrement of temperature

The decrement of temperature due to changing climate is calculated as following formula;

$$\Delta T = \frac{60}{(t+2.5)} - t'$$

where,

ΔT: decrement of temperature (°C)

t : thickness of dam in radial direction (m)

t': preliminary decrement due to sub-cooling (°C)

· Results of calculation of each loads

The loads act on the horizontal and vertical sections under normal and earthquake conditions are shown in Table-3 ~ -6.

Table A-7-3 Horizontal Loads of Normal Condition

EL (m)	Horizontal Loads (t/m^3)			ΔT (°C)
	Pw	Ps	Total	
1197.50	-	-	0.000	2.1
1187.50	8.400	-	8.400	2.1
1170.00	25.900	-	25.900	0.2
1150.00	45.900	-	45.900	-0.1
1130.00	65.900	4.400	70.300	0.4
1110.00	85.900	13.200	99.100	0.1
1090.00	105.900	22.000	127.900	-0.1
1078.00	117.900	27.280	145.180	-0.2

Table A-7-4 Horizontal Loads of Earthquake Condition

EL (m)	Horizontal Loads (t/m^3)					ΔT (°C)
	Pw	Ps	Pe	Pd	Total	
1197.50	-	-	-	-	0.000	2.1
1187.50	9.200	-	2.070	3.888	15.158	2.1
1170.00	26.700	-	5.693	7.098	39.491	0.2
1150.00	46.700	-	9.833	9.524	66.057	-0.1
1130.00	66.700	4.400	13.973	11.446	96.519	0.4
1110.00	86.700	13.200	18.113	13.087	131.100	0.1
1090.00	106.700	22.000	22.253	14.547	165.500	-0.1
1078.00	118.700	27.280	24.737	15.356	186.073	-0.2

Table A-7-5 Uplift Pressure

	C6L	C5L	C4L	C3L	C2L	C1L	Co'
Pv (t)	-15.683	-139.600	-303.120	-512.720	-768.400	-1070.160	-1739.886
e (m)	1.420	3.905	7.360	10.169	12.505	14.455	10.372
Mv (t·m)	-22.27	-545.14	-2230.96	-5213.85	-9608.84	-15469.16	-18046.10
	C1R	C2R	C3R	C4R	C5R	C6R	Co'
Pv (t)	-1070.160	-768.400	-512.720	-303.120	-139.600	-15.683	-1417.228
e (m)	14.455	12.505	10.169	7.360	3.905	1.420	13.532
Mv (t·m)	-15469.16	-9608.84	-5213.85	-2230.96	-545.14	-22.27	-19177.93

* Co' : Earthquake condition

Table A-7-6 Stress due to Decrement of Temperature

EL (m)	t (m)	ΔT' (°C)*	t' (°C)	ΔT (°C)
1197.50	6.00	7.1	5.0	2.1
1187.50	6.00	7.1	5.0	2.1
1170.00	16.50	3.2	3.0	0.2
1150.00	28.50	1.9	2.0	-0.1
1130.0	40.50	1.4	1.0	0.4
1110.0	52.50	1.1	1.0	0.1
1090.00	64.50	0.9	1.0	-0.1
1078.00	71.70	0.8	1.0	-0.2

* ΔT' = 60/(t+2.5)

v) Stability Conditions

· Allowable stress of concrete

Condition	Normal	Earthquake
Allowable compressive stress	80	110
Allowable tensile stress	10	11

(Note) Unit (kgf/cm^2)

· Safety factor against sliding

$$Fs = (f \cdot N + \tau \cdot t)/Q \geq 4$$

where,

Fs: safety factor against sliding
f : coefficient of internal friction (=1.0)
N : axial force (tf/m)
τ : shearing strength (=250 tf/m^2)
t : thickness of section (m)
Q : shearing force (tf/m)

vi) Results

At 1st stage, safety factor against sliding and maximum values of stresses are shown in Table A-7-7.

At final stage, safety factor against sliding is shown in Table A-7-8.

It exceeds 4 in any portion and case. Distribution and maximum values of stresses are shown in Fig. A-7-1- ~ A-7-13 and Table A-7-9 respectively.

Table A-7-7 Results of 1st Stage

Elevation (m)	t (m)	N (tf/m)	Q (tf/m)	Fs	Stress (kgf/m^2)	
					σu	σd
1187.50	6.00	138	0	-	2.3	2.3
1170.00	16.50	535	98	47.5	4.7	1.8
1150.00	28.50	1490	578	14.9	4.7	5.8
1130.00	40.50	2997	1458	9.0	4.2	10.6
1110.00	52.50	5056	2738	6.6	3.5	15.8
1090.00	64.50	7667	4418	5.4	2.7	21.1
1078.00	71.70	9498	5618	4.9	2.2	24.3

Table A-7-8 Safety Factor against Sliding at Final Stage

Cantilever Beam Elements

Elevation (m)	t (m)	Left Bank			Right Bank		
		N (tf/m)	Q (tf/m)	Fs	N (tf/m)	Q (tf/m)	Fs
1187.50	6.00	122	12	131.6	122	14	118.4
		122	21	76.7	122	25	64.8
1170.00	16.50	450	231	19.8	450	214	21.4
		450	302	15.1	450	279	16.4
1150.00	28.50	1322	731	11.6	1322	643	13.1
		1322	886	9.5	1322	702	12.0
1130.00	40.50	2700	1516	8.5	2700	1527	8.4
		2700	1670	7.7	2700	1679	7.6
1110.00	52.50	4585	2912	6.1	4585	2969	6.0
		4585	3273	5.4	4585	3370	5.3
1090.00	64.50	6977	4818	4.8	6977	4849	4.8
		6977	5443	4.2	6977	5462	4.2
1078.00	71.70	8174	6048	4.3			
		8497	6586	4.0			

Horizontal Arch Elements

Elevation (m)	t (m)	Left Bank			Right Bank		
		N (tf/m)	Q (tf/m)	Fs	N (tf/m)	Q (tf/m)	Fs
1197.50	6.00	347	3	583.7	348	3	540.0
		868	20	117.3	868	22	109.7
1187.50	6.00	294	46	38.8	295	48	37.6
		774	44	52.0	775	48	47.0
1170.00	16.50	897	300	16.7	899	346	14.5
		1889	471	12.8	1893	589	10.2
1150.00	28.50	943	776	10.4	938	643	12.5
		1985	1596	5.7	1974	1322	6.9
1130.00	40.50	666	1023	10.5	664	972	11.1
		1523	2229	5.2	1519	2109	5.5
1110.00	52.50	493	1130	12.1	493	1137	12.0
		1086	2482	5.7	1087	2498	5.7
1090.00	64.50	217	843	19.4	219	1059	15.4
		462	1852	9.0	464	2337	7.1

Note: ( ) ... Under earthquake condition

Table A-7-9 Maximum Stresses

	Stress (kgf/m^2)	Remark
Compressive	26.0	Cantilever beam element, EL.1078.00
Stress	30.8	(ditto)
Tensile	-6.4	Horizontal arch element, EL.1130.00
Stress	-13.6	(ditto)

Note: ( ) ... Under earthquake condition

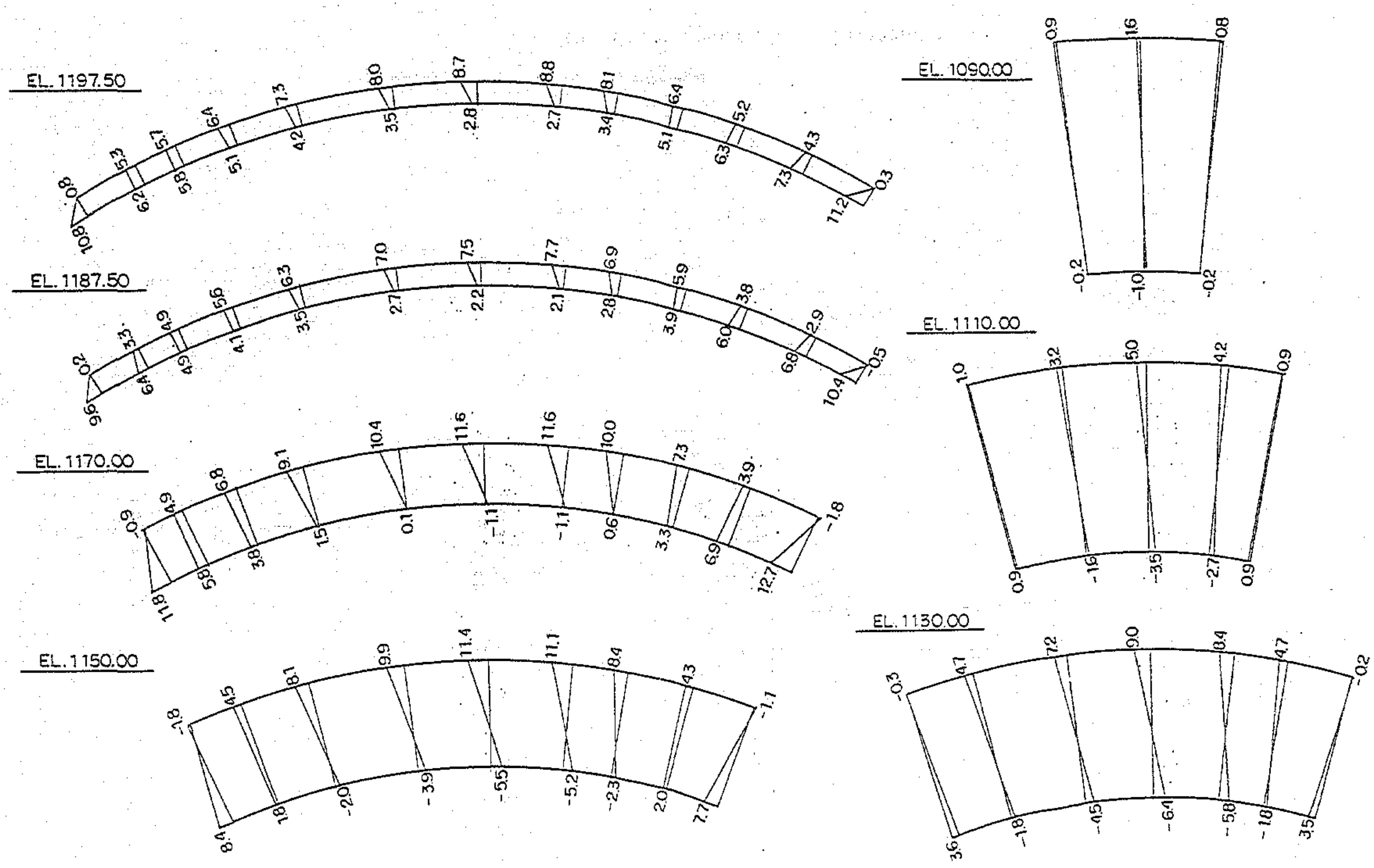


Fig. A-7-10 Distribution of Stress
(Horizontal Arch Element, Normal Condition)

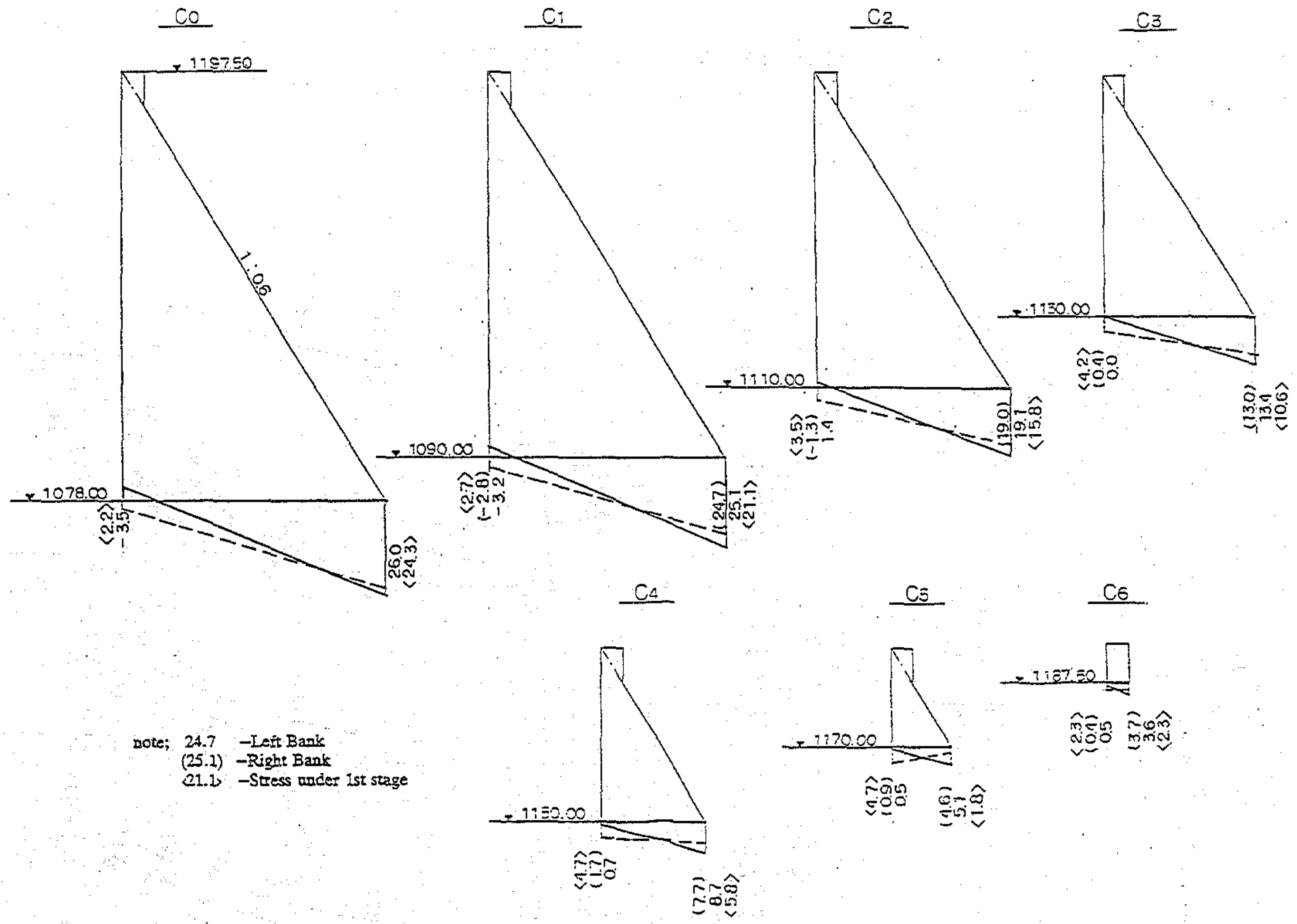


Fig. A-7-11 **Distribution of Stress**
(Cantilever Beam Element, Normal Condition)

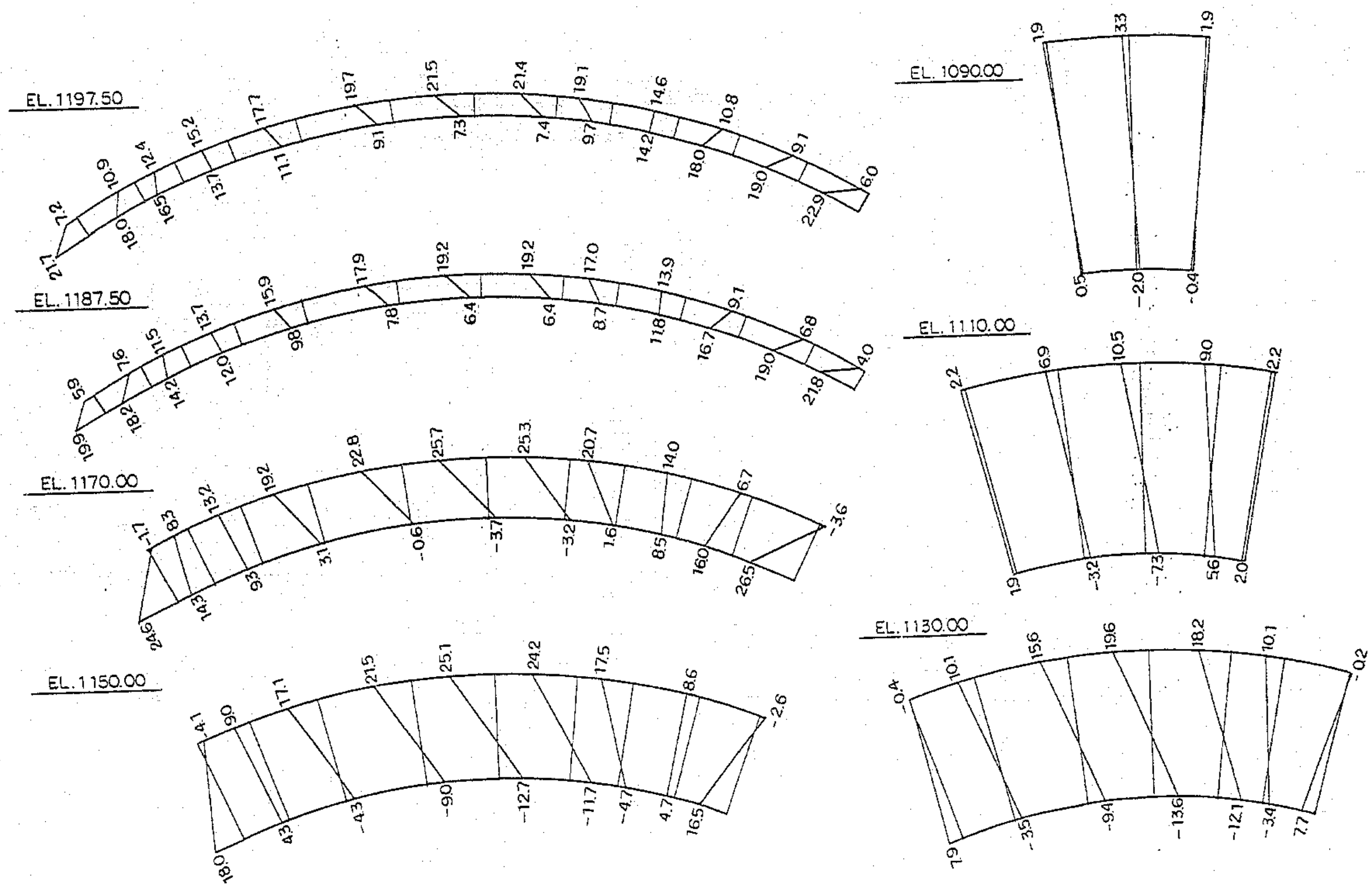


Fig. A-7-12 **Distribution of Stress**

(Horizontal Arch Element, Earthquake Condition)

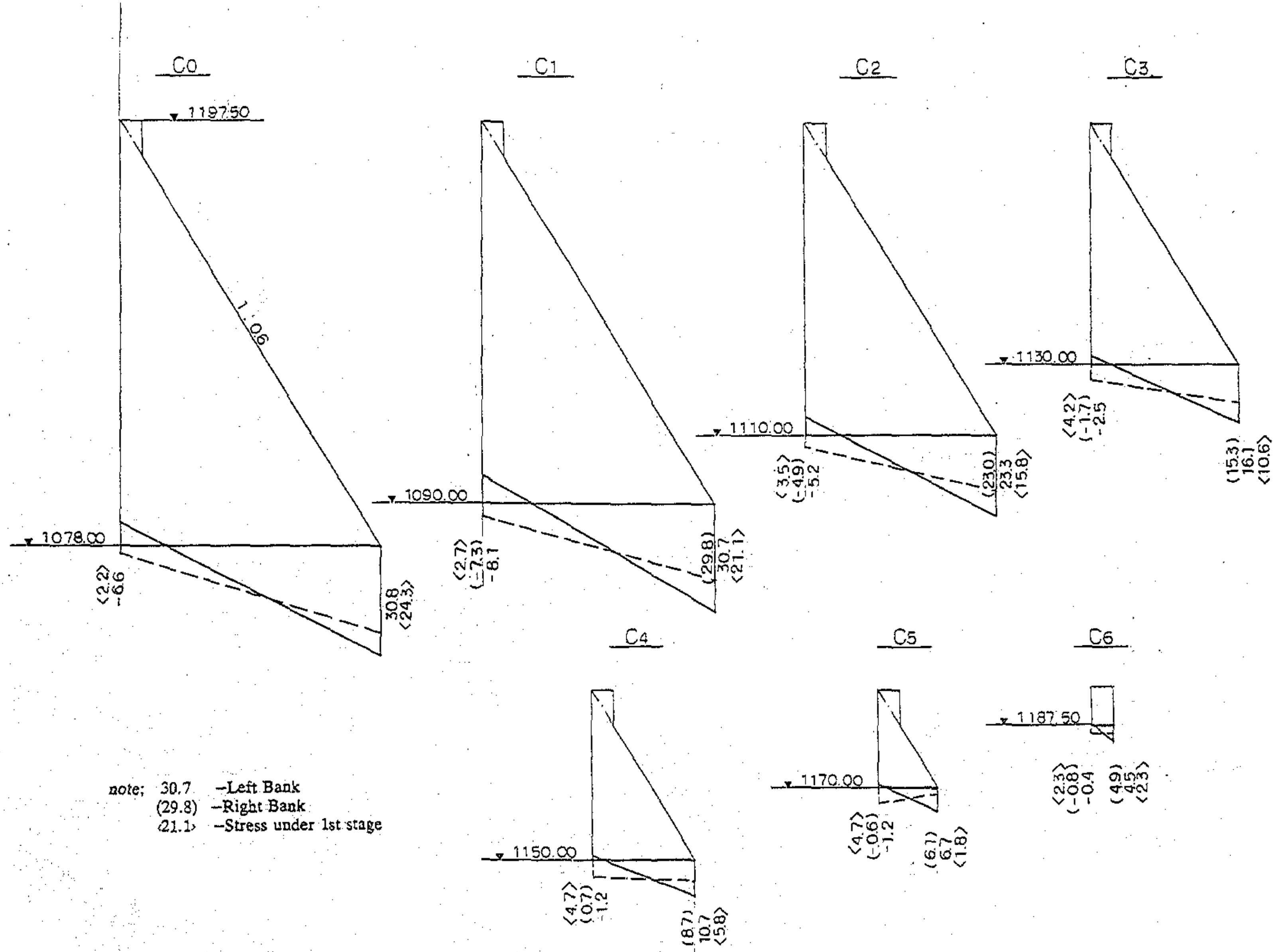


Fig. A-7-13 **Distribution of Stress**
(Cantilever Beam Element, Earthquake Condition)

(2) Calculation of Penstock Steel Liner Thickness

(i) Design Conditions

a) Hydraulic Pressure

The hydraulic water pressure is to be consisted of hydrostatic pressure, surging and pressure rise due to water hammer.

The values of the each pressures are as below;

Maximum hydrostatic pressure (Ho)

Ho = 2,296.00 m of H.W.L - 304.50 m of turbine center
= 890.50 m

Surging (Hs) = 12.50 m
refer to Appendix A-7-1 (5)

Water hammer pressure (Hp)

Hp = Max. hydrostatic pressure x 10%
= 89.05 m

The hydraulic pressure on the each points are assumed below sketch.

b) External Pressure

The external pressure is considered 4.0 kg/cm^2 due to seepage water pressure from around rock.

c) Material

In this calculation, the material for the penstock steel liner is to be applied SM58Q standarded by JIS. The allowable tensile strength of SM58Q is 2,400 kg/cm^2.

(ii) Calculation of Penstock Steel Liner Thickness

The thickness can be calculated as following formula;

Embedded steel liner

$$\sigma=\frac{PD(1-\lambda)}{2(t-\epsilon)\delta},\quad t=\frac{PD(1-\lambda)}{2\,a\cdot\delta}+\epsilon$$

Exposed steel liner

$$\sigma=\frac{PD}{2(t-\epsilon)\delta},\quad t=\frac{PD}{2\,a\cdot\delta}+\epsilon$$

where,

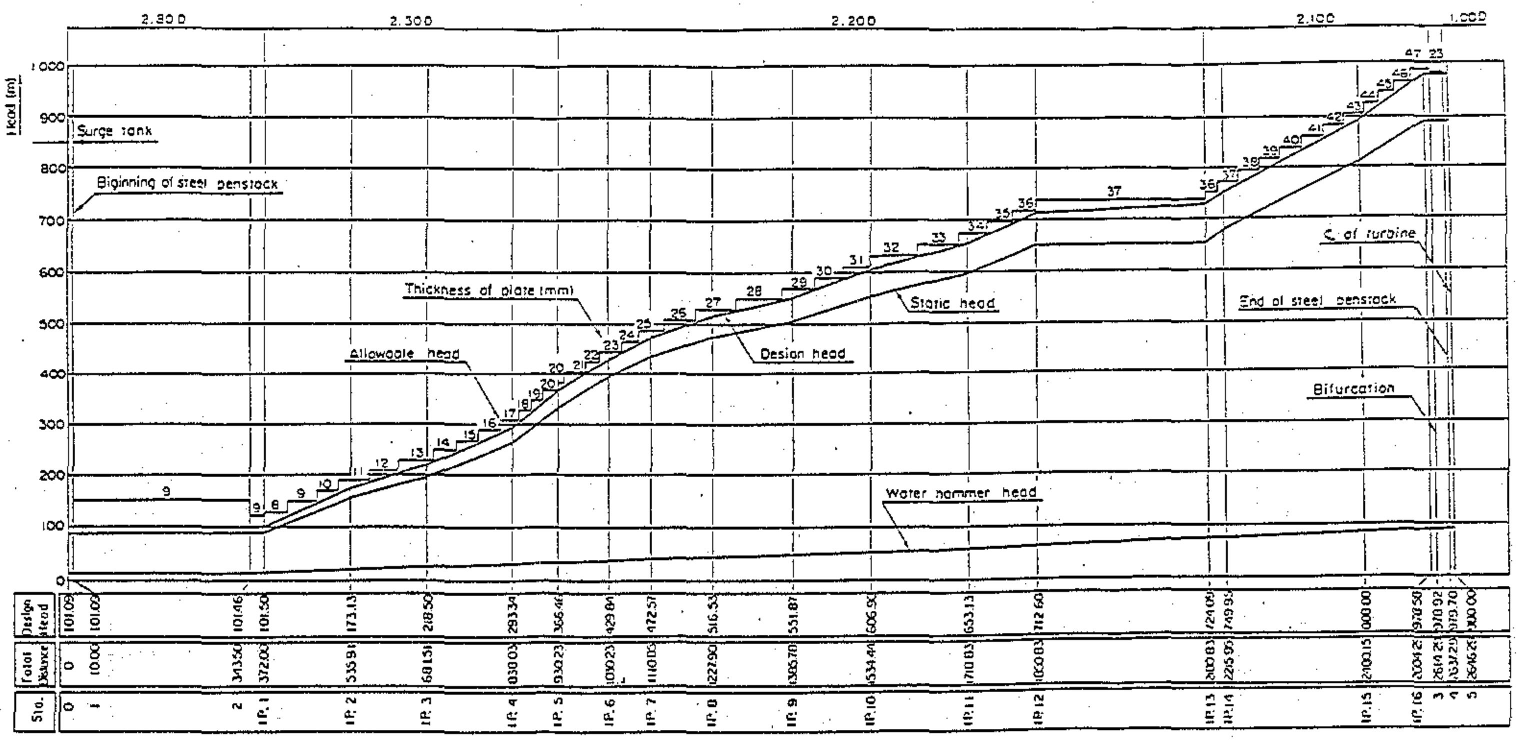
- σ : Circumferential stress (kg/cm^2)
- P : Hydraulic water pressure (kg/cm^2)
- D : Inner diameter (m)
- λ : Ratio of sharing of internal pressure by surrounding rock (20%)
- t : Thickness of steel liner (cm)
- $\in$: Allowance for corrosion and abrasion (=0.15 cm)
- δ : Efficiency of longitudinal joint (=0.95)
- σa: Allowable stress (SM58Q, a = 2,400 kg/cm^2)

The minimum thickness can be estimated as below formula;

$$t = \frac{D+800}{400} \quad \text{(m)}$$

(iii) Results of Calculation

The results of calculation such as design hydraulic water pressure and thickness of pipe at each points are as shown in Fig. A-7-14.



Specification

Maximum discharge	18 m^3/sec
Maximum static head	890.50 m
Water hammer (at turbine)	89.50 m
Closing time	30 sec
Material	
Allowable tensile stress	2 400 kg/cm^2
Welding efficiency	95 %
Corrosion allowance	1.5mm

Fig. A-7-14 Penstock Steel Liner Design Diagram

APPENDIX A-8 ENVIRONMENT

APPENDIX A-8 ENVIRONMENT

Contents

Environmental Water Quality Standards (Dec. 28, 1971, Amendments 1974, 1975, 1982, 1985)

(1) Standards relating to Human Health

Item	Standard values[1]
Cadmium	0.01 mg/ℓ or less
Cyanide	Not detectable
Organic phosphorus[2]	Not detectable
Lead	0.1 mg/ℓ or less
Chromium (hexavalent)	0.05 mg/ℓ or less
Arsenic	0.05 mg/ℓ or less
Total mercury	0.0005 mg/ℓ or less
Alkyl mercury	Not detectable
PCB	Not detectable

Notes : 1. Maximum values. But with regard to total mercury, standard value is based on the yearly average value.
2. Organic phosphorus includes parathion, methyl parathion, methyl demeton and E. P. N.
3. Standard value of total mercury shall be 0.001 mg/ℓ in case river water pollution is known to be caused by natural conditions.

(2) Standards relating to Living Environment

a. Rivers

Category	Item / Purpose of water use	Standard values[1]				
		pH	Biochemical oxygen demand (BOD)	Suspended solids (SS)	Dissolved oxygen (DO)	Number of coliform groups
AA	Water supply, class 1 ; conservation of natural environment, and uses listed in A—E	6.5—8.5	1 mg/ℓ or less	25 mg/ℓ or less	7.5 mg/ℓ or more	50 MPN/100mℓ or less
A	Water supply, class 2 ; fishery, class 1 ; bathing and uses listed in B—E	6.5—8.5	2 mg/ℓ or less	25 mg/ℓ or less	7.5 mg/ℓ or more	1,000 MPN/100mℓ or less
B	Water supply, class 3 ; fishery, class 2, and uses listed in C—E	6.5—8.5	3 mg/ℓ or less	25 mg/ℓ or less	5 mg/ℓ or more	5,000 MPN/100mℓ or less
C	Fishery, class 3 ; industrial water, class 1, and uses listed in D—E	6.5—8.5	5 mg/ℓ or less	50 mg/ℓ or less	5 mg/ℓ or more	—
D	Industrial water, class 2 ; agricultural water[2], and uses listed in E	6.0—8.5	8 mg/ℓ or less	100 mg/ℓ or less	2 mg/ℓ or more	—
E	Industrial water, class 3 ; conservation of environment	6.0—8.5	10 mg/ℓ or less	Floating matter such as garbage scould not be observed	2 mg/ℓ or more	—

Notes : 1. The standard value is based on the daily average value. The same applies to the standard values of lakes and coastal waters.
2. At the intake for agriculture, pH shall be between 6.0 and 7.5 and dissolved oxygen shall not be less than 5 mg/ℓ The same applies to the standard values of lakes.
3. Conservation of natural environment : Conservation of scenic spots and other natural resources.
4. Water supply, class 1—Water treated by simple cleaning operation, such as filtration.
Water supply, class 2—Water treated by normal cleaning operation such as sedimentation and filtration.
Water supply, class 3—Water treated through a highly sophisticated cleaning operation including pretreatment.
5. Fishery, class 1— For aquatic life such as trout and bull trout inhabiting oligosaprobic water, and those of fishery class 2 and class 3.
Fishery, class 2— For aquatic life, such as the salmon family and sweetfish inhabiting oligosaprobic water and those of fishery class 3.
Fishery, class 3— For aquatic life such as carp and crucian carp inhabiting β-mesosaprobic water.
6. Industrial water, class 1—Water given normal cleaning treatment such as sedimentation.
Industrial water, class 2—Water given sophisticated treatment by chemicals.
Industrial water, class 3—Water given special cleaning treatment.
7. Conservation of environment—Up to the linits at which no unpleasantness is caused ot people in their daily life including a walk by the riverside, etc.

b. Lakes (natural lakes, and artificial reservoirs with 10 million cubic meters of water or above)

Category	Purpose of water use \ Item	Standard values				
		pH	Chemical oxygen demand (COD)	Suspended[1] solids (SS)	Dissolved oxygen (DO)	Number of coliform groups
AA	water supply, class 1 ; fishery, class 1 ; conservation of natural environment, and uses listed in A—C	6.5—8.5	1 mg/ℓ or less	1 mg/ℓ or less	7.5 mg/ℓ or more	50 MPN/100 mℓ or less
A	Water supply, classes 2 and 3 ; fishery, class 2 ; bathing and uses listed in B—C	6.5—8.5	3 mg/ℓ or less	5 mg/ℓ or less	7.5 mg/ℓ or more	1,000 MPN/100 mℓ or less
B	Fishery, class 3 ; industrial water, class 1 ; agricultural water, and uses listed in C	6.5—8.5	5 mg/ℓ or less	15 mg/ℓ or less	5 mg/ℓ or more	—
C	Industrial water, class 2 ; conservation of environment	6.0—8.5	8 mg/ℓ or less	Floating matter such as garbage shall not be observed	2 mg/ℓ or more	—

Notes : 1. With regard to fishery, classes 1, 2 and 3, the standard value for suspended solids shall not be applied for the time being.
2. See notes for rivers.
3. Fishery class 1— For aquatic lives such as salmon inhabiting oligotrophic lake type waters, and for those of fishery class 2 and 3.
Fishery class 2— For aquatic lives such as fish of the salmon group and sweet fish inhabiting oligotrophic lake type waters, and for those of fishery class 3.
Fishery class 3— For those aquatic lives such as carp and silver carp inhabiting eutrophic lake type waters.
4. Industrial water class 1— Water given normal treatment such as sedimentation.
Industial water class 2— Water given sophisticated treatment such as chemical injection or special treatment.
5. Conservation of environment— Up to the limits at which no unpleasantness is caused to the people in their daily lives including a walk along the shore.

c. Nitrogen and phosphorus in lakes and reservoirs

Category	Purpose of water use \ Item	Standard velues	
		Total nitrogen[2]	Total phosphorus[3]
I	Conservation of natural environment, and uses listed in II—V	0.1 mg/ℓ or less	0.005 mg/ℓ or less
II	Water supply classes-1, 2 and 3 (excluding special types)? fishery class 1, bathing ; and uses listed inIII—V	0.2 mg/ℓ or less	0.01 mg/ℓ or less
III	Water supply class 3 (special types), and uses listed in IV—V	0.4 mg/ℓ or less	0.03 mg/ℓ or less
IV	Fishery class 2, and uses listed in V	0.6 mg/ℓ or less	0.05 mg/ℓ or less
V	Fishery class 3? industrial water ; agricultula water ; conservation of the living environment	1 mg/ℓ or less	0.1 mg/ℓ or less

Note : 1. Standard values are set in terms of annual averages.
2. Standard values for total nitrogen are applicable to lakes and reservoirs where nitrogen is a causal factor of the growth of phytoplankton.
3. Standard values for total phosphorus are not applicable to agricultural water uses.
4. Conservation of natural environment—Conservation of scenic points and other natural resources.
5. Water supply class 1—Water treatment by simple cleaning operation such as filtration.
Water supply class 2— Water treatment by normal cleaning operation such as sedimentation and filtration.
Water supply class 3— Water treatment by sophisticated cleaning operation including pretreatment. ("special types" mean water treatments by special cleaning operation in which removal of smelling substances is possible.)
6. Fishery class 1—For aquatic lives such as fish of the salmon group and sweet fish, and for those of fishery class 2 and 3.
Fishery class 2—For aquatic lives such as smelt and for those of fishery class 3.
Fishery class 3— For aquatic lives such as carp and silver carp.
7. Conservation of environment—Up to the limits at which no unpleasantness is caused to the people in their daily lives including a walk along the shore.

Table of References

①	Feasibility Study on Pirris Hydroelectric Power Development Project The First Progress Report JICA, 1990
②	Análisis de la cuenca del Río Pirrís Ajun Hazel et el, Universidad de Costa Rica 1981
③	Plan de manejo de la cuenca del Río Parrita Ministerio de Agricultura y Ganadería Dirección General Forestal Conservación de Recursos Naturales 1985.5
④	Imforme de la primera visita al campo, Recopilación de datos ambientales Oficina de estudios especiales P.H.Pirrís, ICE 1990.2
⑤	Proyecto hidroeléctorico Pirrís, banco de datos ambientales Dirección de planificación eléctrica, Oficina de estudios especiales, ICE 1990.3
⑦	Costa Rica, Country Environmental Profile, A Field Study United States Agency for International Development, Tropical Science Center, 1982.12
⑧	Imforme no.2 Gira de reconomiento al sitio propuesto para casa máquinas Dirección planificación eléctrica, Oficina estudios especiales, ICE 1990.4
⑨	地球破壊７つの現場から　石 弘之　朝日選書　1990.7
⑩	Banco de datos del P.H.Pirrís Evaluación ambiental ICE 1990
⑪	Evaluación de la capacidad instalada de las plantas de beneficio Instituto del Café de Costa Rica *Centro de las plantas de beneficio, 1988.8*
⑫	Ley de adquisición expropiaciones y constitución de servisdumble del Costarricense de Electricidad
⑬	Manual de códigos utilizados en la información sobre valores de predios Ministerio de Hasienda, 1989.6
⑭	Programa de la contaminación de agua Ministerio de Salud División de Saneamiento Ambiental
⑮	Tables de los datos bacteriológicos y físico-químicos de las aguas del Río Pirrís Instituto del Costarricense de Acueductos y Alcantarillados

APPENDIX A-9 LIST OF REFERENCE DATA FURNISHED BY ICE

A-9 List of Reference Data Furnished by ICE (1/4)

Field	Title	Description	Publishing Office
Hydrology / Meteorology	Daily / monthly discharge data	Gauging Stations No.2601, No.2602 No.2603, No.2604	ICE
	Hourly water level data for Hurricanes	Gauging Stations No.2601, No.2602 No.2603, No.2604	ICE
	G.S. basic data Q ~ H curve Cross section of river	Gauging Stations No.2601, No.2603 No.2601 ~ No.2604	ICE
	Daily / monthly precipitation record	Precipitation Stations No.073027 and other 10 places	ICE
	Daily / monthly precipitation data	Precipitation Stations No.088003 and other 6 places	IMN
	Daily / monthly precipitation data	No.084001 and other 30 places	
	Hourly precipitation data	No.073027 and other 18 places	
	Monthly average temperature data	Meteorological Station No.088015	ICE
	Daily / monthly temperature data	Meteorological Stations No.088001 and No.088018	IMN
	Monthly evaporation data	Meteorological Station No.088015	ICE
	Monthly average humidity data	M.S. No.088015	ICE
	Daily wind speed/ direction data	*Damas M.S.*	*IMN*

Field	Title	Description	Publishing Office
Hydrology/ Meteorology	Water Quality Measurement Report (Boletin de Calidad Fisicoquimica del Agua No.2 1987 Nov.)		ICE
	Design flood discharge reference data (Comparacion de la Avenida Maxima Probable con Otras Avenidas Maximas Registradas y Calculadas en Costa Rica)		ICE
	Sedimentation Measurement Report (Boletin de Sedimento en Suspencion No.2 1988 Oct.)		ICE
	Documents on Hurricane	Joan Hurricane	ICE
	Isohyetal Precipitation Map (Isoyetas Medias Anuales en la Cuenca del Rio Pirris Periodo de 1963 ~ 1981)		ICE
	Location Map of G.S., P.S. and M.S.	Cuencas No.26 Rio Parrita No.27 Rio Damas y otros No.28 Rio Naranjo No.29 Rio Savegre No.30 Rio Baru y otros	ICE
	Location Map of G.S., P.S. and M.S.	Cuenca No.31 Rio Grande Terraba	ICE
	Meteorology Annual Report 1988		IMN
	Discharge Annual Report (Boletin Hidrologico No.17, 1988 May)		ICE

Field	Title	Description	Publishing Office
Hydrology/ Meteorology	Literature on Meteorology (Temporal and Spetial Rainfall Variability in the Mountainous Region of the Reventazon River Basin, 1984 June by R.E. Chacon, etc.)		ICE
	Literature on Meteorology (El Regimen de la Precipitacion en Costa Rica by Porfirio Machado)		ICE
	Literature on Meteorology (On the Rainfall Distribution with Altitude over Costa Rica by Walter Fernandez, etc.)		ICE
	Climate Atlas (Atlas Climaticas de Costa Rica, 1985)		ICE
Construction Cost Estimation	Costos unitarios para planeamiento de proyectos hidroelectricos vigentes a Diciembre, 1988		ICE
	Indicadores Financieros - Economicos Periodo 1979-1988		ICE
	Construction cost list, Dec. 1989	Answer to JICA survey team's questionnaire	ICE
	Embankment unit price for Sandillal rockfill dam		ICE
Design	Codigo sismico de Costa Rica 1986		Editorial Tecnologia de Costa Rica

Field	Title	Description	Publishing Office
Geology	Analisis Geologico-Geomortologico del Rio Pirris (Parrita) 1985		Instituto Tecnolgico de Costa Rica
	Carta Geologico y Geomorfologica preliminer Cuenca del Rio Parrita	1/50,000	ICE
	Aero-photo maps		Instituto Geografico de Costa Rica
	Informe Hidroelectrico Pirris 1984		ICE
	Informe Geotecnico preliminar No. 1, Sitio de Presa y Tuberia de Presion, Proyecto Hidroelectri-co Pirris 1980		ICE
Seismicity	P.H. Pirris Estudio sismologico preliminar, Nov. 1989		ICE
	Informe sismologico y analisis prelimenar de acelerogramas de la presa San Miguel, May 1989		ICE
Power Generation and Transmission	Programa annual de mantenimiento de Plantas del S.N.I. 1 - 1999		ICE
	Ubicacion geografica plantas S.N.I.		ICE
	Caracteristicas de transformadores de potencia		ICE
	Caracteristicas de lineas de transmision-230 kV		ICE

Field	Title	Description	Publishing Office
Power Generation and Transmission	Caracteristicas de generadores sistema nacional interconectado		ICE
	Sistema nacional interconectado, diagrama unifilar		ICE
	Sistema de transmision, año 1991		ICE
	Carga maxima invierno - 1986.8		ICE
	Carga maxima verano - 1986.8		ICE
	Plan de expansion del sistema de telecomunicaciones		ICE
	Transmission construction cost per km		ICE
	Population of Costa Rica - 1984		ICE
	Costo annual de operacion y mantenimiento de lineas de distribucion		ICE
	Resumen de mantenimiento de equipos e indices de ocupacion de personal - 1988		ICE
	Tipos de cambio del Colon con relacion del U.S. dolar, mercado interbancario - Precio de venta 1979 - 1988		ICE
	Costo por km de lineas de distribucion - 1989.9		ICE
	Costos de modulos de subestacion en miles de U.S. dolar		ICE

Field	Title	Description	Publishing Office
Power Generation and Transmission	Informe de planeamiento obras de transmision 1988 - 1992 Anexo		ICE
	Informe preliminar plan meastro de transmision		ICE
	Oficina de tarifas y mercado electrico informacion requerida para el proyecto		ICE
	Existing power generation facilities location map		ICE
	Maximum load at winter (rainy season) - 1991		ICE
	Maximum load at summer (dry season) - 1991		
Environment	Banco de datos ambientales, Marzo 1990		ICE
	Recopilacion de datos ambientales Feb. 1990 (Informe de la primera visita al campo)		
	Ditto Appendix		
	Analisis de la cuenca de rio Pirris 1981		Universidad de Costa Rica
	Mapa tipos de vegetacion	S=1/250,000 1986	
	Mapa tipos de clima	S=1/250,000 1986	
	Plan de manejo de la Cuenca del rio Pirrita 1985		Ministerio de Agricultura y Ganaderia
	Mapa geologico de Costa Rica	S=1/200,000	Ministerio de Energia y Recursos Naturales

Field	Title	Description	Publishing Office
Environment	Tablas de los datos quimicas de las aguas del rio Pirris 1980 - 1988		ICE
	Tablas de los datos bactereologicos y fisico-quimicos de las aguas del rio Pirris		Instituto Costarricense de Acueductos y Alcantarillados
Reports	Informe de factibilidad desarrollo hidroelectrico del rio Toro, June 1988		ICE
	Ditto drawings		ICE
	Proyecto hidroelectrico Angostura, Informe estudio de alternativas, Dec. 1987		SNC
	Proyecto hidroelectrico Angostura Informe descriptivo texto - Mayo 1979		ICE
Topography	1/5,000 topography map covering the entire project area		ICE
	1/2,000 topography map covering all of the dam, penstock and powerhouse site		ICE
	(Appendix)		
	Table de concesiones de agua en la Cuenca del rio Pirris		SNE
	Program de la contaminacion de agua Mayo, 1981		Ministerio de Salud
	Mapa de la division administrativa de la Cuenca en cantones y distritos		-

Field	Title	Description	Publishing Office
Topography	Mapa de Servicios Sociales basicos		Ministerio de Agricultura y Ganaderia (MAG)
	Infraestructura de la Produccion		MAG
Environment	Decreto de Reglamentos de Beneficios de cafe		
	Grafico de distribucion porcentual de los constituyentes del cafe en fruta, en las diversas etapas del beneficiado		
	Evaluacion de la capacidad instalada de las plantas beneficio Agosto, 1988		Instituto del Cafe de Costa Rica
	Manual de codigos utilizados en la informacion sobre valores de precios		Ministerio de Hacienda
	De los expedientes de las propiedades que han sido catastradas en los distritos de la cuenca del rio Pirris		
	Ley expropiacion del ICE		ICE

A-9 List of Reference Data Furnished by ICE (2/4)

Field	Title	Description	Publishing Office
Electric Generation	Plan de Expansion de la Generacion (Segun Modelo Logos) Fecha 3-agosto-1990		ICE
Hydrology and Meteorology	Isohyetal map	1988. Oct. (Joan) 1988. Sep. (Gilvert)	
	Estudio Hidrometeoro-logico de los Efectos Producidos por el Huracan Joan en Costa Rica : Octubre 1989		
	Estadistico de Sedi-mentos en Suspension en Toneladas		
	Gilvert rainfall data	- Copey - Providencia - El Canon	
	Monthly Precipitation	- Providencia 1978-1989 - Playon 1979-1989 - El Canon 1954-1989 - Naranjillo 1981-1989 - Copey 1981-1988	
	Joan hurricane rainfall data (Oct. 1988)	- Copey - Providencia - El Canon	
	Gilvart hurricane rainfall data (Sep. 1988)	- Providencia - El Canon	
Environment	P.H. Pirris, Creacion de banco de datos ambientales		ICE
	Resultados del P. H. Pirris		ICE
	Guia para la Evalua-cion de Impacto Ambiental		
	Boletin de Calidad Fisico-Quimica del Agua No. 1		

Field	Title	Description	Publishing Office
Environment	Informacion obtanida al mes Octubre 1990	Ley Forest Ley Indigena Perfil ambiental de Costa Plano Areas de Conservacion Ley de Aguas Regulacion para el Ejercicio Ley No 6919 (Ley de conserva-cion de la Fauna Informes de visitas de Campo No.1-No.2	
Electrical References	Distribution Lines (1)	Manual de Normas de Construc-cion (Materiales Normalizados)	ICE
	Distribution Lines (2)	(Materiales Normalizados)	ICE
	Hydroelectric Power Plants/Substations	Equipment Layout Single Line Diagram	ICE
	Thermal Power Plants	Single Line Diagram	ICE
	Load Forecast	GDP data Power Demand Forecast Data	ICE
	Transmission Lines	Line Loute Maps Construction Costs Steel Tower Drawings	ICE
	System Analysis	National System Drawings Impedance Map Power Flow Map	ICE
	Plan of Optimum Development Scheme	LOGOS data WASP data	ICE

A-9 List of Reference Data Furnished by ICE (3/4)

Field	Title	Description	Publishing Office
Cost Estimation	Labor Cost (Minimum Wages)	as of Jan. 1991	ICE
	Construction Cost List	as of Jan. 1991	ICE
	Costo de Equipo de Construction	as of Jan. 1991	ICE
	Sistemas de Compensacion		ICE
Seismicity	Data of Limon Earthquake		ICE
	Sismo del 22 de Diciembre de 1990 (Analysis Preliminar de Acelerogramas Registrados en la Presa San Miguel)		ICE
	Informe Preliminar del Terremoto de Limon (Costa Rica) Registrado el dia 22 de abril de 1991		ICE
	Segundo Reporte Preliminar	Registro de Aceleraciones del Sismo del 22 de abril de 1991	ICE
	The April 22 1991, Valle de la Estrella, Costa Rica Earthquake (May 1991, EQE International)		ICE
	Sismo de Mag ≥3.5 Dentro de un Radio de 100 km del P.H. Pirris Periodo Enero 1990 - Enero 1991		ICE
	Earthquake of Mag. greater than 4.0 within a Radious of 100 km from Pirris (1984-Jan 1991)		ICE
	Informe preliminar de Refraccion Sismica en Sitios de Presa, Tuberia de Presion y Casa de Maquinas		ICE
Laboratory Test	P.H. Pirris, Estudio de Materiales para Nucleo Impermeable		ICE
	Ensayos de Laboratorio al Material de Galeria M.D. P.H. Pirris. (5 de julio de 1991)		
	Resultados Ensayos de Laboratorio P.H. Pirris (17 de Julio de 1991)		ICE

Field	Title	Description	Publishing Office
Laboratory Test	Trabajo Realizado en el P.H. Pirris (18 de Enero de 1991)		ICE
	Resultados de Ensayos de Tension P.H. Pirris		ICE
	Ensayos de Laboratorio al Material de Margen Derecha Sitio Aguas Arriba P.H. Pirris		ICE
	Resultados de Ensayos Triaxiales y de Permeabilidad Material Para Nucleo P.H. Pirris		ICE
General	Costa Rica Generalidades del Pais		ICE
	Sector Energetico de Costa Rica		ICE
	Subsector de Energia Electrica de Costa Rica		ICE
	El Sector Electrico del ICE		ICE
	Indicadores Financieros-Economicos (Periodo 1979-1990)		ICE
	Memoria 1990		ICE
	Informe de Operacion de las Principales Empresas Electricas de Costa Rica 1990		ICE
	Informe Anual de Labores 1990		ICE
	Main River Basin of Costa Rica		ICE
	Information on Underemployment and Turism Earnings		ICE

A-9 List of Reference Data Furnished by ICE (4/4)

Field	Title	Description	Publishing Office
Planning	Plans de Expansion de Generacion	Alternative Thermal Power Plant Data	ICE 1991 Aug.
Transmission Line	Diagrama Unifilar S.E.N.(2000) Distancias y Tipos de Conductor	System of National Transmission Line (2000)	ICE
	Costo por km de Linea de Transmision 230 kV	Doble Circuito 2 x 636 MCm	ICE
General	Organigrama Subgerencia Desarrollo de Enengia	Organigram	ICE