4.2.2.2 End Pier

1. Loading Calculation

Weight of body

Total weights of center weir pier are shown as follows.

Table of total weight of end pier

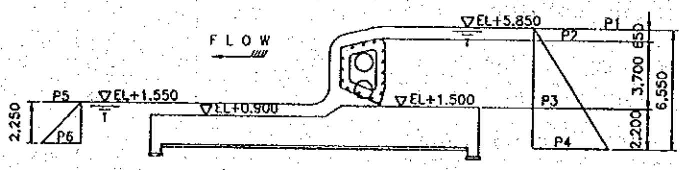
No.	Calculation form	Weight (tf)	X (m)	Y (m)	Z (m)
1	2.20×6.00×4.00×2.50 tf/m³	132.00	3.000	1.100	2.000
	7.75×6.20×2.20×2.50 tf/m³	264.28	3.100	1.100	7.875
2	1.00 ×1.70 × 4.00 × 2.50 tf/m³	17.00	6.500	0.850	2.000
	1.00×0.50×3.45×2.35 tf/m³	4.05	6.500	1.950	1.725
	1.00×0.50×0.55×2.50 tf/m³	0.69	6.500	1.950	3.725
	0.60×7.75×1.70×2.50 tf/m³	19.76	6.500	0.800	7.875
	0.60×6.50×0.50×2.35 tf/m³	4.58	6.500	1.950	8.000
	0.60×0.50×0.50×2.50 tf/m³	0.38	6.500	1.950	11.500
	0.60×0.75×0.50×2.50 tf/m³	0.56	6.500	1.950	4.375
3	0.75×4.00×2.20×2.50 tf/m³	16.50	7.375	1.100	2.000
	0.45×7.75×2.20×2.50 tf/m³	19.18	7.025	1.100	7.875
4	0.90×1.60×4.00×2.50 tf/m³	14.40	8.200	0.800	2.000
	0.50×(0.90×0.60)×4.00×2.50 tf/m³	2.70	8.050	1.800	2.000
	0.90×1.60×7.75×2.50 tf/m³	27.90	7.700	0.800	7.875
	0.50×0.90×0.60×7.75×2.50 tf/m³	5.23	7.550	1.800	7.875
5	1.05×4.00×1.60×2.50 tf/m³	16.80	9.175	0.800	2.000
	1.55×1.60×7.75×2.50 tf/m³	48.05	8.925	0.800	7.875
6	1.10×1.10×4.00×2.50 tf/m³	12.10	10.250	0.550	2.000
	1.10×0.50×3.25×2.35 tf/m³	4.20	10.250	1.350	1.625
	1.10×0.50×0.75×2.50 tf/m³	1.03	10.250	1.350	3.625
	1.10×1.10×7.75×2.50 tf/m³	23.44	10.250	0.550	7.875
	1.10×0.50×6.50×2.35 tf/m3	8.40	10.250	1.350	8.000
	1.1×0.50×0.50×2.50 tf/m³	0.69	10.250	1.350	11.500
	1.10×0.50×0.75×2.50 tf/m³	1.03	10.250	1.350	4.375
7	7.70×1.60×4.00×2.50 tf/m³	123.20	14.650	0.800	2.000
	7.70×1.60×7.75×2.50 tf/m³	238.70	14.650	0.800	7.875
8	2.20×18.5×3.25×2.50 tf/m³	330.69	9.250	1.100	13.375
9	18.50×7.50×1.00×2.50 tf/m³	346.88	9.250	5.950	11.750
10	1/2×π×(1.25²)×7.50×2.50 tf/m³	46.02	1.720	5.950	4.000
11	3.00×1.25×7.50×2.50 tf/m³	70.31	3.750	5.950	3.375
	3.50×1.25×7.50×2.50 tf/m³	82.03	4.000	5.950	4.625
	5.75×1.00×7.50×2.50 tf/m³	107.81	2.875	5.950	11.250
12	2.50×0.55×7.50×2.50 tf/m³	25.78	6.500	5.950	3.725
	1.50×0.75×7.50×2.50 tf/m³	21.09	6.500	5.950	4.375
	1.50×0.50×7.50×2.50 tf/m³	14.06	6.500	5.950	11.500
13	0.70×0.75×7.50×2.35 tf/m³	9.25	5.625	5.950	3.100
	0.50×0.45×7.50×2.35 tf/m³	3.97	5.975	5.950	5.000
	0.50×0.45×7.50×2.35 tf/m³	3.97	5.975	5.950	11.000

No.	Calculation form	Weight (tf)	X (m)	Y (m)	Z (m)
14	0.70×0.75×7.50×2.35 tf/m³	9.25	5.625	5.950	3.100
	0.50×0.45×7.50×2.35 tf/m³	3.97	7.025	5.950	5.000
	0.50×0.45×7.50×2.35 tf/m³	3.97	7.025	5.950	11.000
15	0.50×1.80×7.50×2.50 tf/m³	16.88	7.500	5.950	4.350
16	0.50×0.90×0.60×2.50×2.50 tf/m³	1.69	8.350	2.000	4.000
	0.50×0.90×0.60×1.00×2.50 tf/m³	0.68	7.850	2.000	11.250
17	1.05×0.60×2.50 ×2.50 tf/m³	3.94	9.175	1.900	4.000
	1.55×0.60×1.00×2.50 tf/m³	2.33	8.925	1.900	11.250
18	7.50×1.95×2.50×2.50 tf/m³	91.41	8.715	5.950	4.000
	7.50×2.45×1.00×2.50 tf/m³	45.94	8.475	5.950	4.000
19	0.30×8.10×0.50×2.35 tf/m³×2	5.71	9.850	5.650	4.000
	0.30×8.10×0.50×2.35 tf/m³	2.86	9.850	5.650	11.000
20	0.50×0.30×8.10×2.35 tf/m³×2	5.71	10.650	5.650	4.000
	0.50×0.30×9.60×2.35 tf/m³	3.38	10.650	6.400	11.000
21	1.50×1.10×8.10×2.50 tf/m³	33.41	10.250	5.650	4.000
	0.50×1.10×8.10×2.50 tf/m³	11.14	10.250	5.650	11.500
22	5.45×8.10×2.50×2.50 tf/m³	275.91	13.525	5.650	4.000
	5.45×8.10×1.00×2.50 tf/m³	110.36	13.525	5.650	11.250
23	1.00×2.25×2.50×2.50 tf/m³	14.06	17.375	9.200	4.000
24	1/2×π×(1.25²)×7.10×2.50 tf/m³	43.57	16.780	5.150	4.000
25	(0.50×(1.20×1.20)×0.80×2.50) tf/m³	1.44	10.100	10.100	4.000
	((0.30×0.30)/2)×0.80×2.50 tf/m³×4	0.36	9.900	10.300	4.000
26	0.80×1.50×0.50×2.50 tf/m³	1.50	10.750	10.450	4.000
27	1.069×7.00×1.235×2.50 tf/m³	23.10	14.750	10.235	4.633
27	1.069×7.00×0.78×2.50 tf/m³	14.59	14.750	10.235	11.140
	1.743×7.00×1.22×2.50 tf/m³	37.21	14.750	10.572	12.140
28	0.85×1.25×5.40×2.50 tf/m³×4	57.38	6.500	12.400	4.000
	5.40×1.25×2.00×2.50 tf/m³×2	67.50	6.500	12.400	11.750
29	(0.40×0.80-1/2×π×0.40²)×1.25×2.00×2.50tf/m³	0.43	6.500	12.407	4.000
30	0.80×1.25×3.00×2.50 tf/m³×2	15.00	6.500	13.600	4.000
31	(0.50/6.00)×((7.00×7.00)+(2.50×5.00)+4.00×6.00×4.75)×2.50 tf/m³	36.56	6.500	15.364	4.000
32	(0.50/6.00)×((4.00×7.00)+(2.00×5.00)+4.00×3.00×6.00)×2.50 tf/m³	22.92	6.500	15.413	11.750
33	13.25×7.00×0.70×2.50 tf/m³	162.31	6.500	15.950	7.125
34	0.6.00×0.50×1.00×2.50 tf/m³	0.75	18.000	1.900	4.000
35	Stair	1.07	2.000	11.775	4.000
	Total	3196.98	8.81	4.91	7.50

Hydrostatic pressure

(Normal case)

(Direction of flowing water)



In case of upstream flood discharge gate

$$P1 = 0.00 \times 1.00\ tf/m^3 = 0.00\ tf/m^2$$

$$P2 = 0.65 \times 1.00\ tf/m^3 = 0.65\ tf/m^2$$

$$P3 = 4.35 \times 1.00\ tf/m^3 = 4.35\ tf/m^2$$

$$P4 = 6.55 \times 1.00\ tf/m^3 = 6.55\ tf/m^2$$

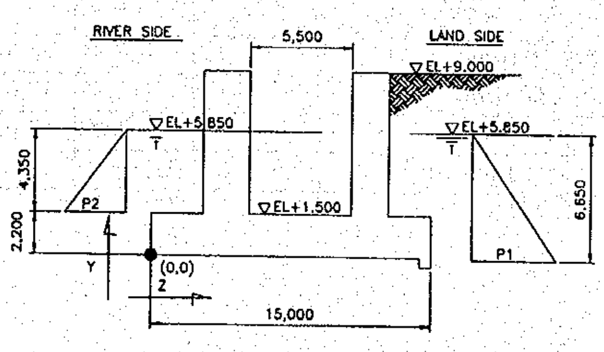
In case of downstream flood discharge gate

$$P5 = 0.00 \times 1.00\ tf/m^3 = 0.00\ tf/m^2$$

$$P6 = 2.25 \times 1.00\ tf/m^3 = 2.25\ tf/m^2$$

Position of load	Calculation form	W (tf)	Y (m)
Upstream of discharge gate	$(0.65+4.35)\times \frac{1}{2}\times 3.70\times 9.25$	85.56	3.59
Upstream of sediment flush gate	$\frac{1}{2}\times 4.35^2\times 5.50$	52.04	3.65
Upstream of pier	$\frac{1}{2}\times 4.35^2\times 2.50$	23.65	3.65
Upstream of slab	$(4.35+6.55)\times \frac{1}{2}\times 2.20\times 15.00$	179.85	1.03
Downstream of slab	$-\frac{1}{2}\times 2.25^2\times 15.00$	-37.97	0.75
Total		303.13	2.44

(Direction weir axis)



$P1 = 6.55 \times 1.00\ tf/m^3 = 6.55\ tf/m^2$

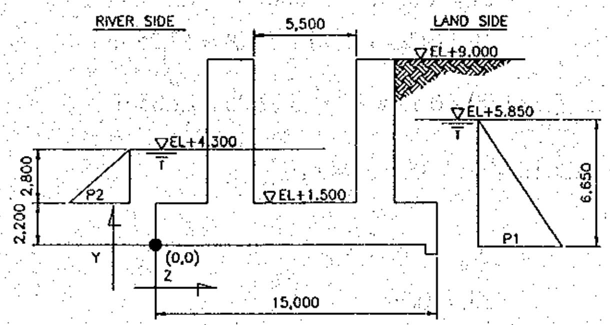
$P2 = 4.35 \times 1.00\ tf/m^3 = 4.35\ tf/m^2$

Position of load	Calculation form	W (tf)	Y (m)
Land side	$\frac{1}{2} \times 6.55^2 \times 18.50$	396.85	2.18
River side	$-\frac{1}{2} \times 4.35^2 \times 5.30$	-50.14	3.65
Total		346.71	1.97

(Seismic case)

Refer to normal condition in hydrostatic pressure.

(Design flooding case)
(Direction of weir axis)

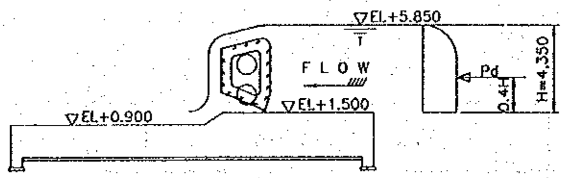


$P1 = 6.55 \times 1.00\ tf/m^3 = 6.55\ tf/m^2$

$P2 = 2.80 \times 1.00\ tf/m^3 = 2.80\ tf/m^2$

Position of load	Calculation form	W (tf)	Y (m)
Land side	$\frac{1}{2} \times 6.55^2 \times 18.50$	396.85	2.18
River side	$-\frac{1}{2} \times 2.80^2 \times 18.50$	-72.52	3.13
Total		324.33	1.98

Hydrodynamic pressure due to earthquake



$$P_d = \frac{7}{12} W_0 \times Kh \times H^2 \times B$$

Where,

P_d : Hydrodynamic pressure (tf)
W_0 : Unit weight of water (tf/m^3)
Kh : Design seismic coefficient
H : Water depth (m)
B : Affected width of load (m)

(Direction of flowing water)

$W_0 = 1.00$ tf/m^3
Kh = 0.12
H = 4.35 m and
B = (9.25 + 2.50 + 5.50) = 17.25 m

$$P_d = \frac{7}{12} \times 1.00 \times 0.12 \times 4.35^2 \times 17.25 = 22.85 \text{ tf}$$

Y = 2.20+0.40×4.35 = 3.94 m

(Direction of weir axis)

$W_0 = 1.00$ tf/m^3
Kh = 0.12
H = 4.35 m and
B = 5.50 m

$$P_d = \frac{7}{12} \times 1.00 \times 0.12 \times 4.35^2 \times 5.50 = 7.29 \text{ tf}$$

Y = 2.20+0.40×4.35 = 3.94 m

Following water force

$$P = K \times V^2 \times A$$

Where,

K : coefficient of pier resistance
V : maximum flow velocity (m/s)
A : projective area of pier in vertical direction (m^2)

In design flooding case, there is supercritical flow around Simongan weir, because downstream position of Simongan weir has about 2.70 m drop between top of slab and downstream design riverbed.

Velocity of supercritical flow is faster than uniform flow. Therefore, velocity of supercritical flow is adopted.

The velocity is used in design discharge by non-uniformed flow calculation at WF.98.

$Q = 790\ m^3/s$

$H = 2.80\ m$

$V = 4.20\ m/s$

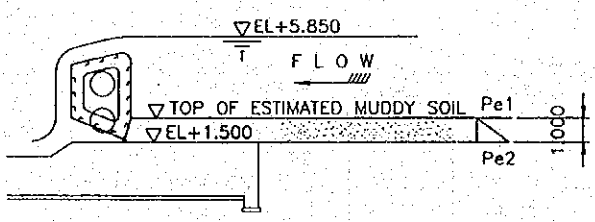
$K = 0.04$

Therefore

$P = 0.04 \times 4.20^2 \times (2.50 \times 4.35) = 7.67\ tf$

$Y = 0.60 \times 2.80 + 2.20 = 3.88\ m$

Muddy soil pressure



The pressure of muddy soil is estimated as follows

$Pe = Ce \times W1 \times D$

Where

Pe : muddy soil pressure (tf/m^2)

Ce : coefficient of muddy soil pressure (Ce = 0.4 ~ 0.6)

W1 : unit weight of muddy soil (tf/m^3)

D : depth from the surface (m)

$Ce = 0.5$

$W1 = 1.00\ tf/m^2$

$D = 1.00\ m$

$Pe_1 = 0.00\ tf/m^2$

$Pe_2 = 0.5 \times 1.00 \times 1.00 = 0.50\ tf/m^2$

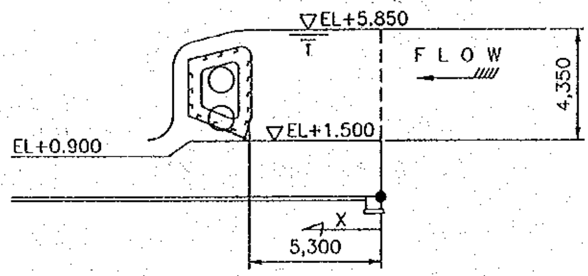
Therefore

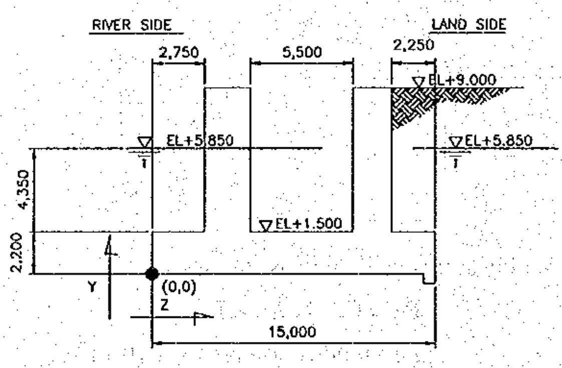
$P_E = \frac{1}{2} \times 0.50 \times 1.00 \times (9.25 + 2.50 + 5.50) = 4.31\ tf$

$Y = \frac{1}{3} \times 1.00 + 2.20 = 2.53\ m$

Weight of water

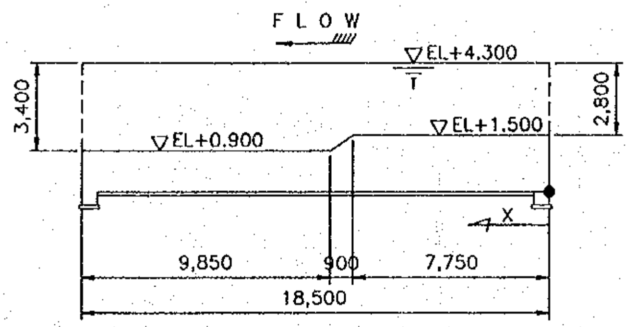
(Normal case)

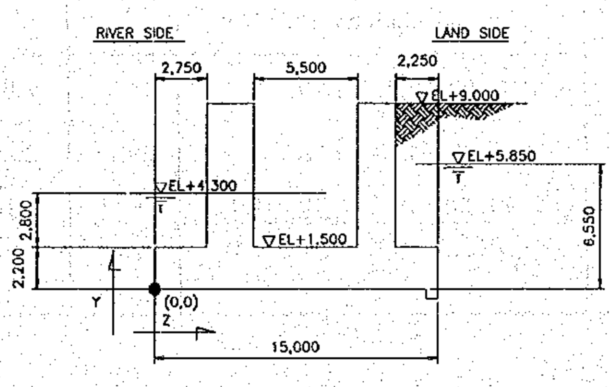




Position of load	Calculation form	W (tf)	X (m)	Z (m)
Discharge gate	5.30×4.35×2.75×1.00	63.40	2.65	1.38
Sediment gate	5.30×4.35×5.50×1.00	126.80	2.65	8.00
Section of pier	(1.25+1.00)×2.50×4.35×1.00	24.47	1.13	4.00
	$-\pi/4 \times 2.50^2 \times 1/2 \times 4.35 \times 1.00$	-10.68	1.72	4.00
Land side	18.50×4.35×2.25×1.00	181.07	9.25	13.88
Total		385.06	5.68	9.53

(Design flooding case)



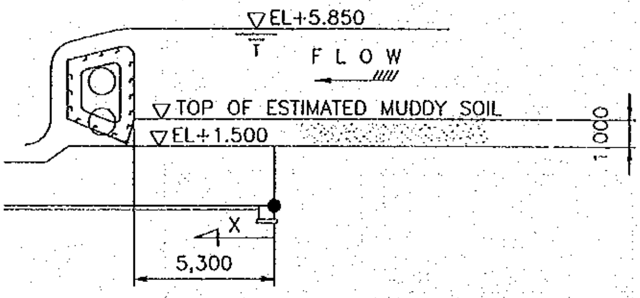


Position of load	Calculation form	W (tf)	X (m)	Z (m)
Upstream section at river side	7.75×2.80×2.75×1.00	59.68	3.88	1.38
	7.75×2.80×5.50×1.00	119.35	3.88	8.00
	(1.25+1.00)×2.50×2.80×1.00	15.75	1.13	4.00
	$-\pi/4\times2.50^2\times1/2\times2.80\times1.00$	-6.87	1.72	4.00
Slop section at river side	$(2.80+3.40)\times1/2\times0.90\times2.75\times1.00$	7.67	7.61	1.38
	$(2.80+3.40)\times1/2\times0.90\times5.50\times1.00$	15.35	7.61	8.00
Downstream section at river side	9.85×3.40×2.75×1.00	92.10	13.58	1.38
	9.85×3.40×5.50×1.00	184.20	13.58	8.00
	(1.25+1.00)×2.50×3.40×1.00	19.13	17.37	4.00
	$-\pi/4\times2.50^2\times1/2\times3.40\times1.00$	-8.34	16.78	4.00
Land side	18.50×4.35×2.25×1.00	181.07	9.25	13.88
Total		679.09	9.56	7.90

(Seismic case)

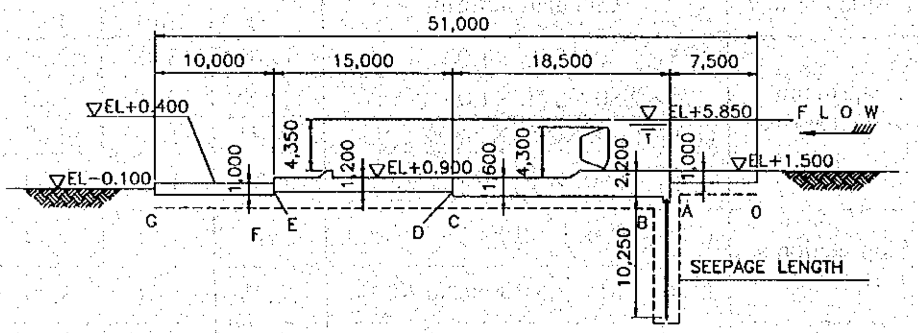
Refer to normal case.

Weight of muddy soil



Position of load	Calculation form	W (tf)	X (m)	Z (m)
Section of discharge gate	5.30×1.00×2.75×1.00	14.58	2.65	1.38
Section of sediment gate	5.30×1.00×5.50×1.00	29.15	2.65	8.00
Section of pier	(1.25+1.00)×2.50×1.00×1.00	5.63	1.13	4.00
	$-\pi/4 \times 2.50^2 \times 1/2 \times 1.00 \times 1.00$	-2.45	1.72	4.00
Total		46.91	2.52	5.67

Uplift



Vertical creep length

$$Lv := (2.20-1.00)+10.25\times 2+(1.60-1.20)+((1.00+0.50)-1.20)=22.40\ m$$

Horizontal creep length $Lh = 51.00\ m$

Weighted creep length $Lw = 51.00/3 + 22.40 = 39.40\ m$

Different water level $\Delta h = 4.35\ m$

In between "0" point to "A" point weight creep length

$$Lwa = 7.50/3 + (2.20-1.00) = 3.70\ m$$

In between "0" point to "B" point weight creep length

$$Lwb = \frac{7.50}{3} + (2.20 - 1.00) + 10.25 \times 2 = 24.20 \text{ m}$$

In between "0" point to "C" point weight creep length

$$Lwc = \frac{26.00}{3} + (2.20 - 1.00) + 10.25 \times 2 = 30.37 \text{ m}$$

Uplift at "A" point $Ua = (4.35 + 2.20) - \frac{3.70}{39.40} \times 4.35 = 6.14 \text{ tf/m}^2$

Uplift at "B" point $Ub = (4.35 + 2.20) - \frac{24.20}{39.40} \times 4.35 = 3.88 \text{ tf/m}^2$

Uplift at "C" point $Uc = (4.35 + 2.20) - \frac{30.37}{39.40} \times 4.35 = 3.20 \text{ tf/m}^2$

Position of load	Calculation form	U (tf)	X (m)	Z (m)
Upstream section of seepage blocking	$6.14 \times 0.60 \times 15.00$	55.26	0.30	7.50
Downstream section of seepage blocking	$(3.88 + 3.20) \times \frac{1}{2} \times 17.90 \times 15.00$	950.49	9.54	7.50
Total		1005.75	9.03	7.50

(Design flooding case)

$\Delta h = (EL + 4.30 \text{ m} - EL + 1.50 \text{ m}) + 2.20 = 5.00 \text{ m}$

$Ua = Ub = Uc = 5.00 \times 1.00 \text{ tf/m}^3 = 5.00 \text{ tf/m}^2$

Therefore

$U = 5.00 \times 18.50 \times 15.00 = 1387.50 \text{ tf}$

$X = \frac{1}{2} \times 18.50 = 9.25 \text{ m}$

$Z = 7.50 \text{ m}$

(Seismic case)

Refer to Normal case in uplift.

Wind pressure

(Normal case: Direction of Flowing water)

Direction of wind: from upstream to downstream

Position of load	Calculation form	U (tf)	Y (m)
Control house section	13.05×4.85×0.15 tf/m²	9.49	18.03
Haunch of control rack section	(6.80 + 2.50) × $\frac{1}{2}$ × 0.50 × 0.15 tf/m²	0.35	15.39
	(3.80 + 2.00) × $\frac{1}{2}$ × 0.50 × 0.15 tf/m²	0.22	15.39
Gate post section	3.40×(2.50 + 2.00)×0.15 tf/m²	2.30	13.40
Maintenance bridge section	2.00×(10.50 + 5.50)×0.15 tf/m²	4.80	10.70
Gate pier section	(EL + 9.00-EL +5.85)×2.50×0.15 tf/m²	1.18	8.13
Total		18.34	13.35

(Normal case: Direction of weir axis)

Position of load	Calculation form	U (tf)	Y (m)
Control house section	6.70×4.85×0.15 tf/m²	4.87	18.03
Haunch of control rack section	(6.70 + 5.00) × $\frac{1}{2}$ × 0.50 × 0.15 tf/m²	0.44	15.36
Gate post section	5.40×2.50×0.15 tf/m²	2.03	12.40
Gate pier section	1.00×17.50×0.15 tf/m²	2.63	9.20
	(EL + 8.00-EL +5.85)×16.50 ×0.15 tf/m²	5.32	7.63
Total		15.29	12.07

(Design flooding case: Direction of flowing water)

Direction of wind: from upstream to downstream

Position of load	Calculation form	U (tf)	Y (m)
Control house section	13.05×4.85×0.15 tf/m²	9.49	18.03
Haunch of control rack section	(6.80 + 2.50) × $\frac{1}{2}$ × 0.50 × 0.15 tf/m²	0.35	15.39
	(3.80 + 2.00) × $\frac{1}{2}$ × 0.50 × 0.15 tf/m²	0.22	15.39
Gate post section	3.40×(2.50 +2.00)×0.15 tf/m²	2.30	12.40
Maintenance bridge section	2.00×(10.50 + 5.50)×0.15 tf/m²	4.80	10.70
Gate pier section	(EL + 9.00-EL +8.00)×2.50×0.15 tf/m²	0.38	9.20
Gate section	18.50×3.70×0.15	10.27	11.55
Total		27.81	13.73

(Design flooding case: Direction of weir axis)

Position of load	Calculation form	U (tf)	Y (m)
Control house section	6.70×4.85×0.15 tf/m²	4.87	18.03
Haunch of control rack section	$(6.70+5.00)\times \frac{1}{2}\times 0.50\times 0.15$ tf/m²	0.44	15.36
Gate post section	5.40×2.50×0.15 tf/m²	2.03	12.40
Gate pier section	1.00×17.50×0.15 tf/m²	2.63	9.20
Total		9.97	14.44

(Constructional case: Direction of flowing water)

Direction of wind: from upstream to downstream

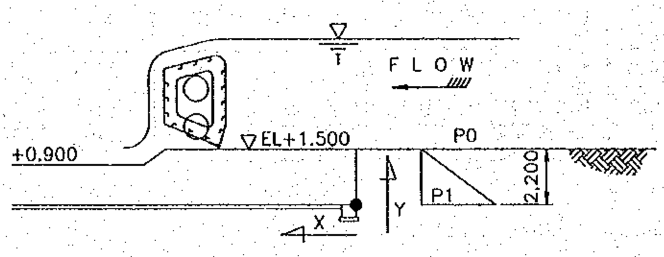
Position of load	Calculation form	U (tf)	Y (m)
Control house section	13.05×4.85×0.15 tf/m²	9.49	18.03
Haunch of control rack section	$(6.80+2.50)\times \frac{1}{2}\times 0.50\times 0.15$ tf/m²	0.35	15.39
	$(3.80+2.00)\times \frac{1}{2}\times 0.50\times 0.15$ tf/m²	0.22	15.39
Gate post section	3.40×(2.50+2.00)×0.15 tf/m²	2.30	12.40
Maintenance bridge section	2.00×(10.50+5.50)×0.15 tf/m²	4.80	10.70
Gate pier section	(EL+9.00-EL+1.50)×2.50×0.15 tf/m²	2.81	5.95
Gate section	18.50×3.70×0.15 tf/m²	10.27	11.55
Total		30.24	13.07

(Construction case: Direction of weir axis)

Position of load	Calculation form	U (tf)	Y (m)
Control house section	6.70×4.85×0.15 tf/m²	4.87	18.03
Haunch of control rack section	$(6.70+5.00)\times \frac{1}{2}\times 0.50\times 0.15$ tf/m²	0.44	15.39
Gate post section	5.40×2.50×0.15 tf/m²	2.03	12.40
Gate pier section	1.00×17.50×0.15 tf/m²	2.63	9.20
	6.50×16.50×0.15 tf/m²	16.09	5.45
	$(9.75+8.85)\times \frac{1}{2}\times 0.60\times 0.15$ tf/m²	0.84	1.90
Total		26.90	8.67

Earth pressure

(Direction of flowing water)



Earth pressure is adopted in case of direction of flowing water.

(Normal case)

The earth pressure acting is calculated by the following Coulom's formulas.

Unit weight of soil	$\gamma' = 1.00$ tf/m^3 (under water)
Coefficient of active earth pressure	Ka = 0.308
Depth	$\Delta h = 2.20$ m

Therefore

$P0 = 0.00$ tf/m^2

$P1 = 0.308 \times 1.00 \times 2.20 = 0.678$ tf/m^2

$P = \frac{1}{2} \times 0.678 \times 2.20 \times 15.00 = 11.19$ tf

$Y = \frac{1}{3} \times 2.20 = 0.73$ m

$Z = 7.50$ m

(Design flooding case)

Refer to Normal case in earth pressure.

(Construction case)

Unit weight of soil	$\gamma\tau = 1.80$ tf/m^3
Coefficient of active earth pressure	Ka = 0.308
Depth	$\Delta h = 2.20$ m

Therefore

$P0 = 0.00$ tf/m^2

$P1 = 0.308 \times 1.80 \times 2.20 = 1.220$ tf/m^2

$P = \frac{1}{2} \times 1.220 \times 2.20 \times 15.00 = 20.13$ tf

$Y = \frac{1}{3} \times 2.20 = 0.73$ m

Z = 7.50 m

(Seismic case)

Unit weight of soil	γ' = 1.00 tf/m^3 (under water)
Coefficient of active earth pressure	Kae = 0.492 (underwater)
Depth	Δh = 2.20 m

Therefore

$Pe0 = 0.00$ tf/m^2

$Pe1 = 0.492 \times 1.00 \times 2.20 = 1.082$ tf/m^2

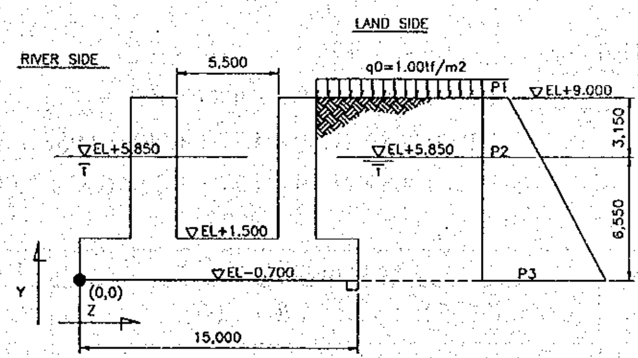
$Pe = \frac{1}{2} \times 1.082 \times 2.20 \times 15.00 = 17.85$ tf

$Y = \frac{1}{3} \times 2.20 = 0.73$ m

Z = 7.50 m

(Direction of weir axis)

(Normal case: Standard section)



(STANDARD SECTION)

Unit weight of soil	γ = 1.80 tf/m^3
	γ' = 1.00 tf/m^3 (under water)
Surcharge load	q0 = 1.00 tf/m^2
Coefficient of active earth pressure	Ka = 0.308

Therefore

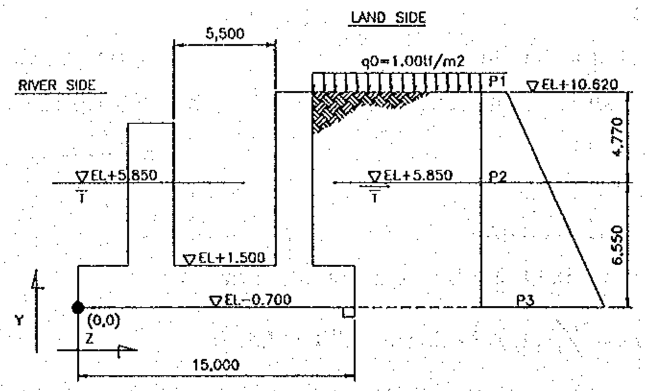
$P1 = 0.308 \times 1.00 = 0.308$ tf/m^2

$P2 = 0.308 \times (1.80 \times 3.15 + 1.00) = 2.054$ tf/m^2

$P3 = 0.308 \times (1.80 \times 3.15 + 1.00 \times 6.55 + 1.00) = 4.072$ tf/m^2

Position of load	Calculation form	P (tf)	Y (m)
Aerial	$(0.308 + 2.054) \times \frac{1}{2} \times 3.150 \times (18.50 - 7.00)$	42.78	7.74
Underwater	$(2.054 + 4.072) \times \frac{1}{2} \times 6.550 \times (18.50 - 7.00)$	230.72	2.92
Total		273.50	3.67

(Normal case: Maintenance bridge section)



(MAINTENANCE BRIDGE SECTION)

Unit weight of soil	$\gamma = 1.80$ tf/m^3
	$\gamma' = 1.00$ tf/m^3 (under water)
Surcharge load	q0 = 1.00 tf/m^2
Coefficient of active earth pressure	Ka = 0.308

Therefore

$$P1 = 0.308 \times 1.00 = 0.308 \text{ tf/m}^2$$
$$P2 = 0.308 \times (1.80 \times 4.77 + 1.00) = 2.952 \text{ tf/m}^2$$
$$P3 = 0.308 \times (1.80 \times 4.77 + 1.00 \times 6.55 + 1.00) = 4.970 \text{ tf/m}^2$$

Position of load	Calculation form	P (tf)	Y (m)
Aerial	$(0.308 + 2.952) \times \frac{1}{2} \times 4.770 \times 7.00$	54.43	8.29
Underwater	$(2.952 + 4.970) \times \frac{1}{2} \times 6.550 \times 7.00$	181.61	3.00
Total		236.04	4.22

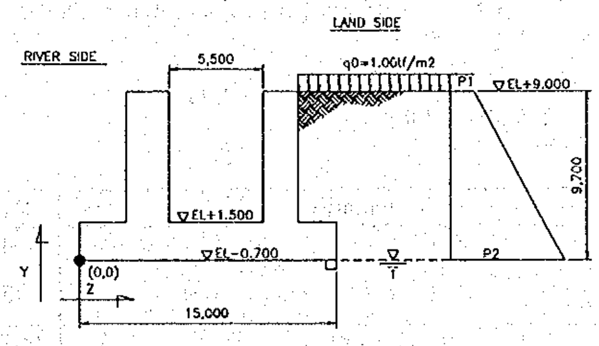
Total load

Position of load	Calculation form	P (tf)	Y (m)
Standard section		273.50	3.67
Maintenance bridge section		236.04	4.22
Total		509.54	3.92

(Design flooding case)

Refer to Normal case

(Construction case: Standard section)



(STANDARD SECTION)

Unit weight of soil	$\gamma = 1.80$ tf/m³
Surcharge load	$q0 = 1.00$ tf/m²
Coefficient of active earth pressure	$Ka = 0.308$

Therefore

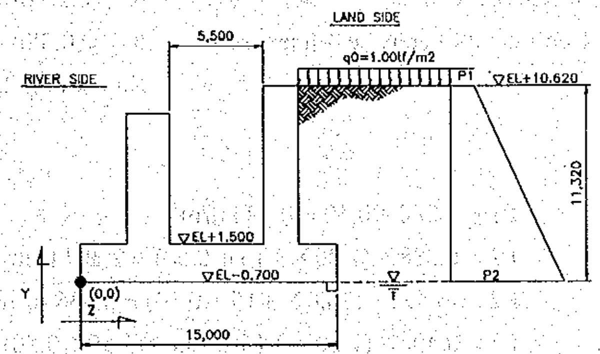
$$P1 = 0.308 \times 1.00 = 0.308 \text{ tf/m}^2$$

$$P2 = 0.308 \times (1.80 \times 9.70 + 1.00) = 5.686 \text{ tf/m}^2$$

$$P2 = \frac{1}{2} \times (0.308 + 5.686) \times 9.700 \times 11.500 = 334.32 \text{ tf}$$

$$Y2 = \frac{(5.686 + 2 \times 0.308)}{(5.686 + 0.308)} \times \frac{9.700}{3} = 3.40 \text{ m}$$

(Construction case: Maintenance bridge section)



(MAINTENANCE BRIDGE SECTION)

Unit weight of soil	$\gamma = 1.80$ tf/m³
Surcharge load	$q0 = 1.00$ tf/m²
Coefficient of active earth pressure	$Ka = 0.308$

Therefore

$$P1 = 0.308 \times 1.00 = 0.308 \text{ tf/m}^2$$

$$P2 = 0.308 \times (1.80 \times 11.32 + 1.00) = 6.584 \text{ tf/m}^2$$

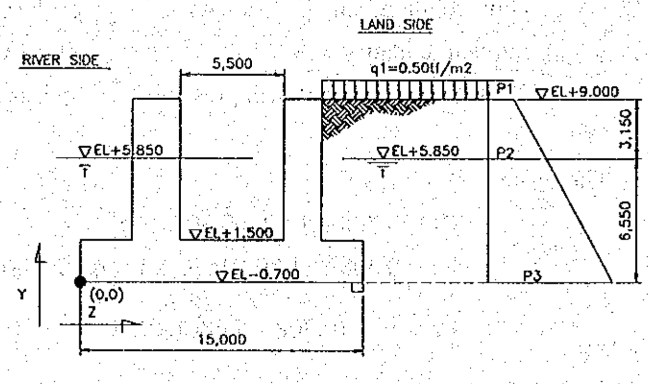
$$P2 = \frac{1}{2} \times (0.308 + 6.584) \times 11.320 \times 7.000 = 273.06 \text{ tf}$$

$$Y2 = \frac{(6.584 + 2 \times 0.308)}{(6.584 + 0.308)} \times \frac{11.320}{3} = 3.94 \text{ m}$$

Total load

Position of load	Calculation form	P (tf)	Y (m)
Standard section		334.32	3.40
Maintenance bridge section		273.06	3.94
Total		607.38	3.64

(Seismic case: Standard section)



(STANDARD SECTION)

Unit weight of soil	$\gamma = 1.80$ tf/m^3
	$\gamma' = 1.00$ tf/m^3 (under water)
Surcharge load	$q1 = 0.50$ tf/m^2
Coefficient of active earth pressure	$Kae = 0.388$
	$Kae' = 0.492$

Therefore

$$P1 = 0.388 \times 0.50 = 0.194 \text{ tf/m}^2$$

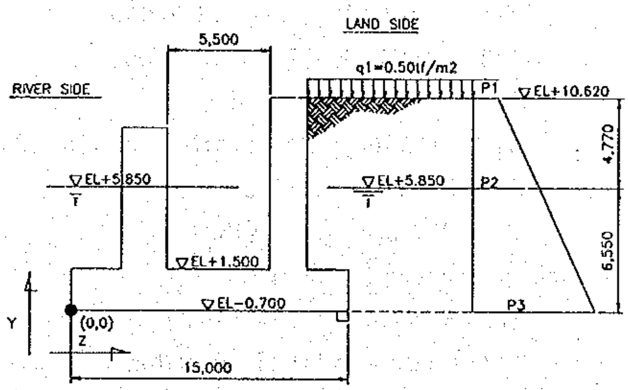
$$P2 = 0.388 \times (1.80 \times 3.15 + 0.50) = 2.394 \text{ tf/m}^2$$

$$P2' = 0.492 \times (1.80 \times 3.15 + 0.50) = 3.036 \text{ tf/m}^2$$

$$P3 = 0.492 \times (1.80 \times 3.15 + 1.00 \times 6.55 + 0.50) = 6.258 \text{ tf/m}^2$$

Position of load	Calculation form	P (tf)	Y (m)
Aerial	$(0.194 + 2.394) \times \frac{1}{2} \times 3.150 \times (18.50 - 7.00)$	46.88	7.68
Underwater	$(3.036 + 6.258) \times \frac{1}{2} \times 6.550 \times (18.50 - 7.00)$	350.04	2.90
Total		396.92	3.46

(Seismic case: Maintenance bridge section)



(MAINTENANCE BRIDGE SECTION)

Unit weight of soil $\gamma = 1.80$ tf/m^3

$\gamma' = 1.00$ tf/m^3 (under water)

Surcharge load q1 = 0.50 tf/m^2

Coefficient of active earth pressure Kae = 0.388

Kae' = 0.492

Therefore

$P1 = 0.388 \times 0.50 = 0.194$ tf/m^2

$P2 = 0.388 \times (1.80 \times 4.77 + 0.50) = 3.525$ tf/m^2

$P2' = 0.492 \times (1.80 \times 4.77 + 0.50) = 4.470$ tf/m^2

$P3 = 0.492 \times (1.80 \times 4.77 + 1.00 \times 6.55 + 0.50) = 7.693$ tf/m^2

Position of load	Calculation form	P (tf)	Y (m)
Aerial	$(0.194+3.525) \times \frac{1}{2} \times 4.770 \times 7.00$	62.09	8.22
Underwater	$(4.470+7.693) \times \frac{1}{2} \times 6.550 \times 7.00$	278.84	2.99
Total		340.93	3.94

Total load

Position of load	Calculation form	P (tf)	Y (m)
Standard section		396.92	3.46
Maintenance bridge section		340.93	3.94
Total		737.85	3.68

Weight of earth

Unit weight of soil $\gamma = 1.80$ tf/m^3 (Aerial)

$\gamma' = 1.00$ tf/m^3 (Underwater)

Surcharge load q = 1.00 tf/m^2 (Normal case)

q' = 0.50 tf/m^2 (Seismic case)

(Normal case: Standard section)

$W1 = 1.80 \times 3.15 \times 2.25 = 12.76$ tf/m

$W2 = 1.00 \times 4.35 \times 2.25 = 9.79$ tf/m

$W3 = 1.00 \times 2.25 = 2.25$ tf/m

$\Sigma W = (12.76 + 9.79 + 2.25) \times 11.50 = 285.20$ tf

$X = 1/2 \times 11.50 = 5.75$ m

$Z = 1/2 \times 2.25 + 12.75 = 13.88$ m

(Normal case: Maintenance bridge section)

$W1 = 1.80 \times 4.77 \times 2.25 = 19.32$ tf/m

$W2 = 1.00 \times 4.35 \times 2.25 = 9.79$ tf/m

$W3 = 1.00 \times 2.25 = 2.25$ tf/m

$\Sigma W = (19.32 + 9.79 + 2.25) \times 7.00 = 219.52$ tf

$X = 1/2 \times 7.00 + 11.50 = 15.00$ m

$Z = 1/2 \times 2.25 + 12.75 = 13.88$ m

Total load

Position of load	Calculation form	P (tf)	X (m)	Z (m)
Standard section		285.20	5.75	13.88
Maintenance bridge section		219.52	15.00	13.88
Total		504.72	9.77	13.88

(Design flooding case)

Refer to Normal case

(Construction case: Standard section)

$W1 = 1.80 \times 7.50 \times 2.25 = 30.38$ tf/m

$W2 = 1.00 \times 2.25 = 2.25$ tf/m

$\Sigma W = (30.38 + 2.25) \times 11.50 = 375.25$ tf

$X = 1/2 \times 11.50 = 5.75$ m

$Z = 1/2 \times 2.25 + 12.75 = 13.88$ m

(Normal case: Maintenance bridge section)

$W1 = 1.80 \times 9.12 \times 2.25 = 36.94$ tf/m

$W2 = 1.00 \times 2.25 = 2.25$ tf/m

$\Sigma W = (36.94 + 2.25) \times 7.00 = 274.33$ tf

$X = 1/2 \times 7.00 + 11.50 = 15.00$ m

$Z = 1/2 \times 2.25 + 12.75 = 13.88$ m

Total load

Position of load	Calculation form	P (tf)	X (m)	Z (m)
Standard section		375.25	5.75	13.88
Maintenance bridge section		274.33	15.00	13.88
Total		649.58	9.67	13.88

(Seismic case: Standard section)

$W1 = 1.80 \times 3.15 \times 2.25 = 12.76$ tf/m

$W2 = 1.00 \times 4.35 \times 2.25 = 9.79$ tf/m

$W3 = 0.50 \times 2.25 = 1.13$ tf/m

$\Sigma W = (12.76 + 9.79 + 1.13) \times 11.50 = 272.32$ tf

$X = 1/2 \times 11.50 = 5.75$ m

$Y = 1/2 \times (3.15 + 4.35) + 2.20 = 5.95$ m

$Z = 1/2 \times 2.25 + 12.75 = 13.88$ m

(Seismic case: Maintenance bridge section)

$W1 = 1.80 \times 4.77 \times 2.25 = 19.32$ tf/m

$W2 = 1.00 \times 4.35 \times 2.25 = 9.79$ tf/m

$W3 = 0.50 \times 2.25 = 1.13$ tf/m

$\Sigma W = (19.32 + 9.79 + 1.13) \times 7.00 = 211.68$ tf

$X = 1/2 \times 7.00 + 11.50 = 15.00$ m

$Y = 1/2 \times (4.77 + 4.35) + 2.20 = 6.61$ m

$Z = 1/2 \times 2.25 + 12.75 = 13.88$ m

Total load

Position of load	Calculation form	P (tf)	X (m)	Y (m)	Z (m)
Standard section		272.32	5.75	5.95	13.88
Maintenance bridge section		211.68	15.00	6.61	13.88
Total		484.00	9.80	6.24	13.88

Load Combination

Load combinations for stability analysis are made as follows.

Load \ Condition		Normal case	Design flooding case	Construction case	Seismic case
The Vertical load	Weight of body	○	○	○	○
	Weight of gate	○	○	○	○
	Weight of maintenance bridge	○	○	○	○
	Weight of control house	○	○	○	○
	Weight of machine	○	○	○	○
	Weight of earth	○	○	○	○
	Weight of water	○	○		○
	Weight of muddy soil	○			○
	Uplift	○	○		○
The horizontal load	Hydrostatic pressure	○	○	○	○
	Hydrodynamic pressure due to earthquake				○
	Flowing water force		○		
	Earth pressure	○	○	○	○
	Muddy soil pressure	○			○
	Wind pressure	○	○	○	
	Horizontal earthquake load				○

Symbol " ○ " shows that it puts in the calculation.

Calculation loads are categorized for each calculation cases as follows.

[Normal case: Direction of flowing water]

	Vertical			Horizontal		
	V(tf)	X(m)	Mx(tf-m)	H(tf)	Y(m)	My(tf-m)
Weight of body	3196.980	8.810	28165.394			
Weight of muddy soil	46.910	2.520	118.213			
Weight of water	385.060	5.680	2187.141			
Weight of earth	504.720	9.770	4931.114			
Weight of maintenance bridge	328.800	15.000	4932.000			
Weight of control house	75.600	6.500	491.400			
Weight of machine	49.000	6.500	318.500			
Weight of gate	35.000	6.500	227.500			
Hydrostatic pressure				303.130	2.440	739.637
Flowing water force				7.670	3.880	29.760
Earth pressure				11.190	0.730	8.169
Muddy soil pressure				4.310	2.530	10.904
Wind pressure				18.340	13.350	244.839
Uplift	-1005.750	9.030	-9081.923			
Total	3616.320		32289.340	344.640		1033.309

Vn = 3,616.32 tf

Hn = 344.64 tf

Mn = Mx + My = 33,322.65 tf m

[Normal case: Direction of weir axis]

	Vertical			Horizontal		
	V(tf)	X(m)	Mx(tf-m)	H(tf)	Y(m)	My(tf-m)
Weight of body	3196.980	7.500	23977.350			
Weight of muddy soil	46.910	5.670	265.980			
Weight of water	385.060	9.530	3669.622			
Weight of earth	504.720	13.880	7005.514			
Weight of maintenance bridge	328.800	5.251	1726.529			
Weight of control house	75.600	7.125	538.650			
Weight of machine	49.000	7.125	349.125			
Weight of gate	35.000	4.250	148.750			
Hydrostatic pressure				346.710	1.970	683.019
Flowing water force						
Earth pressure				509.540	3.920	1997.397
Muddy soil pressure						
Wind pressure				15.290	12.070	184.550
Uplift	-1005.750	7.500	-7543.125			
Total	3616.320		30138.394	871.540		2864.966

Vn = 3,616.32 tf

Hn = 871.54 tf

Mn = Mz - My = 27,273.43 tf m

[Design flooding case: Direction of flowing water]

	Vertical			Horizontal		
	V(tf)	X(m)	Mx(tf-m)	H(tf)	Y(m)	My(tf-m)
Weight of body	3196.980	8.810	28165.394			
Weight of muddy soil						
Weight of water	679.090	9.560	6492.100			
Weight of earth	504.720	9.770	4931.114			
Weight of maintenance bridge	328.800	15.000	4932.000			
Weight of control house	75.600	6.500	491.400			
Weight of machine	49.000	6.500	318.500			
Weight of gate	35.000	6.500	227.500			
Hydrostatic pressure						
Flowing water force				7.670	3.880	29.760
Earth pressure				11.190	0.730	8.169
Muddy soil pressure						
Wind pressure				27.810	13.730	381.831
Uplift	-1387.500	9.250	-12834.375			
Total	3481.690		32723.634	46.670		419.760

Vf = 3,481.69 tf

Hf = 46.67 tf

Mf = Mx + My = 33,143.39 tf m

[Design flooding case: Direction of weir axis]

	Vertical			Horizontal		
	V(tf)	X(m)	Mx(tf-m)	H(tf)	Y(m)	My(tf-m)
Weight of body	3196.980	7.500	23977.350			
Weight of muddy soil						
Weight of water	679.090	7.900	5364.811			
Weight of earth	504.720	13.880	7005.514			
Weight of maintenance bridge	328.800	5.251	1726.529			
Weight of control house	75.600	7.125	538.650			
Weight of machine	49.000	7.125	349.125			
Weight of gate	35.000	4.250	148.750			
Hydrostatic pressure				324.330	1.980	642.173
Flowing water force						
Earth pressure				509.540	3.920	1997.397
Muddy soil pressure						
Wind pressure				9.970	14.440	143.967
Uplift	-1387.500	7.500	-10406.250			
Total	3481.690		28704.478	843.840		2783.537

Vf = 3,481.69 tf

Hf = 843.84 tf

Mf = Mz - My = 25920.94 tf m

[Construction case: Direction of flowing water]

	Vertical			Horizontal		
	V(tf)	X(m)	Mx(tf-m)	H(tf)	Y(m)	My(tf-m)
Weight of body	3196.980	8.810	28165.394			
Weight of muddy soil						
Weight of water						
Weight of earth	649.580	9.670	6281.439			
Weight of maintenance bridge	193.800	15.000	2907.000			
Weight of control house	75.600	6.500	491.400			
Weight of machine	49.000	6.500	318.500			
Weight of gate	35.000	6.500	227.500			
Hydrostatic pressure						
Flowing water force						
Earth pressure				20.130	0.730	14.695
Muddy soil pressure						
Wind pressure				30.240	13.070	395.237
Uplift						
Total	4199.960		38391.232	50.370		409.932

Vc= 4,199.96 tf

Hc = 50.37 tf

Mc = Mx + My = 38,801.16 tf m

[Construction case: Direction of weir axis]

	Vertical			Horizontal		
	V(tf)	X(m)	Mx(tf-m)	H(tf)	Y(m)	My(tf-m)
Weight of body	3196.980	7.500	23977.350			
Weight of muddy soil						
Weight of water						
Weight of earth	649.580	13.880	9016.170			
Weight of maintenance bridge	193.800	5.251	1017.644			
Weight of control house	75.600	7.125	538.650			
Weight of machine	49.000	7.125	349.125			
Weight of gate	35.000	4.250	148.750			
Hydrostatic pressure						
Flowing water force						
Earth pressure				607.380	3.640	2210.863
Muddy soil pressure						
Wind pressure				26.900	8.670	233.223
Uplift						
Total	4199.960		35047.689	634.280		2444.086

Vc= 4,199.96 tf

Hc = 634.28 tf

Mc = Mz - My = 32,603.60 tf m

[Seismic case: Direction of flowing water]

	Vertical			Horizontal		
	V(tf)	X(m)	Mx(tf-m)	H(tf)	Y(m)	My(tf-m)
Weight of body	3196.980	8.810	28165.394	383.638	4.917	1886.346
Weight of muddy soil	46.910	2.520	118.213	5.629	2.700	15.199
Weight of water	385.060	5.680	2187.141			
Weight of earth	484.000	9.800	4743.200	58.080	6.240	362.419
Weight of maintenance bridge	193.800	15.000	2907.000	23.256	10.510	244.421
Weight of control house	47.250	6.500	307.125	5.670	18.375	104.186
Weight of machine	49.000	6.500	318.500	5.880	16.450	96.726
Weight of gate	35.000	6.500	227.500	4.200	4.571	19.198
Hydrostatic pressure				303.130	2.440	739.637
Hydrodynamic pressure				22.850	3.940	90.029
Flowing water force				7.670	3.880	29.760
Earth pressure				17.850	0.730	13.031
Muddy soil pressure				4.310	2.530	10.904
Wind pressure						
Uplift	-1005.750	9.030	-9081.923			
Total	3432.250		29892.150	842.163		3611.856

Vs= 3,432.25 tf

Hs = 842.163 tf

Ms = Mx + My = 33,504.01 tf m

[Seismic case: Direction of weir axis]

	Vertical			Horizontal		
	V(tf)	X(m)	Mx(tf-m)	H(tf)	Y(m)	My(tf-m)
Weight of body	3196.980	7.500	23977.350	383.638	4.917	1886.346
Weight of muddy soil	46.910	5.670	265.980	5.629	2.700	15.199
Weight of water	385.060	9.530	3669.622			
Weight of earth	484.000	13.880	6717.920	58.080	6.240	362.419
Weight of maintenance bridge	193.800	5.251	1017.644	23.256	10.510	244.421
Weight of control house	47.250	7.125	336.656	5.670	18.375	104.186
Weight of machine	49.000	7.125	349.125	5.880	16.450	96.726
Weight of gate	35.000	4.250	148.750	4.200	4.571	19.198
Hydrostatic pressure				346.710	1.970	683.019
Hydrodynamic pressure						
Flowing water force						
Earth pressure				737.850	3.680	2715.288
Muddy soil pressure						
Wind pressure						
Uplift	-1005.750	7.500	-7543.125			
Total	3432.250		28939.922	1570.913		6126.802

Vs= 3,432.25 tf

Hs = 1,570.91 tf

Ms = Mz - My = 22,813.12 tf m

2. Stability Analysis

Type of Pile

The prestressed concrete pile is adopted for the foundation pile of end piers.

Refer to stability calculation of center pier.

Pile Diameter and Arrangement

There are many cases for the combination of pile diameter and pile arrangement (number of pile). Judging from the structural size, geological and soil mechanical conditions, the following three alternatives are selected for comparative study. It is noted that the maximum pile diameter which is available in this country, is 600 mm.

Alternative-1	PC Pile Dia.600 mm, type A	80 piles
Alternative-2	PC Pile Dia.600 mm, type B	72 piles
Alternative-3	PC Pile Dia.600 mm, type A + Concrete filling	36 piles

The allowable bearing capacity of ground is shown in each alternative pile as follows.

Layer	Li (m)	N – Value Average	Fi (tf / m)	Li·Fi (tf / m)
As	5.20	33	6.60	34.32
Ac	4.60	22	13.20	60.72
Total	9.80			95.04

(Dia 600 mm)

$$A = \pi/4\, D^2 = \pi/4 \times (0.60)^2 = 0.283 m^2$$

$$qd = 500\, tf / m^2 \times A = 141.50\, tf$$

$$U = \pi D = \pi \times 0.60 = 1.885\, m$$

$$Ru = 141.50 + 1.885 \times 95.04 = 320.65\, tf / pile$$

Allowable bearing capacity
for PC pile (Dia 600 mm)

Case	Safety factor	Allowable bearing capacity (tf / pile)
Normal	3	106.88
Seismic	2	160.33

Calculation Results

Pile stability analyses for Alternative-1, Alternative-2 and Alternative-3 were conducted based on the conditions mentioned above. As a result Alternative-3 (pile dia.=600mm, n=56 piles) was selected for the economical reason. The calculation results are shown as follows.

COMPARATIVE STUDY ON PILE FOUNDATION FOR END PIER

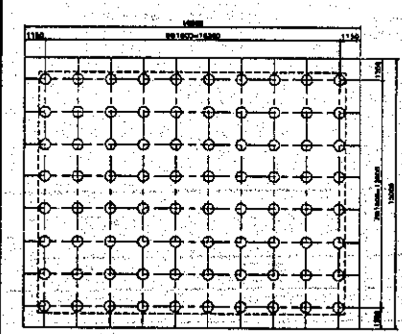
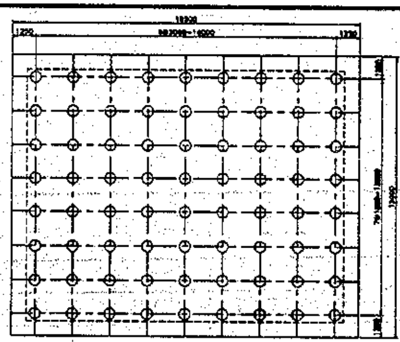
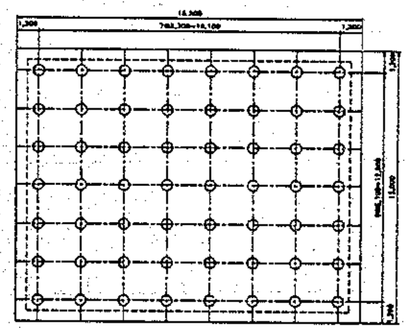
Kind of pile	Alternative-1 Dia. 600 (A)			Alternative-2 Dia. 600 (B)			Alternative-3 Dia. 600 (A) +Concrete Filling		
Pile Arrangement	 FLOW			 FLOW			 FLOW		
Number of necessary pile	80 piles (L=9.80m)			72 piles (L=9.80m)			56 piles (L=9.80m)		
Displacement	Calculation (mm)	Allowable capacity (mm)		Calculation (mm)	Allowable capacity (mm)		Calculation (mm)	Allowable capacity (mm)	
Normal Case	0.7	10		0.8	10		0.9	10	
Design flooding Case	0.4	10		0.4	10		0.5	10	
Constructional Case	0.6	10		0.7	10		0.8	10	
Seismic Case	0.7	15		0.8	15		0.9	15	
Force / Moment Acting on Pile	Axial load (tf/pile)	Bending moment (tf-m)		Axial load (tf/pile)	Bending moment (tf-m)		Axial load (tf/pile)	Bending moment (tf-m)	
		Calculation	Allowable capacity		Calculation	Allowable capacity		Calculation	Allowable capacity
Normal Case	42.84	8.56	11.42	48.34	9.58	10.56	75.85	11.55	12.15
Design flooding Case	28.07	5.25	9.88	43.82	5.88	11.01	50.41	7.07	11.94
Constructional Case	44.31	6.70	11.57	67.59	7.51	8.66	104.68	9.04	11.89
Seisimic Case	28.69	14.01	15.20	58.94	15.68	24.50	53.80	18.60	18.87
Bearing capacity (tf) Normal	106.88			106.88			106.88		
Bearing capacity (tf) Seisimic	160.33			160.33			160.33		
Summary of cost	Rp 135.6 million			Rp 147.9 million			Rp 111.6million		
Evaluation	Not adopted			Not adopted			Adopted		

TABLE OF STABILITY CALCULATION FOR END PIER

Direction		Direction of flowing water				Direction of weir axis			
Case		Normal case	Design Flooding case	Construction case	Seismic case	Normal case	Design Flooding case	Construction case	Seismic case
Quantity of displacement for footing (m)	Horizontal (δX m)	0.0003818	0.0000334	0.0000327	0.0010195	0.0009366	0.0005483	0.0008108	0.0009497
	Allowable	0.010	0.010	0.010	0.015	0.010	0.010	0.010	0.015
	Vertical (δY m)	0.0007768	0.0005867	0.0010032	0.0005487	0.0006135	0.0006078	0.0005233	0.0008721
	Allowable	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Axial force (tf/pile)	No.1	58.8838	44.6196	75.3333	43.5461	48.9273	46.1127	45.5434	64.4055
	No.2	59.8855	45.6595	75.2695	47.9905	53.4148	46.8283	55.3989	62.6375
	No.3	60.8872	46.6994	75.2057	52.4349	57.9023	47.5438	65.2544	60.8695
	No.4	61.8890	47.7393	75.1419	56.8792	62.3898	48.2593	75.1100	59.1014
	No.5	62.8924	48.7793	75.0781	61.3236	66.8773	48.9748	84.9655	57.3334
	No.6	63.8941	49.8192	75.0143	65.7680	71.3648	49.6903	94.8211	55.5654
	No.7	64.8941	50.8591	74.9505	70.2124	75.8523	50.4058	104.6766	53.7974
	No.8	65.8959	51.8990	74.8867	74.6567	-	-	-	
	No.9	-	-	-	-	-	-	-	
Allowable bearing capacity (tf/pile)		106.88	106.88	106.88	160.33	106.88	106.88	106.88	160.33
Shearing stress (tf)		5.6259	0.4200	0.4938	14.8871	13.5737	8.1214	11.2021	25.4211
Bending moment (tf-m/pile)		4.8713	0.2994	0.4376	12.7710	11.5524	7.0707	9.0382	18.5952
Allowable bending moment (tf-m/pile)		12.90	11.83	14.10	18.11	12.15	11.94	11.89	18.87

Number of piles: n=56 piles

Pile head condition: Fixing

<u>Pile condition</u>

1. Diameter: Dia.600 mm
2. Geometrical moment of area: $I = 0.0063600\ m^4$
3. Section area of pile $A = 0.282000\ m^2$