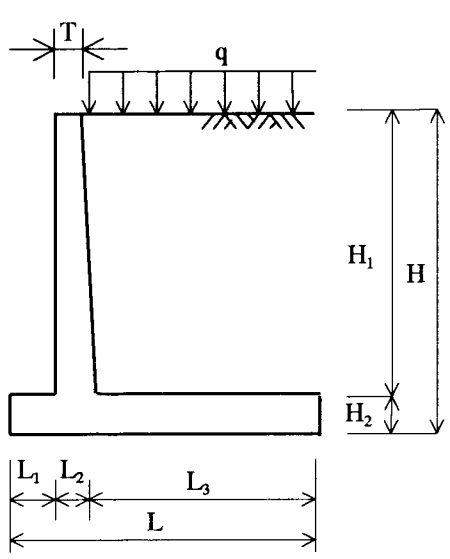
APPENDIX C.4.6-1 Structural Analysis of Retaining Wall

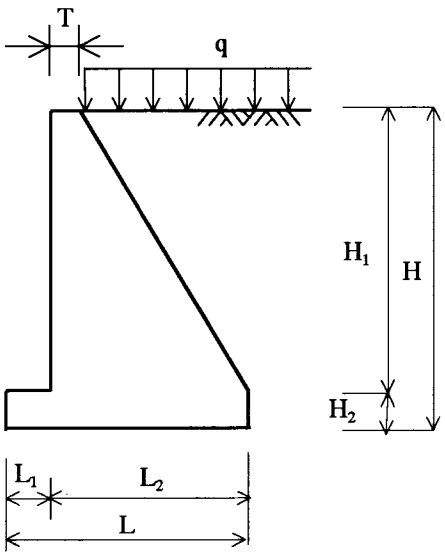
(1) Stability Analysis of Retaining Wall

(a) Design Criteria

1) Sectional Dimension for Analysis



Type W1～W6



Type W7

Table 1 Dimensions of inverted T-shape Wall

Type	W 1	W 2	W 3	W 4	W 5	W 6	W 7
H (m)	6.80	6.70	4.00	8.90	9.00	4.60	2.50
L (m)	4.90	4.40	4.50	5.80	11.00	2.80	1.80
T (m)	0.30	0.30	0.30	0.30	0.30	0.30	0.30
H_1 (m)	6.20	6.10	3.50	8.00	8.00	4.00	1.90
H_2 (m)	0.60	0.60	0.50	0.90	1.00	0.60	0.60
L_1 (m)	1.50	1.50	2.00	1.50	5.00	0.70	0.70
L_2 (m)	0.60	0.60	0.50	0.90	1.00	0.50	1.10
L_3 (m)	2.80	2.30	2.00	3.40	5.00	1.60	—

2) Coefficient of Earth Pressure ; Ka=0.333

3) Live Load ; q=1.00 tf/m^2 (Type W2,6,7)
q=2.00 tf/m^2 (Type W1)
q=0.00 tf/m^2 (Type W3,5)
q=3.489 tf/m^2 (Type W4) ※

4) Case Studies on Stability Analysis

The two case studies as follows have been carried out on the necessary stability analysis.

Case 1 : After Construction

Case 2 : Under Construction

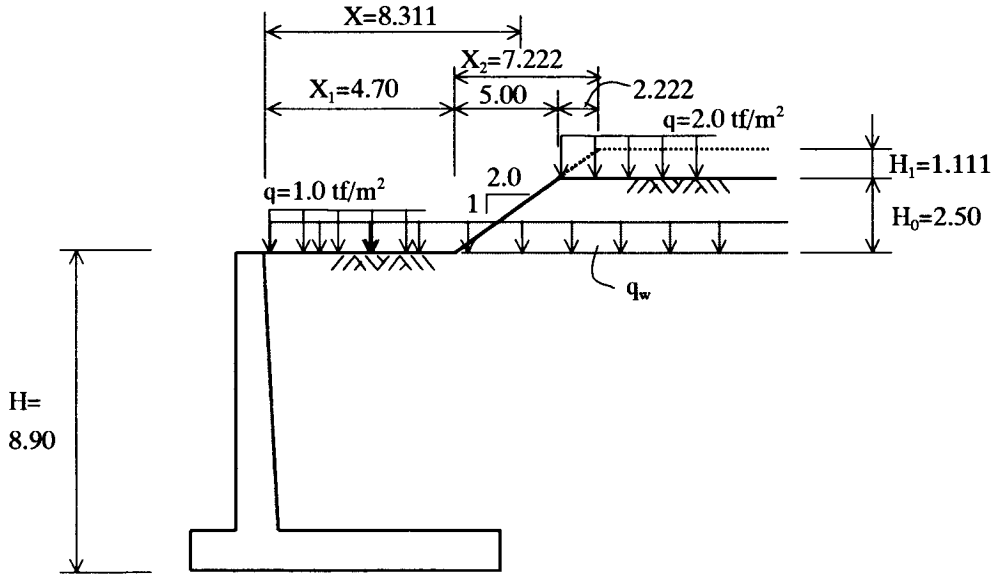
(b) Check of Stability

The Wall stability analysis has been made to show the results in Table 2.

(2) Structural Analysis of Retaining Wall

Results of Calculation of wall have been made to show the results in Table 3.

※ Calculation of Live Load for Type W4
Sectional dimension for calculation



Live load should be calculated by following method.

$$H1 = \frac{q}{\gamma} = \frac{2.0}{1.8} = 1.111 \quad (m)$$

$$X = X_1 + \frac{X_2}{2} = 4.7 + \frac{X_2}{2} = 8.311 \quad (m)$$

$$\frac{X}{H} = \frac{8.311}{8.9} = 0.934$$

$$I_w = 1 + \left(\frac{X}{H}\right)^2 - \frac{2}{\pi}\left\{1 + \left(\frac{X}{H}\right)^2\right\} \tan^{-1}\left(\frac{X}{H}\right) - \frac{2}{\pi}\left(\frac{X}{H}\right)$$

$\tan^{-1}\left(\frac{X}{H}\right)$: radian

$$= 1 + 0.934^2 - \frac{2}{\pi}\left(1 + 0.934^2\right) \tan^{-1} 0.934 - \frac{2}{\pi} \times 0.934$$

$$= 0.383$$

$$q_w = \gamma \ (H_0 + H_1)\, I_w$$
$$= 1.8 \times (2.5 + 1.111) \times 0.383$$
$$= 2.489 \quad (tf/m^2)$$
$$Q = 2.489 + 1.000 = 3.489 \quad (tf/m^2)$$

Table 2 Result of Stability Analysis

Type		Vertical Force ΣV (tf)	Stabilizing Moment ΣV · x (tf·m)	Horizontal Force ΣH (tf)	Overturning Moment ΣV·x (tf·m)	Against Sliding Factor of Safety Fs	Fsa	Against Overturning E (m)	B/6 (m)	Soil Reaction Q_1 (t/m^2)	Q_2 (t/m^2)
W1	Case 1	46.961	142.221	18.387	46.815	1.53	> 1.50	0.418	< 0.817	14.494	4.674
	Case 2	14.039	29.496	0.000	0.000	—	—	0.349	< 0.817	4.089	1.641
W2	Case 1	40.094	111.242	15.685	37.517	1.53	> 1.50	0.361	< 0.733	13.600	4.624
	Case 2	13.193	25.885	0.000	0.000	—	—	0.238	< 0.733	3.972	2.025
W3	Case 1	16.117	45.053	8.000	10.664	1.21	> 1.20	0.116	< 0.750	4.137	3.026
	Case 2	8.942	20.120	0.000	0.000	—	—	0.000	< 0.750	1.987	1.987
W4	Case 1	91.785	321.825	34.079	116.447	1.62	> 1.50	0.662	< 0.967	26.669	4.981
	Case 2	24.549	58.549	0.000	0.000	—	—	0.515	< 0.967	6.488	1.978
W5	Case 1	81.090	566.552	40.500	121.500	1.20	= 1.20	0.012	< 1.833	7.419	7.325
	Case 2	39.690	218.295	0.000	0.000	—	—	0.000	< 1.833	3.608	3.608
W6	Case 1	20.246	33.086	7.874	13.246	1.54	> 1.50	0.419	< 0.466	13.738	0.739
	Case 2	8.017	9.276	0.000	0.000	—	—	0.242	< 0.466	4.351	1.381
W7	Case 1	6.911	7.662	2.706	2.601	1.53	> 1.50	0.168	< 0.300	5.986	1.693
	Case 2	5.543	5.565	0.000	0.000	—	—	-0.104	< 0.300	2.012	4.147
Bridge	—	284.42	2,940.964	0.000	0.000	—	—	0.910	< 3.917	15.708	9.573
Gate	—	238.87	2,428.538	0.000	0.000	—	—	1.083	< 3.917	13.682	7.550

Table 3 Result of Structural Analysis for Retaining Wall (1/2)

Type	Item		Stem		Toe	Heel
W1	Position		H=0.0 m	H=3.4 m	—	—
	Moment	(t·m)	36.609	4.803	13.700	23.354
	Shear Force	(t)	15.650	4.214	17.729	14.806
	Reg'd Reinf.	(cm^2)	42.644	8.480	16.664	28.406
	Reinf.	(cm^2)	5-D22+5-D25 =43.55	5-D16 =10.05	5-D13+5-D16 =16.70	5-D16+5-D22 =29.05
	Stress	σ_c (kg/cm^2)	78.2	31.6	40.5	56.4
		σ_s (kg/cm^2)	1,752	1,429	1,695	1,706
		τ (kg/cm^2)	3.4	1.3	3.7	3.1
W2	Position		H=0.0 m	H=2.8 m	—	—
	Moment	(t·m)	28.871	5.404	12.531	16.389
	Shear Force	(t)	13.183	4.363	16.067	12.745
	Reg'd Reinf.	(cm^2)	33.262	8.150	15.242	19.935
	Reinf.	(cm^2)	10-D22 =38.00	5-D16 =10.05	10-D16 =20.10	10-D16 =20.10
	Stress	σ_c (kg/cm^2)	64.7	31.9	34.6	45.2
		σ_s (kg/cm^2)	1,554	1,364	1,301	1,699
		τ (kg/cm^2)	2.9	1.2	3.3	2.7
W3	Position		H=0.0 m	—	—	—
	Moment	(t·m)	7.146	—	5.497	3.070
	Shear Force	(t)	6.125	—	5.332	2.905
	Reg'd Reinf.	(cm^2)	9.733	—	8.241	4.603
	Reinf.	(cm^2)	5-D16 =10.05	—	5-D16 =10.05	5-D13 =6.65
	Stress	σ_c (kg/cm^2)	36.4	—	27.8	18.3
		σ_s (kg/cm^2)	1,621	—	1,380	1,145
		τ (kg/cm^2)	16.0	—	1.3	0.7
W4	Position		H=0.0 m	H=4.5 m	—	—
	Moment	(t·m)	88.328	11.399	25.418	62.856
	Shear Force	(t)	28.475	7.738	32.488	29.770
	Reg'd Reinf.	(cm^2)	65.541	13.889	19.742	48.819
	Reinf.	(cm^2)	6-D25+6-D28 =66.42	6-D25 =29.46	6-D13+6-D16 =20.04	6-D22+6-D25 =52.26
	Stress	σ_c (kg/cm^2)	77.9	78.4	34.0	59.0
		σ_s (kg/cm^2)	1,763	829	1,657	1,641
		τ (kg/cm^2)	4.0	3.2	4.2	4.1

Table 3 Result of Structural Analysis for Retaining Wall (2/2)

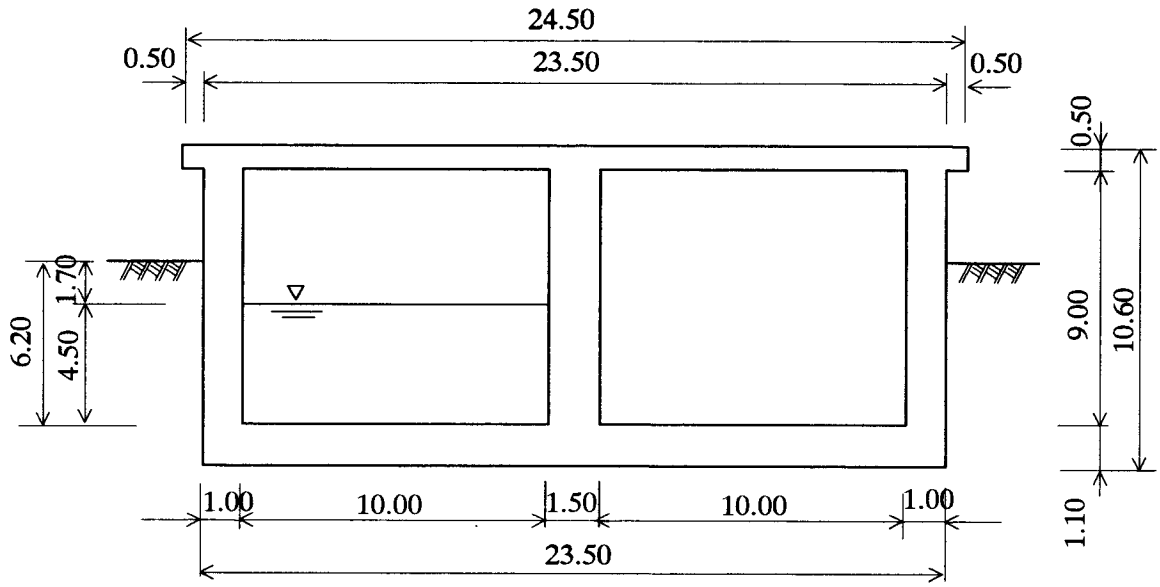
Type	Item		Stem	Toe	Heel	
W5	Position		H=0.0 m	H=3.6 m	—	—
	Moment	(t·m)	85.333	14.201	61.939	38.893
	Shear Force	(t)	32.000	9.680	24.739	15.521
	Reg'd Reinf.	(cm^2)	55.871	13.237	42.935	26.960
	Reinf.	(cm^2)	10-D28 =61.60	5-D28 =30.08	5-D22+5-D25 =43.55	10-D19 =28.35
	Stress	σ_c (kg/cm^2)	64.0	27.0	51.4	37.9
		σ_s (kg/cm^2)	1,603	763	1,707	1,617
		τ (kg/cm^2)	3.9	1.8	3.0	3.0
W6	Position		H=0.0 m	H=2.0 m	—	—
	Moment	(t·m)	9.058	1.465	2.757	6.891
	Shear Force	(t)	6.127	1.865	7.537	6.841
	Reg'd Reinf.	(cm^2)	12.557	2.359	3.353	8.382
	Reinf.	(cm^2)	8-D16 =16.08	4-D16 =8.04	4-D13 =5.32	4-D19 =11.34
	Stress	σ_c (kg/cm^2)	38.6	12.5	13.0	23.7
		σ_s (kg/cm^2)	1,326	491	1,030	1,237
		τ (kg/cm^2)	1.6	0.6	1.5	1.4
W7	Position		—	—	—	—
	Moment	(t·m)	—	—	0.967	—
	Shear Force	(t)	—	—	2.635	—
	Reg'd Reinf.	(cm^2)	—	—	—	—
	Reinf.	(cm^2)	—	—	—	—
	Stress	σ_c (kg/cm^2)	—	—	1.61 < 3.00	—
		σ_s (kg/cm^2)	—	—	—	—
		τ (kg/cm^2)	—	—	0.44 < 7.00	—

APPENDIX C.4.6-2 Structural Analysis for Gate Section

(1) Gate Section

(a) Design Criteria

1) Sectional Dimension for Analysis



Gate Section

2) Case of analysis

Considering condition, next cases should be analyzed.

Case 1 ; 1 Cell is filled by water (Depth=4.5m)

Case 2 ; Empty

3) Active Load

Crowd Load on Top Slab ; $q = 0.30$ tf/m^2

Live Load ; $Q = 2.00$ tf/m^2

Gate Weight ; $F_1 = 3.50$ tf/m

Hoist Weight ; $F_2 = 1.00$ tf/m

4) Earth Pressure

Coefficient of Earth Pressure ; Ka=0.333

Earth Weight ; $\gamma_t = 1.8$ tf/m^3

5) Calculation of Soil Reaction

Case 1 (1cell filled by water)

Item	Vertical Load (tf)	χ (m)	Moment (tf·m)
Own Weight	170.52	11.25	1,918.35
Water Weight	45.00	5.50	247.50
Crowd Load	7.35	11.25	82.69
Gate & Hoist Weight	16.00	11.25	180.00
Total	238.87		2,428.54

$\chi = (\Sigma M / \Sigma V) =$ 10.167 (m)

Bottom Slab Length = 22.5 (m) (Rigid Frame Dimension)

Eccentric Length e = 1.083 (m)

Soil Reaction $Q_1 =$ 13.682 (tf/m^2)

$Q_2 =$ 7.550 (tf/m^2)

Case 2 (Empty)

Item	Vertical Load (tf)
Weight of Top Slab & Wall	107.19
Crowd Load	7.35
Gate & Hoist Weight	16.00
Total	130.54

Bottom Slab Length = 22.5 (m) (Rigid Frame Dimension)

Soil Reaction = 5.802 (tf/m^2)

6) Design of Reinforcement

Design of reinforcement is decided by using biggest required area of tension reinforcement.

(b) Result of Structural Analysis

Load and sectional force are showed Figure 1 and 2, and results of analysis are showed Table 1 and 2.

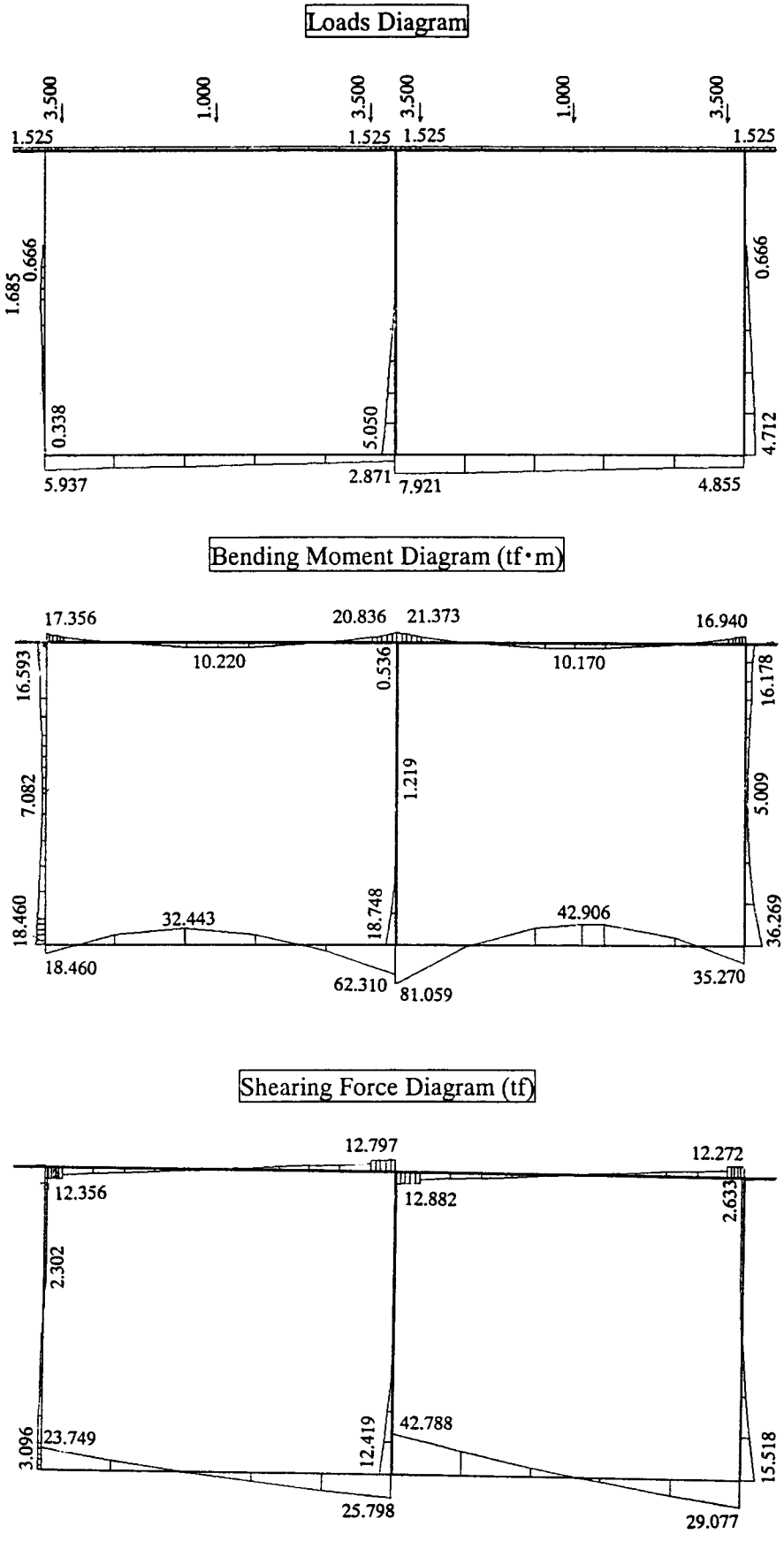


Figure 1 Load and Sectional Force of Case 1 (1cell filled by water)

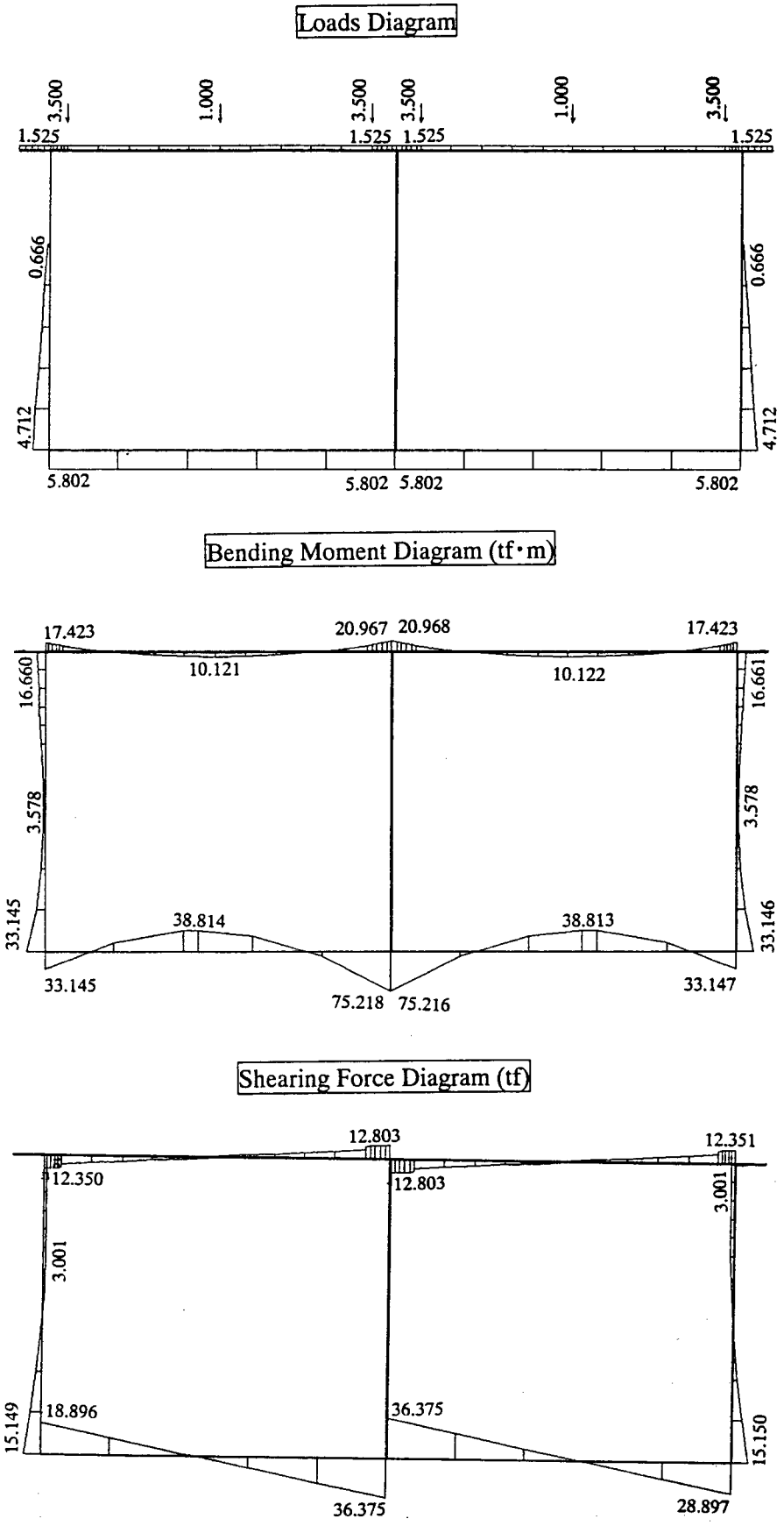


Figure 2 Load and Sectional Force of Case 2 (Empty)

Table 1 Structural Analysis of Gate Section Case 1 (1 Cell filled by water)

Item		Bending Moment (tf·m)	Shearing Force (tf)	Axial Force (tf)	Effective Depth (m)	Required Effective Depth (m)	Required Area of Tension Reinforcement (cm^2)	Reinforcing Bar Schedule (cm^2)
Upper Plate (Left)	Left End	**17.356**	**12.356**	**2.302**	**0.430**	**0.342**	**25.362**	**10-D19=28.35**
	Center	**10.220**	**0.530**	**2.302**	**0.430**	**0.265**	**14.664**	**5-D13+5-D16=16.70**
	Right End	**20.836**	**12.797**	**2.302**	**0.430**	**0.374**	**30.579**	**5-D19+5-D22=33.18**
Upper Plate (Right)	Left End	21.373	12.882	2.634	0.430	0.379	31.290	5-D19+5-D22=33.18
	Center	10.170	0.615	2.634	0.430	0.265	14.494	5-D13+5-D16=16.70
	Right End	16.940	12.272	2.634	0.430	0.339	24.645	10-D19=28.35
Side Wall (Left)	Upper End	16.593	2.302	13.881	0.930	0.385	7.928	5-D19=14.18
	Center	**7.082**	**0.000**	**13.881**	**0.930**	**0.293**	**1.335**	**5-D16=10.05**
	Lower End	18.460	3.096	13.881	0.930	0.401	9.222	5-D25=24.55
Separate Wall	Upper End	0.536	0.331	25.679	1.430	0.344	0.000	5-D16=10.05
	Center	1.219	0.000	25.679	1.430	0.351	0.000	5-D16=10.05
	Lower End	**18.748**	**12.419**	**25.679**	**1.430**	**0.488**	**2.058**	**5-D16=10.05**
Side Wall (Right)	Upper End	16.178	2.633	13.797	0.930	0.382	7.662	5-D19=14.18
	Center	5.009	0.000	13.797	0.930	0.268	0.000	5-D16=10.05
	Lower End	**36.269**	**15.517**	**13.797**	**0.930**	**0.527**	**21.588**	**5-D25=24.55**
Bottom Plate (Left)	Left End	18.460	23.749	3.096	1.030	0.362	10.764	5-D25=24.55
	Center	32.442	0.000	3.096	1.030	0.473	19.515	5-D16+5-D19=24.23
	Right End	62.310	25.796	3.096	1.030	0.648	38.209	10-D25=49.10
Bottom Plate (Right)	Left End	**81.058**	**42.788**	**15.515**	**1.030**	**0.763**	**46.774**	**10-D25=49.10**
	Center	**42.906**	**0.000**	**15.515**	**1.030**	**0.576**	**22.895**	**5-D16+5-D19=24.23**
	Right End	**36.270**	**29.077**	**15.515**	**1.030**	**0.537**	**18.742**	**5-D25=24.55**

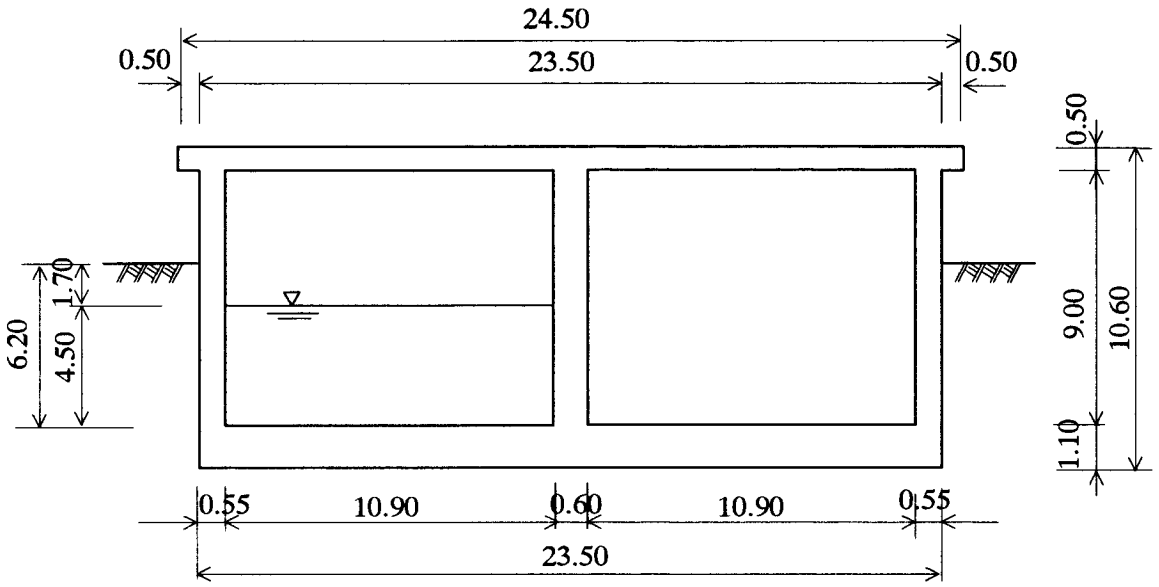
Table 2 Structural Analysis of Gate Section Case 2 (Empty)

Item		Bending Moment (tf·m)	Shearing Force (tf)	Axial Force (tf)	Effective Depth (m)	Required Effective Depth (m)	Required Area of Tension Reinforcement (cm^2)	Reinforcing Bar Schedule (cm^2)
Upper Plate (Left)	Left End	17.423	12.350	3.001	0.430	0.344	26.263	10-D19=28.35
	Center	10.121	0.464	3.001	0.430	0.265	14.317	5-D13+5-D16=16.70
	Right End	20.967	12.803	3.001	0.430	0.376	30.576	5-D19+5-D22=33.18
Upper Plate (Right)	Left End	20.968	12.803	3.001	0.430	0.376	30.577	5-D19+5-D22=33.18
	Center	10.122	0.536	3.001	0.430	0.265	14.317	5-D13+5-D16=16.70
	Right End	17.423	12.351	3.001	0.430	0.344	25.263	10-D19=28.35
Side Wall (Left)	Upper End	16.660	3.001	13.875	0.930	0.386	7.976	5-D19=14.18
	Center	3.578	0.000	13.875	0.930	0.251	0.000	5-D16=10.05
	Lower End	**33.144**	**15.149**	**13.875**	**0.930**	**0.507**	**19.402**	**5-D25=24.55**
Separate Wall	Upper End	0.000	0.000	25.606	1.430	0.339	0.000	5-D16=10.05
	Center	0.000	0.000	25.606	1.430	0.339	0.000	5-D16=10.05
	Lower End	0.000	0.000	25.606	1.430	0.339	0.000	5-D16=10.05
Side Wall (Right)	Upper End	**16.660**	**3.001**	**13.875**	**0.930**	**0.386**	**7.976**	**5-D19=14.18**
	Center	3.578	0.000	13.875	0.930	0.251	0.000	5-D16=10.05
	Lower End	33.144	15.149	13.875	0.930	0.507	19.402	5-D25=24.55
Bottom Plate (Left)	Left End	33.145	28.896	15.149	1.030	0.516	16.879	5-D25=24.55
	Center	38.813	0.000	15.149	1.030	0.551	20.427	5-D16+5-D19=24.23
	Right End	75.218	36.376	15.149	1.030	0.737	43.212	10-D25=49.10
Bottom Plate (Right)	Left End	75.218	36.376	15.149	1.030	0.737	43.212	10-D25=49.10
	Center	38.813	0.000	15.149	1.030	0.551	20.427	5-D16+5-D19=24.23
	Right End	33.145	28.896	15.149	1.030	0.516	16.879	5-D25=24.55

(2) Block out Section

(a) Design Criteria

1) Sectional Dimension for Analysis



Gate Section

2) Case of analysis

Considering condition, next cases should be analyzed.

Case 1 ; 1 Cell is filled by water (Depth=4.5m)

Case 2 ; Empty

3) Active Load

Crowd Load on Top Slab ; $q = 0.30$ tf/m^2

Live Load ; $Q = 2.00$ tf/m^2

Gate Weight ; $F_1 = 3.50$ tf/m

Hoist Weight ; $F_2 = 1.00$ tf/m

4) Earth Pressure

Coefficient of Earth Pressure ; Ka=0.333

Earth Weight ; $\gamma_t = 1.8$ tf/m^3

5) Calculation of Soil Reaction

Case 1 (1cell filled by water)

Item	Vertical Load (tf)	χ (m)	Moment (tf·m)
Own Weight	130.83	11.475	1,501.27
Water Weight	45.00	5.725	257.63
Crowd Load	7.35	11.475	84.34
Gate & Hoist Weight	16.00	11.475	183.60
Total	199.18		2,026.84

$\chi = (\Sigma M / \Sigma V) =$ 10.176 (m)

Bottom Slab Length = 22.95 (m) (Rigid Frame Dimension)

Eccentric Length e = 1.299 (m)

Soil Reaction $Q_1 =$ 11.626 (tf/m^2)

$Q_2 =$ 5.731 (tf/m^2)

Case 2 (Empty)

Item	Vertical Load (tf)
Weight of Top Slab & Wall	67.50
Crowd Load	7.35
Gate & Hoist Weight	16.00
Total	90.85

Bottom Slab Length = 22.95 (m) (Rigid Frame Dimension)

Soil Reaction = 3.959 (tf/m^2)

6) Design of Reinforcement

Design of reinforcement is decided by using biggest required area of tension reinforcement.

(b) Result of Structural Analysis

Load and sectional force are showed Figure 3 and 4, and results of analysis are showed Table 3 and 4.

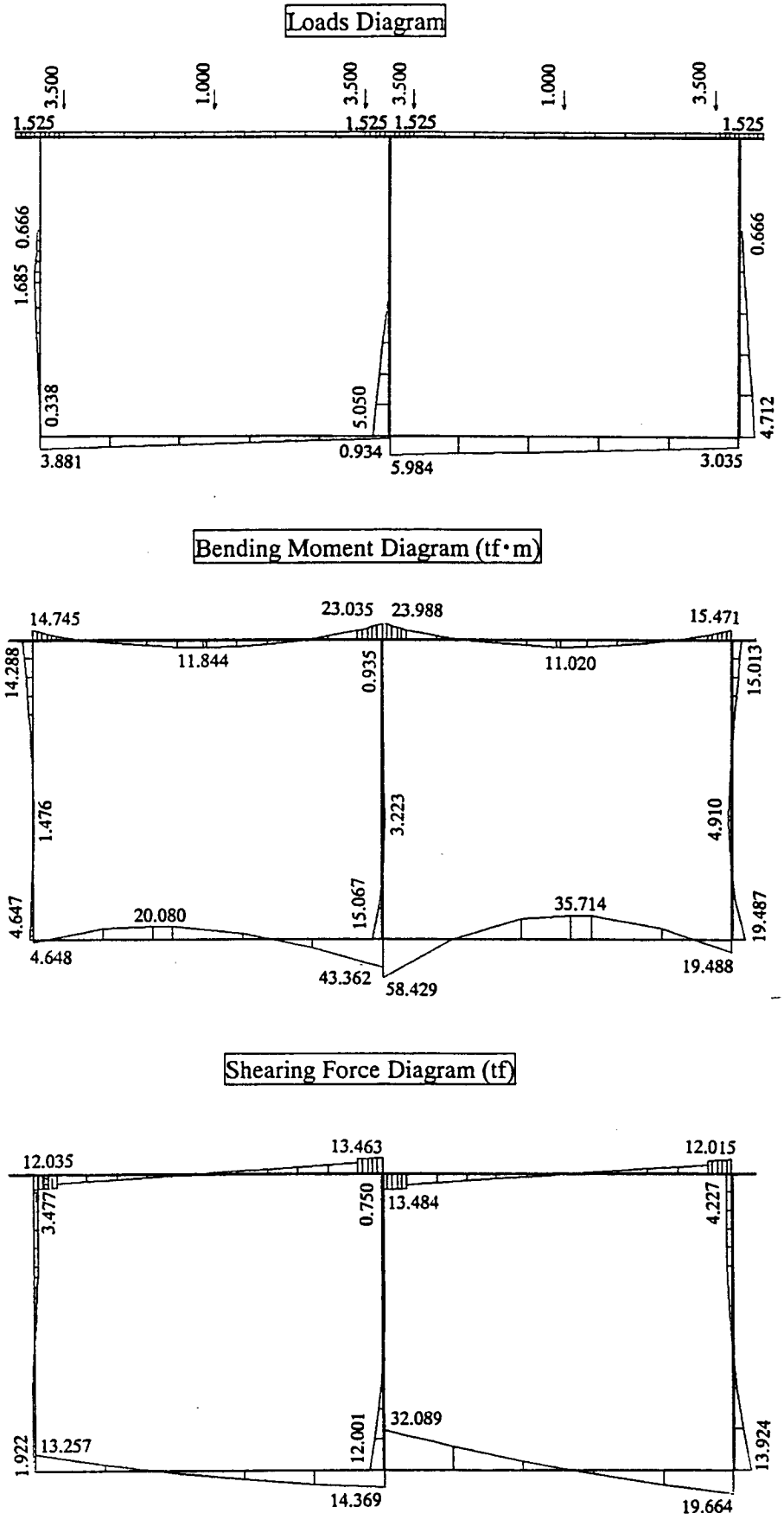


Figure 3 Load and Sectional Force of Case 1 (1cell filled by water)

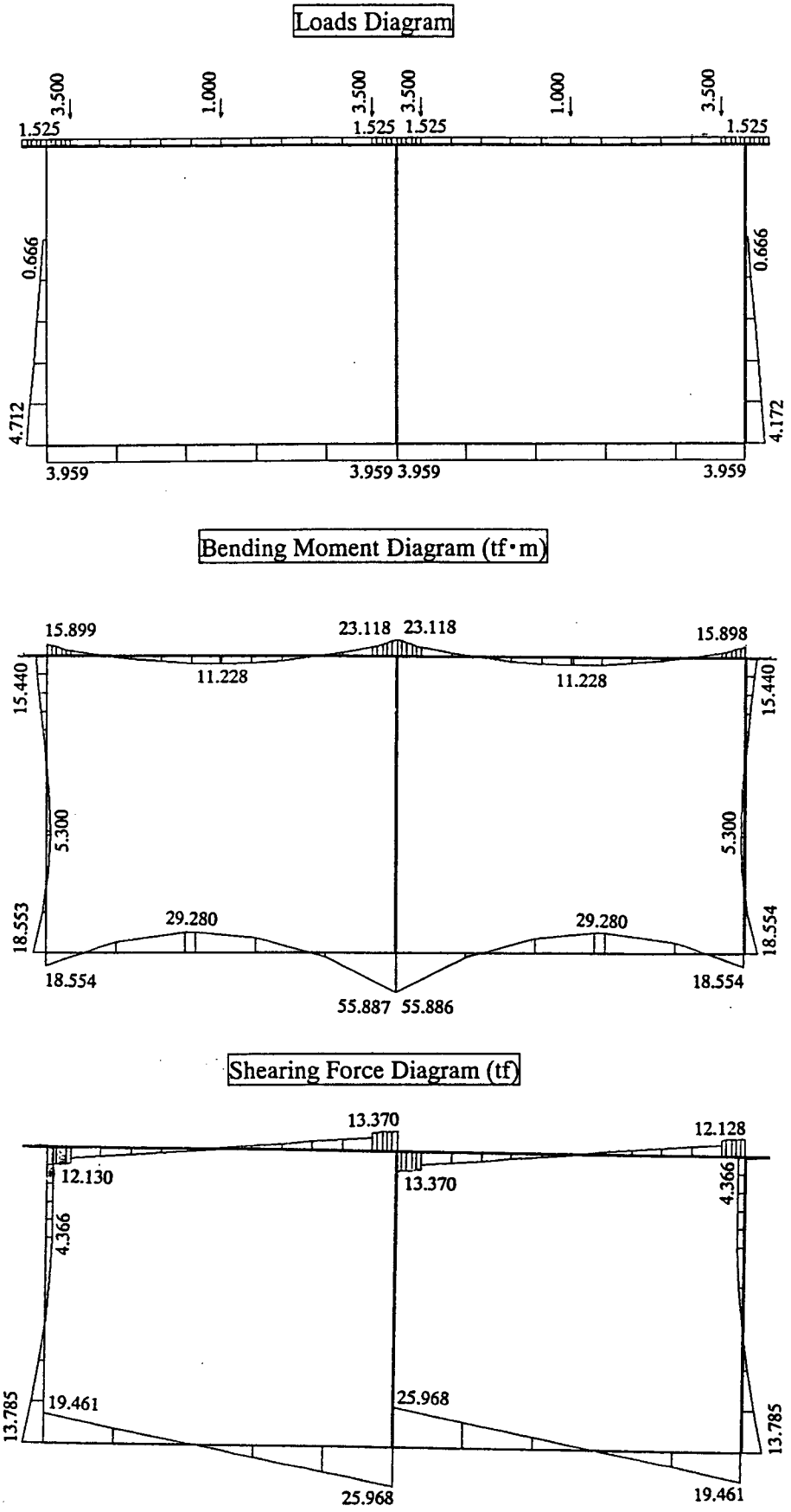


Figure 4 Load and Sectional Force of Case 2 (Empty)

Table 3 Structural Analysis of Block out Section Case 1 (1Cell filled by water)

Item		Bending Moment (tf·m)	Shearing Force (tf)	Axial Force (tf)	Effective Depth (m)	Required Effective Depth (m)	Required Area of Tension Reinforcement (cm^2)	Reinforcing Bar Schedule (cm^2)
Upper Plate (Left)	Left End	14.745	12.035	3.477	0.430	0.318	21.113	10-D19=28.35
	Center	**11.856**	**0.000**	**3.477**	**0.430**	**0.287**	**16.781**	**5-D13+5-D16=16.70**
	Right End	23.035	13.463	3.477	0.430	0.395	33.541	5-D19+5-D22=33.18
Upper Plate (Right)	Left End	**23.988**	**13.484**	**4.227**	**0.430**	**0.404**	**34.755**	**5-D19+5-D22=33.18**
	Center	11.020	0.000	4.227	0.430	0.279	15.313	5-D13+5-D16=16.70
	Right End	15.470	12.015	4.227	0.430	0.327	21.986	10-D19=28.35
Side Wall (Left)	Upper End	14.288	3.477	13.217	0.480	0.335	15.485	5-D19=14.18
	Center	1.476	0.000	13.217	0.480	0.166	0.000	5-D16=10.05
	Lower End	4.647	1.922	13.217	0.480	0.220	2.537	5-D25=24.55
Separate Wall	Upper End	0.953	0.750	26.947	0.530	0.217	0.000	5-D16=10.05
	Center	3.222	0.750	26.947	0.530	0.249	0.000	5-D16=10.05
	Lower End	**15.067**	**12.001**	**26.947**	**0.530**	**0.374**	**10.894**	**5-D16=10.05**
Side Wall (Right)	Upper End	15.013	4.227	13.197	0.480	0.342	16.464	5-D19=14.18
	Center	4.910	0.000	13.197	0.480	0.224	2.896	5-D16=10.05
	Lower End	**19.487**	**13.924**	**13.197**	**0.480**	**0.382**	**22.473**	**5-D25=24.55**
Bottom Plate (Left)	Left End	4.648	13.257	1.922	1.030	0.192	2.419	5-D25=24.55
	Center	20.080	0.000	1.922	1.030	0.372	12.078	5-D16+5-D19=24.23
	Right End	43.362	14.369	1.922	1.030	0.540	26.649	10-D25=49.10
Bottom Plate (Right)	Left End	**58.429**	**32.089**	**13.923**	**1.030**	**0.655**	**33.017**	**10-D25=49.10**
	Center	**35.714**	**0.000**	**13.923**	**1.030**	**0.528**	**18.801**	**5-D16+5-D19=24.23**
	Right End	**19.487**	**19.663**	**13.923**	**1.030**	**0.415**	**8.645**	**5-D25=24.55**

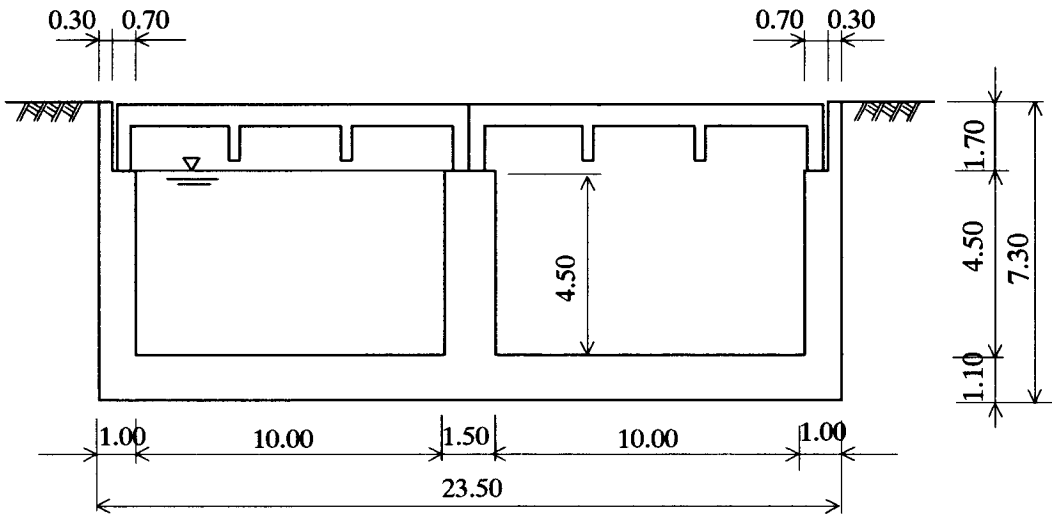
Table 4 Structural Analysis of Block out Section Case 2 (Empty)

Item		Bending Moment (tf·m)	Shearing Force (tf)	Axial Force (tf)	Effective Depth (m)	Required Effective Depth (m)	Required Area of Tension Reinforcement (cm^2)	Reinforcing Bar Schedule (cm^2)
Upper Plate (Left)	Left End	**15.899**	**12.130**	**4.366**	**0.430**	**0.331**	**22.589**	**10-D19=28.35**
	Center	11.228	0.000	4.366	0.430	0.281	15.586	5-D13+5-D16=16.70
	Right End	23.118	13.370	4.366	0.430	0.397	33.411	5-D19+5-D22=33.18
Upper Plate (Right)	Left End	23.118	13.370	4.366	0.430	0.397	33.411	5-D19+5-D22=33.18
	Center	11.228	0.000	4.366	0.430	0.281	15.586	5-D13+5-D16=16.70
	Right End	15.898	12.128	4.366	0.430	0.331	22.587	10-D19=28.35
Side Wall (Left)	Upper End	**15.440**	**4.366**	**13.312**	**0.480**	**0.346**	**17.006**	**5-D19=14.18**
	Center	5.300	0.000	13.312	0.480	0.230	3.387	5-D16=10.05
	Lower End	**18.553**	**13.785**	**13.312**	**0.480**	**0.374**	**21.187**	**5-D25=24.55**
Separate Wall	Upper End	0.000	0.000	26.741	0.530	0.201	0.000	5-D16=10.05
	Center	0.000	0.000	26.741	0.530	0.201	0.000	5-D16=10.05
	Lower End	0.000	0.000	26.741	0.530	0.201	0.000	5-D16=10.05
Side Wall (Right)	Upper End	**15.440**	**4.366**	**13.310**	**0.480**	**0.346**	**17.006**	**5-D19=14.18**
	Center	5.300	0.000	13.310	0.480	0.230	3.388	5-D16=10.05
	Lower End	18.554	13.785	13.310	0.480	0.374	21.188	5-D25=24.55
Bottom Plate (Left)	Left End	18.554	19.461	13.785	1.030	0.407	8.095	5-D25=24.55
	Center	29.280	0.000	13.785	1.030	0.486	14.808	5-D16+5-D19=24.23
	Right End	55.886	25.968	13.785	1.030	0.642	31.461	10-D25=49.10
Bottom Plate (Right)	Left End	55.886	25.968	13.785	1.030	0.642	31.461	10-D25=49.10
	Center	29.280	0.000	13.785	1.030	0.486	14.808	5-D16+5-D19=24.23
	Right End	18.554	19.461	13.785	1.030	0.407	8.095	5-D25=24.55

APPENDIX C.4.6-3 Structural Analysis for Bridge Section

(1) Design Criteria

(a) Sectional Dimension for Analysis



Bridge Section

(b) Case of analysis

Considering condition, next cases should be analyzed.

Case 1 ; 1 Cell is filled by water (Depth=4.5m)

Case 2 ; Empty

(c) Active Load

Live Load	;	Q = 2.00	tf/m^2
Bridge Load (Right, Left)	;	F_1 = 35.0	tf/m
(Center)	;	F_2 = 65.0	tf/m

(d) Earth Pressure

Coefficient of Earth Pressure ; Ka=0.333

Earth Weight ; γ_t = 1.8 tf/m^3

(e) Calculation of Soil Reaction

Case 1 (1cell filled by water)

Item	Vertical Load (tf)	χ (m)	Moment (tf·m)
Own Weight	104.42	11.25	1,174.71
Water Weight	45.00	5.50	247.50
Bridge Load	135.00	11.25	1,518.75
Total	284.42		2,940.96

$\chi = (\Sigma M / \Sigma V) =$ 10.340 (m)

Bottom Slab Length = 22.5 (m) (Rigid Frame Dimension)

Eccentric Length e = 0.910 (m)

Soil Reaction $Q_1 =$ 15.708 (tf/m^2)

$Q_2 =$ 9.573 (tf/m^2)

Case 2 (Empty)

Item	Vertical Load (tf)
Weight of Top Slab & Wall	41.09
Bridge Load	135.00
Total	176.09

Bottom Slab Length = 22.5 (m) (Rigid Frame Dimension)

Soil Reaction = 7.826 (tf/m^2)

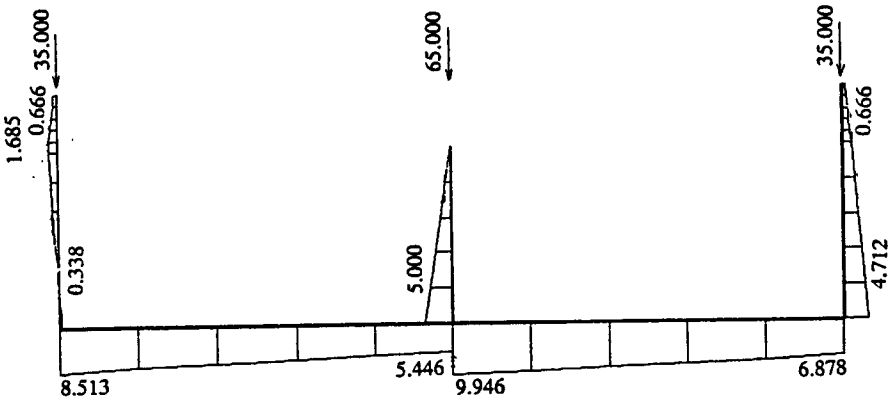
(f) Design of Reinforcement

Design of reinforcement is decided by using biggest required area of tension reinforcement.

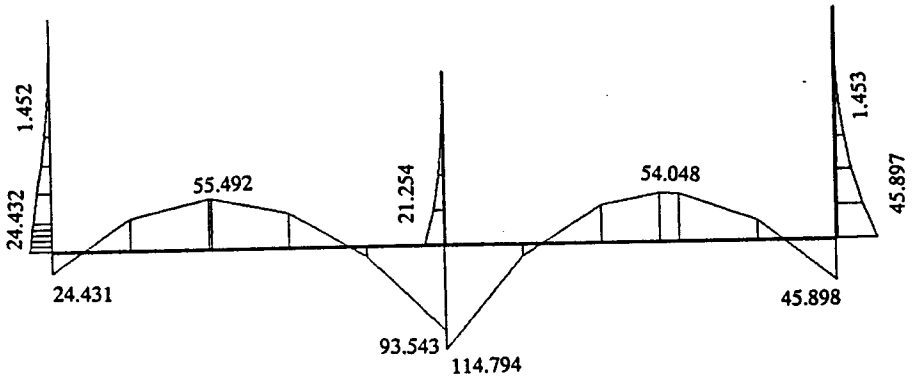
(2) Result of Structural Analysis

Load and sectional force are showed Figure 1 and 2, and results of analysis are showed Table 1 and 2.

Loads Diagram



Bending Moment Diagram (tf·m)



Shearing Force Diagram (tf)

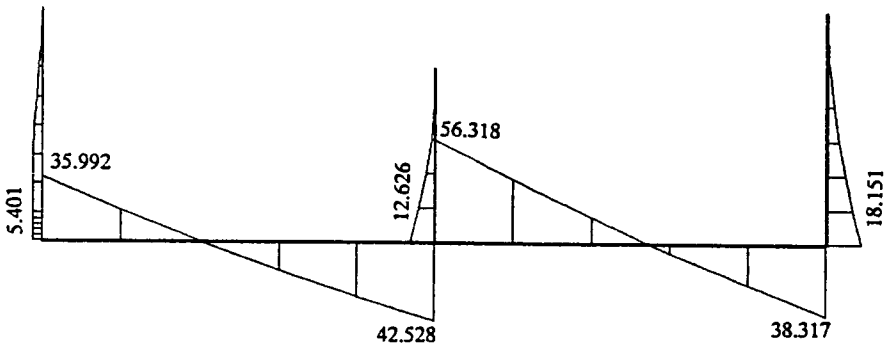
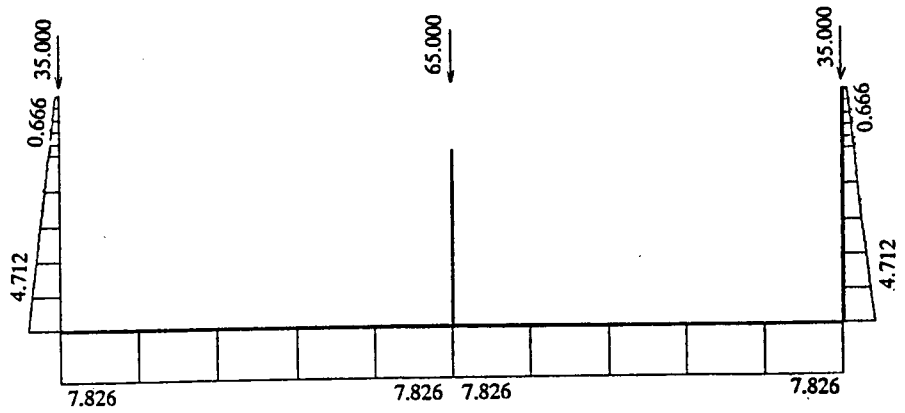
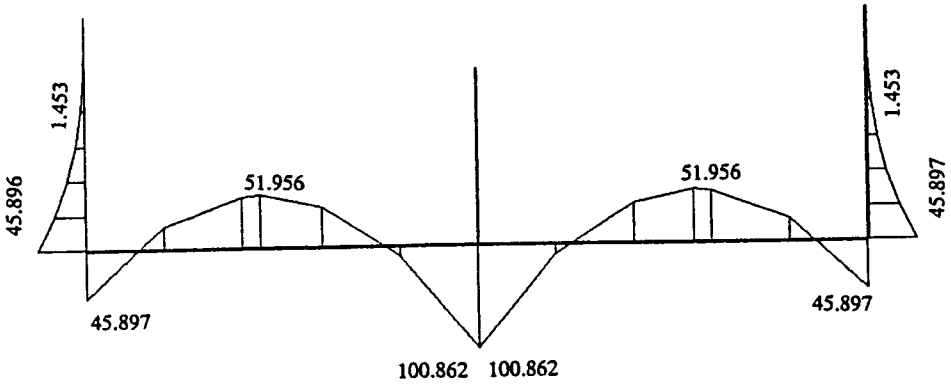


Figure 1 Load and Sectional Force of Case 1 (1 cell filled by water)

Loads Diagram



Bending Moment Diagram (tf·m)



Shearing Force Diagram (tf)

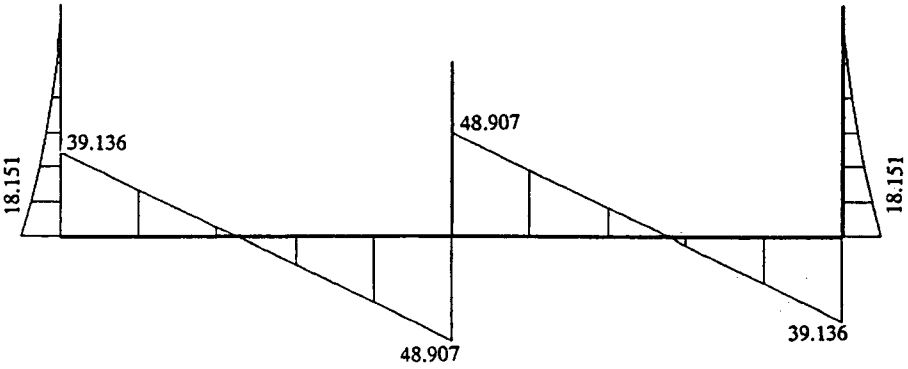


Figure 2 Load and Sectional Force of Case 2 (Empty)

Table 1 Structural Analysis of Bridge Section Case 1 (1 Cell filled by water)

Item		Bending Moment (tf·m)	Shearing Force (tf)	Axial Force (tf)	Effective Depth (m)	Required Effective Depth (m)	Required Area of Tension Reinforcement (cm^2)	Reinforcing Bar Schedule (cm^2)
Side Wall (Left)	Upper End	0.000	0.000	0.000	0.230	0.002	0.000	6-D16=12.06
	Lower End	**24.432**	**5.401**	**35.000**	**0.930**	**0.510**	**7.923**	**6-D13=7.98**
Separate Wall	Upper End	0.003	0.000	65.000	1.430	0.540	0.000	6-D13=7.98
	Lower End	21.254	12.626	65.000	1.430	0.657	0.000	6-D13=7.98
Side Wall (Right)	Upper End	0.000	0.000	0.000	0.230	0.001	0.000	6-D16=12.06
	Lower End	**45.896**	**18.151**	**35.000**	**0.930**	**0.633**	**22.802**	**12-D16=24.12**
Bottom Plate (Left)	Left End	24.430	35.992	5.401	1.030	0.422	13.913	12-D16=24.12
	Center	**55.492**	**0.000**	**5.401**	**1.030**	**0.618**	**33.353**	**12-D19=34.02**
	Right End	93.543	42.528	5.401	1.030	0.796	57.168	12-D25=58.92
Bottom Plate (Right)	Left End	**114.793**	**56.318**	**18.027**	**1.030**	**0.902**	**67.248**	**12-D25=58.92**
	Center	54.048	0.000	18.027	1.030	0.643	29.228	12-D19=34.02
	Right End	45.897	38.317	18.027	1.030	0.599	24.127	12-D16=24.12

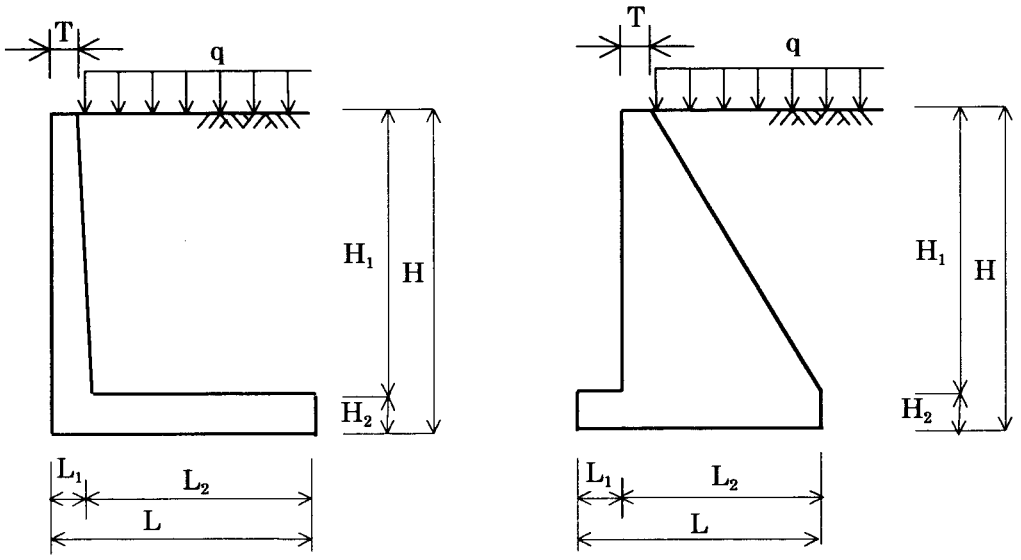
Table 2 Structural Analysis of Bridge Section Case 2 (Empty)

Item		Bending Moment (tf·m)	Shearing Force (tf)	Axial Force (tf)	Effective Depth (m)	Required Effective Depth (m)	Required Area of Tension Reinforcement (cm^2)	Reinforcing Bar Schedule (cm^2)
Side Wall (Left)	Upper End	**0.000**	**0.000**	**0.000**	**0.230**	**0.002**	**0.000**	**6-D16=12.06**
	Lower End	**45.896**	**18.151**	**35.000**	**0.930**	**0.633**	**22.802**	**12-D16=24.12**
Separate Wall	Upper End	0.000	0.000	65.000	1.430	0.539	0.000	6-D13=7.98
	Lower End	0.000	0.000	65.000	1.430	0.539	0.000	6-D13=7.98
Side Wall (Right)	Upper End	**0.000**	**0.000**	**0.000**	**0.230**	**0.000**	**0.000**	**6-D16=12.06**
	Lower End	**45.896**	**18.151**	**35.000**	**0.930**	**0.633**	**22.802**	**12-D16=24.12**
Bottom Plate (Left)	Left End	45.897	39.135	18.151	1.030	0.600	24.095	12-D16=24.12
	Center	51.956	0.000	18.151	1.030	0.632	28.887	12-D19=34.02
	Right End	**100.862**	**48.907**	**18.151**	**1.030**	**0.849**	**58.496**	**12-D25=58.92**
Bottom Plate (Right)	Left End	100.862	48.907	18.151	1.030	0.849	58.496	12-D25=58.92
	Center	51.956	0.000	18.151	1.030	0.632	28.887	12-D19=34.02
	Right End	**45.897**	**39.135**	**18.151**	**1.030**	**0.600**	**24.095**	**12-D16=24.12**

APPENDIX C.4.7-1 Structural Analysis of Retaining Wall

(1) Design Criteria

(a) Sectional Dimension for Analysis



L-Shape Gravity

Table 1 Dimensions of Retaining Wall

Type	L-Shape	Gravity
H (m)	10.50	3.10
L (m)	7.50	2.30
T (m)	0.30	0.30
H_1 (m)	9.00	2.50
H_2 (m)	1.50	0.60
L_1 (m)	1.20	0.50
L_2 (m)	6.30	1.80

(b) Coefficient of Earth Pressure ; Ka=0.333

(c) Live Load ; q=1.00 tf/m^2 (L-Shape)
q=2.00 tf/m^2 (Gravity)

(d) Case Studies on Stability Analysis

The two case studies as follows have been carried out on the necessary stability analysis.

Case 1 : After Construction

Case 2 : Under Construction

(2) Check of Stability

The Wall stability analysis has been made to show the results in Table 2.

Table 2 Result of Stability Analysis for Retaining Wall

Type		Vertical Force ΣV (tf)	Stabilizing Moment ΣV · x (tf·m)	Horizontal Force ΣH (tf)	Overturning Moment ΣV·x (tf·m)	Against Sliding Factor of Safety Fs	Fsa	Against Overturning E (m)	B/6 (m)	Soil Reaction Q_1 (t/m²)	Q_2 (t/m²)
L-Shape	Case 1	153.450	560.816	36.538	134.001	2.52	> 1.50	0.969	< 1.250	36.313	4.607
	Case 2	44.100	110.294	0.000	0.000	—	—	1.249	< 1.250	11.755	0.005
Gravity	Case 1	12.586	16.456	4.945	6.176	1.53	> 1.50	0.333	< 0.383	10.229	0.715
	Case 2	9.211	10.381	0.000	0.000	—	—	0.023	< 0.383	4.245	3.764

Table 3 Result of Structural Analysis for Retaining Wall

Type	Item		Stem		Toe	Heel
L-Shape	Position		H=0.0 m	H=4.5 m	—	—
	Moment	(t·m)	86.314	12.475	—	126.596
	Shear Force	(t)	27.273	7.567	—	12.429
	Reg'd Reinf.	(cm^2)	45.054	10.285	—	57.070
	Reinf.	(cm^2)	10-D25 =49.10	5-D25 =24.55	—	5-D25+5-D28 =55.35
	Stress	σ_c (kg/cm^2)	51.2	21.9	—	47.6
		σ_s (kg/cm^2)	1,586	717	—	1,768
		τ (kg/cm^2)	2.7	1.2	—	1.0
Gravity	Position		—	—	—	—
	Moment	(t·m)	—	—	1.038	—
	Shear Force	(t)	—	—	4.029	—
	Reg'd Reinf.	(cm^2)	—	—	—	—
	Reinf.	(cm^2)	—	—	—	—
	Stress	σ_c (kg/cm^2)	—	—	1.73 < 3.00	—
		σ_s (kg/cm^2)	—	—	—	—
		τ (kg/cm^2)	—	—	0.67 < 7.00	—

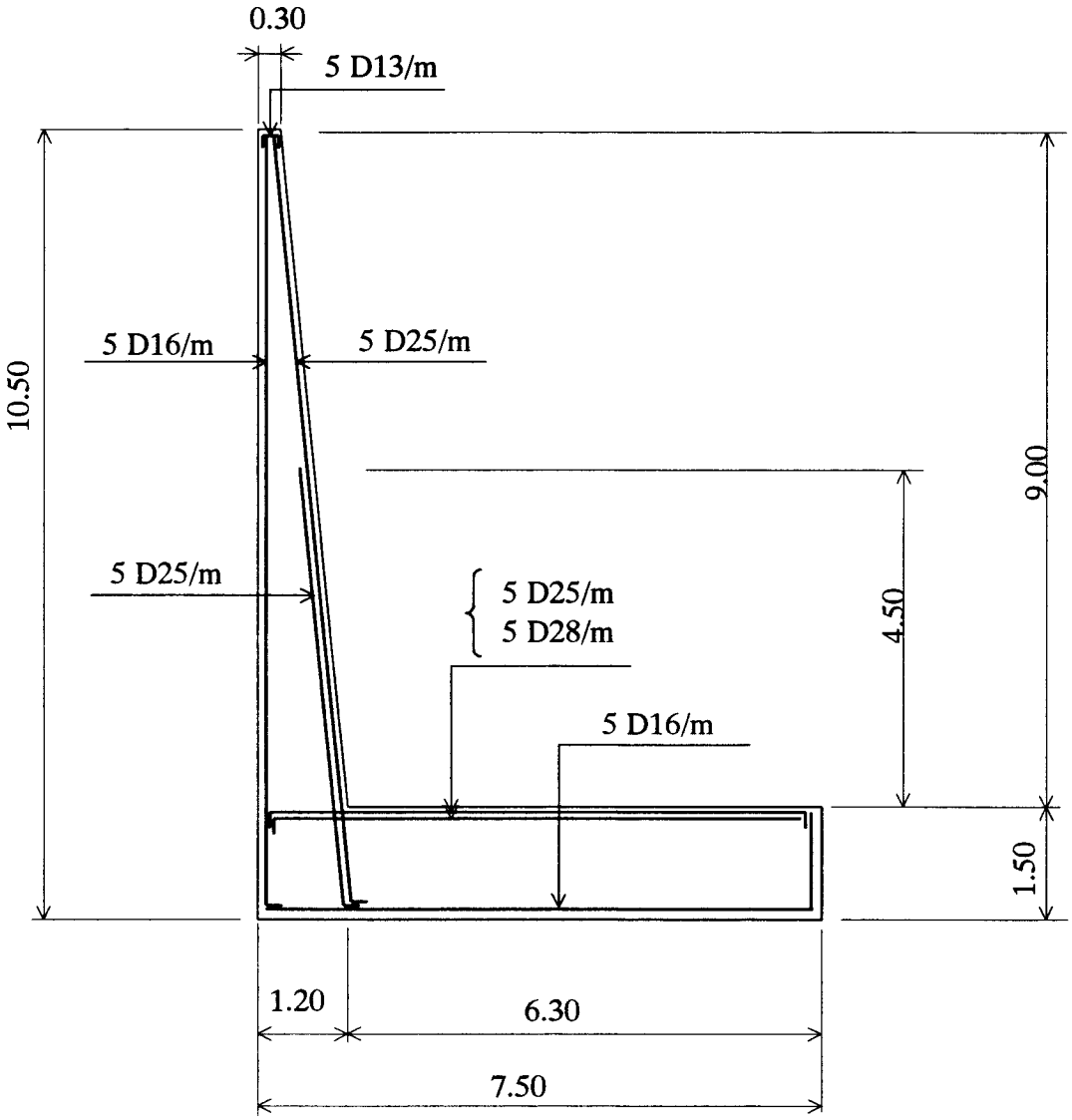
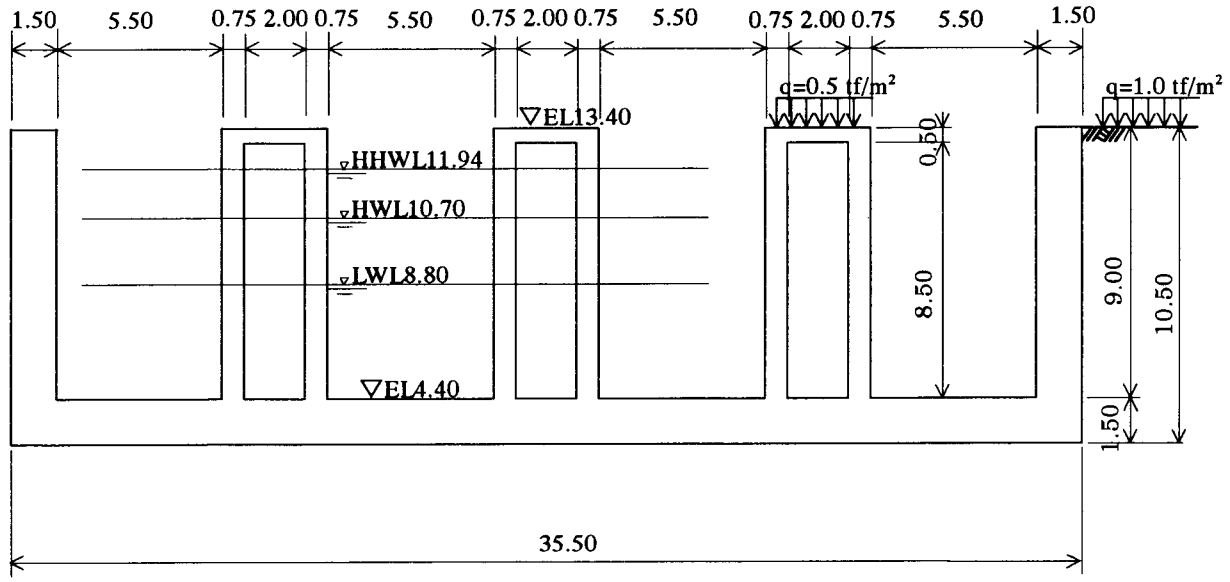


Figure 1 Arrangement of Reinforcement

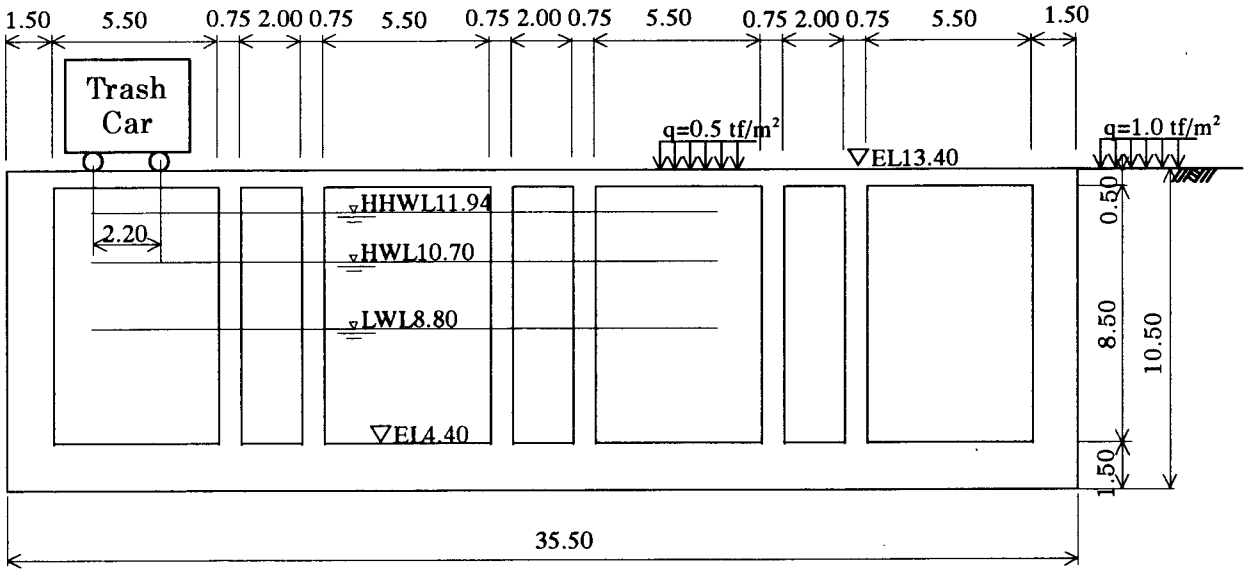
APPENDIX C.4.7-2 Structural Calculation of Intake Canal

(1) Design Criteria

(a) Sectional Dimension for Analysis



Flume Section



Box Culvert Section

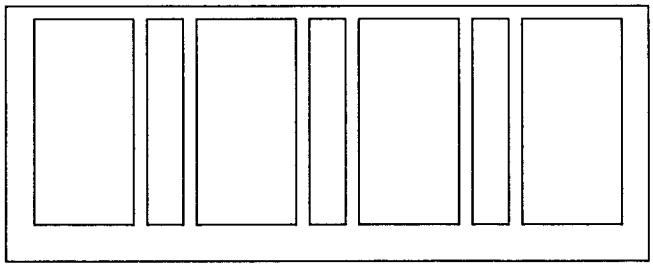
(b) Case of Analysis

Considering condition, next cases should be analyzed each section.

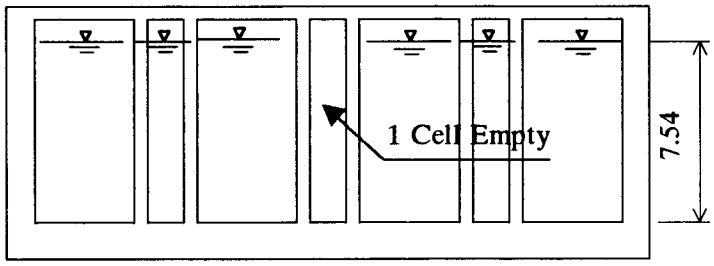
Case 1 Empty in all cell box

Case 2 Filled in by water except 1 cell box

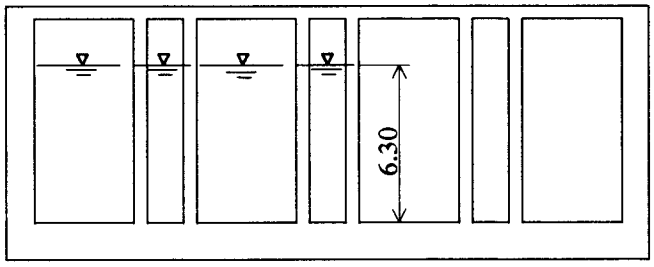
Case 3 Filled 4 cell box filled by Water



Case 1



Case 2



Case 3

(c) Active Load

Live Load ; Trash Car P= 4.3 tf/wheel (4 wheels)

q=0.50 tf/m^2 (on the top plate)

q=1.00 tf/m^2 (on the ground surface)

(d) Earth Pressure

Coefficient of Earth Pressure ; Ka=0.333 (Flume type side wall)

Ka=0.50 (Box rahmen type side wall)

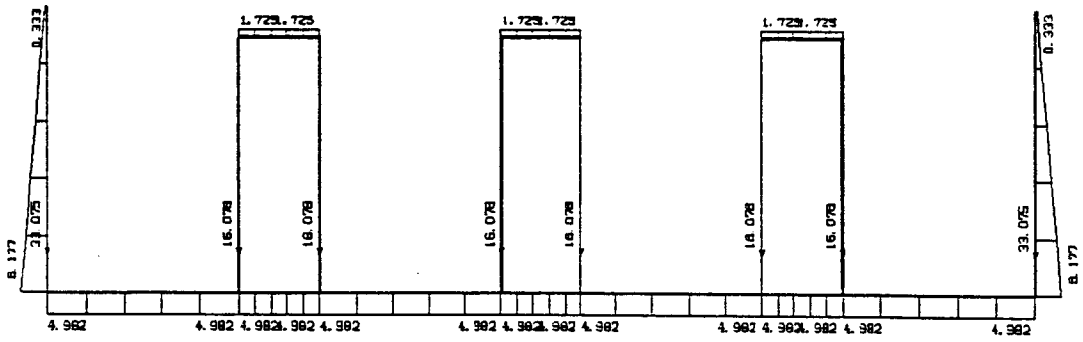
Earth Weight ; γ_t=1.8 tf/m^3

(e) Design of Reinforcement

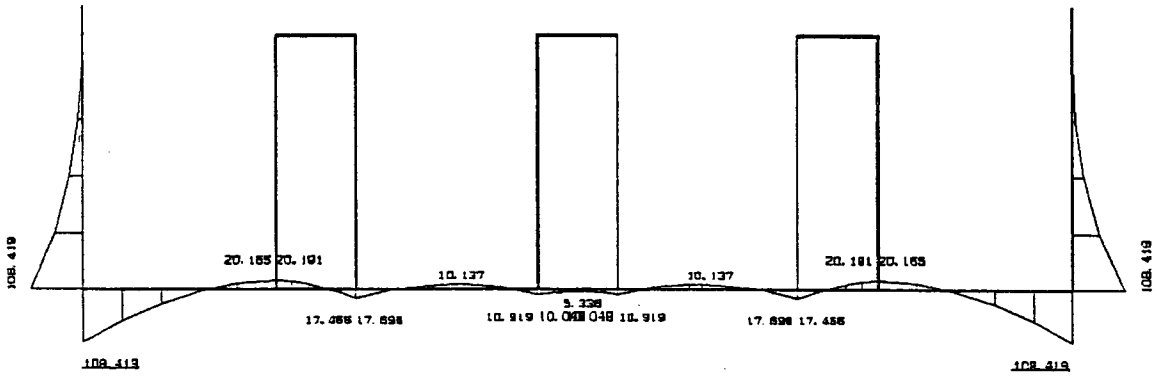
Design of reinforcement is decided by using the biggest required area of tension reinforcement

(2) Result of Structural Analysis

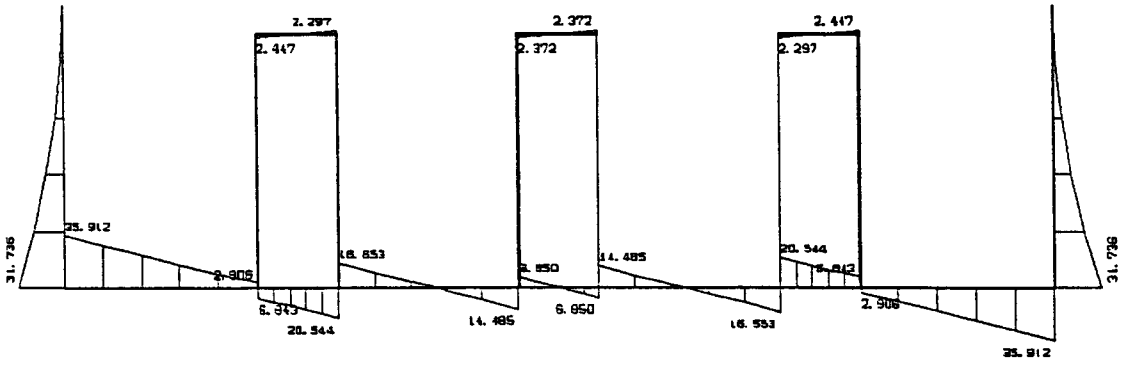
Load and sectional force are showed Figure 1～6, and arrangement of and reinforcement are showed Figure 7.



Load Distribution (tf/m,tf/m^2)

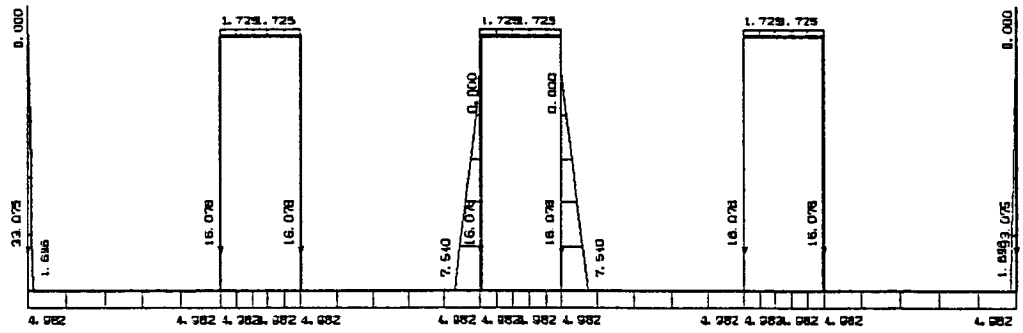


Bending Moment (tf·m)

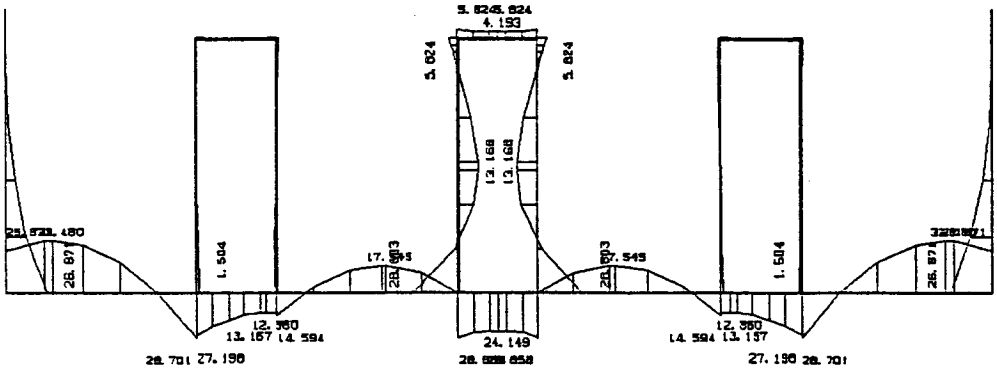


Shearing Force (tf)

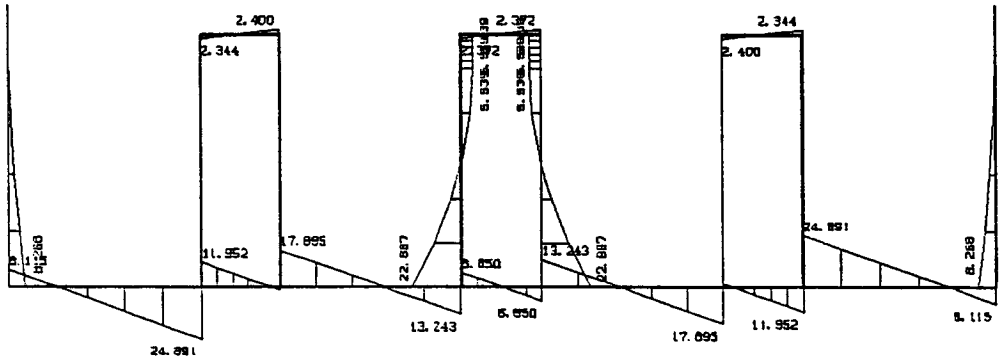
Figure 1 Load and Sectional Force of Flume Section (Case 1)



Load Distribution (tf/m,tf/m^2)

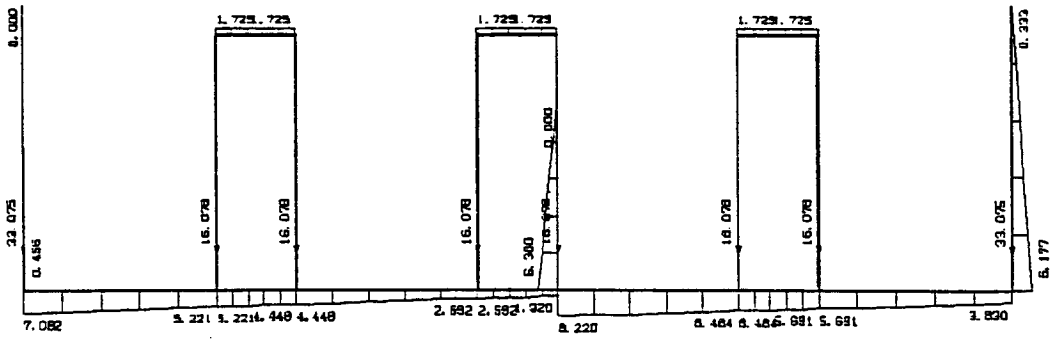


Bending Moment (tf·m)

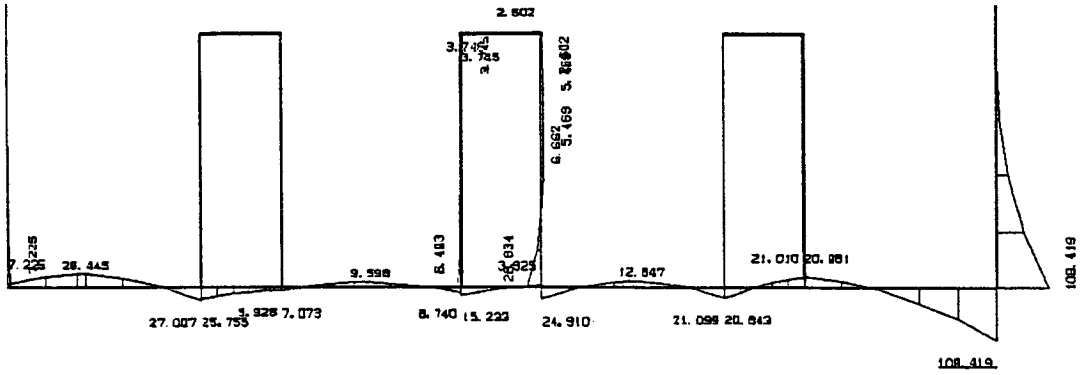


Shearing Force (tf)

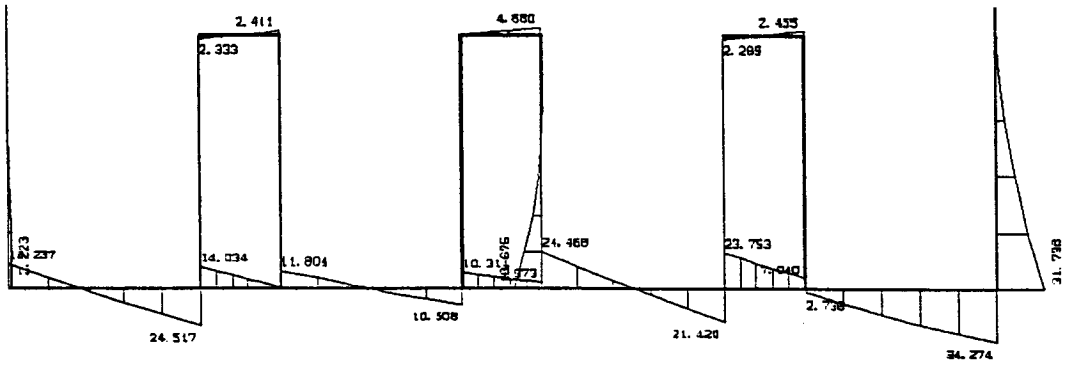
Figure 2 Load and Sectional Force of Flume Section (Case 2)



Load Distribution (tf/m,tf/m^2)

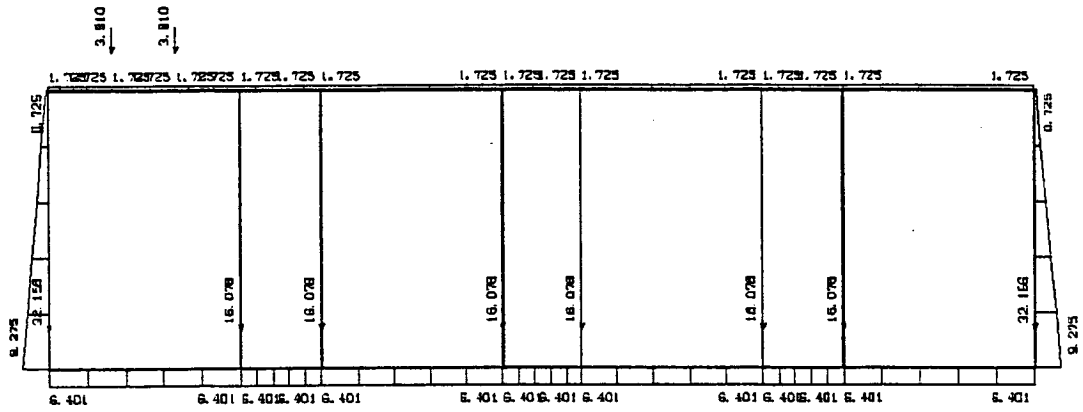


Bending Moment (tf·m)

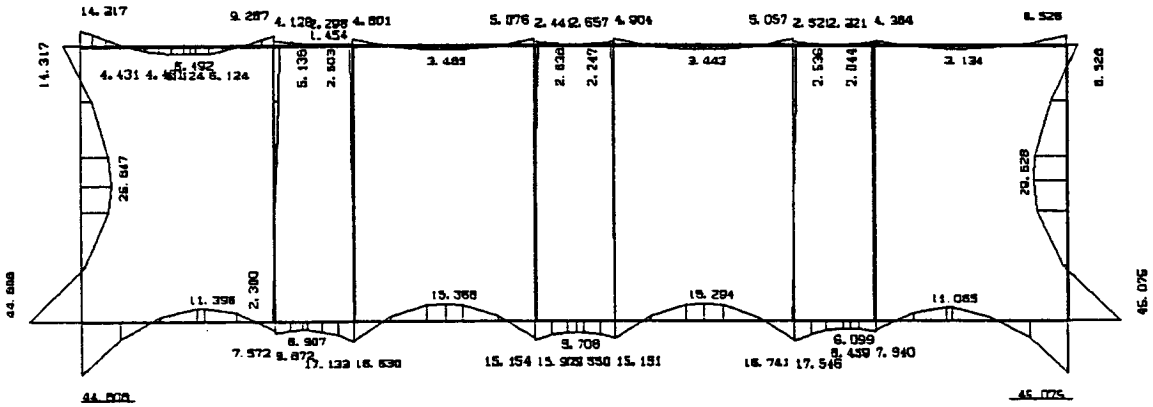


Shearing Force (tf)

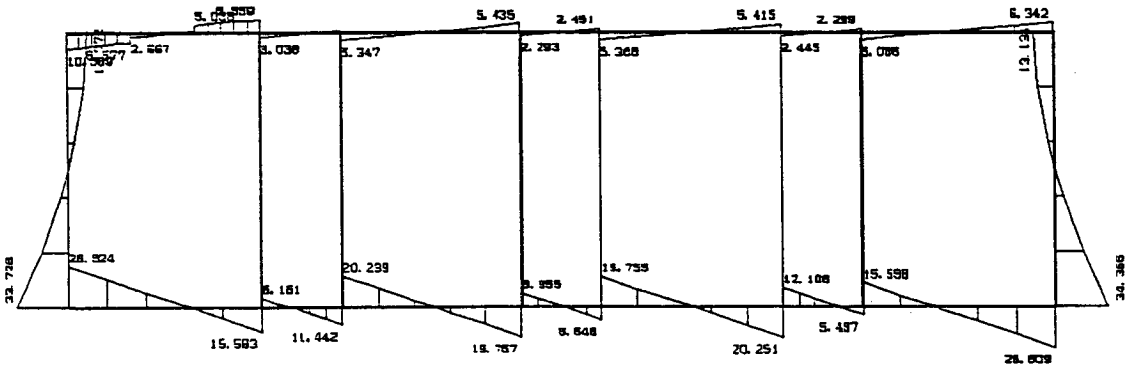
Figure 3 Load and Sectional Force of Flume Section (Case 3)



Load Distribution (tf/m,tf/m^2)

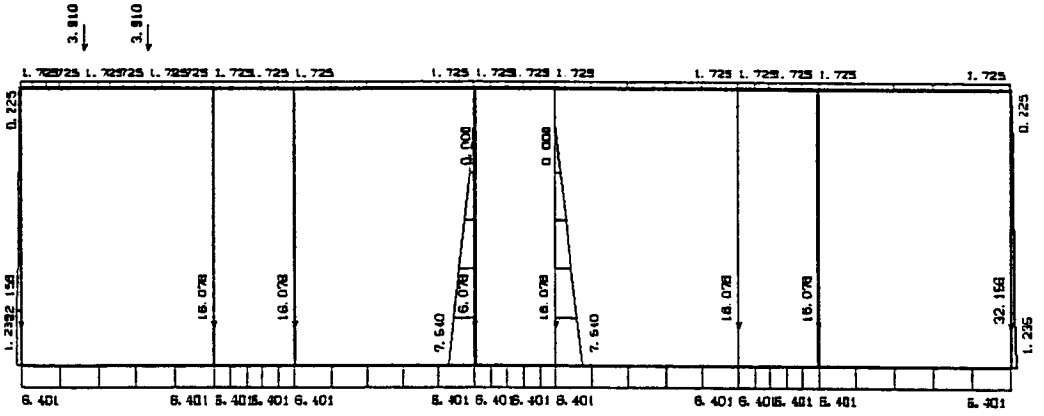


Bending Moment (tf·m)

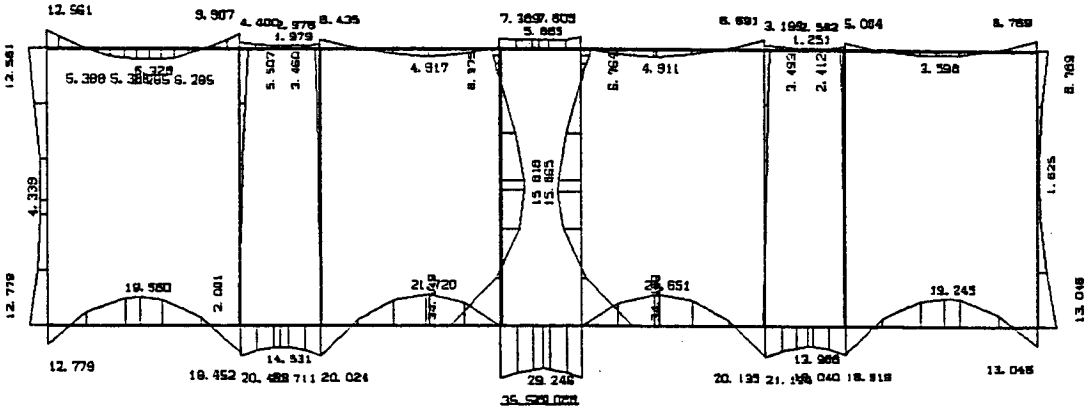


Shearing Force (tf)

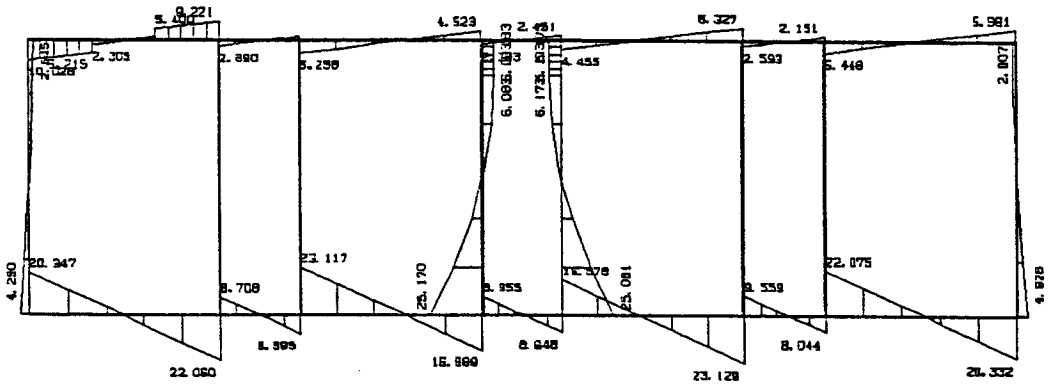
Figure 4 Load and Sectional Force of Box Culvert Section (Case 1)



Load Distribution (tf/m,tf/m^2)

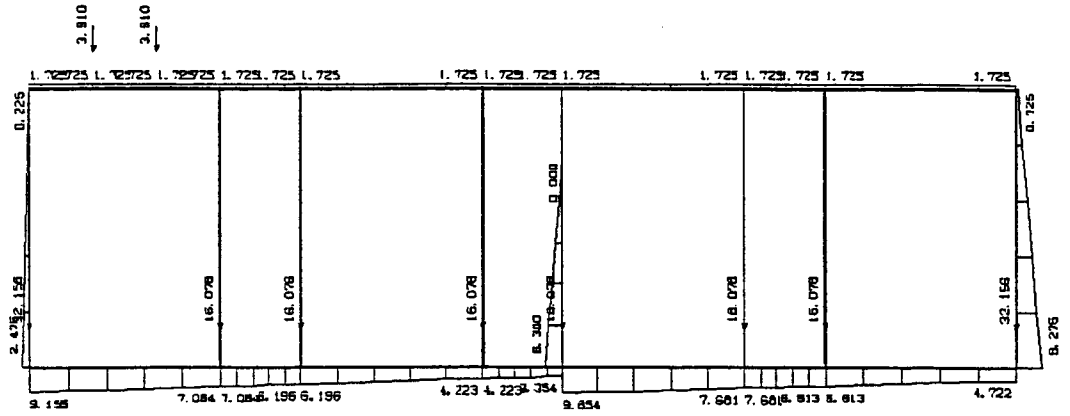


Bending Moment (tf·m)

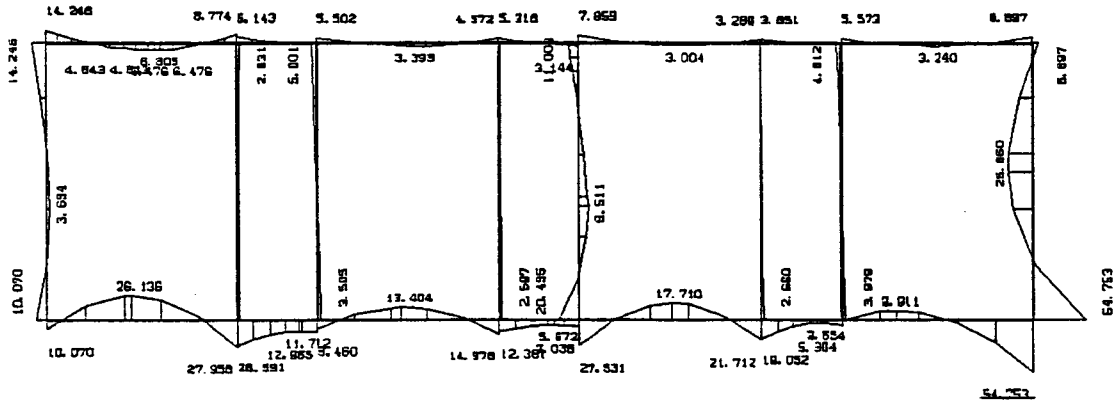


Shearing Force (tf)

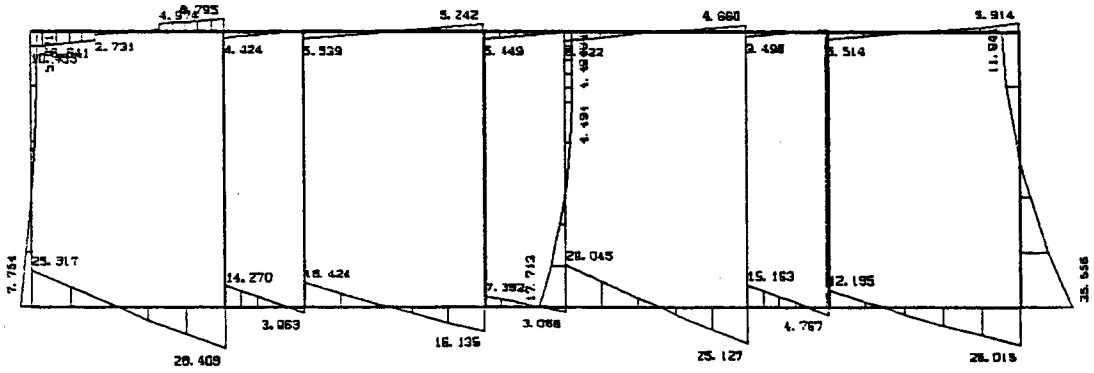
Figure 5 Load and Sectional Force of Box Culvert Section (Case 2)



Load Distribution (tf/m,tf/m^2)

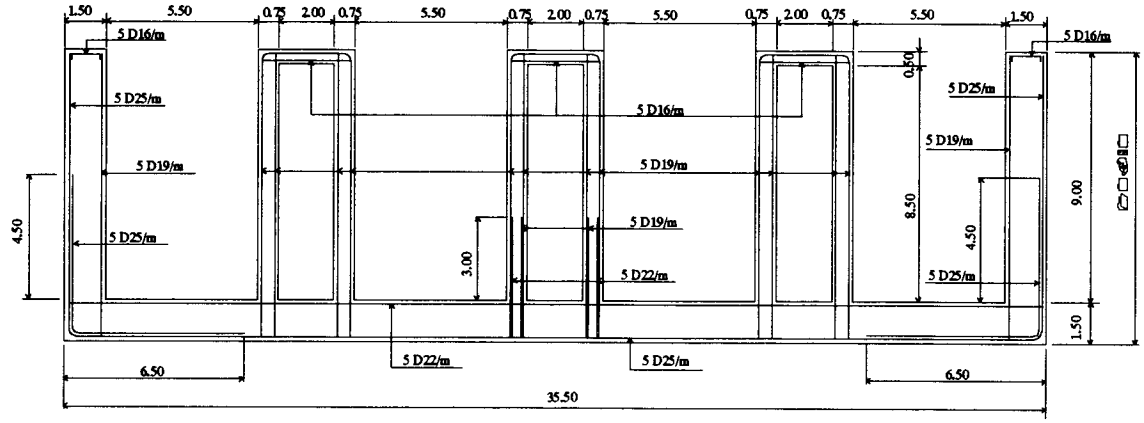


Bending Moment (tf·m)

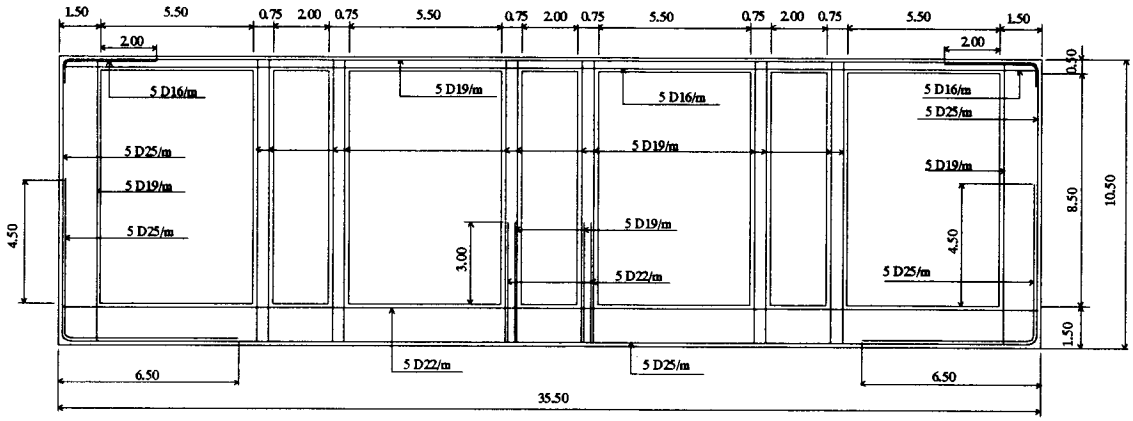


Shearing Force (tf)

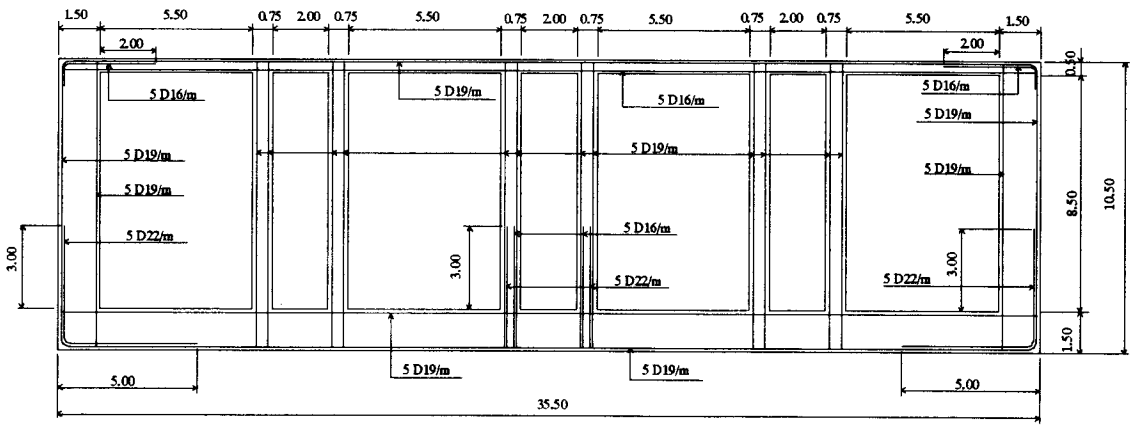
Figure 6 Load and Sectional Force of Box Culvert Section (Case 3)



Flume Section



Box Culvert Section (Intake Side)



Box Culvetrt Section (Pump Room Side)

Figure 7 Reinforcement Arrangement of Intake Canal

APPENDIX C.4.7-3 Structural Calculation of Pump Room

(3) Design Given Conditions

(a) Sections to be analyzed

Structural calculation for main flame of the pump room was carried out the following four flames, i.e. ② Lane、④～⑥ Lane、⑧ Lane and middle section of the A～B Lane.

(b) Active Load

Dead Load ;	Slab weight	$q=1.23tf/m^2$
	Main beam weight	w=1.96tf/m
	Sub-beam weight	p=4.26tf
Live Load ;	70 tf Trailer (Floor of maintenance space)	
	52.2 tf (Total weight of electrical panel equipment)	
	$0.50\ tf/m^2$ (unit weight of ground floor)	
Earth Pressure;	Coefficient of Earth Pressure, Ka=0.50	
	Earth Weight	$\gamma_t=1.8tf/m^3$ (Wet earth)
		$\gamma_s=2.0tf/m^3$ (Saturated earth)
	Ground Water Surface, EL 2.30m	
	Uniform load on the ground surface,	$q=1.00tf/m^2$

(c) Axial force at the column bottom by the pump buildings

Axial force and bending moment of the building acting at the column bottom was considered to input the following figures into the joints of the pump flame as active load.

Table 1 Load of Building Column

Lane	Lane	Axial Force (tf)	Bending Moment (tf･m)
②	A	384.74	131.9
	B	332.32	-143.1
④～⑥	B	423.71	-155.5
⑧	A	359.25	143.4
	B	332.43	-148.9

(c) Pump equipment loads

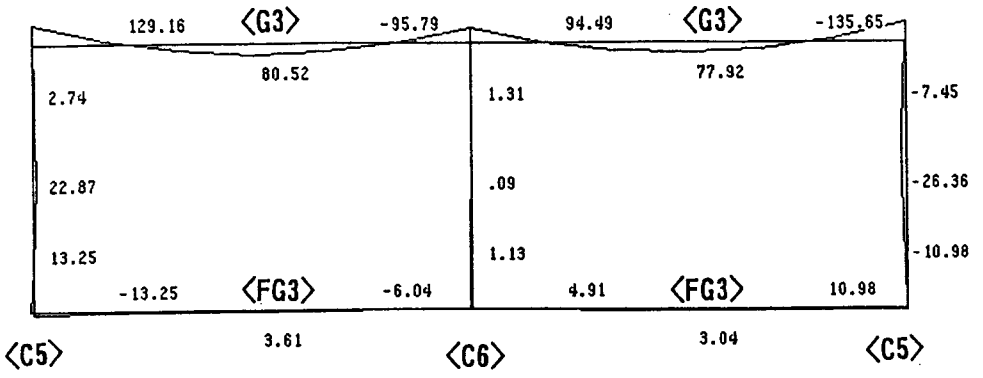
In addition to the above, major active load of the pump equipment can be tabulated in the Table-2.

Table 2 Major Mechanical Load

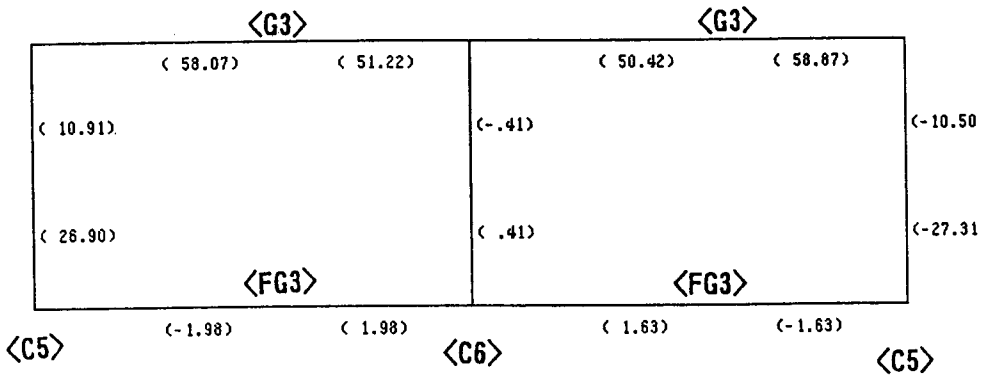
Description	Unit	Axial Force	Remarks
Main pump	tf/unit	99.6	Dead load including water x 1.2
Main motor	tf/unit	224	Dead load x 1.2 + axial thrust
Intermediate shaft bearing	tf/unit	13.2	Dead load x 1.2
Suction pipe	tf/unit	188	Dead load including water x 1.2
Header pipe	tf	678	Dead load including water x 1.2
Discharge valve	tf/unit	15.6	Dead load including water x 1.2
Isolating valve	tf/unit	18	Dead load including water x 1.2
Gantry crane	tf/wheel	17	4 wheels

(4) Result of Structural Analysis

Sectional force are showed Figure 1~4, and results of analysis are showed Table 3,4,5 and 6.

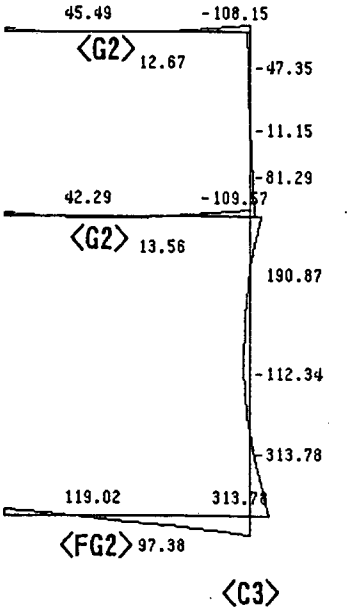


Bending Moment (tf·m)

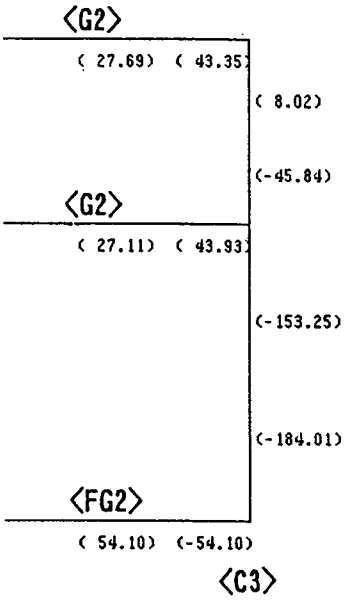


Shearing Force (tf)

Figure 1 Sectional Force of ② Lane

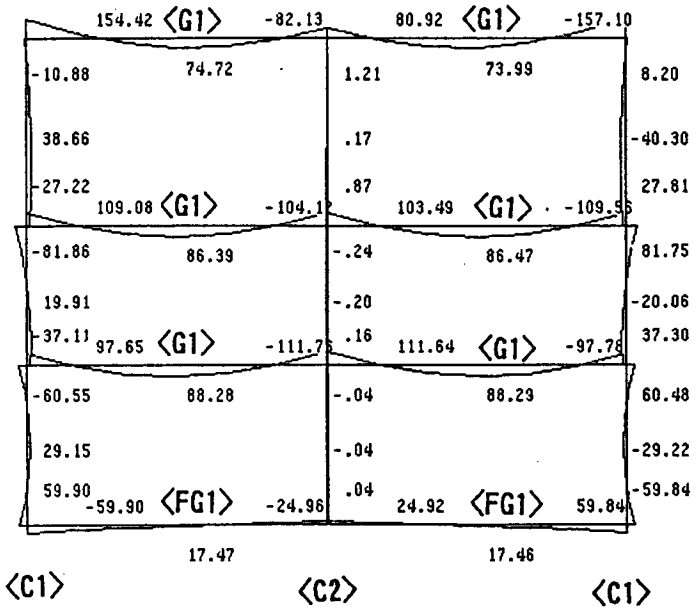


Bending Moment (tf·m)

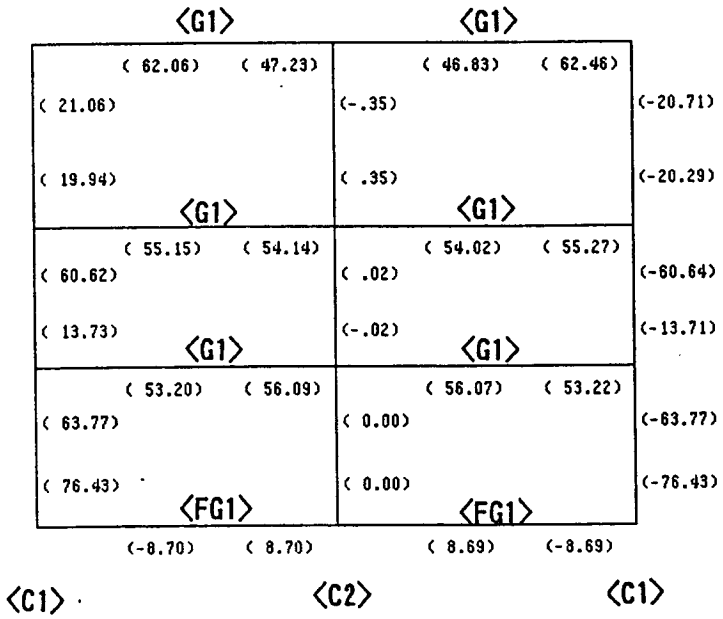


Shearing Force (tf)

Figure 2 Sectional Force of ④~⑥ Lane

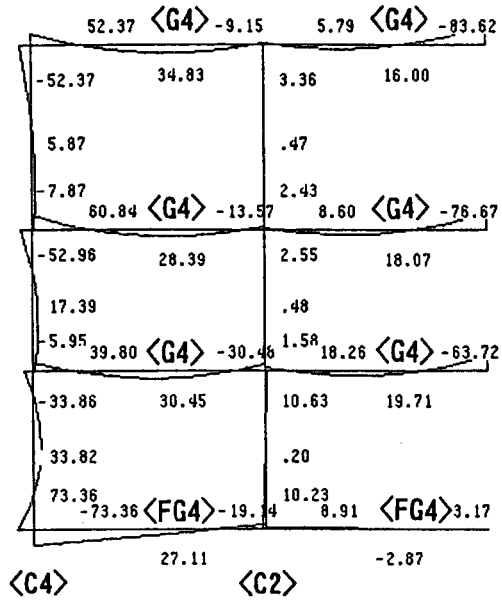


Bending Moment (tf·m)

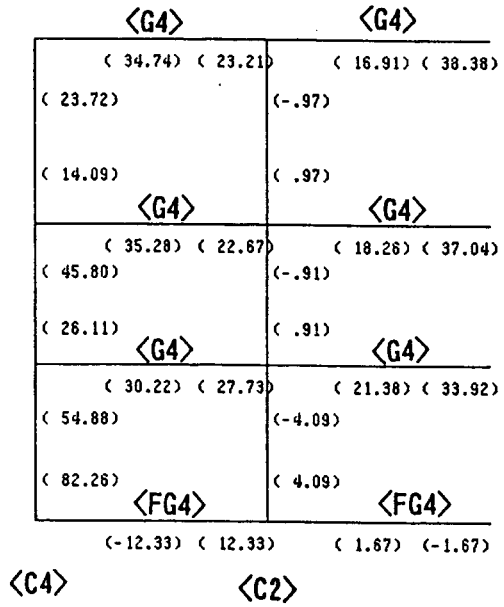


Shearing Force (tf)

Figure 3 Sectional Force of ⑧ Lane



Bending Moment (tf·m)



Shearing Force (tf)

Figure 4 Sectional Force of Middle Section of A and B Lane

Table 3 Calculation of Bending Moment, Section Force and Reinforcement for Main Girder

Item		B x D (m)	Bending Moment (tf·m)	Shearing Force (tf)	Axial Force (tf)	Effective Depth (m)	Required Area of Tension Reinforcement (cm^2)	Reinforcing Bar Schedule (cm^2)
	Outside End		157.10	62.46			70.24	12-D28 = 73.92
G1	Center	0.80 x 1.50	74.72			1.42	33.41	8-D28 = 55.44
(Ground F)	Inside End		82.13	47.23			36.72	8-D28 = 55.44
G1	End	0.80 x 1.50	109.56	55.27		1.42	48.99	10-D25 = 49.10
(B1F)	Center		86.47				38.66	10-D25 = 49.10
G1	End	0.80 x 1.50	111.76	56.09		1.42	49.97	11-D25 = 54.01
(B2F)	Center		88.29				39.48	10-D25 = 49.10
	Outside End		108.15	43.35			48.36	10-D28 = 61.6
G2	Center	0.80 x 1.50	12.67			1.42	5.67	6-D28 = 36.96
(Ground F)	Inside End		45.49	27.69			20.34	6-D28 = 36.96
G2	End	0.80 x 1.50	109.57	43.93		1.42	48.99	10-D25 = 49.10
(B1F)	Center		13.56				6.06	6-D25 = 29.46
	Outside End		135.65	58.87			60.65	10-D28 = 61.60
G3	Center	0.80 x 1.50	80.52			1.42	36.00	7-D28 = 43.12
(Ground F)	Inside End		95.79	51.22			42.83	8-D28 = 49.28
G4	End	0.80 x 1.50	83.62	38.38		1.42	37.92	8-D25 = 39.28
(Ground F)	Center		34.83				15.80	5-D25 = 24.55
G4	End	0.80 x 1.50	76.67	37.04		1.42	34.77	8-D25 = 39.28
(B1F)	Center		28.39				12.88	5-D25 = 24.55
G4	End	0.80 x 1.50	63.72	33.92		1.42	28.90	8-D25 = 39.28
(B2F)	Center		30.45				13.81	5-D25 = 24.55
FG1	End	0.80x2.00	59.90	8.70		1.92	19.81	6-D25 = 29.46
FG2	End	0.80x2.00	129.77	54.10		1.92	42.91	10-D25 = 49.10
FG3	End	0.80x1.50	13.25	1.98		1.42	5.92	5-D25 = 24.55
FG4	End	0.80x2.00	73.36	12.33		1.92	24.26	6-D25 = 29.46

Table 4 Calculation of Bending Moment, Section Force and Reinforcement for Column

Item		Depth	Bending Moment	Shearing Force	Axial Force	Effective Depth	Reinforcing Bar Schedule	Reinforcement Tensile Stress	Concrete Compressive Stress
		(m)	(tf·m)	(tf)	(tf)	(m)	(cm^2)	(kgf/cm^2)	(kgf/cm^2)
C1	X Line	2.00	81.75	76.43	421.71	1.92	7-D25 = 34.37	1	45.91
(B1～B3)	Y Line	1.00			421.71	0.92	7-D25 = 34.37		22.92
C2	X Line	1.00	1.21	0.35	283.28	0.92	5-D25 = 24.55	-212	38.01
(B1～B3)	Y Line	1.00	10.23	4.09	283.28	0.92	5-D25 = 24.55	-200	40.71
C3	X Line	2.00	81.29	45.84	467.06	1.92	7-D25 = 34.37	-122	37.81
(B1)	Y Line	1.00			467.06	0.92	7-D25 = 34.37		25.38
C3	X Line	2.00	129.77	184.01	510.99	1.92	9-D25 = 44.15	-90	45.87
(B2～B3)	Y Line	1.00			510.99	0.92	7-D25 = 34.37		27.77
C4	X Line	1.00			314.38	0.92	5-D25 = 24.55		22.78
(B1～B3)	Y Line	1.50	73.36	82.26	314.38	1.42	7-D25 = 34.37	-46	40.72
C5	X Line	2.00	84.68	27.44	443.61	1.92	7-D25 = 34.37	-110	36.67
(B1)	Y Line	1.00			443.61	0.92	7-D25 = 34.37		24.11
C6	X Line	1.00	1.31	0.41	195.70	0.92	5-D25 = 24.55	-146	26.36
(B1)	Y Line	1.00	3.36	0.97	195.70	0.92	5-D25 = 24.55	-143	26.98

Table 5 Calculation of Bending Moment, Section Force and Reinforcement for Slab and Wall

Item		Thickness (m)	Bending Moment (tf·m)	Shearing Force (tf)	Axial Force (tf)	Effective Depth (m)	Reinforcing Bar Schedule (cm^2)	Reinforcement Tensile Stress (kgf/cm^2)	Concrete Compreessive Stress (kgf/cm^2)
S1	Short side upper/lower	0.50	11.16	15.87		0.44	6-D19 = 17.01	1,649	44.36
	Long side upper/lower		1.49	3.78		0.44	5-D16 = 10.05	365	7.26
S2	Long/short side upper/lower	0.50	8.77	6.93		0.44	6-D16 = 12.06	1,802	39.74
S3	Long/short side upper/lower	0.50	4.68	4.93		0.44	5-D16 = 10.05	1,146	22.79
S4	Long/short side upper/lower	0.30	2.19	4.28		0.24	5-D13 = 6.65	1,497	33.21
S5	Long/short side upper/lower	0.50				0.44	5-D16 = 10.05	Same as S3	
CS1	Short side upper	0.50	13.80	18.90		0.44	7-D19 = 19.85	1,760	51.82
FS1	X Line upper/lower	2.00	143.69	112.44		1.94	7-D28 = 43.12	1,858	36.39
	Y Line upper/lower		215.53	122.01			10-D28 = 61.60	1,978	47.46
FS2	X Line upper/lower	2.00	84.82	65.25		1.94	7-D22 = 26.60	1,751	26.19
	Y Line upper/lower		81.94	64.12			7-D22 = 26.60	1,691	25.3
FS3	Y Line upper/lower	2.00	122.90	69.58		1.94	10-D22 = 38.00	1,796	32.75
W20	V,H-out/inside	0.20				0.14	5-D13 = 6.65	Minimun	
W60	Vertical-out/inside	0.60	6.50	7.80		0.54	5-D16 = 10.05	1,288	22.83
	Horizontal-out/inside						5-D16 = 10.05	Same as vertical	
W120	Vertical-outside	1.20	33.02	39.21		1.13	5-D22 = 19.00	1,648	27.61
	Vertical-inside		16.05	28.04			5-D19 = 14.18	1,064	15.16
	Horizontal-out/inside						5-D19 = 14.18		
W120A	Vertical-outside	1.20	45.16	52.37		1.13	7-D22 = 26.60	1,629	32.94
	Vertical-inside		12.95	52.37			7-D19 = 19.85	620	10.63
	Horizontal-outside		46.56	47.30			7-D22 = 26.60	1,679	33.97
	Horizontal-inside		18.41	47.30			7-D19 = 19.85	881	15.12

Table 6 Calculation of Bending Moment, Section Force and Reinforcement for Beam

Item		B x D (m)	Bending Moment (tf·m)	Shearing Force (tf)	Axial Force (tf)	Effective Depth (m)	Required Area of Tension Reinforcement (cm^2)	Reinforcing Bar Schedule (cm^2)
b1	End upper	0.50 x 1.00	74.09	35.20		0.93	50.58	9-D28 = 55.44
	Center lower		50.71				34.62	7-D28 = 49.28
b2	End upper	0.50 x 1.00	49.43	24.70		0.93	33.75	7-D25 = 34.37
	Center lower		34.48				23.54	6-D25 = 29.46
b3	All	0.30 x0.70					Minimum	3-D22 = 11.40
b4	End upper	0.50 x 0.80	21.55	17.00			18.49	5-D25 = 24.55
	Center lower		25.42			1.42	21.81	5-D25 = 24.55
Fb1	End upper	0.30 x 1.80	23.75	14.14		1.73	8.72	3-D22 = 11.40
	Center lower		15.52				5.70	3-D22 = 11.40
Fb2	End upper	0.40 x 1.00	14.26	17.91		0.93	9.74	4-D22 = 15.20
	Center lower		36.10				24.65	7-D22 = 26.60
Fb3	End upper	0.40 x 1.00	25.76	19.08		0.93	17.59	4-D25 = 19.64
CFG1	End upper	0.40 x 1.50～1.00	61.39	21.54		1.43	27.26	7-D25 = 34.34
CGb1	End upper	0.40 x 1.50～1.00		Same as CFG1		1.43		7-D25 = 34.34
Cb1	End upper	1.00 x 2.50	274.98	77.81		2.43	71.84	12-D28 = 73.92