baru-pier+footing

Case 2 : Normal-dry

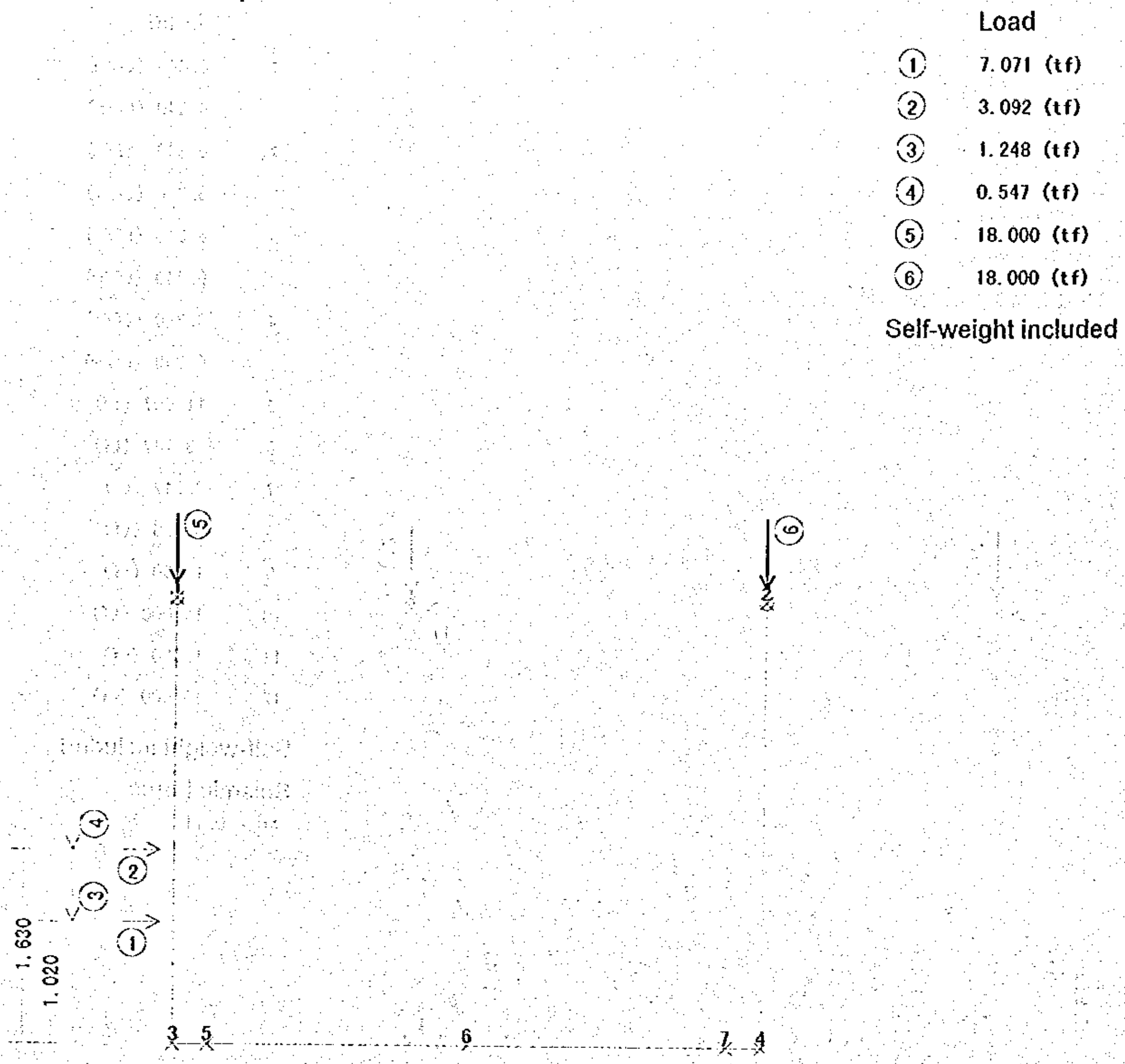
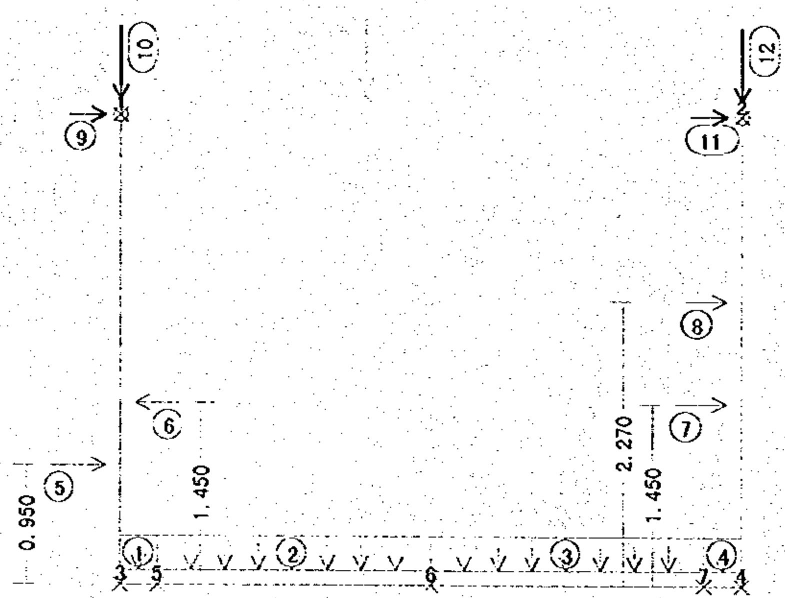


Figure - 21

baru-pier+footing

Case 3 : Seismic-water



Load

①	6.840 (tf/m)
	6.840 (tf/m)
②	6.840 (tf/m)
	6.840 (tf/m)
③	6.840 (tf/m)
	6.840 (tf/m)
④	6.840 (tf/m)
	6.840 (tf/m)
⑤	11.007 (tf)
⑥	-9.747 (tf)
⑦	9.747 (tf)
⑧	0.528 (tf)
⑨	1.650 (tf)
⑩	15.000 (tf)
⑪	1.650 (tf)
⑫	15.000 (tf)

Self-weight included

Seismic Force

KH = 0.11

Figure – 22

baru-pier+footing

Case 4 : Seismic-dry

Load

①	11.007 (tf)
②	1.650 (tf)
③	18.000 (tf)
④	1.650 (tf)
⑤	18.000 (tf)

Self-weight included

Seismic Force

KH = 0.11

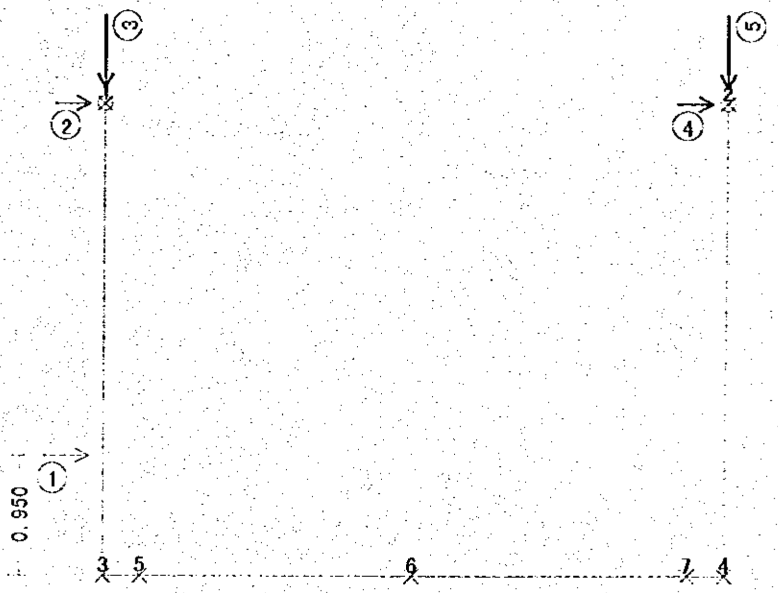


Figure - 23

baru-pier+footing

Case 1: Normal-water

Deformation Scale ―― : 0.331cm max. : 0.208 cm

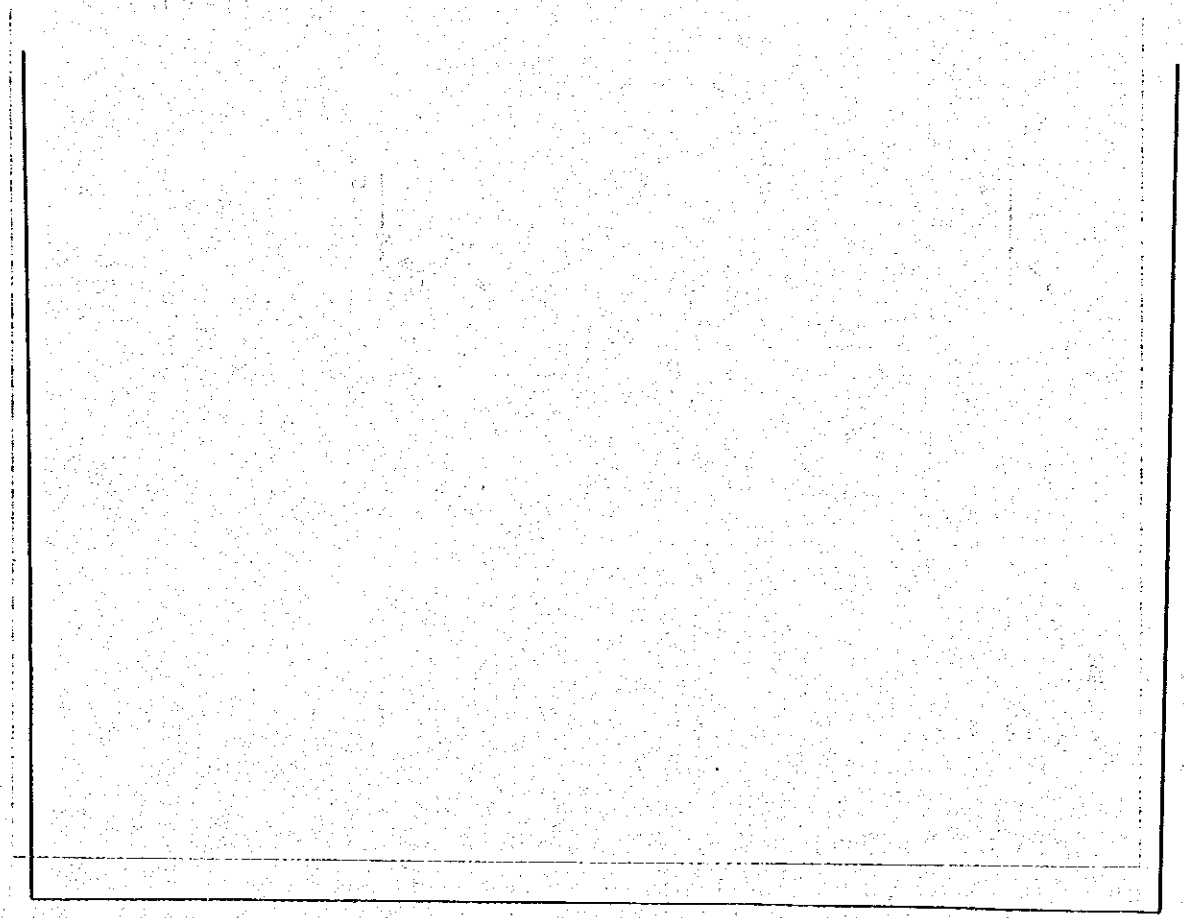


Figure-24(1)

baru-pier+footing

Case 1: Normal-water

Bending Moment Scale : 38.81tf·m max. : -38.30 tf·m

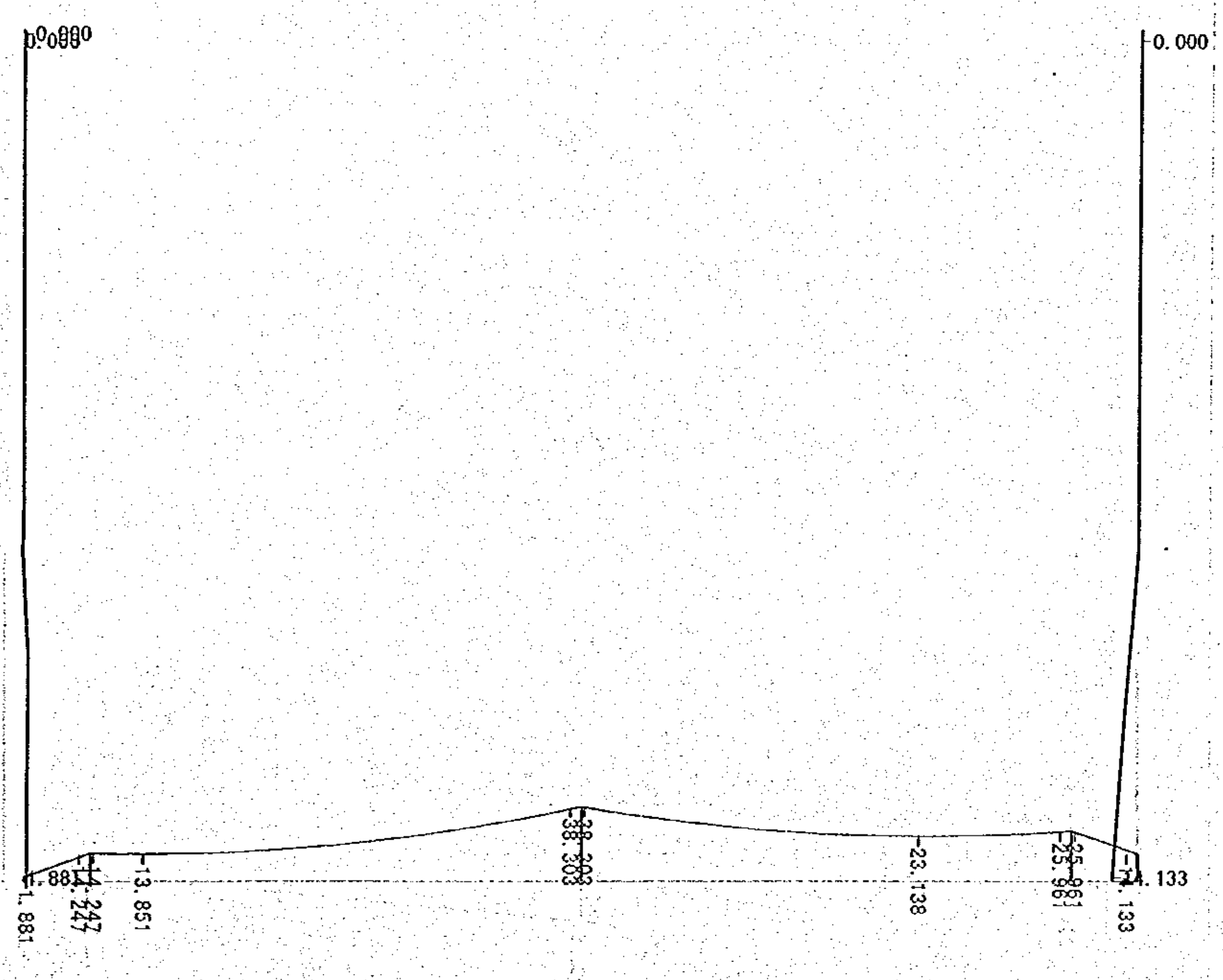


Figure -24(2)

baru-pier+footing

Case 1: Normal-water

Shear Stress Scale ——— : 44.10tf max. : -43.15 tf

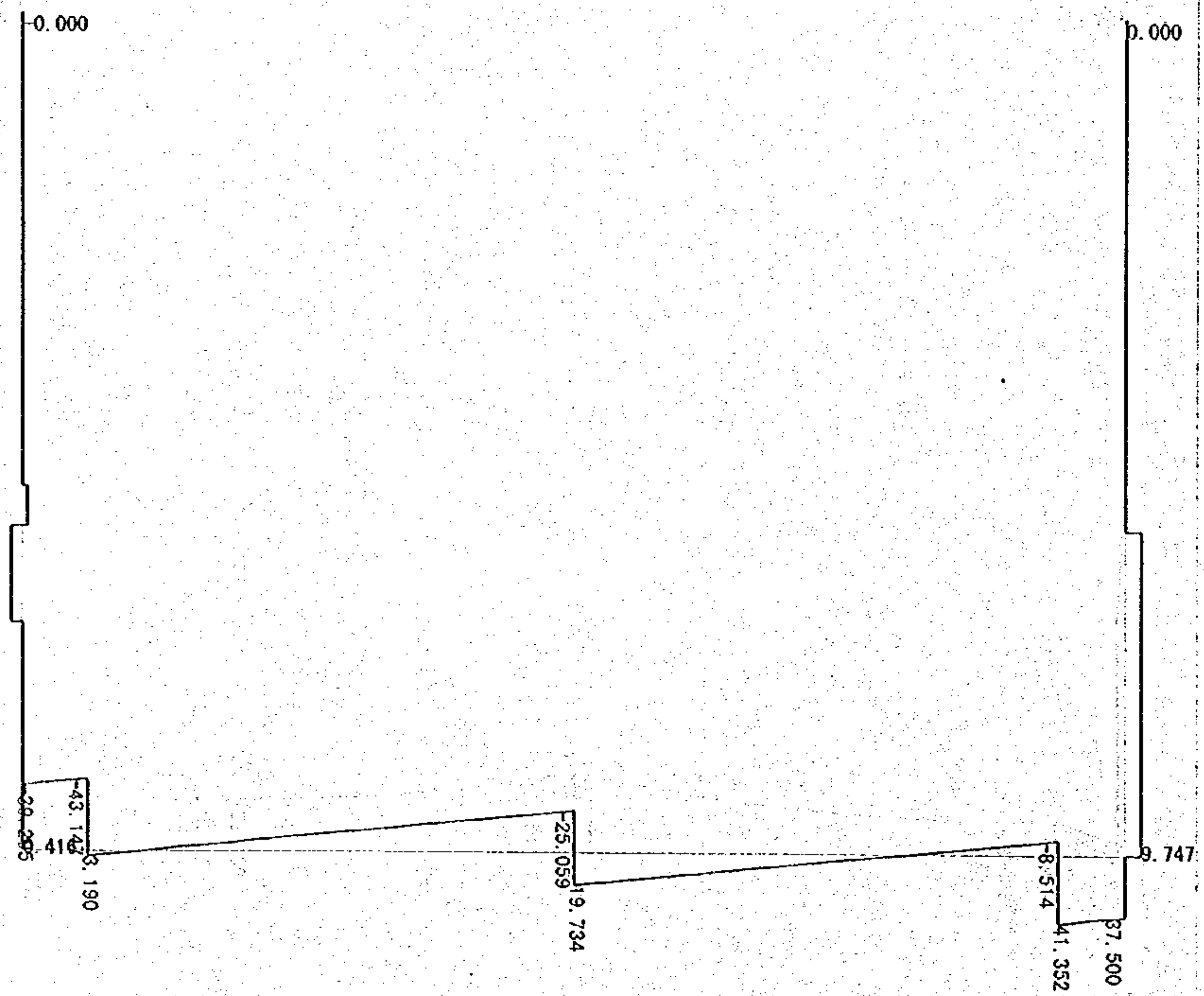


Figure -24(3)

baru-pier+footing

Case 1: Normal-water

Axial Stress Scale : 42.29tf max. : 39.29 tf

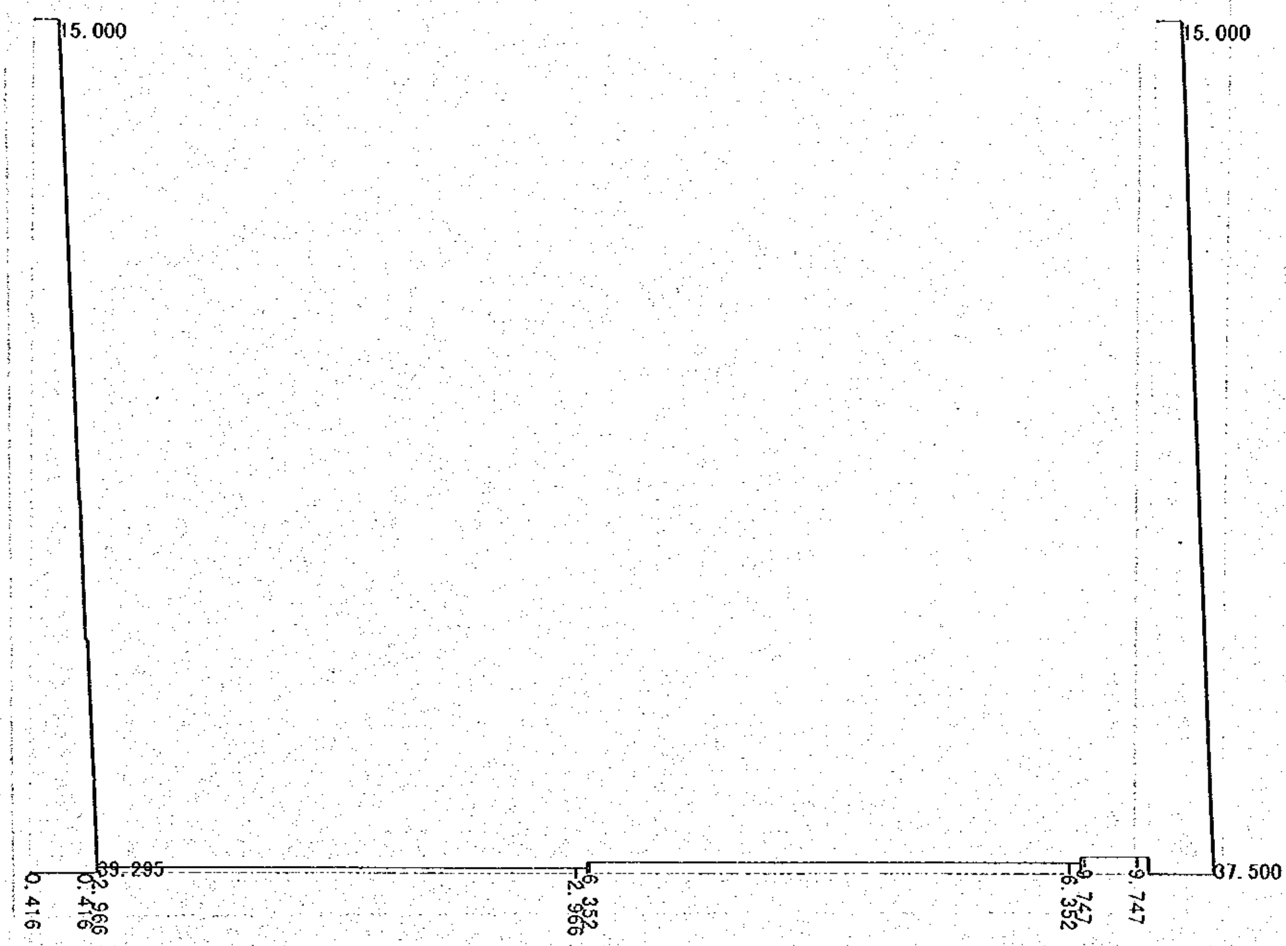


Figure - 24(4)

baru-pier+footing

Case 2: Normal-dry

Deformation Scale : 0.331cm max. : 0.168 cm

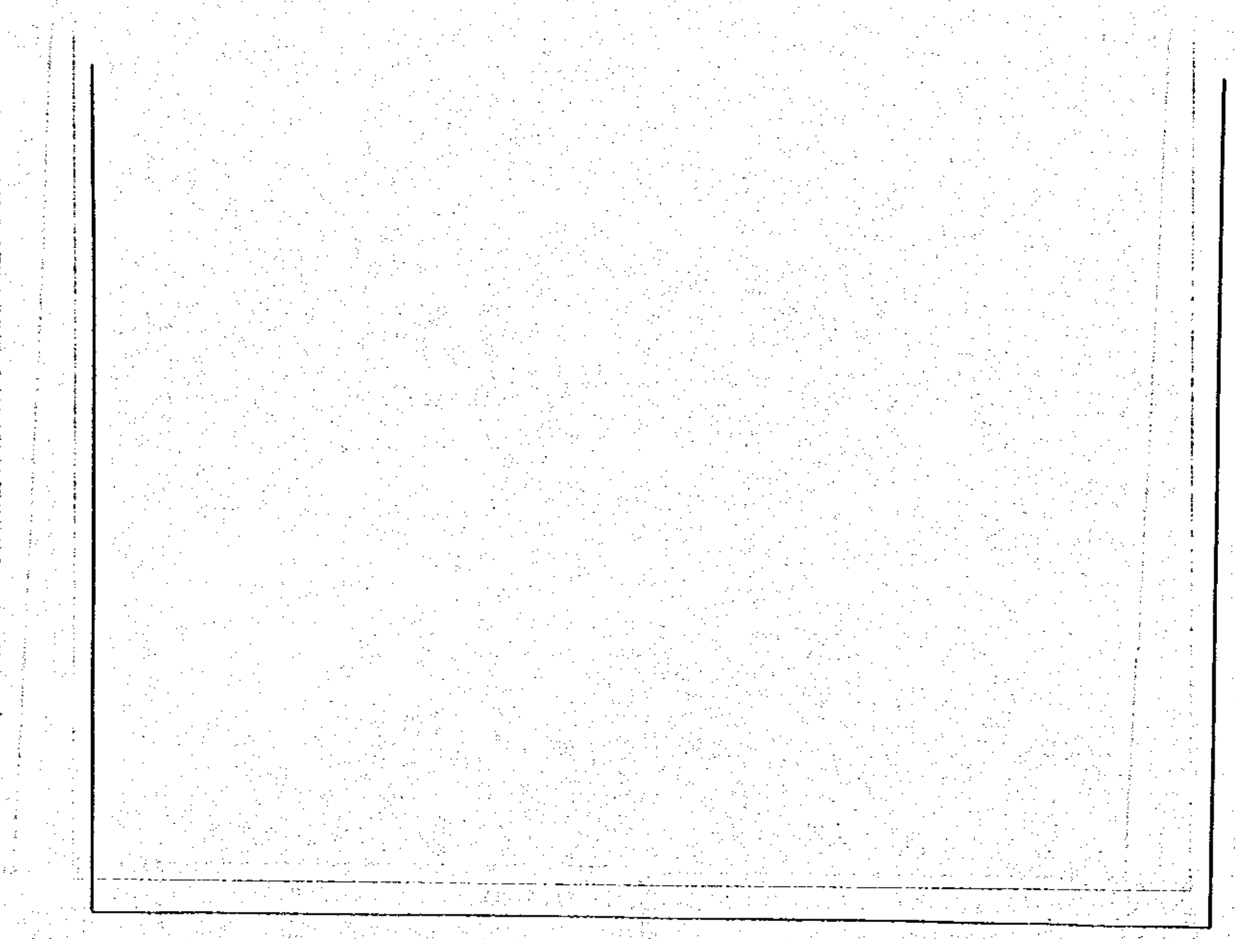


Figure - 25 (1)

baru-pier+footing

Case 2: Normal-dry

Bending Moment Scale : 38.81tf·m max. : -31.54 tf·m

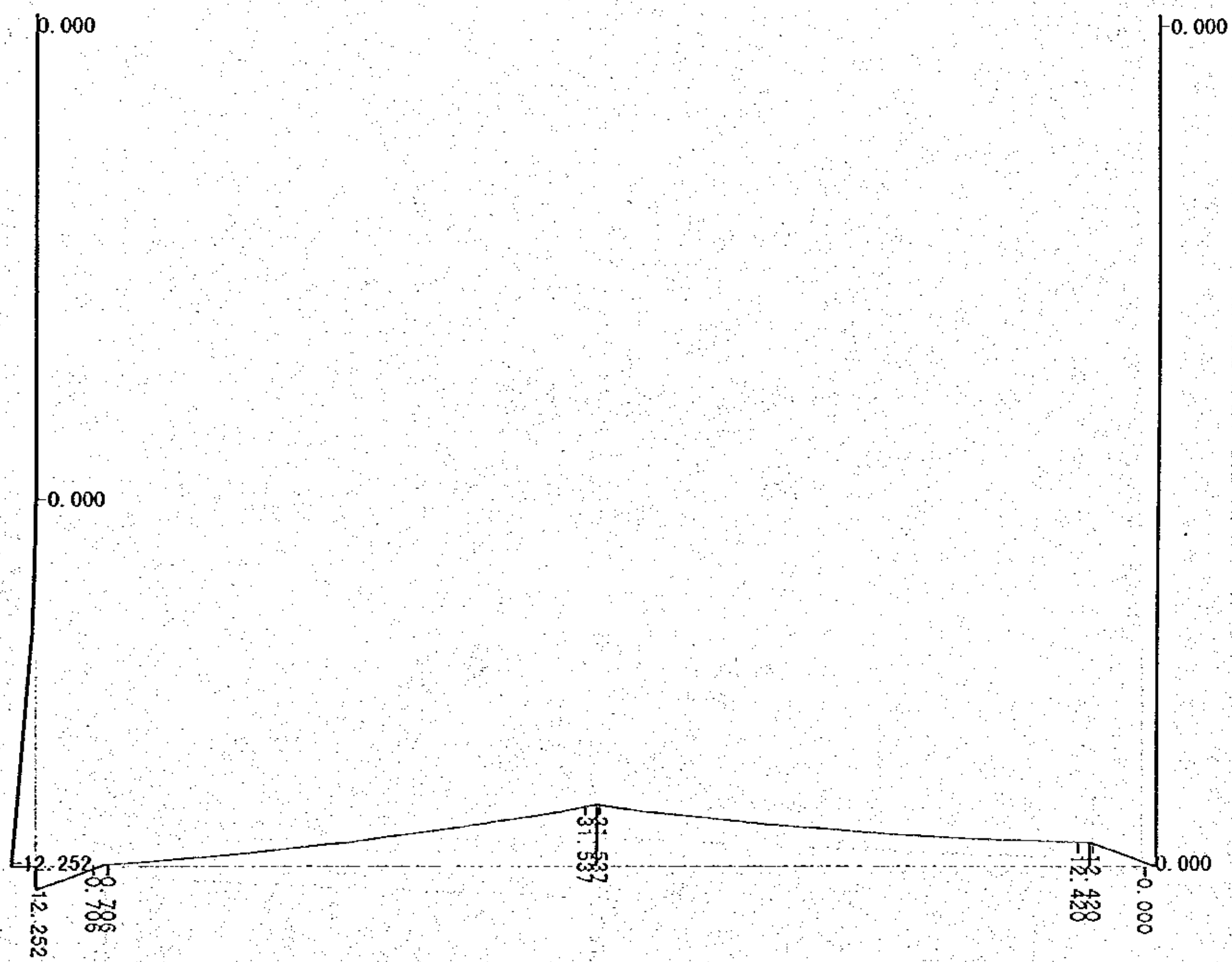


Figure - 25 (2)

baru-pier+footing

Case 2: Normal-dry

Shear Stress Scale : 44.10tf max. : -44.10 tf

Figure - 25 (3)

baru-pier+footing

Case 2: Normal-dry

Axial Stress Scale ------ : 42.29tf max. : 42.29 tf

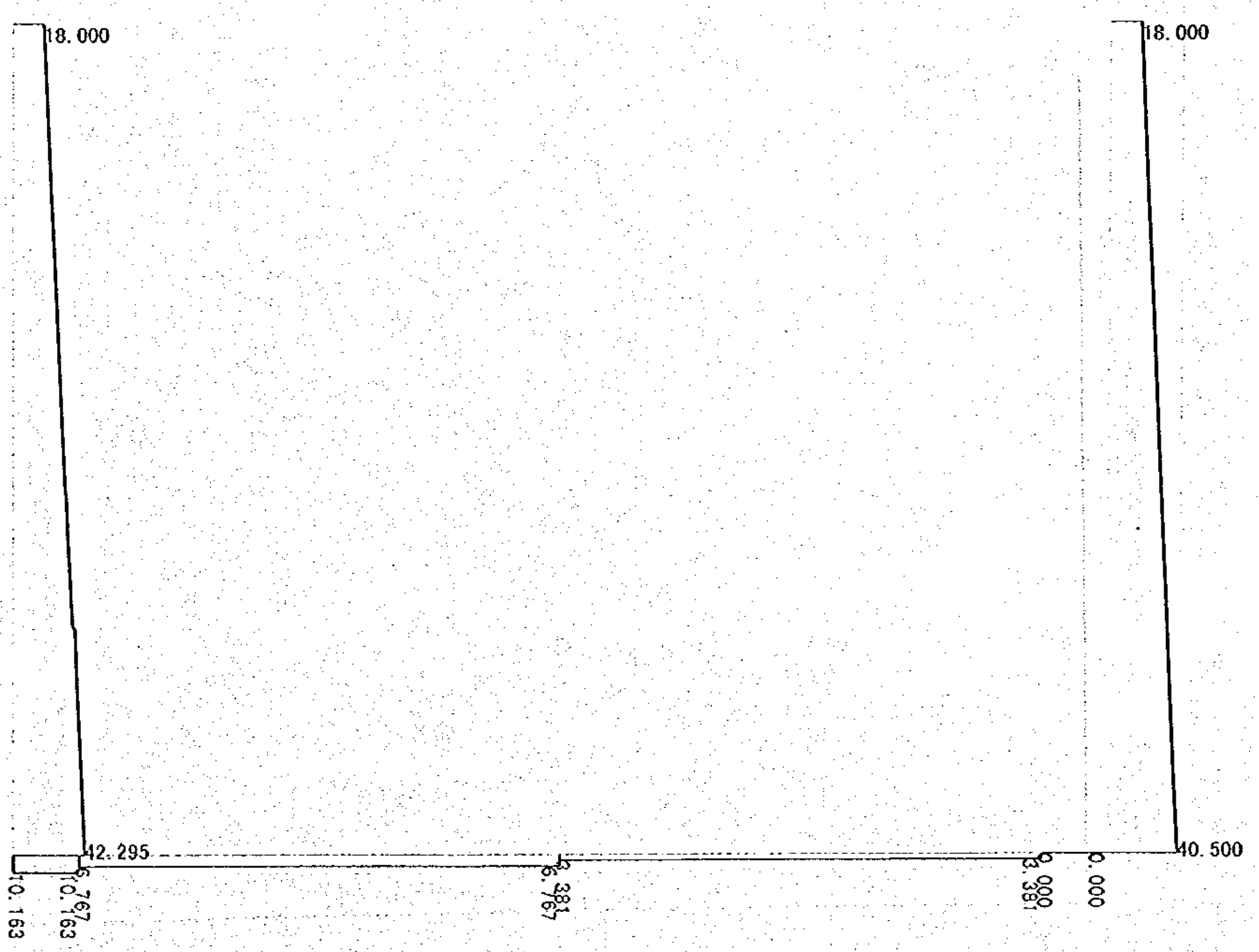


Figure - 25 (4)

baru-pier+footing

Case 3: Seismic-water

Deformation Scale : ——— : 0.331cm max. : 0.331 cm

Figure - 26 (1)

baru-pier+footing

Case 3: Seismic-water

Bending Moment Scale : 38.81tf·m max. : -38.81 tf·m

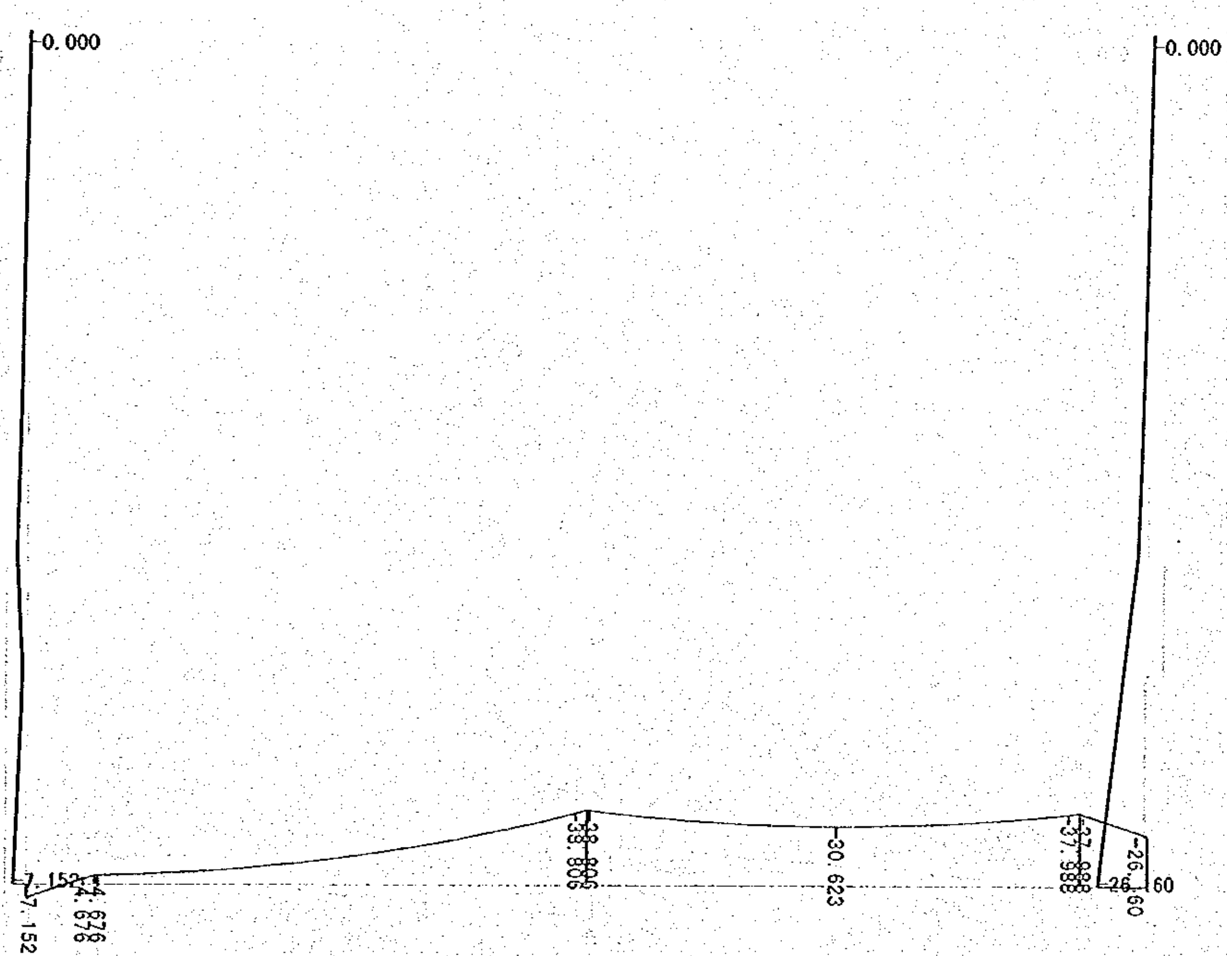


Figure - 26 (2)

baru-pier+footing

Case 3: Seismic-water

Shear Stress Scale ------- : 44.10tf max. : -41.35 tf

Figure - 26(3)

baru-pier+footing

Case 3: Seismic-water

Axial Stress Scale : 42.29tf max. : 37.50 tf

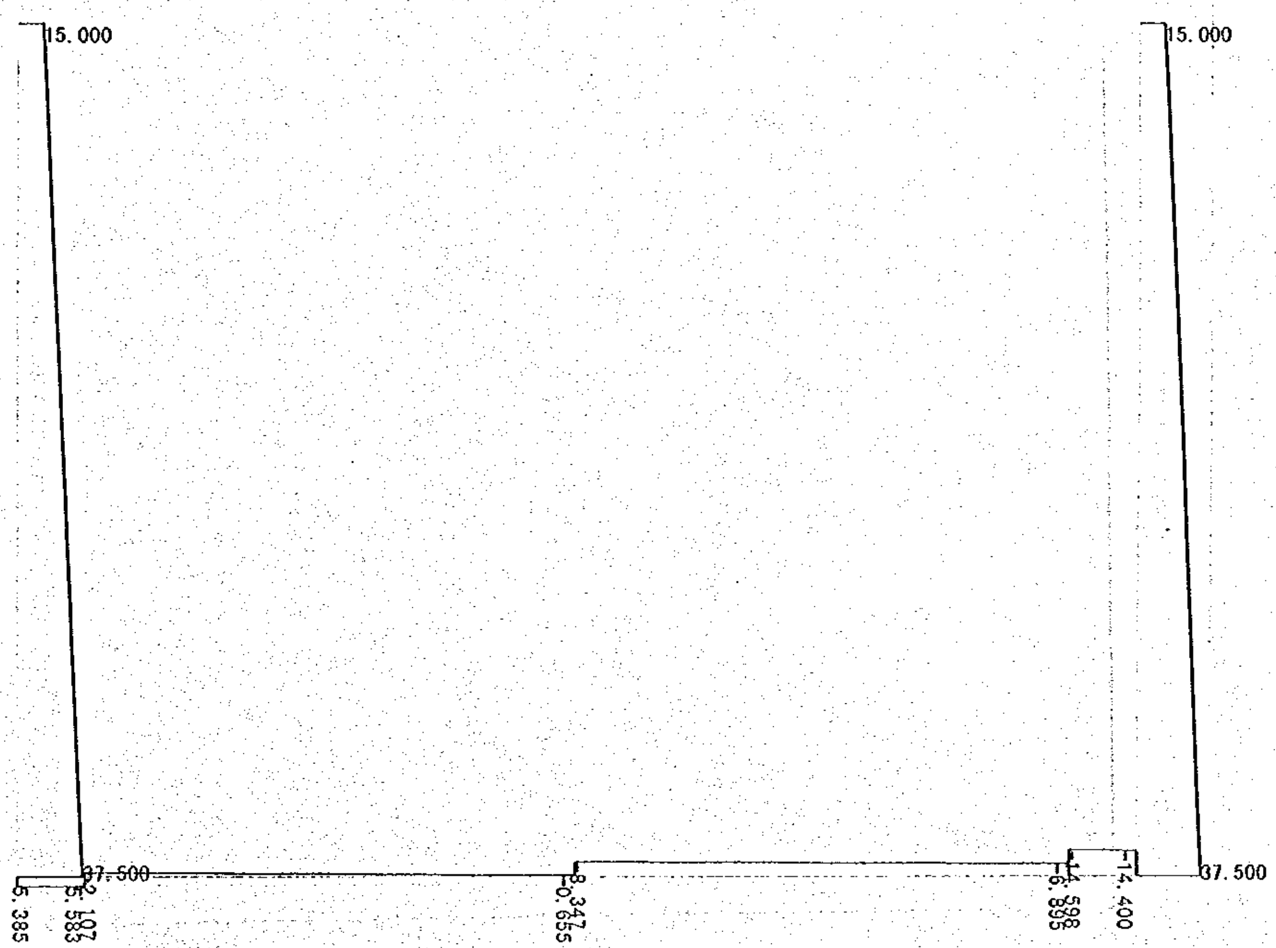


Figure - 26 (4)

baru-pier+footing

Case 4: Seismic-dry

Deformation Scale ———— : 0.331cm max. : 0.299 cm

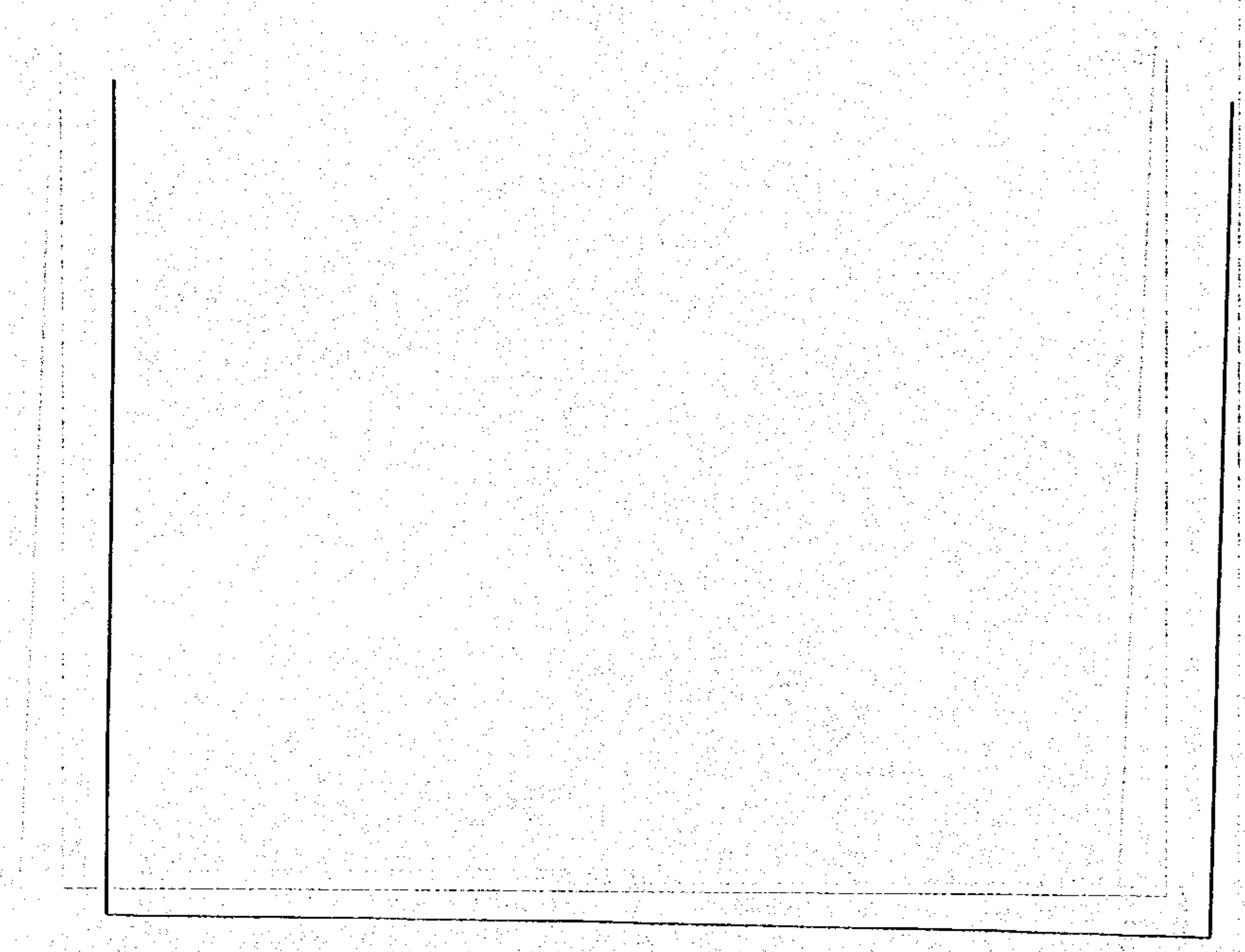


Figure - 27(1)

baru-pier+footing

Case 4: Seismic-dry

Bending Moment Scale ├──┤ : 38.81tf·m max. : -31.49 tf·m

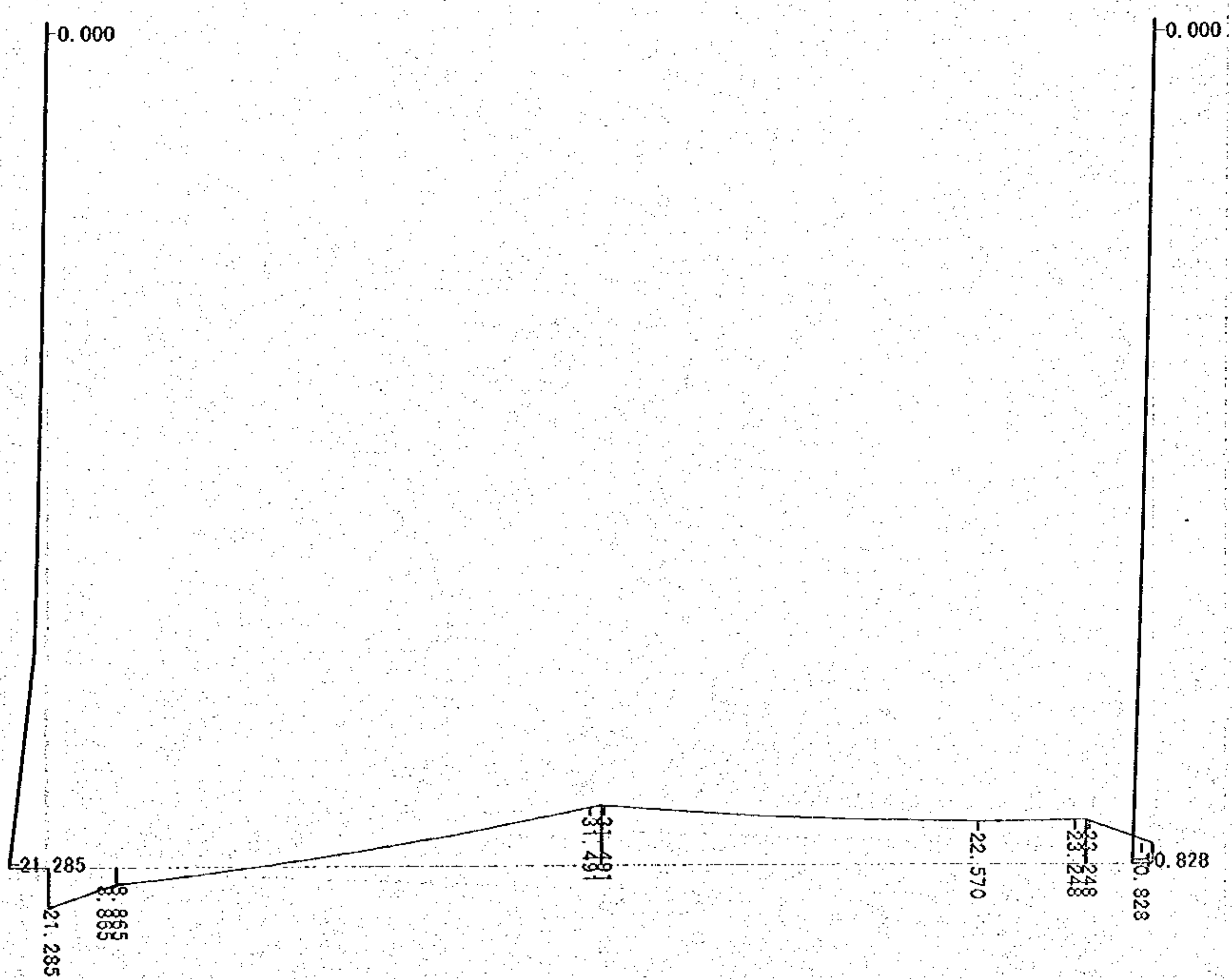


Figure - 27 (2)

baru-pier+footing

Case 4: Seismic-dry

Shear Stress Scale : 44.10tf max. : -42.30 tf

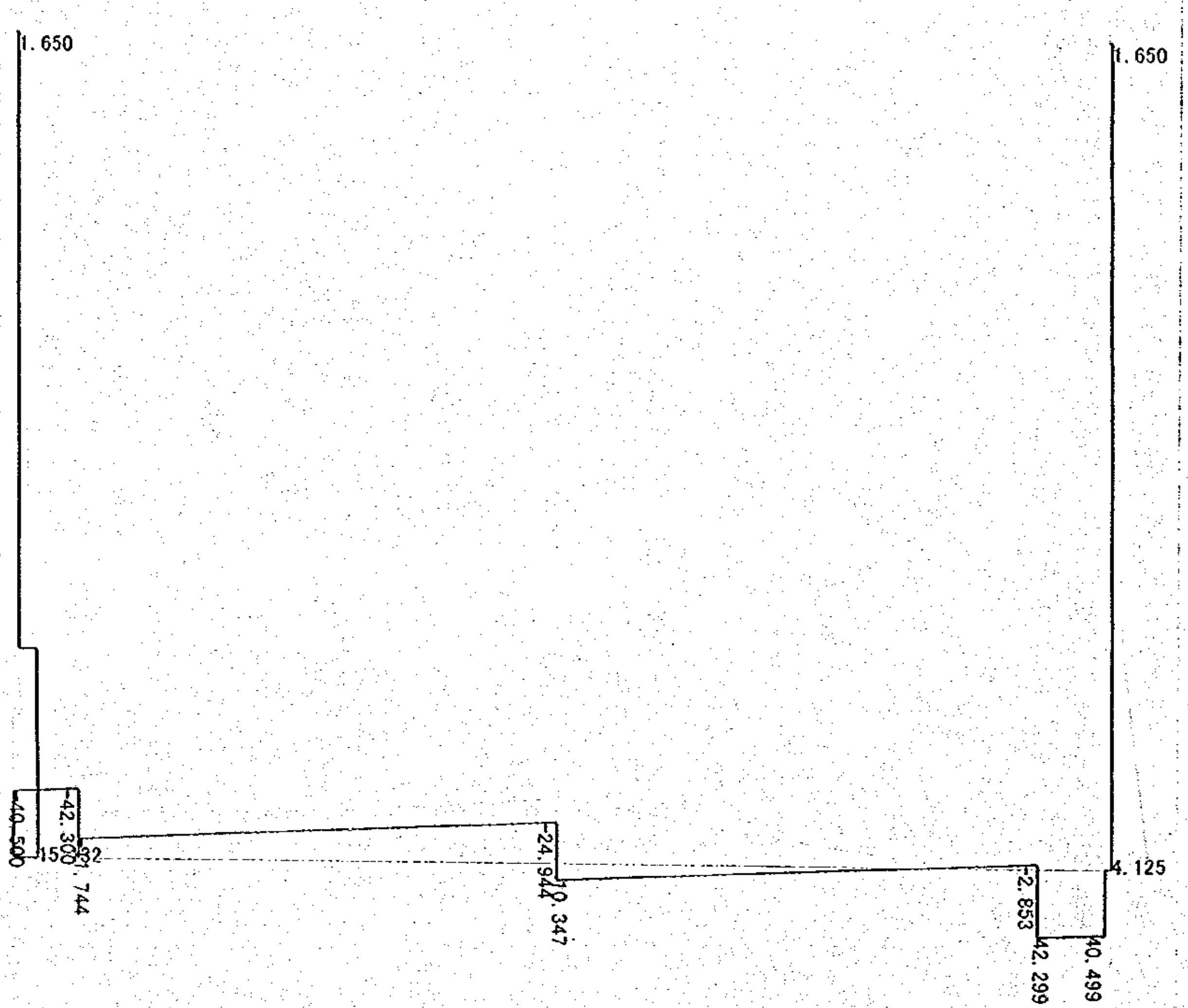


Figure - 27(3)

baru-pier+footing

Case 4: Seismic-dry

Axial Stress Scale : 42.29tf max. : 40.50 tf

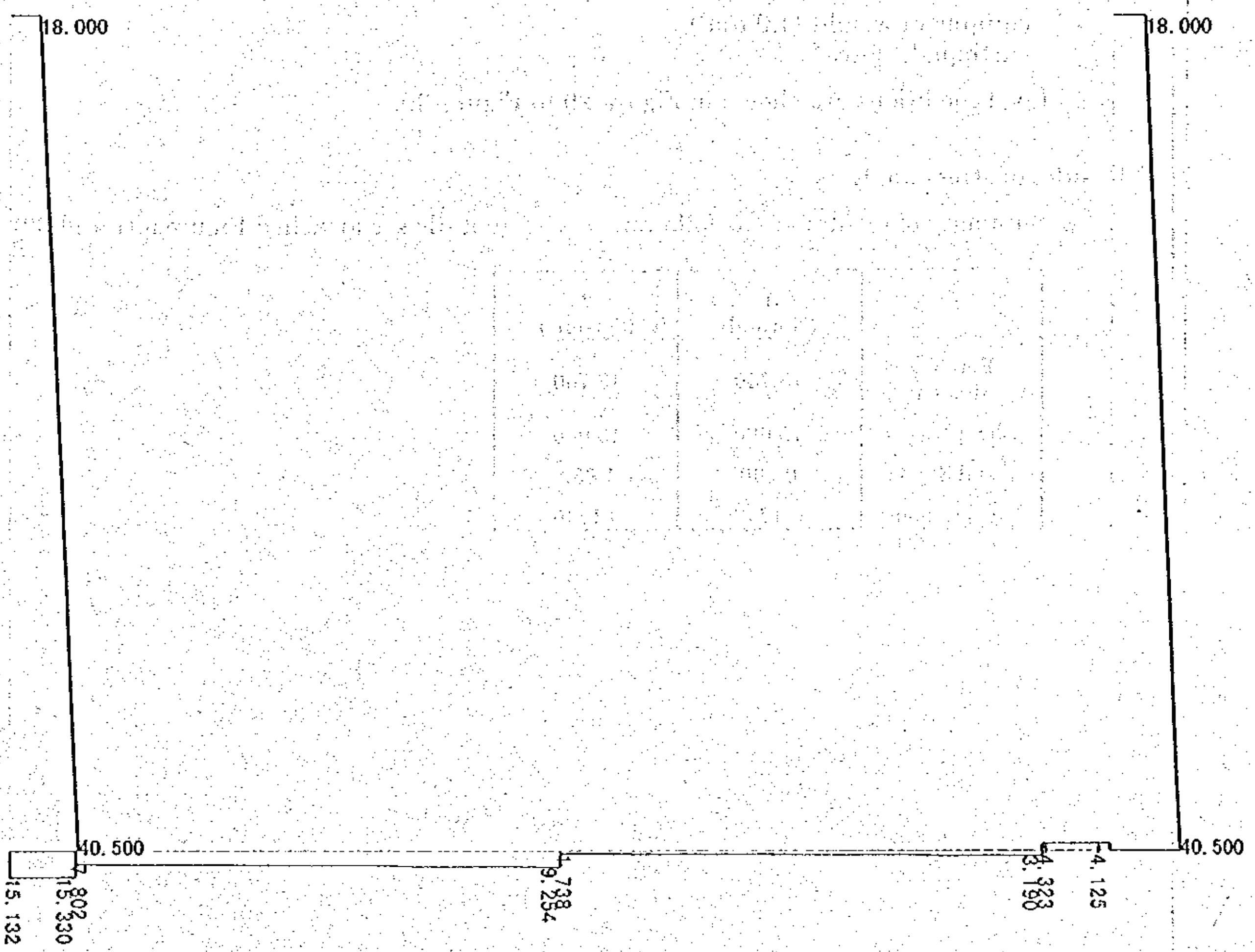


Figure - 27 (4)

3. O/M Bridge

1) Assumed dimensions

Assumed dimensions for analysis are shown in Figure-28.

2) Cross sectional area and moment of inertia

cross sectional area (A): 1.2 m^2
moment of inertia (I): 0.016 m^4

3) Load condition

Case-1: Normal condition

Case-2: Seismic condition

Loads to be considered are as follows: (details see figure)

- self-weight
- equipment weight (1.0 t/m^2)
- earthquake force

Load conditions are shown in Figure-29 to Figure-30.

4) Results of stress analysis

Summary of results are as follows: (details see attached Figures-31 and 32)

	1 (Normal)	2 (Seismic)
Bending Moment	18.750	18.750
Shear Stress	15.000	15.000
Axial Stress	0.000	1.650
Displacement	0.1246	0.1246

O/M Bridge

縮尺 1/ 33

骨組図

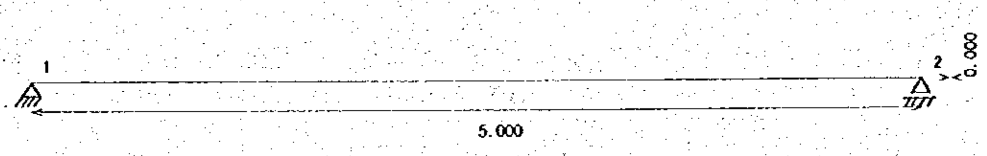


Figure - 28 Dimension for Analysis

O/M Bridge

Case 1 : Normal

Load

① 3.000 (tf/m)

3.000 (tf/m)

Self-weight included

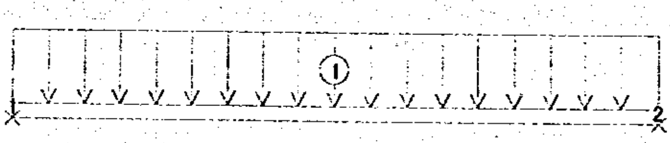


Figure - 29

O/M Bridge

Case 2 : seismic

Load

① 3.000 (tf/m)

3.000 (tf/m)

② 0.330 (tf/m)

0.330 (tf/m)

Self-weight included

Seismic Force

KH = 0.11

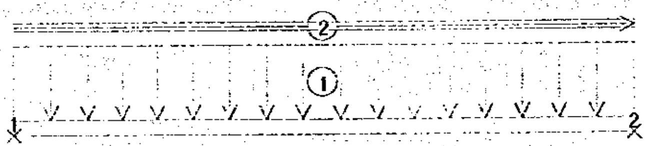


Figure - 30

O/M Bridge

Case 1: Normal

Bending Moment Scale : 18.75tf·m max. : 18.75 tf·m

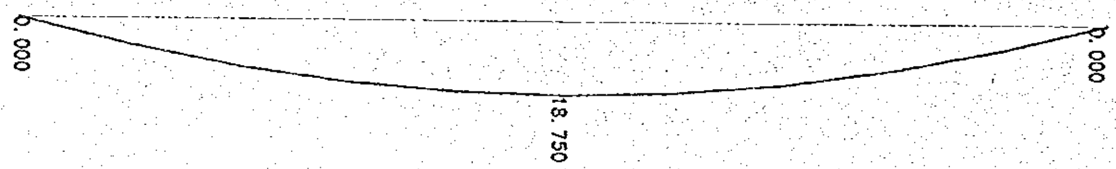


Figure – 31 (2)

O/M Bridge

Case 1: Normal

Deformation Scale ├──┤ : 0.125cm max. : 0.125 cm

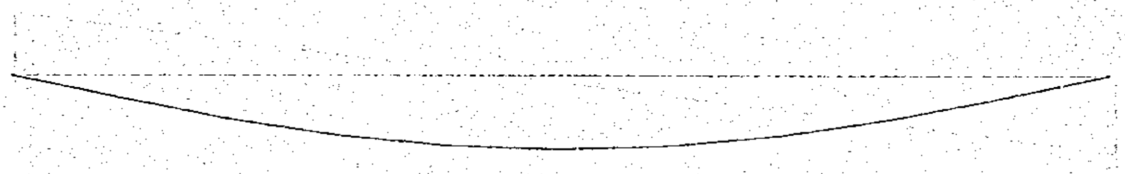


Figure - 31 (1)

O/M Bridge

Case 1: Normal

Shear Stress Scale : 15.00tf max. : 15.00 tf

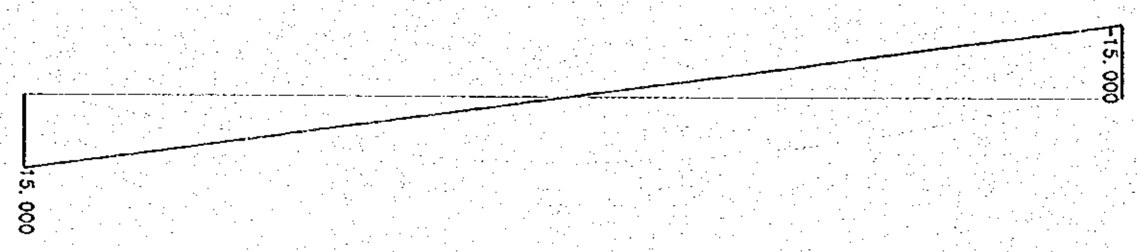


Figure — 31 (3)

O/M Bridge

Case 1: Normal

Axial Stress Scale ├──┤ : 1.65tf max. : 0.00 tf

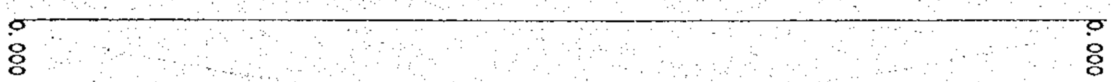


Figure —31 (4)

O/M Bridge

Case 2: seismic

Deformation Scale : 0.125cm max. : 0.125 cm

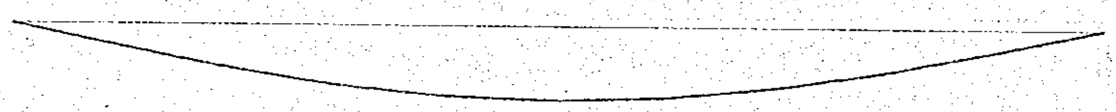


Figure – 32 (1)

O/M Bridge

Case 2: seismic

Bending Moment Scale : 18.75tf·m max. : 18.75 tf·m

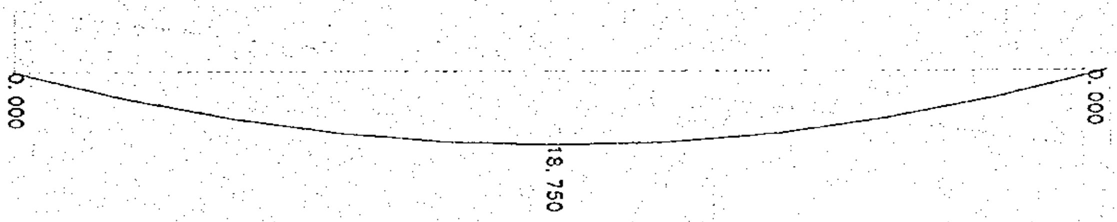


Figure - 32(2)

O/M Bridge

Case 2: seismic

Shear Stress Scale ------ : 15.00tf max. : 15.00 tf

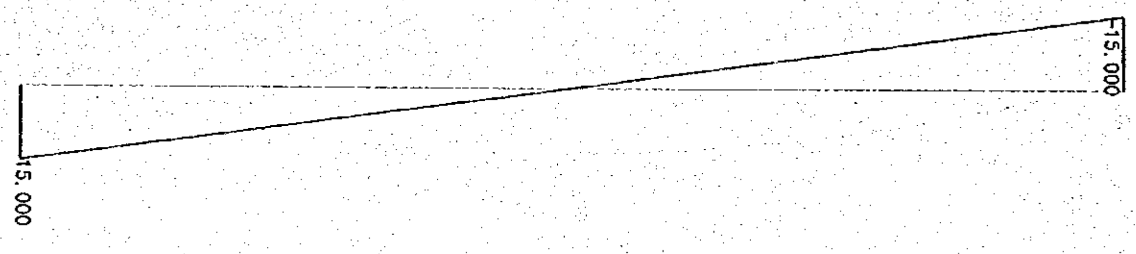


Figure - 32 (3)

O/M Bridge

Case 2: seismic

Axial Stress Scale : 1.65tf max. : -1.65 tf

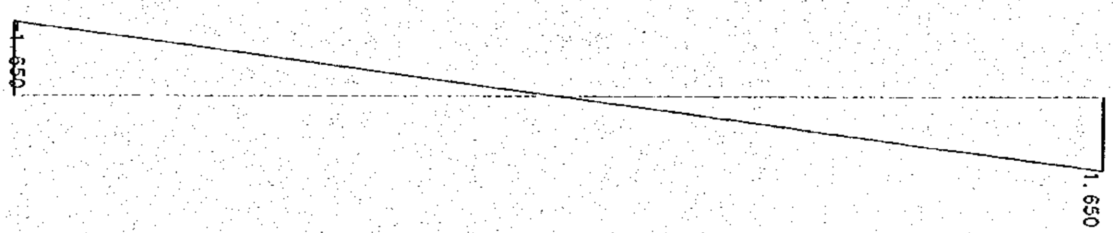


Figure – 32 (4)

3.1 Baru Pumping Station

3.1.4 Reinforcing Bar Arrangement Calculation of Gate

Name of Structure	Baru Gate	Category of calculation	Reinforcing bar arrangement	Page	1 / 9

Calculation Part

1) Gate frame   2) Pier and Footing   3) O/M bridge

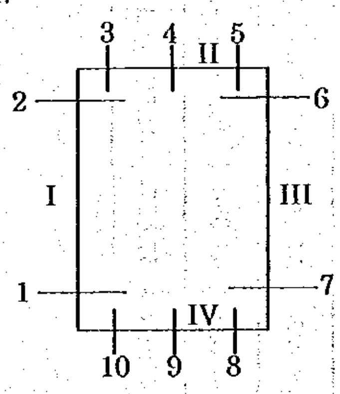
General condition of calculation

	Normal	Seismic
Allowable compressive stress of concrete:	75 kg/cm^2	112.5 kg/cm^2
Allowable shear stress of concrete:	7.5 kg/cm^2	11.25 kg/cm^2
Allowable tensile stress of reinforcing bar:	1400 kg/cm^2	2100 kg/cm^2

Minimum coverage of concrete: 15 cm at footing bottom, 10 cm at other part
Minimum ratio of reinforcing bar: 0.2% in principle

1) Gate frame

Calculated parts of main reinforcing bar arrangement are classified into three members, such as column of gate (I, III), footing of gate (IV) and slab of control room (II) as shown in following Fig.-1. Stress checkpoints of members for calculation of reinforcing bar arrangement are also shown in Fig-1.



Member I, III: column of gate frame
Member IV: footing of gate
Member II: slab of control room
1 to 10: checkpoint of member stress

Figure-1

Stresses at each checkpoint are shown in Table-1.

Load for calculation and cross section of each member are shown in Table-2 and Fig-2.

Main reinforcing bar arrangement (calculation results are shown in Table-3)

Member I, III: column of gate frame

① and ② : D19@125 mm
③ : D13@125 mm

Member IV: footing of gate

① : D22@125 mm
② : D19@125 mm

Member II: slab of control room

① and ② : D22@125 mm

Table-1 Stress at checkpoint (Gate Frame)

	Normal-Open			Normal-Close			Seismic-Open			Seismic-Close		
	M	A	S	M	A	S	M	A	S	M	A	S
1	6.618	58.697	5.844	0.069	56.447	0.475	31.566	50.251	12.911	24.045	48.336	6.380
2	18.730	35.309	2.626	17.242	33.059	2.045	1.311	28.364	1.330	0.615	26.449	1.704
3	-18.730	2.267	35.309	-17.242	2.045	33.059	-1.311	1.330	28.364	0.615	1.704	26.449
4	21.730	↑	0	21.532	↑	0	23.729	↑	0	23.407	↑	0
5	-19.684	↑	35.691	-18.195	↑	33.441	-36.993	6.486	42.636	-34.622	5.611	40.051
6	-19.684	35.691	2.626	-18.195	33.441	2.045	-36.993	42.636	6.480	-34.622	40.051	5.611
7	2.641	57.578	↑	9.191	55.328	8.945	28.316	64.524	8.887	34.381	61.939	15.392
8	-20.072	-2.626	58.600	-25.947	-8.945	57.151	-47.831	-8.887	70.643	-53.120	-15.508	76.261
9	-45.493	3.015	34.866	-44.485	-6.109	41.634	-45.140	-1.994	34.420	-44.312	-8.523	41.130
10	6.618	5.843	59.747	0.069	-3.288	57.497	31.566	13.027	51.301	24.045	6.501	49.386

M : Moment
A : Axial Stress
S : Shear Stress

Table-2 and Figure-2

Table-2 (1)
Member I and III

	Normal			Seismic		
	①	②	③	①	②	③
Moment	20	10	44	37	35	58
Axial Stress	36	56	51	43	62	51
Shear Stress	3	9	26	7	16	28

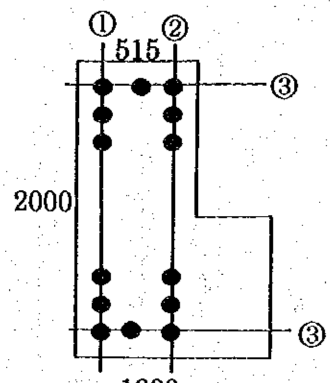


Figure-2 (1)

Table-2 (2)
Member IV (Footing of gate)

	Normal		Seismic	
	①	②	①	②
Moment	44.5	7	54	32
Axial Stress	-6.5	6	-16	14
Shear Stress	42	60	77	52

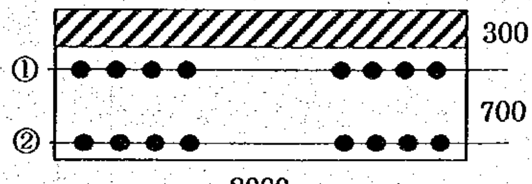


Figure-2 (2)

Table-2 (3)
Member II (Slab of control room)

	Normal		Seismic	
	①	②	①	②
Moment	20	22	37	24
Axial Stress	3	3	7	1
Shear Stress	35	0	43	0

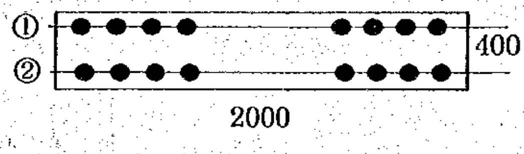
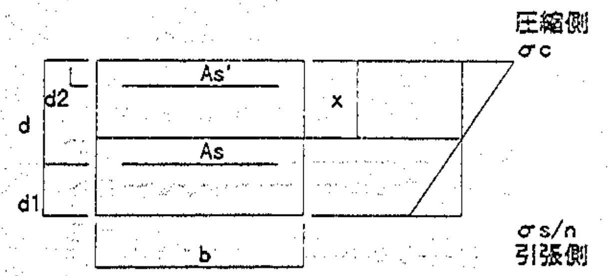


Figure-2 (3)

Table－3

検討断面・矩形断面(単鉄筋)

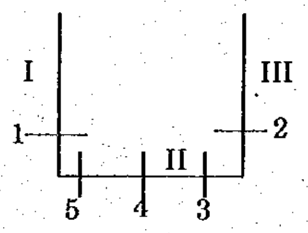


断面照査位置	断面形状 Condition of Calc										計算結果 Results					
	有効高さ d (cm)	引張鉄筋かぶり d1 (cm)	圧縮鉄筋かぶり d2 (cm)	計算幅 b (cm)	引張鉄筋鉄筋量 As (cm²)	圧縮鉄筋鉄筋量 As' (cm²)	鉄筋比	曲げモーメント M (tf·m)	軸力 N (tf)	せん断力 Q (tf)	コンクリート圧縮応力度 σc (kgf/cm²)	判定	鉄筋引張応力度 σs (kgf/cm²)	判定	コンクリートせん断応力度 τc (kgf/cm²)	判定
1	41.5	10.0	0.0	200.0	45.843	0.000	0.0055	20.000	36.000	3.000	40.2	OK	791.4	OK	0.398	OK
2	41.5	10.0	0.0	200.0	45.843	0.000	0.0055	10.000	56.000	9.000	19.4	OK	97.3	OK	0.787	OK
3	41.5	10.0	0.0	200.0	45.843	0.000	0.0055	37.000	43.000	7.000	74.2	OK	1710.9	OK	0.942	OK
4	41.5	10.0	0.0	200.0	45.843	0.000	0.0055	35.000	62.000	16.000	70.4	OK	1395.2	OK	2.126	OK
5	190.0	10.0	0.0	51.5	5.219	0.000	0.0005	44.000	51.000	26.000	28.4	OK	658.4	OK	1.658	OK
6	190.0	10.0	0.0	51.5	5.219	0.000	0.0005	58.000	51.000	28.000	44.7	OK	1764.7	OK	2.551	OK
7	60.0	10.0	0.0	200.0	61.932	0.000	0.0052	44.500	-6.500	42.000	42.4	OK	1393.4	OK	3.922	OK
8	55.0	15.0	0.0	200.0	45.843	0.000	0.0042	7.000	6.000	60.000	8.7	OK	237.8	OK	6.010	OK
9	60.0	10.0	0.0	200.0	61.932	0.000	0.0052	54.000	-16.000	77.000	50.9	OK	1755.2	OK	7.187	OK
10	55.0	15.0	0.0	200.0	45.843	0.000	0.0042	32.000	14.000	52.000	39.8	OK	1242.1	OK	5.237	OK
11	45.0	10.0	0.0	200.0	61.932	0.000	0.0069	20.000	3.000	35.000	31.2	OK	792.0	OK	4.423	OK
12	30.0	10.0	0.0	200.0	61.932	0.000	0.0103	22.000	-3.000	0.000	67.5	OK	1351.7	OK	0.000	OK
13	45.0	10.0	0.0	200.0	61.932	0.000	0.0069	37.000	7.000	43.000	57.7	OK	1453.5	OK	5.434	OK
14	30.0	10.0	0.0	200.0	61.932	0.000	0.0103	24.000	1.000	0.000	73.5	OK	1494.7	OK	0.000	OK

Aren of Reinforcing Bar　　Moment　Axial Stress　Shear Stress

2) Pier and Footing

Calculated parts of main reinforcing bar arrangement are classified into two members, such as pier (I, III), footing (II) as shown in Fig.-3. Stress checkpoints of members for calculation of reinforcing bar arrangement are also shown in Fig-3.



Member I, III:	pier
Member II:	footing
1 to 5:	checkpoint of member stress

Figure-3

Stresses at each checkpoint are shown in Table-4.

Load for calculation and cross section of each member are shown in Table-5 and Fig-4.

Main reinforcing bar arrangement (calculation results are shown in Table-6)

Member I, III: Pier

① (outside) : D19@125
② (inside) : D16@125

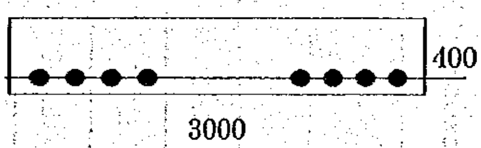
Member II: footing

① and ② : D19@125

3) O/M bridge

Moment and stress, and dimension of calculated cross section are shown in following table and figure.

		Normal	Seismic
Bending Moment		20	20
Axial Stress	+	0	5
	-	0	-5
Shear Stress		15	15



Required reinforcing bar arrangement is D19@125 mm.

(see Table-7, calculation Sheet)

Table-4 Stress at checkpoint (Pier and Footing)

	Normal-Open			Normal-Close			Seismic-Open			Seismic-Close		
	M	A	S	M	A	S	M	A	S	M	A	S
1	1.881	39.295	0.416	-12.252	42.295	10.163	-7.152	37.500	5.385	-21.285	40.500	15.132
2	-14.133	37.500	9.747	0	40.500	0	-26.160	37.500	14.400	10.828	40.500	4.125
3	-25.961	-9.747	49.866	-12.420	3.381	42.300	-37.988	-14.598	55.103	-23.248	-4.323	45.152
4	-38.303	-6.352	44.793	-31.537	6.767	35.903	-38.806	-8.347	44.134	-31.491	9.254	35.291
5	-14.247	0.416	46.347	12.252	10.163	44.091	7.152	5.583	41.352	21.285	15.330	42.300

M : Moment
A : Axial Stress
S : Shear Stress

Table-5 and Figure-4

Table-5 (1)
<u>Member I and III</u>

	Normal		Seismic	
	①	②	①	②
Moment	15	13	22	27
Axial Stress	38	43	41	38
Shear Stress	10	11	16	15

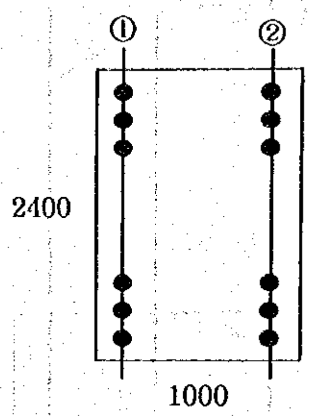


Figure-4 (1)

Table-5 (2)
<u>Member IV</u> (Footing of gate)

	Normal		Seismic	
	①	②	①	②
Moment	39	13	38	22
Axial Stress	-7	11	-15	16
Shear Stress	45	45	55	42

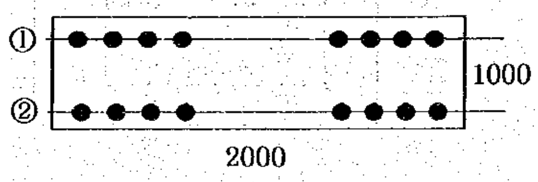
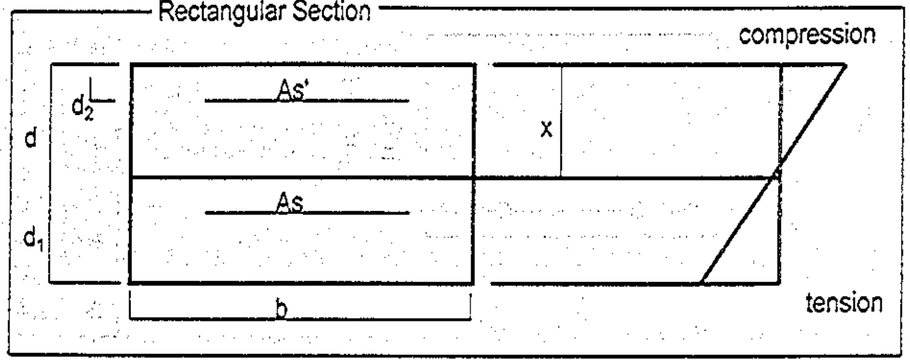


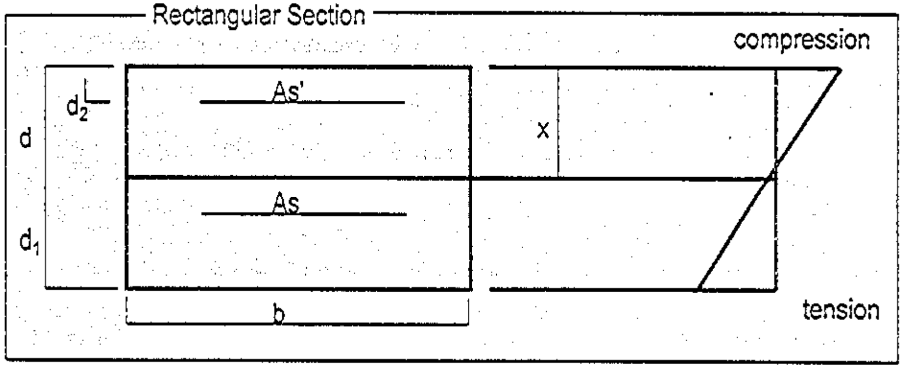
Figure-4 (2)

Table - 6



section number	Condition of Calculation										Result		
	effective height d (cm)	cover d1 (cm)	cover d2 (cm)	calculation width b (cm)	bar area tensile As (cm²)	bar area compression As' (cm²)	bar ratio	bending moment M (tf.m)	axial force N (tf)	shearing force Q (tf)	concrete compression stress σ c (kgf/cm²)	bar tensile stress σ s (kgf/cm²)	concrete shearing stress τ c (kgf/cm²)
1	90.0	10.0	0.0	240.0	55.012	0.000	0.0025	15.000	38.000	10.000	6.6	68.4	0.335
2	90.0	10.0	0.0	240.0	38.123	0.000	0.0018	13.000	43.000	11.000	5.7	32.3	0.197
3	90.0	10.0	0.0	240.0	55.012	0.000	0.0025	22.000	41.000	16.000	10.0	172.8	0.687
4	90.0	10.0	0.0	240.0	38.123	0.000	0.0018	27.000	38.000	15.000	14.1	394.9	0.695
5	90.0	10.0	0.0	240.0	55.012	0.000	0.0025	39.000	-7.000	45.000	17.8	917.9	2.264
6	85.0	15.0	0.0	240.0	55.012	0.000	0.0027	13.000	11.000	45.000	6.7	204.6	2.363
7	90.0	10.0	0.0	240.0	55.012	0.000	0.0025	38.000	-15.000	55.000	17.0	967.2	2.762
8	85.0	15.0	0.0	240.0	55.012	0.000	0.0027	22.000	16.000	42.000	11.3	368.6	2.217

Table - 7

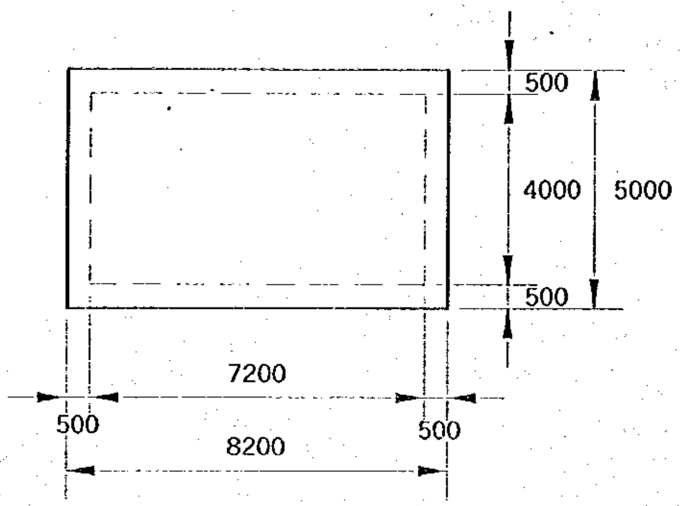


section number	Condition of Calculation										Result		
	effective height d (cm)	cover d1 (cm)	cover d2 (cm)	calculation width b (cm)	bar area tensile As (cm²)	bar area compression As' (cm²)	bar ratio	bending moment M (tf.m)	axial force N (tf)	shearing force Q (tf)	concrete compression stress σ c (kgf/cm²)	bar tensile stress σ s (kgf/cm²)	concrete shearing stress τ c (kgf/cm²)
1	30.0	10.0	0.0	300.0	68.765	0.000	0.0076	20.000	0.000	15.000	44.9	1109.1	1.907
2	30.0	10.0	0.0	300.0	68.765	0.000	0.0076	20.000	5.000	15.000	45.0	1068.3	1.906
3	30.0	10.0	0.0	300.0	68.765	0.000	0.0076	20.000	-5.000	15.000	44.7	1150.2	1.906

3.1 Baru Pumping Station

3.1.5 Structural Calculation of Gate House

Plan of Roof



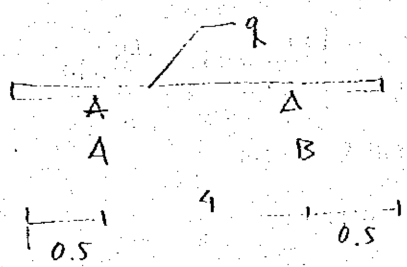
Tebal Plat = 14 cm
Selimut = 5 cm
h = cm

LOAD

Uniform Load

Water	q	=	0.05 x 1 x 1 x 1	=	0.050 t/m²
Live load	q	=	0.25 x 1 x 1	=	0.250 t/m²
Concrete	q	=	0.19 x 1 x 1 x 25	=	0.475 t/m²
			q	=	0.775 t/m²

M_A = $q\ell \, ½ \, \ell$
= $½ \, q\ell^2$
= $½(0.775)(0.5)^2$
= 0.097 t.m



M_{max} = $⅛ \, q \, \ell^2$
= $⅛(0.775) \times 4^2$
= 1.55 t.m

M_T = 1.55 – 0.097
= 1.453 t.m

Concrete

K_{225} - $\bar{\sigma}_b = 75 kg/cm^2$
U_{24} - $\bar{\sigma}_a = 1400 kg/cm^2$

n = 15

$$\phi_o = \frac{\bar{\sigma}_a}{n\bar{\sigma}_b} = \frac{1400}{15 \cdot (75)} = 1.244$$

h = 18 – 5 = 13 cm

$$Ca = \frac{h}{\sqrt{\frac{n \times m}{b \times \bar{\sigma} a}}} = \frac{13}{\sqrt{\frac{15 \times (1.453)}{1 \times 1.400}}} = \frac{13}{3.295} = 3,295$$

Ca = 3.295 δ = 1

$$\rightarrow \phi = 2.175, \quad \phi' = 3.186, \quad \phi_o = 1.244$$

$$100 n\omega = 10.56$$

$$A = \frac{b \cdot h \cdot n\omega}{n}$$

$$= \frac{100 \cdot 13 \cdot 0.1056}{15} = 9.15 cm^2$$

$$A = A'$$

D13-125 = 11.97 cm²

~~Shear~~ strengh

$$\sigma_b' = \frac{\sigma_a}{n\phi} = \frac{1400}{15(2.175)} = 42.91 \, Kg/cm^2$$

$$\sigma_a' = \frac{\sigma_a}{\phi'} = \frac{1400}{3.186} = 439.42 \, kg/cm^2$$

Tebal plat di A = 13 cm

M_A = 0.097 t.m

h = 13 – 5 = 8 cm

$$Ca = \frac{h}{\sqrt{\frac{n \times m}{b \times \bar{\sigma} a}}} = \frac{8}{\sqrt{\frac{15 \times (0.095)}{1 \times 1.400}}} = \frac{13}{1.008} = 7.9$$

Ca = 7.9 δ = 1

$$\rightarrow \phi = 5.061, \quad \phi' = 12.85, \quad \phi_o$$

$$n\omega = 0.01768$$

$$A = \frac{b \cdot h \cdot n\omega}{n}$$

$$= \frac{100 \cdot 8 \cdot 0.01768}{\cdot 15} = 0.942 cm^2$$

$$A = A' \rightarrow D_{13} - 125 = 11.97\, cm^2$$

~~Shear~~ strength

$$\sigma_b' = \frac{\sigma_a}{n\phi} = \frac{1400}{15(5.061)} = 18\, {Kg}/{cm^2} < \bar{\sigma}_b$$

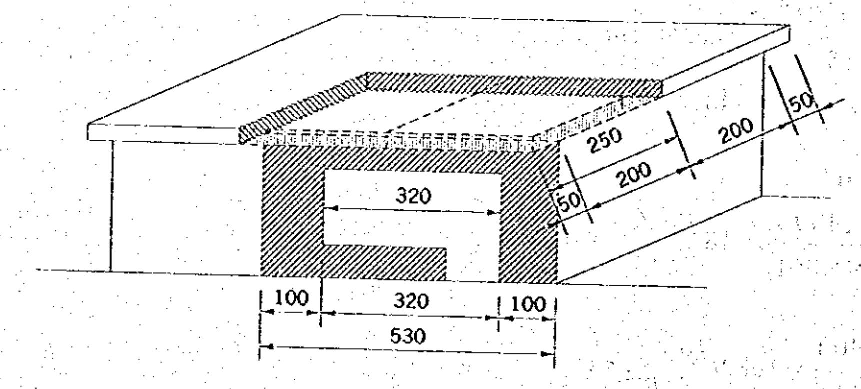
$$\sigma_a = \frac{\sigma_a}{\phi'} = \frac{1400}{12.85} = 108.9\, {kg}/{cm^2} < \bar{\sigma}_a$$

Weight per slab

Max weight of slab = 1.50 x 5 x 0.19 x 2.5 = 3.562 ton

Diameter of steel = $\frac{3.562}{1400} = 2.54 cm^2$

Ø19mm = 2.84 cm² > 2.54 cm



Load :

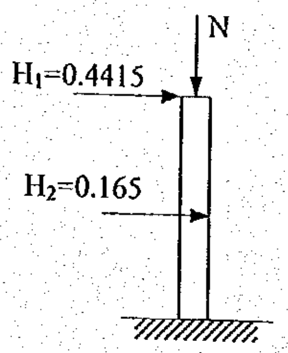
$q_1 \quad = \quad 2.5\times\left(1+\frac{3.2}{2}\right)\times 0.19\times 2.5 \quad = \quad 3.090$ ton (concrete)

$q_2 \quad = \quad 2.5\times\left(1+\frac{3.2}{2}\right)\times 0.05\times 1 \quad = \quad 0.325$ ton (water)

$q_3 \quad = \quad 0.75\times 0.20\left(\frac{3.2}{2}\right)\times 2.5 \quad = \quad$ <u>0.600 ton (balk)</u>

Total = 4.015 ton

Wall = 3 x 0.2 x 1 x 2.5 = 1.5 ton



H_1 = 0.11 x 4.015 = 0.4415

H_2 = 0.11 x 1.5 = 0.1650

N = 4.015 + 1.5 = 5.515 t

M = 0.4415 x 3 9 0.165 x 1.5
= 1.324 + 0.247
= 1.571 t.m

K_{225} - σ_b = 75 kg/cm²

U_{24} - σ_a = 1400 kg/cm²

Assume n = 15

$$\varnothing_0 = \frac{\sigma_a}{n\sigma_b} = \frac{1400}{15\times 75} = 1.244$$

$$o1 = \frac{M}{N} = \frac{1.695}{5.515} = 0.307$$

$$o2 = \tfrac{1}{30}ht = \frac{1}{30}\cdot 0.2 = 0.007 \qquad \text{min} = 0.02 \text{ m}$$

$$o = o1 + o2 = 0.327$$

$$\frac{\ell_0}{ht} = \frac{0.327}{0.2} = 1.635 > 1 \rightarrow c = 7$$

$$_1 \;=\; c\left(\frac{\ell_k}{100ht}\right)^2 \times ht = 7\left(\frac{3}{100(0.2)}\right)^2 \cdot 0.2 = 0.031$$

$$_2 \;=\; 0.15\,ht \;=\; 0.15 \times 0.2 \;=\; 0.03$$

$$= \;_0 + \;_1 + \;_2 \;=\; 0.327 + 0.031 + 0.03 \;=\; 0.388$$

$$_a \;=\; +\tfrac{1}{2}\,ht - 0.05 \;=\; 0.388 + 0.10 - 0.05 \;=\; 0.438$$

$N_{ea} = 5.515 \times 0.438 = 2.415$ t.m

$$Ca = \frac{h}{\sqrt{\dfrac{n \times m}{b \times \tau a}}} = \frac{14}{\sqrt{\dfrac{15 \times (2.415)}{1 \times 1400}}} = \frac{14}{5.086} = 2.752$$

Symmetrical Bar

$$\delta = 1 - \tfrac{7}{8}\frac{\ell}{\ell_a}$$

$$= 1 - \tfrac{7}{8}\frac{0.14}{0.43}$$

$$\delta = 0.8$$

$$\phi = 1.778$$

$= 0.715$ $\qquad \phi' = 2.462$

$$\zeta = 0.886$$

$$W_0 n\omega = 15$$

$$\sigma_a = \bar{\sigma}_a = 1400\,{}^{kg}\!/\!_{cm^2}$$

$$\bar{\sigma}_b' = \frac{\sigma_a}{n\phi} = \frac{1400}{15 \cdot (1.778)} = \frac{400}{26.67} = 52.493 < 75\,{}^{kg}\!/\!_{cm^2}$$

$$\sigma\;' = \frac{\sigma_a}{\phi} = \frac{1400}{2.462} = 568.643$$

$$\left.\begin{array}{l} \dfrac{\ell_a}{n} = \dfrac{0.43}{0.14} = 3.071 \\ \zeta = 0.886 \end{array}\right\} \; i = 1.34$$

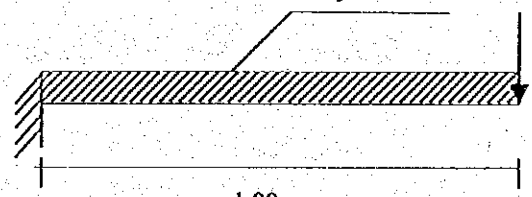
$$iA \;=\; wbh \;=\; \frac{15}{15(100)}(100(14) = 14cm^2$$

$$\left.\begin{aligned} A &= \frac{iA}{i} = \frac{14}{1.34} = 10.447cm^2 \\ A' &= \delta iA = 0.8(14) = 11.2 \end{aligned}\right\rangle D_{16} - 12.5 = 16cm^2 > 11.2$$

I. **Load**: <u>For 1 m width of Floor</u>

q_1	= 2.5 x 1 x 0.19 x 2.5	= 1.187 t	(concrete roof)
q_2	= 1 x 1 x 0.05 x 2.5	= 0.125 t	(water)
q_3	= 0.1 x 2.5	= 0.250 t	(live load of roof)
q_4	= 3 x 0.2 x 2.5	= 1.500 t	(wall)
q_{total}		= 3.062 t	(P)

q_5	= 0.25 x 1 x 1	= 0.250 t/m²	(live load of floor)
q_6	= 0.4 x 1 x 1 x 2.5	= 1.000 t/m²	(concrete floor)
		= 1.250 t/m²	(q)



$M_1 = P(1) = 3.062 \times 1 = 3.062$

$M_2 = q\ell \cdot \frac{1}{n}\ell = 1.25(1)(\frac{1}{2}) = 0.625$

$M_{total} = 3.687$ t.m

h = 40 cm

b = 100 cm

= 40 – 5 – 1.9 – 0.8 = 32 cm

Concrete : K_{225} - $\bar{\sigma}_b = 75 \, kg/cm^2$

- $\tau_b = 7 \, kg/cm^2$

U_{24} - $\bar{\sigma}_a = 1400 \, kg/cm^2$

- $n = 15$

$$\phi_o = \frac{\sigma_a}{n\sigma_b} = \frac{1400}{15(75)} = 1.244$$

h = 32 cm

$$Ca = \frac{h}{\sqrt{\frac{n \times m}{b \times \bar{\sigma} a}}} = \frac{32}{\sqrt{\frac{15 \times (3687)}{1 \times 1400}}} = \frac{32}{6.28} = 5.09$$

$$Ca = 5.09,\quad = 1 \;\Big\}\; \phi = 3.255,\; \phi'_1 = 5.667 \Big\rangle\; \phi = 1.244$$

$$100n\omega = 4.383$$

$$A = \frac{b \cdot h \cdot n\omega}{n}$$

$$100n\omega = 4.383$$

$$100n\frac{A}{bh} = 4.383$$

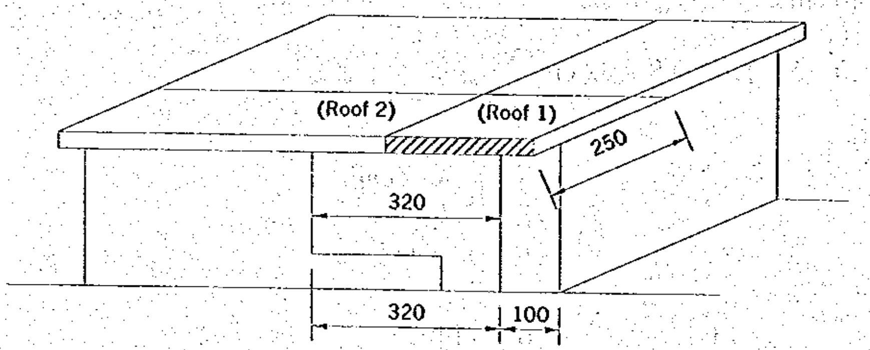
$$A = \frac{4.383bh}{100(n)}$$

$$= \frac{4.383(100)(32)}{100(15)}$$

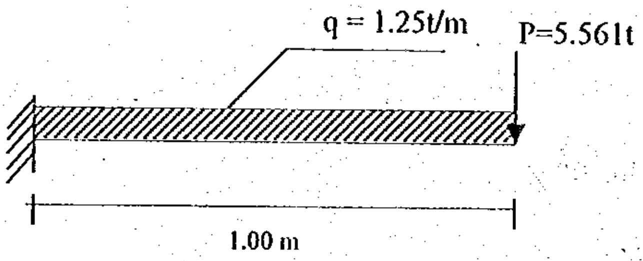
$$= 9.35cm^2$$

$$D_{13}\text{-}@125 = \frac{1000}{125} \times 1.33 = 10.64\ \text{cm}^2 \rightarrow \text{OK}$$

II. Load



q_1	=	2.5 x 1 x 0.19 x 2.5	= 1.187 t	(concrete roof)
q_2	=	1 x 1 x 0.05 x 2.5	= 0.125 t	(water)
q_3	=	0.1 x 2.5	= 0.250 t	(live load of roof)
q_{total}			= 1.562 t	($Roof_1$)
q_3	=	$\frac{3.2}{2} \times 1.562$	= 2.499 t +	($Roof_2$)
q_{roof}	=		= 4.061 t	(P)
q_{wall}	=		1.5 t	→ P = 5.561 ton
q_5	=	0.25 x 1 x 1	= 0.250 t	(live load)
q_6	=	0.4 x 1 x 1.25	= 1.000 t	(concrete floor)
		q	= 1.250 t/m	



M_1	=	5.561 x 1	=	5.561 t
M_2	=	1.25 x 1 ½	=	0.625 t
M_{total}			=	6.186 t

Concrete : K_{225} - $\bar{\sigma}_b = 75 \, kg/cm^2$

- $\tau_b = 7 \, kg/cm^2$

U_{24} - $\bar{\sigma}_a = 1400 \, kg/cm^2$

- $n = 15$

$$\phi_o = \frac{\sigma_a}{n\sigma_b} = \frac{1400}{15(75)} = 1.244$$

h = 32 cm

$$Ca = \frac{h}{\sqrt{\frac{n \times m}{b \times \bar{\sigma} a}}} = \frac{32}{\sqrt{\frac{15 \times (6186)}{1 \times 1400}}} = \frac{32}{8.14} = 3.93$$

$$\left.\begin{array}{l} Ca = 3.93 \\ \quad = 1 \end{array}\right\} \quad \left.\begin{array}{l} \phi = 2.571 \\ \phi'_1 = 4.000 \end{array}\right\rangle \phi = 1.244$$

$100n\omega = 7.259$

$$100n\frac{A}{bh} = 7.259$$

$$A = \frac{7.259(100)(32)}{(100)(15)}$$

$$A' = 15.48 cm^2$$

$$D_{16} - @125 = \frac{1000}{125} \times 2.01 = 16.08 \text{ cm}^2 > \text{A}$$

Control:

$$\sigma_a = \bar{\sigma}_a = 1400 \, {}^{kg}\!/_{cm^2}$$

$$\sigma_b' = \frac{\sigma_a}{n\phi} = \frac{1400}{15(2.571)} = 36.30 \, {}^{kg}\!/_{cm^2}$$

$$\sigma_a' = \frac{\sigma_a}{\phi'} = \frac{1400}{4.00} = 350 \, {}^{kg}\!/_{cm^2}$$