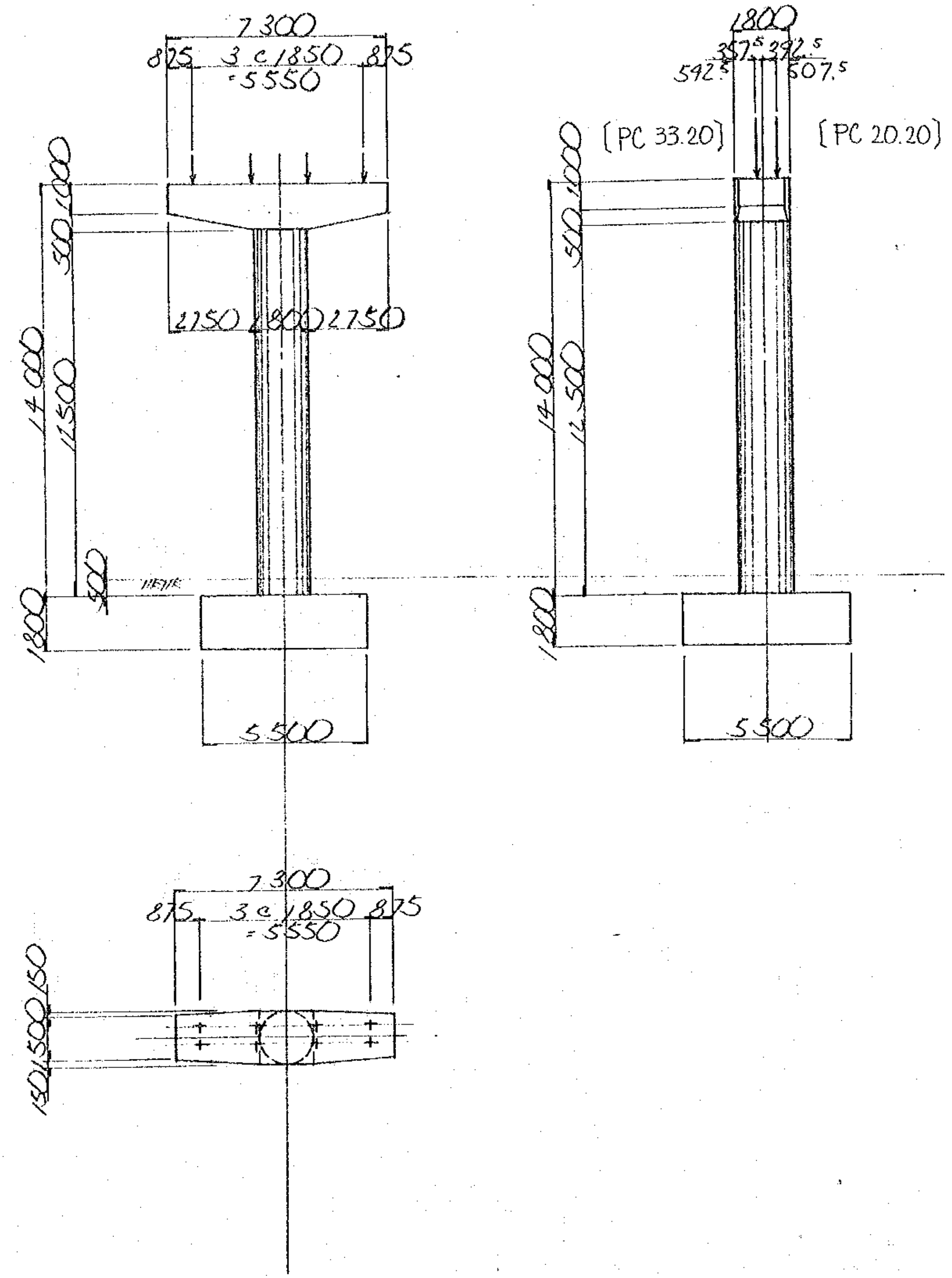
§§ 4   H = 15.80 m

E - RAMP   P1

§ 1 STRUCTURAL FIGURE



§ 2 REACTION OF SUPERSTRUCTURE

2-1 whole reaction of superstructure

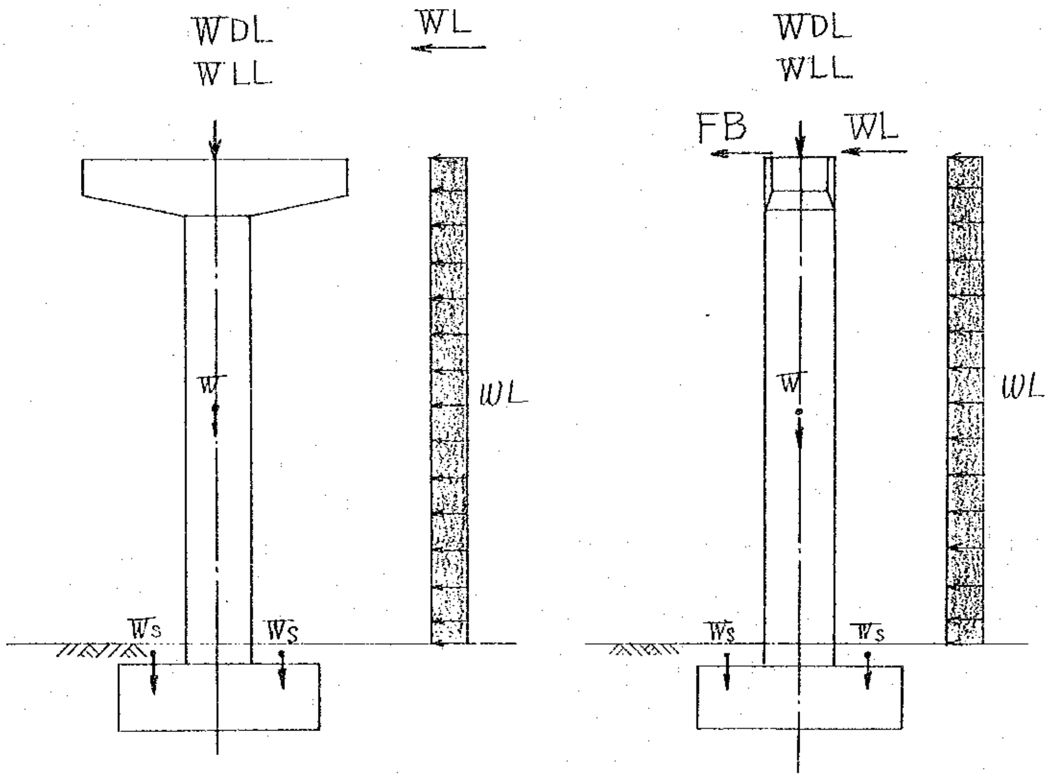
dead load of deck		227.7	151.5
H. A Live load		119.7	64.9
H. B Live load		68.3	63.1
crowd load		—	—
longitudinal forces	under H.A	12.90	
	under H.B	19.10	

2-2 reaction per each girder

		G 1	G 2	G 3	G 4
dead load of deck		95.8	96.5	96.5	95.8
live load	H A	42.9	50.6	50.6	42.9
	H B	56.7	53.9	53.9	56.7
TOTAL	H A	138.7	147.1	147.1	138.7
	H B	152.5	150.4	150.4	152.5

§ 3 CALCULATION OF LOAD

3-1 loading diagram



WDL : dead load of deck

WLL : max LL reaction under HA & HB

F B : HA & HB braking or fraction

W : self weight

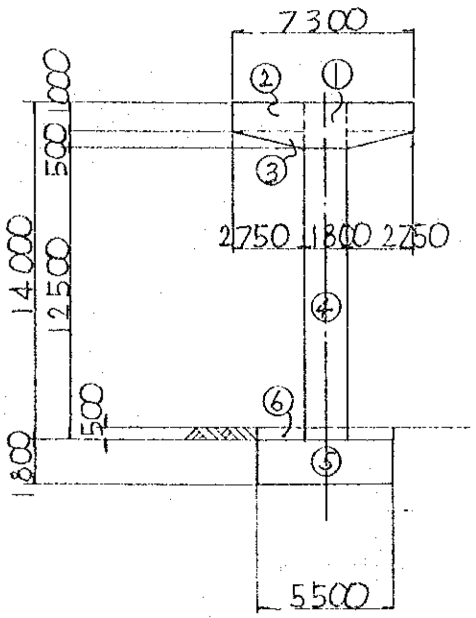
Ws : weight of soil

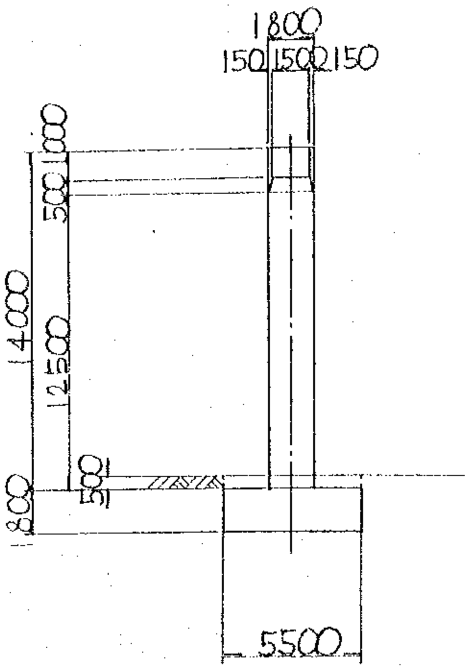
WL : wind load on the superstructure

wL : wind load on the pier

B : buoyancy

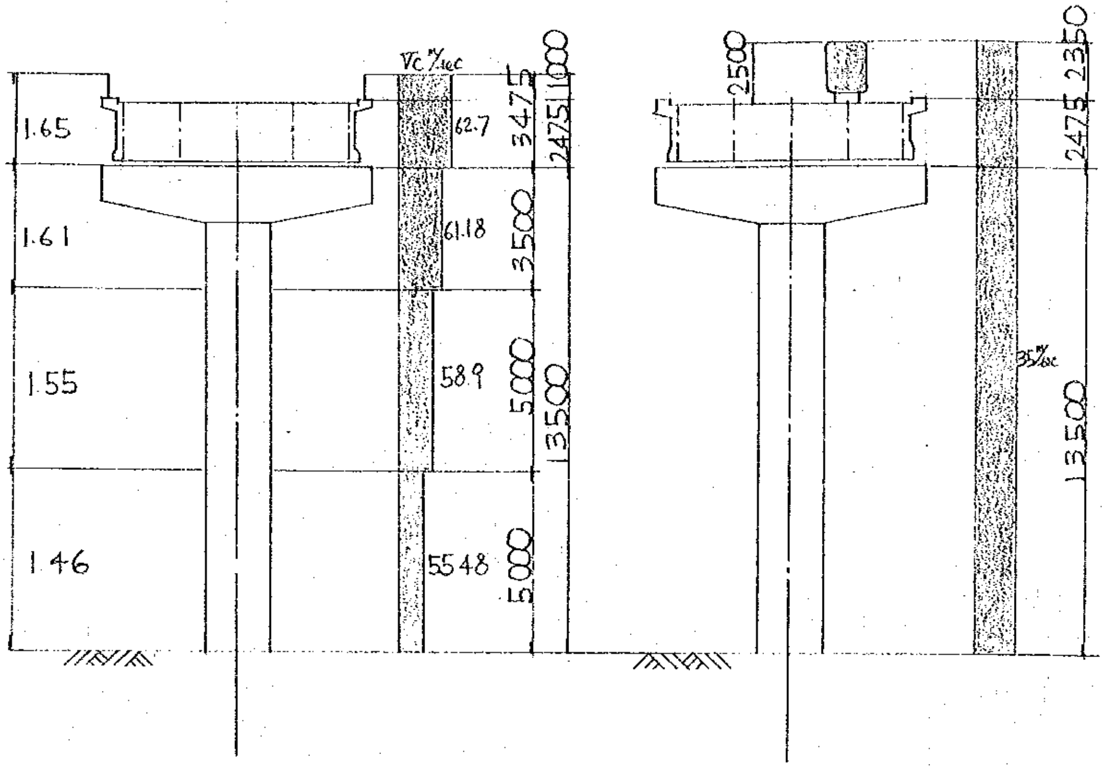
3 - 2 self weight and weight of soil





		N (t)
①	1.80 × 1.50 × 1.80 × 2.41	11.71
②	{1/2 × (1.50 + 1.80) × 2.75 × 1.00} × 2 × 2.41	21.87
③	{1/6 × 0.50 × 2.75 × (2 × 1.80 + 1.50)} × 2 × 2.41	5.63
④	π/4 × 1.80² × 12.50 × 2.41	76.66
⑤	5.50 × 5.50 × 1.80 × 2.41	131.22
⑥	(5.50 × 5.50 − π/4 × 1.80²) × 0.50 × 1.9	26.32
		273.41

3-3 wind pressure



wind gust speed

$$V_c = v \cdot k_1 \cdot s_1 \, s_2$$

case 1 (without live load)

$$V_c = 38 \times 1.0 \times 1.1 \times 1.0 = 38.s_2 \ \text{m/sec}$$

case 2 (with live load)

$$V_c = 35.00 \ \text{m/sec}$$

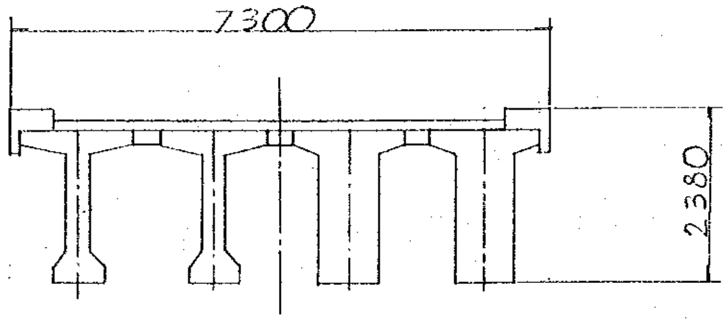
(A) transverse wind load

(A - 1) for superstructures

$$P_t = q \cdot A \cdot C_d \quad (t)$$
$$q = 0.613 \cdot V_c^2 \times 0.102 \quad (kg/m^2)$$

C_d : drag coefficient

A : loading area (m^2)



case 1

$$q = 0.613 \times 62.7^2 \times 0.102 \times 10^{-3} = 0.25 \; t/m^2$$
$$A = 2.38 \times 1/2 \times (34.00 + 20.90) = 65.33 \; m^2$$
$$C_d = 1.45 \quad (b/d = 7.30/2.38 = 3.07)$$

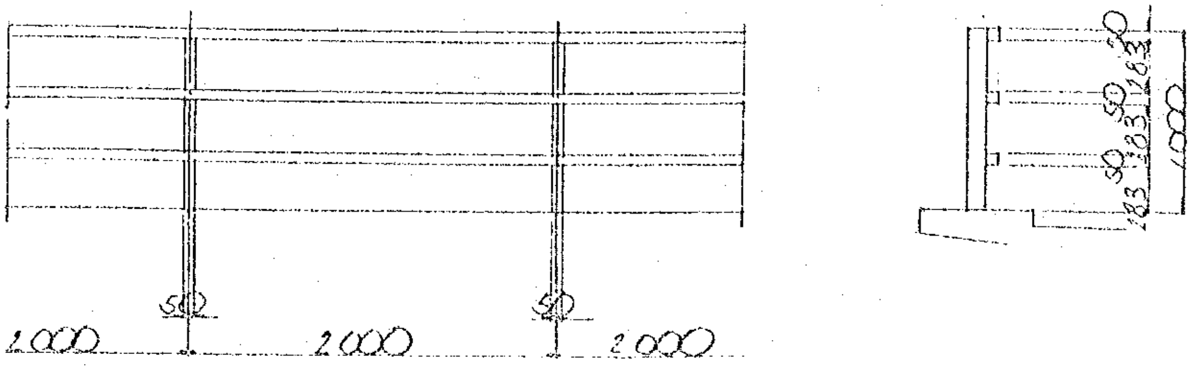
$$P_t = 0.25 \times 65.33 \times 1.45 = 23.68 \; t$$

case 2

$$q = 0.613 \times 35^2 \times 0.102 \times 10^{-3} = 0.077 \; t/m^2$$
$$A = 4.73 \times 1/2 \times (34.00 + 20.90) = 129.84$$
$$C_d = 1.43 \quad (b/d = 7.30/2.50 = 2.92)$$

$$P_t = 0.077 \times 129.84 \times 1.43 = 14.30 \; t$$

(A − 2) for parapet



case 1

$$A = 0.05 \times 3 \times 27.45 + (1.00 - 0.05 \times 3) \times \frac{27.45}{2.00}$$

$$= 15.78 \ m^2$$

$$q = 0.613 \times 62.7^2 \times 0.102 \times 10^{-3} = 0.25 \ t/m^2$$

$$C_d = 1.1 \quad (\text{from table 8})$$

$$P_t = 0.25 \times 15.78 \times 1.1 = 4.34 \ t$$

(A-3) for substructure

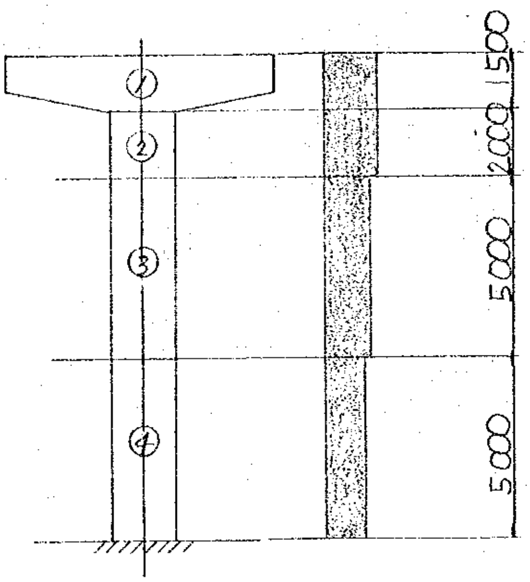
case 1

$$V_c = v \cdot k_1 \cdot s_1 \cdot s_2$$

$$= 38 \times 1.0 \times 1.0 \times S_2 = 38 \cdot S_2 \quad m/sec$$

$$q = 0.613 \cdot V_c^2 \times 0.102 \times 10^{-3} = 0.0903 \cdot (S_2)^2 \quad t/m^2$$

$$P_t = q \cdot A \cdot C_d$$



	V_c (m/sec)	q (t/m²)	t/b	C_d
①	61.18	0.23	>4	1.1
②	61.18	0.23	○	1.2
③	58.9	0.22	○	1.2
④	55.48	0.19	○	1.2

	A (m^2)		P_t (t)	y (m)	$P_t \cdot y$ (tm)
①	1.80 × 1.50	2.70	0.68	15.05	10.23
②	1.80 × 2.00	3.60	0.99	13.30	13.17
③	1.80 × 5.00	9.00	2.38	9.80	23.32
④	〃	9.00	2.05	4.80	9.84
		24.30	6.10		56.56

case – 2

$$V_c = 35 \ m/sec$$

$$q = 0.613 \times 35^2 \times 0.102 \times 10^{-3} = 0.077 \ t/m^2$$

$$A = 24.30 \ m^2$$

$$C_d = (11 \times 2.70 + 21.6 \times 1.2) \times 1/24.30 = 1.19$$

$$P_t = 0.077 \times 24.30 \times 1.19 = 2.23 \ t$$

$$y = \frac{2.70 \times 15.05 + 21.6 \times 8.30}{24.30} = 9.05 \ m$$

(B) longitudinal wind load

(B - 1) for superstructure

case 1

$$P_{LS} = 0.25 \cdot P_t$$

$$= 0.25 \times 23.68 = 5.92^{t}$$

case 2

$$P_{LS} = 0.25 \cdot P_t$$

$$P_t = q \cdot A \cdot C_d \ , \quad A = l \cdot d$$

$$P_{LS} = 0.25 \times 0.077 \times (27.45 \times 2.38) \times 1.45$$

$$= 1.82^{t}$$

$$P_{LL} = 0.5 \cdot P_t$$

$$P_t = q \cdot A \cdot C_d \qquad A = 2.50 \cdot l \qquad C_d \geqq 1.45$$

$$P_{LL} = 0.5 \times 0.077 \times (2.50 \times 27.45) \times 1.45$$

$$= 3.83^{t}$$

(B − 2) for palapet

for vertical members

$$P_{L1} = 0.8 \cdot P_t$$

$$P_t = q \cdot A \cdot C_d \qquad C_d = 1.1$$

$$A = 0.05 \times (1.00 - 3 \times 0.05) \times 27.45 / 2.00 = 0.58^{m^2}$$

$$P_{L1} = 0.8 \times 0.23 \times 0.58 \times 1.1 = 0.12^{t}$$

for horizontal members.

$$P_{L2} = 0.4 \cdot P_t$$

$$P_t = q \cdot A \cdot C_d \qquad C_d = 1.1$$

$$A = 27.45 \times 0.05 \times 3 = 4.12^{m^2}$$

$$P_{L2} = 0.4 \times 0.23 \times 4.12 \times 1.1 = 0.42^{t}$$

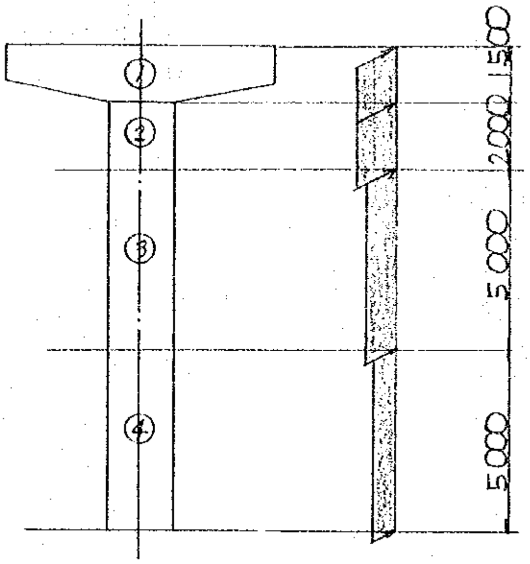
(B - 3) for substructure

case 1

$$V_c = v \cdot k_1 \cdot S_1 \cdot S_2$$
$$= 38 \times 1.0 \times 1.0 \times S_2 = 38 \cdot S_2 \quad m/sec$$

$$q = 0.613 \cdot V_c^2 \times 0.102 \times 10^{-3} = 0.0903 \cdot (S_2)^2 \quad t/m^2$$

$$P_t = q \cdot A \cdot C_d$$



	Vc (m/sec)	q (t/m²)	t/b	Cd
①	61.18	0.23	< 1/4	2.1
②	61.18	0.23	○	1.2
③	58.9	0.22	○	1.2
④	55.48	0.19	○	1.2

		A (m²)	Pt (t)	y (m)	Pt·y (tm)
①	7.30 × 1.00 + ½ × (1.80 + 7.30) × 0.50	9.58	4.63	15.05	69.68
②	1.80 × 2.00	3.60	0.99	13.30	13.17
③	1.80 × 5.00	9.00	2.38	9.80	23.32
④	1.80 × 5.00	9.00	2.05	4.80	9.84
		31.18	10.05		116.01

case 2

$$V_c = 35 \ m/sec$$

$$q = 0.613 \times 35^2 \times 0.102 \times 10^{-3} = 0.077 \ t/m^2$$

$$A = 31.18 \ m^2$$

$$C_d = (2.1 \times 9.58 + 1.2 \times 21.60) \times 1/31.18 = 1.48$$

$$P_t = 0.077 \times 31.18 \times 1.48 = 3.55 \ t$$

$$y = \frac{9.58 \times 15.05 + 21.60 \times 8.30}{31.18} = 10.374 \ m$$

(C) vertical wind load

case 1

$$P_V = q \cdot A \cdot C_L$$

$A = 7.30 \times 27.45 = 200.39\ m^2$

$C_L = 0.40 \quad (b/d = 7.30/2.38 = 3.07)$

$$P_V = 0.23 \times 200.39 \times 0.40 = 18.44\ t$$

case 2

$$P_V = q \cdot A \cdot C_L$$

$A = 200.39\ m^2$

$C_L = 0.4$

$$P_V = 0.077 \times 200.39 \times 0.4 = 6.17\ t$$

§ 4 CALCULATION OF STABILITY

4 - 1 longitudinal direction

case 1 (HA loading)

	N (t)	x (m)	N·x (tm)	H (t)	y (m)	H y (tm)
WDL . WLL	563.8	——	39.26	——	——	——
F B	——	——	——	12.90	15.80	203.82
W. Ws	273.41	——	——	——	——	——
TOTAL	837.21		39.26	12.90		203.82

1) check for eccentricity

$$e = \frac{\Sigma N x + \Sigma H y}{\Sigma N} = \frac{39.26 + 203.82}{837.21} = 0.29^{m}$$

$$< \frac{B}{6} = 0.92^{m}$$

2) soil reaction

$$q = \frac{\Sigma N}{B \cdot L}\left(1 \pm \frac{6 \cdot e}{B}\right)$$

$$= \frac{837.21}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.29}{5.50}\right) = \begin{cases} 36.43\ t/m^2 \\ 18.92 \end{cases} < 60\ t/m^2$$

3) check for sliding

$$H_u = c \cdot A' + N \tan\phi' \qquad c = 0 \qquad \tan\phi' = 0.6$$

$$F = \frac{0.6 \times 837.21}{12.90} = 39. \quad > F_a = 1.5$$

case 2 (wind loading)

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL		379.2	——	21.94	——	——	——
W, Ws		273.41	——	——	——	——	——
wind Plassure	B-1	——	——	——	5.92	15.80	93.54
	B-2	——	——	——	(0.12+0.42) 0.54	15.80	8.53
	B-3	——	——	——	10.05	——	116.01
TOTAL		652.61		21.94	16.51		218.08

1) check for eccentricity

$$e = \frac{21.94 + 218.08}{652.61} = 0.37^{m} < \frac{B}{6} \cdot 1.15 = 1.05^{m}$$

2) soil reaction

$$q = \frac{652.61}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.39}{5.50}\right) = \begin{cases} 30.75 \ t/m^2 \\ 12.40 \ " \end{cases} < 69 \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 652.61}{16.51} = 24 \qquad > Fa = 1.5 \cdot 1/1.15 = 1.3$$

case 3 (HA loading + wind B)

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL.WLL		563.8	———	39.26	———	———	———
F B		———	———	———	12.90	15.80	203.82
W , Ws		273.41	———	———	———	———	———
wind pressure	B-1	———	———	———	(1.82+3.83) 5.65	15.80	89.27
	B-3	———	———	———	3.55	10.374	36.83
TOTAL		837.21		39.26	22.10		329.92

1) check for eccentricity

$$e = \frac{39.26 + 329.92}{837.21} = 0.44^{m} < \frac{B}{6} \cdot 1.15 = 1.05^{m}$$

2) soil reaction

$$q = \frac{837.21}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.44}{5.50}\right) = \begin{cases} 40.96 \ t/m^2 \\ 14.39 \ " \end{cases} < 69 \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 837.21}{22.10} = 23 \qquad > Fa = 1.5 \times 1/1.15 = 1.3$$

case 4 (HA loading + wind (1/2 A + B + C))

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL, WLL		563.8	—	39.26	—	—	—
F B		—	—	—	12.90	15.80	203.82
W, Ws		273.41	—	—	—	—	—
wind pressure (B)	B-1	—	—	—	5.65	15.80	89.27
	B-3	—	—	—	3.55	10.374	36.83
	C	6.17	—	—	—	—	—
wind pressure (A)	A-1	—	—	—	(7.15)	18.26	(130.56)
	A-3	—	—	—	(1.12)	9.05	(10.14)
TOTAL		843.38		39.26	22.10 (8.27)		329.92 (140.70)

1) check for eccentricity

$$e = \frac{39.26 + 329.92}{843.38} = 0.44^{m} < \frac{B}{6} \times 1.15 = 1.05^{m}$$

2) soil reaction

$$q = \frac{843.38}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.44}{5.50}\right) \pm \frac{6 \times 140.70}{5.50 \times 5.50^2} = \begin{cases} 46.34 \ t/m^2 \\ 9.42 \end{cases}$$

$< 69 \ t/m^2$

3) check for sliding

$$F = \frac{0.6 \times 843.38}{22.10} = 22.90 < Fa = 1.3$$

4 - 2 transverse direction

case 1 (H A loading)

	N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL	379.2	—	—	—	—	—
WLL	184.6	—	—	—	—	—
W . Ws	273.41	—	—	—	—	—
TOTAL	837.21		—	—		—

1) check for eccentricity

$$e = \frac{0 + 0}{837.21} = 0^{m} < \frac{B}{6} = 0.92^{m}$$

2) soil reaction

$$q = \frac{837.21}{5.50 \times 5.50} = 27.68 \, t/m^2 < 60 \, t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 837.21}{0} = \infty > F_a = 1.5$$

case 2 (wind loadig)

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL		379.2	—	—	—	—	—
W . Ws		273.41	—	—	—	—	—
wind pressere	A-1	—	—	—	23.68	17.085	404.57
	A-2	—	—	—	4.34	18.775	81.48
	A-3	—	—	—	6.10	—	56.56
TOTAL		652.61		—	34.12		542.61

1) check for eccentricity

$$e = \frac{0 + 542.61}{652.61} = 0.83^{m} < \frac{B}{6} \times 1.15 = 1.05^{m}$$

2) soil reaction

$$q = \frac{652.61}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.83}{5.50}\right) = \begin{cases} 411 \ t/m^2 \\ 204 \ " \end{cases} < 69 \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 652.61}{34.12} = 11 \quad > F_a = 1.5 \times 1/1.15 = 1.3$$

case 3 (HA loading + wind A)

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL		379.2	—	—	—	—	—
WLL		184.6	—	—	—	—	—
W . W_s		273.41	—	—	—	—	—
wind pressure	A-1	—	—	—	14.3	18.26	261.12
	A-3	—	—	—	2.23	9.05	20.18
TOTAL		837.21		—	16.53		281.30

1) check for eccentricity

$$e = \frac{0 + 281.30}{837.21} = 0.34^{m} < \frac{B}{6} \times 1.15 = 1.05^{m}$$

2) soil reaction

$$q = \frac{837.21}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.34}{5.50}\right) = \left\{ \begin{array}{l} 37.94\ t/m^2 \\ 17.41 \end{array} \right. < 69\ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 837.21}{16.53} = 30 \quad > F_a = 1.3$$

case 4 (HA loading + wind (A + C))

		N (t)	x (m)	N x (t m)	H (t)	y (m)	H y (t m)
WDL		379.2	—	—	—	—	—
WLL		184.6	—	—	—	—	—
W . Ws		273.41	—	—	—	—	—
wind pressure	A-1	—	—	—	14.3	—	261.12
	A-2	—	—	—	2.23	—	20.18
	C	6.17	—	—	—	—	—
TOTAL		843.38		—	16.53		281.30

1) check for eccentricity

$$e = \frac{0 + 281.30}{843.38} = 0.33^{m} < \frac{B}{6} \times 1.15 = \quad ^{m}$$

2) soil reaction

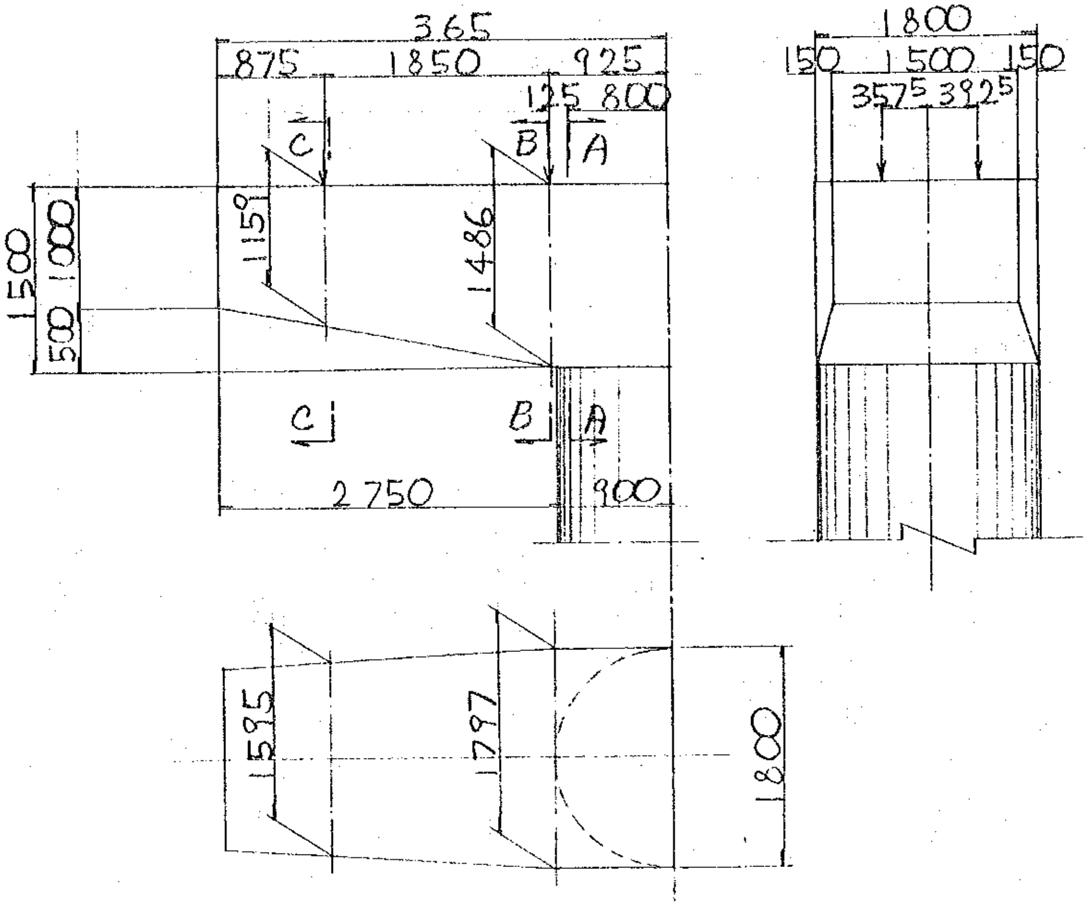
$$q = \frac{843.38}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.33}{5.50}\right) = \begin{cases} 37.92 \ t/m^2 \\ 17.84 \ " \end{cases} < 69 \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 843.38}{16.53} = 31. \quad > F_a = 1.3$$

§ 5 CALCULATION OF BEAM SECTION

5-1 dimension of beam and load



		G 1	G 2	G 3	G 4
WDL		95.8	96.5	96.5	95.8
WLL	H A	42.9	50.6	50.6	42.9
	H B	56.7	53.9	53.9	56.7
TOTAL	H A	138.7	147.1	147.1	138.7
	H B	152.5	150.4	150.4	152.5

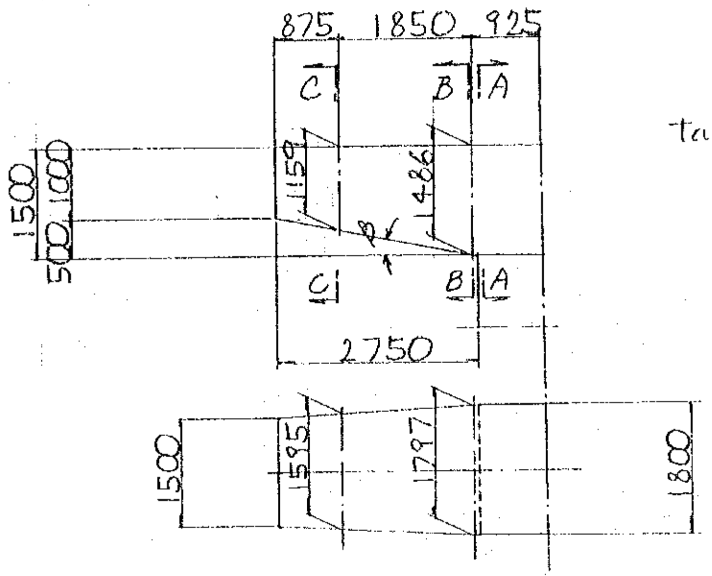
5-2 sectional force of beam (HA loding)

			S (t)	x (m)	M (tm)
A - A	W 1	0.10 × 1.50 × 1.80 × 2.41	0.65	0.05	0.03
	W 2	1/2 × (1.50 + 1.80) × 2.75 × 1.00 × 2.41	10.94	1.433	15.68
	W 3	1/6 × 0.50 × 2.75 × (2 × 1.80 + 1.50) × 2.41	2.82	0.99	2.79
	R 1	————	147.1	0.125	18.39
	R 2	————	138.7	1.975	273.93
	Σ		300.21		310.82
B - B	W 1	1/2 × (1.50 + 1.797) × 2.725 × 1.00 × 2.41	10.83	1.322	14.32
	W 2	1/6 × 0.486 × 2.725 × (2 × 1.797 + 1.50) × 2.41	2.71	0.882	2.39
	R 1	————	(147.1)	0	0
	R 2	————	138.7	1.85	256.60
	Σ		299.34 (152.24)		273.31
C - C	W 1	1/2 × (1.50 + 1.595) × 0.875 × 1.00 × 2.41	3.26	0.433	1.41
	W 2	1/6 × 0.341 × 0.875 × (2 × 1.595 + 1.50) × 2.41	0.56	0.289	0.16
	R 1	————	(138.7)	0	0
	Σ		142.52 (3.82)		1.57

5 - 3 list of stresses σ_c, σ_s, τ : working stress.
$\sigma_{ca}, \sigma_{sa}, \tau_a$: Permissible stress.

	A - A	B - B	C - C			
M	310.82	273.31	1.57			
N	——	——	——			
S	300.21	299.34	142.52			
b	180	180	160			
h	140	139	106			
d'	10	10	10			
As	14 - D32 112.56	14 - D32 112.56	12 - D32 96.48			
As'	——	——	——			
f/d	0	0				
M'/bd^2	8.81	7.86				
S/bd	11.91	11.96				
n·P	0.067	0.0675				
C	7.30	7.30				
S	16.62	16.51				
Z	1.11	1.11				
σ_c	64	57				
σ_s	2196	1946				
τ	13	13				
σ_{ca}	83	→	→			
σ_{sa}	2346	→	→			
τ_a	8.2	→	→			

5 - 4 check for sturrup



$\tan\beta = \frac{0.50}{2.75}$

$= 0.182$

	M (tm)	S (t)	d (m)	$\frac{M}{d}(\tan\beta)$ (t)	S_h (t)
section A-A	310.82	300.21	1.400	40.37	259.84
〃 B-B	273.31	299.34	1.390	69.07	230.27
〃 C-C	1.57	142.52	1.060	0.30	142.22

$$S_h = S - \frac{M}{d}(\tan\beta) \quad (t)$$

	b (cm)	d (cm)	τ_a (kg/cm²)	S_c (t)	S_h' (t)
section A-A					
〃 B-B					
〃 C-C					

$$S_c = \tau_a \cdot b \cdot d \cdot 10^{-3} \quad (t)$$

$$S_h' = S_h - S_c \quad (t)$$

check for stirrups

$$\tau = \frac{Sh}{b \cdot d} \times Z$$

$$= \frac{259.84 \times 10^3}{180 \times 140} \times 1.11 = 11.44 \, kg/cm^2 > \tau_a = 8.2 \, kg/cm^2$$

$$req. A_w = \frac{Sh' \times a}{\sigma_{sa} \cdot d} \times Z \quad (cm^2)$$

$$Sh' = Sh - Sc$$

$$Sc = \tau a \times b \times d \times \frac{1}{Z}$$

$$= 0 \times \quad \times \quad \times \text{——} = 0$$

$$req. A_w = \frac{259.84 \times 10^3 \times 15}{1780 \times 140} \times 1.11 = 17.36 \, cm^2$$

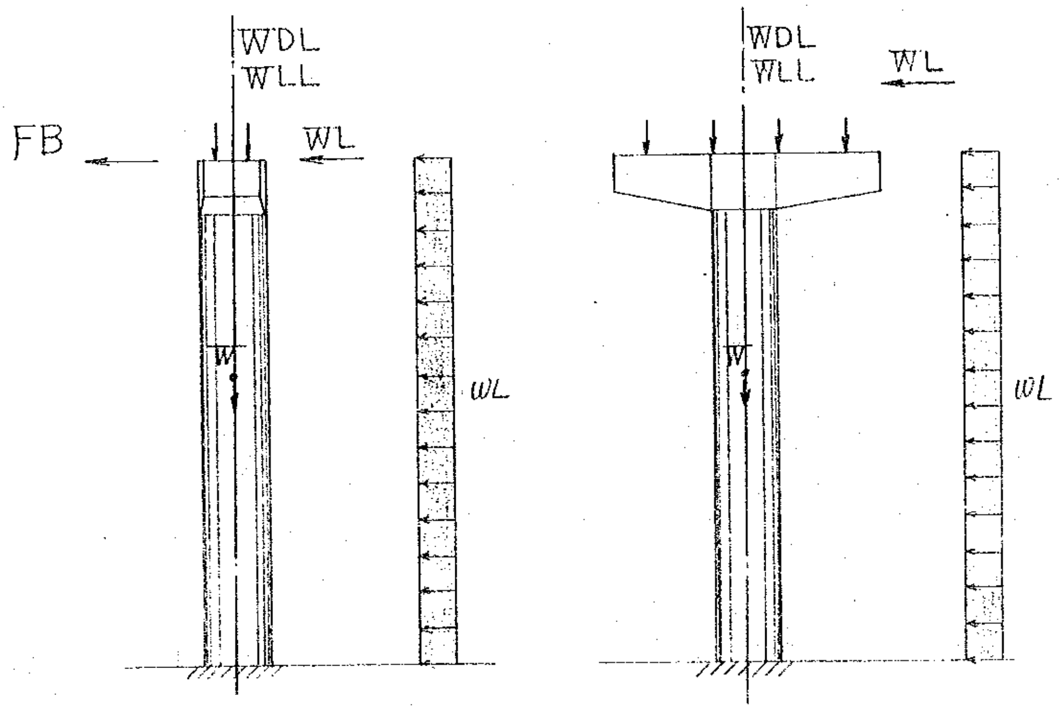
Φ 20 - ctc 150 $\quad n = 6$

Used $A_w = 3.14 \times 6 = 18.84 \, cm^2 > req. A_w = 17.36 \, cm^2$

§ 6 CALCULATION OF COLUMN SECTION

6-1 dimension of column and load

longitudinal direction　　　transverse direction

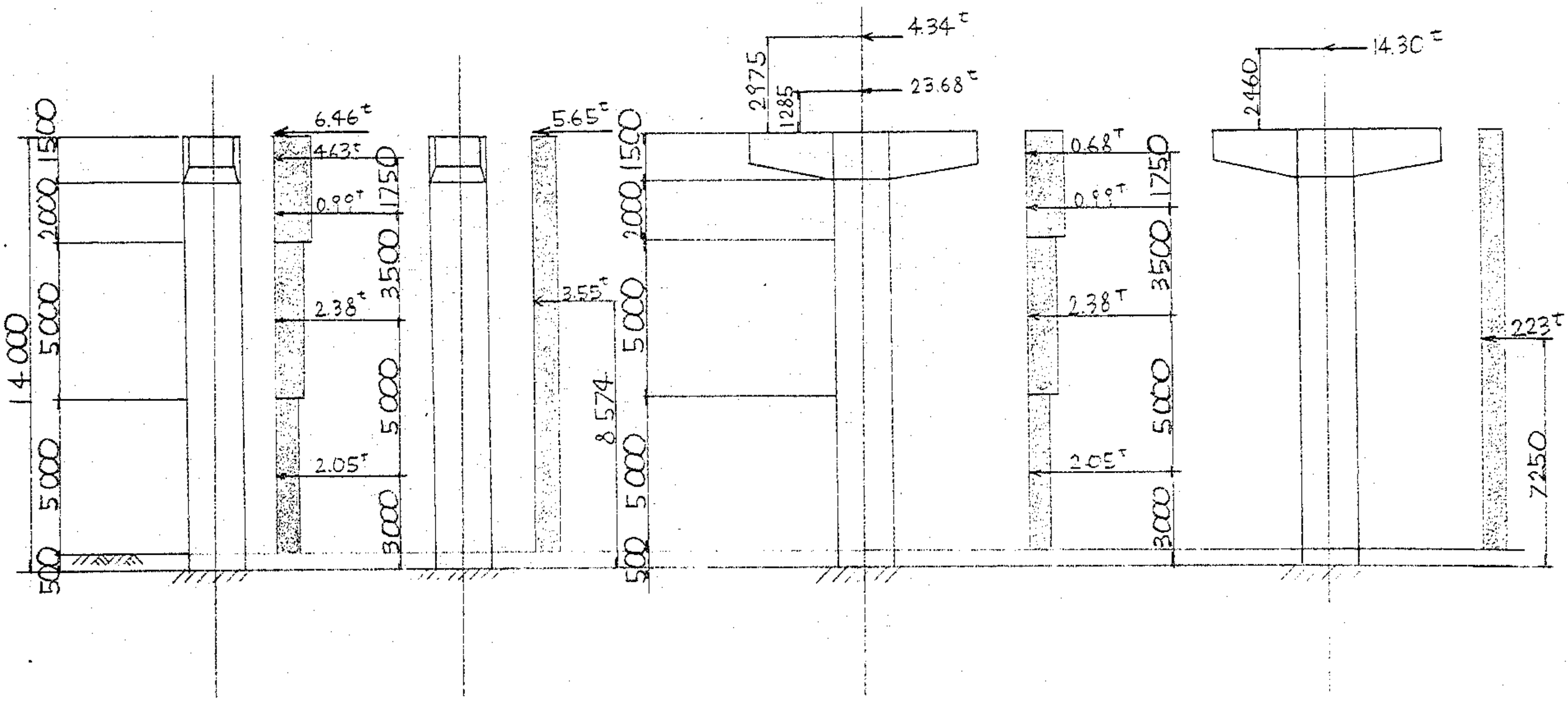


	HA loading		HB loading	
dead load of deck	227.7	151.5	227.7	151.5
live load	119.7	64.9	68.3	63.1
longitudinal forces	12.90		19.10	

wind load

longitudinal direction | transverse direction

(without live load) (with live load) | (without live load) (with live load)



6 - 2 sectional force of column

1) longitudinal direction

			N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
case 1 (HA loading)	WDL		379.2	——	21.94	——	——	——
	WLL		184.6	——	17.32	——	——	——
	F B		——	——	——	12.90	15.80	203.82
	W		115.87	——	——	——	——	——
			679.67		39.26	12.90		203.82
case 2 (wind)	WDL		379.2	——	21.94	——	——	——
	W		115.87	——	——	——	——	——
	wind	B -1, 2	——	——	——	6.46	14.00	90.44
		B-3	——	——	——	10.05	——	97.92
			495.07		21.94	16.51		188.36
	(α = 1.15)		(430.50)		(19.08)	(14.36)		(163.79)
case 3 (HA loading + wind)	WDL		379.2	——	21.94	——	——	——
	WLL		184.6	——	17.32	——	——	——
	F B		——	——	——	12.90	15.08	203.82
	W		115.87	——	——	——	——	——
	wind	B-1	——	——	——	5.65	14.00	79.10
		B-2	——	——	——	3.55	8.574	30.44
			679.67		39.26	22.10		313.36
	(α = 1.15)		(591.02)		(34.14)	(19.22)		(272.49)

2) transverse direction

			N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
case 1 (wind)	WDL		379.2	——	——	——	——	——
	W		115.87	——	——	——	——	——
	wind	A-1	——	——	——	23.68	15.285	361.95
		A-2	——	——	——	4.34	16.975	73.67
		A-3	——	——	——	6.10	——	45.59
	(α = 1.15)		495.07 (430.50)			34.12 (29.67)		481.21 (418.44)
case 2 (H A loading + wind)	WDL		379.2	——	——	——	——	——
	WLL		184.6	——	——	——	——	——
	W		115.87	——	——	——	——	——
	wind	A-1	——	——	——	14.30	16.46	235.38
		A-3	——	——	——	2.23	7.25	16.17
	(α = 1.15)		679.67 (591.02)			16.53 (14.37)		251.55 (218.74)

6 − 3 List of stresses σ_c, σ_s : working stress
σ_{ca}, σ_{sa} : permissible stress

	longitudinal direction			transverse direction	
	case 1	〃 2	〃 3	〃 1	〃 2
M	243.08	182.87	306.63	418.44	218.74
N	679.67	430.50	591.02	430.50	591.02
r	90	→	→	→	→
rs	80	→	→	→	→
As	50−D32 ctc 100 402.0	→	→	→	→
e	35.76	42.48	51.88	97.20	37.01
e/r	0.40	0.47	0.58	1.08	0.41
M'	854.78	570.32	838.55	805.89	750.66
M'/r³	117.25	78.23	115.03	110.55	102.97
n P	0.237	0.237	0.237	0.237	0.237
rs/r	0.90	0.90	0.90	0.90	0.90
[C]	0.455	0.491	0.544	0.756	0.461
[S]	0.063	0.125	0.224	0.698	0.074
σ_c	53	38	63	83	47
σ_s	111	147	387	1157	114
σ_{ca}	83	→	→	→	→
σ_{sa}	2346	→	→	→	→

6-4 check for buckling of column

$$Pa = \frac{1}{3} \times (0.85 \cdot f_{ck} \cdot Ac + f_{sy}' \cdot As)$$

$$\alpha = 1.45 - 0.03 \cdot \frac{he}{d}$$

$$he = (14.00 + 1.80) \times 2 = 31.60^{m}$$

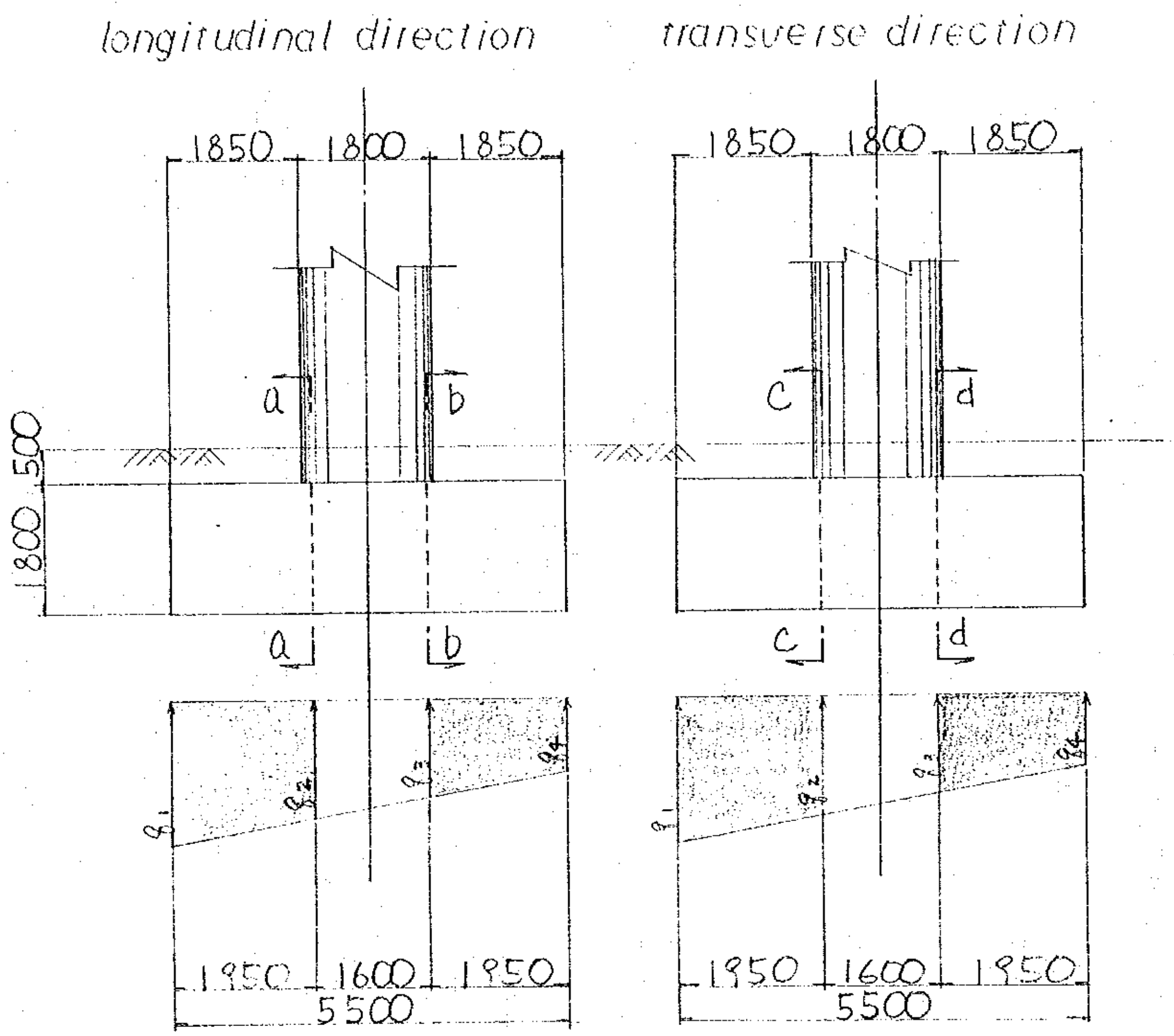
$$Pa = 1/3 \times (0.85 \times 250 \times \pi/4 \times 180^2 + 2500 \times 402.0)$$
$$= 6410000^{kg} \quad 6410^{t}$$

$$\alpha = 1.45 - 0.03 \times 31.60/1.80$$
$$= 0.92$$

$$\therefore Paa = 6410 \times 0.92$$
$$= 5897^{t} \quad > PN = 679.67^{t}$$

§ 7 CALCULATION OF FOOTING SECTION

7-1 dimension and soil reaction



case	longitudinal direction				transverse direction			
	q1	q2	q3	q4	q1	q2	q3	q4
1	36.43	30.22	25.13	18.92	27.68	27.68	27.68	27.68
2	30.75	24.24	18.91	12.40	41.1	27.25	15.89	2.04
3	40.96	31.54	23.81	14.39	37.94	30.66	24.69	17.41
4	41.26	31.77	23.99	14.50	37.92	30.80	24.96	17.84

section A − A

			S (t)	x (m)	Sx (tm)
case 1	Wd	(1.80 × 2.41 + 0.50 × 1.9) × 1.95 × 5.50	56.71	0.975	55.29
	q	½ × (36.43 + 30.22) × 1.95 × 5.50	−357.41	1.005	−359.20
			300.7		303.91
case 2	Wd	————	56.71	——	55.29
	q	½ × (30.75 + 24.24) × 1.95 × 5.50	−294.88	1.013	−298.71
(α = 1.15)			238.17 (207.10)		243.42 (211.67)
case 3	Wd	————	56.71	——	55.29
	q	½ × (40.96 + 31.54) × 1.95 × 5.50	−388.78	1.017	−395.39
(α = 1.15)			332.07 (288.76)		340.10 (295.74)
case 4	Wd	————	56.71	——	55.29
	q	½ × (41.26 + 31.77) × 1.95 × 5.50	−391.62	1.017	−398.28
(α = 1.15)			334.91 (291.23)		342.99 (298.25)

section B − B

$M_{upper} = 0$

section c – c

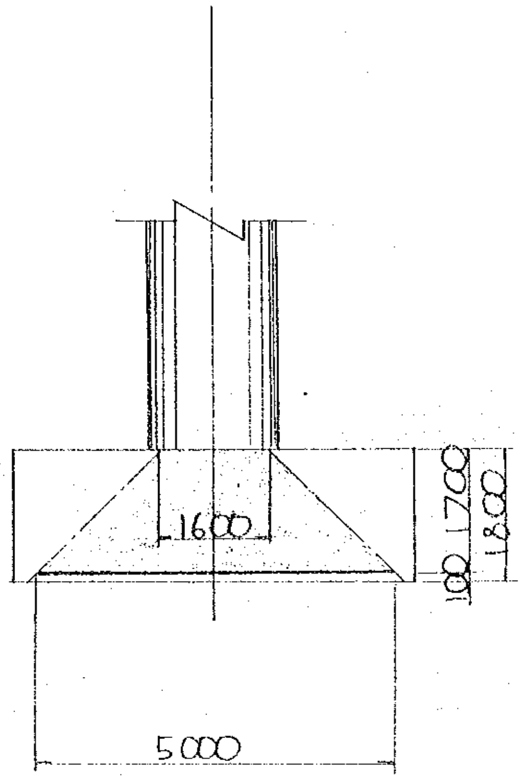
			S (t)	x (m)	Sx (tm)
case 1	wd	————	56.71	——	55.29
	q	27.68 × 1.95 × 5.50	−296.87	0.975	−289.45
			240.16		234.16
case 2 (α = 1.15)	wd	————	56.71	——	55.29
	q	½×(41.1+27.25)×1.95×5.50	−366.53	1.041	−381.56
			309.82 (269.41)		326.27 (283.71)
case 3 (α = 1.15)	wd	————	56.71	——	55.29
	q	½×(37.94+30.66)×1.95×5.50	−367.87	1.009	−371.18
			311.16 (270.57)		315.89 (274.69)
case 4 (α = 1.15)	wd	————	56.71	——	55.29
	q	½×(37.92+30.80)×1.95×5.50	−368.51	1.009	−371.83
			311.80 (271.13)		316.54 (275.25)

section d-d

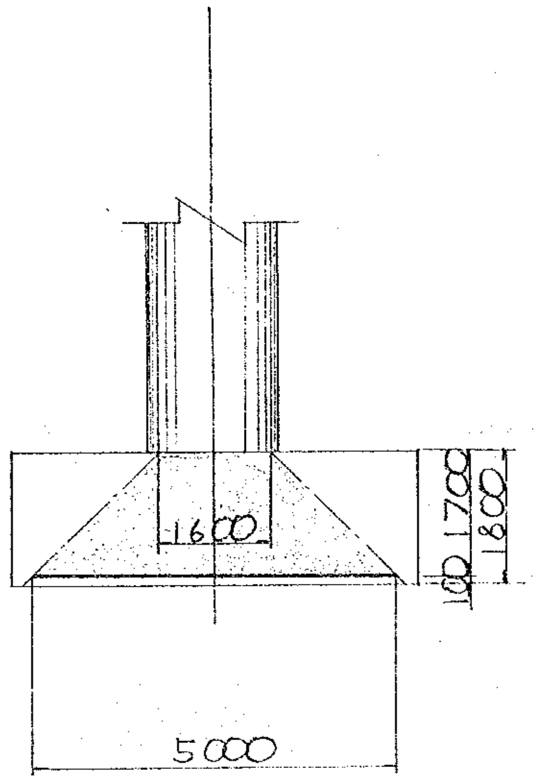
$M_{upper} = 0$

7 - 2 calculation of members

longitudinal direction



transverse direction



$$B_1 = 1.60 + 1.70 \times 2 = 5.00^{m}$$

$$B_2 = 1.60 + 1.70 \times 2 = 5.00^{m}$$

7 - 3 list of stresses σ_c, σ_s, τ : working stress.
$\sigma_{ca}, \sigma_{sa}, \tau_a$: permissible stress.

	a - a	b - b		c - c	d - d	
M	303.91			283.71		
N	———			———		
S	300.7			271.13		
b	500			500		
h	170			170		
d'	10			10		
As	D25 @150 106.76			D25 @150 106.76		
As'	———			———		
f/d	0			0		
M'/bd^2	2.10			1.96		
S/bd	3.54			3.19		
n.P	0.0188			0.0188		
C	12.07			12.07		
S	56.52			56.52		
Z	1.06			1.06		
σ_c	25			24		
σ_s	1783			1665		
τ	3.8			3.4		
σ_{ca}	83	→				
σ_{sa}	2346	→				
τ_a	2.35	→				

Check for stirrups

Sect a-a

$$\tau = \frac{S}{b \cdot d} Z = \frac{300.7 \times 10^3}{500 \times 170} \times 1.06 = 3.75 \, kg/cm^2 < \tau_a = 2.35 \, kg/cm^2$$

$$S' = S - S_c$$

$$S_c = \tau_a \cdot b \cdot d \cdot 1/Z = 2.35 \times 500 \times 170 \times 1/1.06 = 188.44 \times 10^3 \; kg$$

$$S' = (300.70 - 188.44) \times 10^3 = 112.26 \times 10^3$$

$$Req \; A_v = \frac{S' \times a}{\sigma_{sa} \cdot d} \times Z = \frac{112.26 \times 10^3 \times 50}{1780 \times 170} \times 1.06 = 19.66 \; cm^2$$

$$Req \; A_v / 1.0m = 19.66 / 5.0^m = 3.93 \; cm^2$$

$\Phi 16$ - ctc 500 $\quad n = 2$

$$A_s = 2.01 \times 2 = 4.02 \; cm^2 > Req \; A_v = 3.93 \; cm^2$$

5. Motorway Junction Bridge (Abutment and Approach Slab)

Page

CONTENTS

§§ 1. DESIGN CONDITIONS

§ 1. DESIGN CONDITIONS

1 Abutment type

cantilever type H < 9.5 meters

counterfort type H ≥ 9.5 meters

2. foundation type

Spread footing

3 unit weight of reinforced concrete and soil

reinforced concrete 2.41 ton/m^3

soil 1.90 ton/m^3

4 bearing capacity

permissible bearing capacity $q_a = 60\ t/m^2$

5 permissible stress of reinforced concrete

1) Concrete grade 25

specified cube strength at 28 days $25\ N/mm^2 = 255\ kg/cm^2$

permissible compressive stress $\sigma_{ca} = 85\ kg/cm^2$

permissible shear stress $\tau_a = 0.81\ N/mm^2 = 8.2\ kg/cm^2$

permissible shear in solid slab without shear reinforcement

Percentage of flexural tensile steel $100\ A_s/b \cdot d$		0.25 or less	0.5	1.0	2.0	3.0 or more
Permissible shear	N/mm^2	0.23	0.34	0.46	0.63	0.70
	kg/cm^2	2.35	3.47	4.69	6.43	7.14

2) Reinforcement

hot rolled high yield bars

specified characteristic stress $\sigma su = 410\ N/mm^2 = 4180\ kg/cm^2$

permissible tensile stress $\sigma sa = 230\ N/mm^2 = 2340\ kg/cm^2$

permissible tensile stress in shera reinforcement $\sigma sa = 175\ N/mm^2 = 1780\ kg/cm^2$

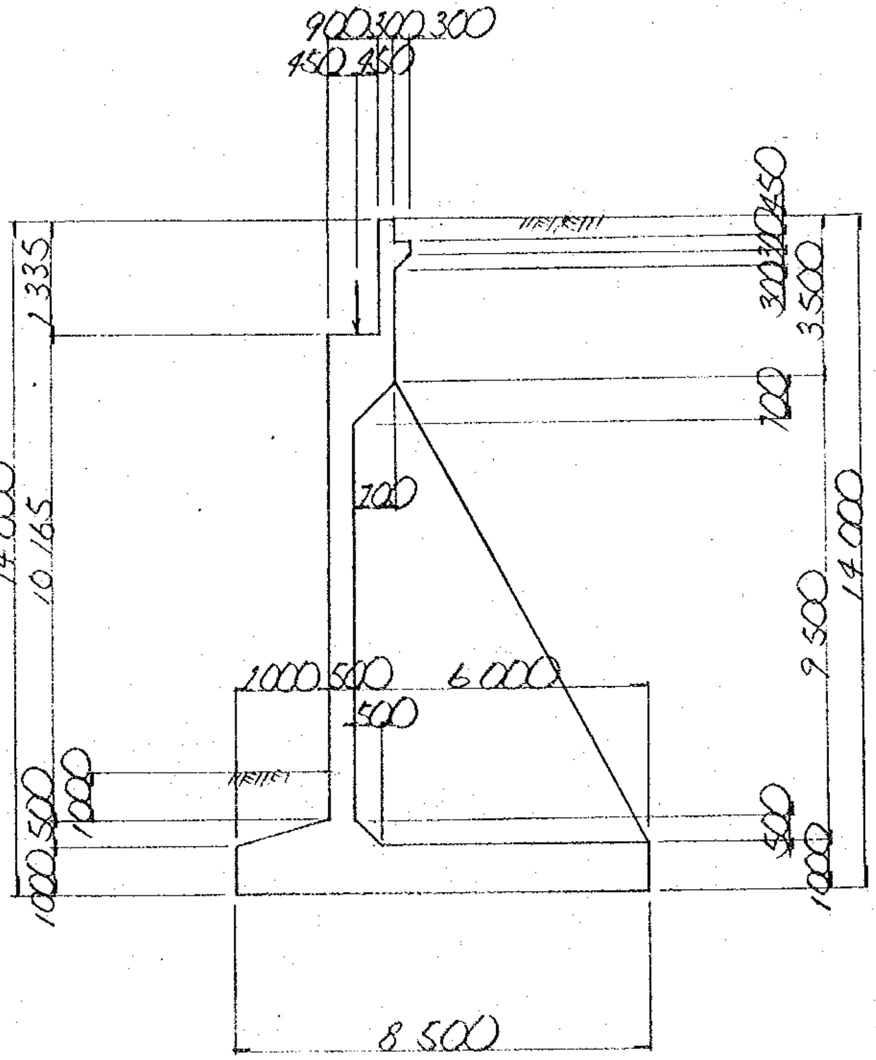
6 Permissible increase in basic working stresses

Load combination	Increase in basic permissible stresses (per cent)
Dead Load + HA Loading	0
Dead Load + HB Loading	25
Dead Load + Wind Load	15
Dead Load + HA Loading + Wind Load	15
Dead Load + HB Loading + Wind Load	30

§§ 2 $H = 14.00$ m

A-L-2 , A_1
B-L-2 , A_1, A_2

§ 1 STRUCTURAL FIGURE



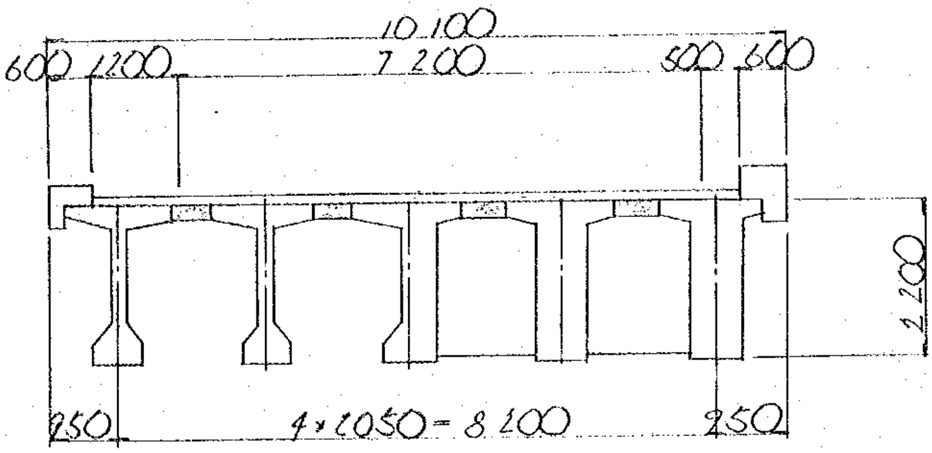
buttress span $l = 3.100^m$

(A - LINE 2 , A 1)

(B - LINE 2 , A1 , A 2)

§ 2 REACTION OF SUPERSTRUCTURE

2-1 structural figure

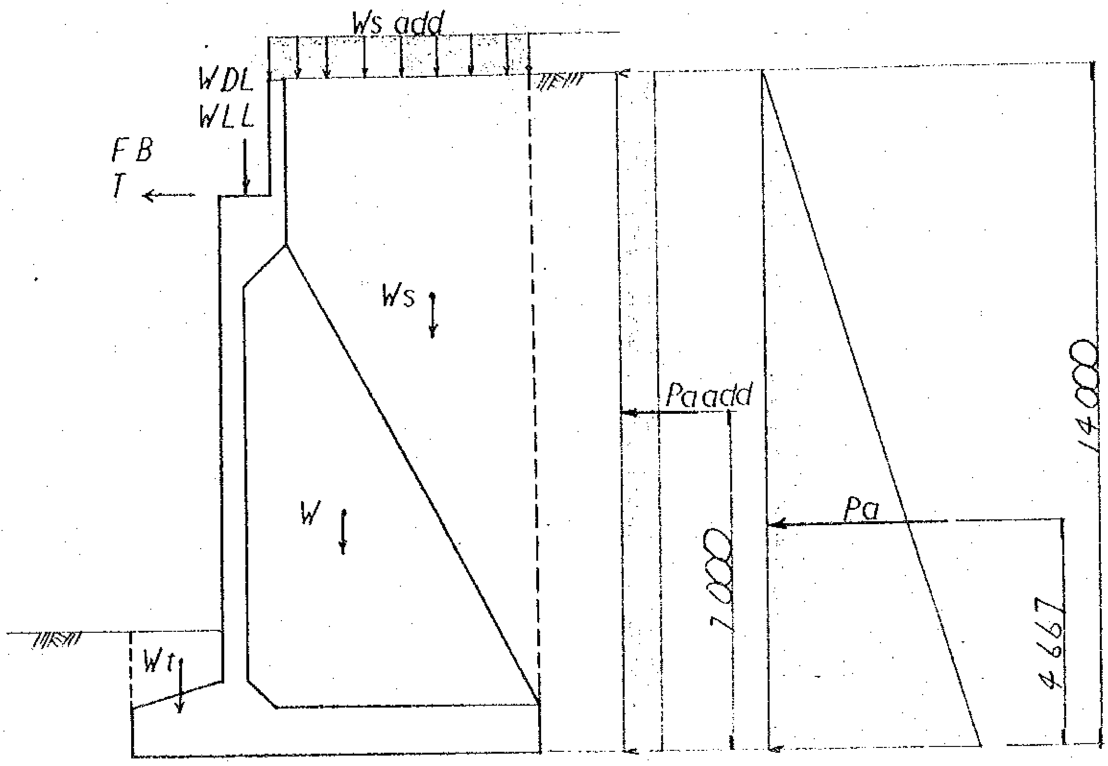


2-2 whole reaction of superstructure

		HA loading		HB loading	
		N (t)	H (t)	N (t)	H (t)
dead load of deck	I	154.3	———	154.3	———
	II	41.8	———	41.8	———
live load		138.0	———	150.3	———
crowd load		———	———	———	———
longitudinal forse		———	25.8	———	38.2
TOTAL		434.1	25.8	446.4	38.2

§ 3 CALCULATION OF LOAD

3 - 1 loading diagram



WDL : dead load of deck

WLL : max LL reaction under HA & HB

F B : HA & HB braking

W : self weight

Ws : weight of soil

Wt : fill on toe

Ws add : weight of surcharge

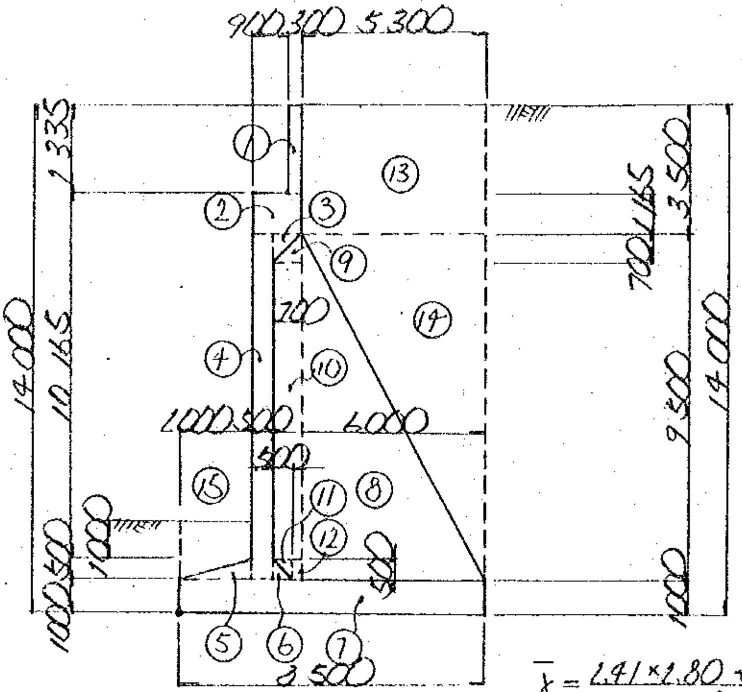
P_A : active pressure

P_P : passive pressure

P_A add : surcharge

T : temperatwe load

3-2 self weight and weight of soil



$$\bar{\gamma} = \frac{2.41 \times 2.80 + 1.9 \times 7.30}{10.10} = 2.06 \ t/m^3$$

		N (t)	x (m)	N x (t m)
①	0.30 × 2.335 × 10.10 × 2.41	17.05	3.050	52.01
②	1.20 × 1.165 × 10.10 × 2.41	34.03	2.600	88.47
③	1/2 × 0.70 × 0.70 × 10.10 × 2.41	5.96	2.773	16.54
④	0.50 × 10.665 × 10.10 × 2.41	129.80	2.250	292.05
⑤	1/2 × 2.00 × 0.50 × 10.10 × 2.41	12.17	1.333	16.22
⑥	1/2 × 0.50 × 0.50 × 10.10 × 2.41	3.04	2.667	8.11
⑦	8.50 × 1.00 × 10.10 × 2.41	206.90	4.250	879.32
⑧	1/2 × 5.30 × 9.30 × 10.10 × 2.06	523.79	4.967	2601.67
⑨	1/2 × 0.70 × 0.70 × 10.10 × 2.06	5.10	2.967	15.12
⑩	0.70 × 8.30 × 10.10 × 2.06	120.88	2.850	344.52
⑪	1/2 × 0.50 × 0.50 × 10.10 × 2.06	2.60	2.834	7.37
⑫	0.20 × 0.50 × 10.10 × 2.06	2.08	3.100	6.45
⑬	5.30 × 3.50 × 10.10 × 1.9	355.97	5.850	2082.45
⑭	1/2 × 5.30 × 9.50 × 10.10 × 1.9	483.11	6.733	3252.77
⑮	1/2 × (1.00 + 0.50) × 2.00 × 10.10 × 1.9	47.98	0.993	47.64
Σ		1950.46		9710.71

3-3 weight of surcharge

under H.A $= 1.02 \times 5.60 \times 10.10 = 57.69^{t}$

under H.B $= 1.66 \times 5.60 \times 10.10 = 93.89^{t}$

3-4 earth pressure

unit weight of soil $\gamma_s = 1.9 \ t/m^3$

angle of internal friction $\phi = 35°$

(1) active pressure

$$Pa = \frac{1}{2} \cdot K \cdot \gamma_s \cdot H^2 \cdot L$$

$$= \frac{1}{2} \times \frac{1 - \sin 35°}{1 + \sin 35°} \times 1.9 \times 14.00^2 \times 10.10 = 507.77^{t}$$

(2) active pressure due to surcharge

under H.A surcharge

$q = 1.02 \ t/m^2$

$$Pa\ add = K \cdot q \cdot H \cdot L$$

$$= 0.27 \times 1.02 \times 14.00 \times 10.10 = 38.94^{t}$$

under H.B surcharge

$q = 1.66 \ t/m^2$

$$Pa\ add = K \cdot q \cdot H \cdot L$$

$$= 0.27 \times 1.66 \times 14.00 \times 10.10 = 63.38^{t}$$

٢

3-5 temperature load

$$P_H = \frac{G_o \cdot A \cdot \delta}{\Sigma \cdot te}$$

$$\delta = \mathcal{I} \cdot l \qquad \mathcal{I} = \begin{cases} P.C \longrightarrow 0.7 \\ R.C \longrightarrow 0.5 \end{cases}$$

$$\begin{bmatrix} \delta = 0.7 \times 33.20 = 23.24^{mm} \\ R(d+l) = 434.1 \times 1/5 \times 1.4 = 121^{t} \end{bmatrix}$$

RING SHOE
- 130 TON
- $D\phi$: 58 cm
- $d\phi$: 34 "
- A : 2642 cm^2
- t : 7.5 cm
- G_o : 13.5 kg/cm^2 (modulus of rigidity)

$$P_H = \frac{13.5 \times 2642 \times 2.32}{7.5} = 11032^{kg} = 11.03^{t}$$

$$\Sigma P_H = n \cdot P_H \cdot 1/2$$

$$= 5 \times 11.03 \times 1/2 = 27.58^{t}$$

§ 4 CALCULATION OF STABILITY

case 1 HA loading

	N (t)	x (m)	N·x (tm)	H (t)	y (m)	H·y (tm)
WDL, WLL	434.10	2.450	1 063.55	—	—	—
F B	—	—	—	25.80	11.665	300.96
T	—	—	—	27.58	11.665	321.72
W, Ws, WT	1 950.46		9 710.71	—		—
Ws add	57.69	5.700	328.83	—		—
P a	—	—	—	507.77	4.667	2 369.76
Pa add	—	—	—	38.94	7.000	272.58
TOTAL	2 442.25		11 103.09	600.09		3 265.02

1) check for eccentric

$$x = \frac{\Sigma Nx - \Sigma HY}{\Sigma N} = \frac{11\,103.09 - 3265.02}{2\,442.25} = 3.20 \text{ m}$$

$$e = \frac{B}{2} - x = \frac{8.500}{2} - 3.200 = 1.05 \text{ m} < \frac{B}{6} = 1.42 \text{ m}$$

2) soil reaction

$$q = \frac{\Sigma N}{B \cdot L}\left(1 \pm \frac{6 \cdot e}{B}\right) = \frac{2\,442.25}{8.50 \times 10.10} \times \left(1 \pm \frac{6 \times 1.05}{8.50}\right)$$

$$= \begin{cases} 49.53 \ t/m^2 \\ 7.36 \end{cases} < 60 \ t/m^2$$

3) check for sliding

$$H_u = C \cdot A' + N \cdot \tan\phi' \qquad C = 0 \qquad \tan\phi' = 0.6$$

$$F = \frac{H_u}{\Sigma H} = \frac{2\,442.25 \times 0.6}{600.09} = 2.44 > F_a = 1.5$$

case 2 HB loading

	N (t)	x (m)	N·x (tm)	H (t)	y (m)	H·y (tm)
WDL. WLL	446.40	2.450	1093.68	——	——	——
F B	——	——	——	38.20	11.665	445.60
T	——	——	——	27.58	11.665	321.72
W. Ws. WT	1950.46		9710.71	——	——	——
Ws add	93.89	5.700	535.17	——	——	——
P a	——	——	——	507.77	4.667	2369.76
Pa add	——	——	——	63.38	7.000	443.66
TOTAL	2490.75		11339.56	636.93		3580.74

1) check for eccentric

$$x = \frac{\Sigma N\cdot x + \Sigma H\cdot y}{\Sigma N} = \frac{11339.56 - 3580.74}{2490.75} = 3.11^{m}$$

$$e = \frac{B}{2} - x = \frac{8.50}{2} - 3.11 = 1.14^{m} < \frac{B}{3} = 2.83^{m}$$

2) soil reaction

$$q = \frac{2442.25}{8.50 \times 10.10} \times \left(1 \pm \frac{6 \times 1.14}{8.50}\right) = \begin{cases} 51.34 \ {}^{t}/m^{2} < 75 \ {}^{t}/m^{2} \\ 5.56 \end{cases}$$

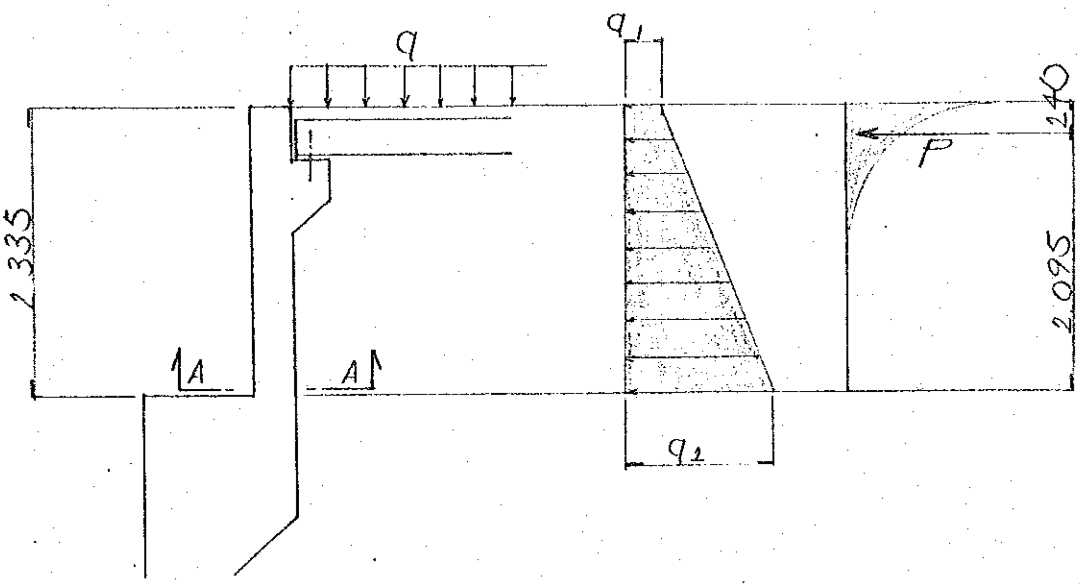
3) check for sliding

$$Hu = c\cdot A' + N \cdot \tan\phi' \qquad c = 0 \qquad \tan\phi' = 0.6$$

$$F = \frac{Hu}{\Sigma H} = \frac{0.6 \times 2490.75}{636.93} = 2.3 \quad > Fa = 1.2$$

§ 5 CALCULATION OF PARAPET SECTION

5-1 dimenston and loading



	q_1	q_2
HA loading	0.28	1.48
HB loading	0.45	1.68

$$q_1 = q \cdot K \qquad = 0.27 \cdot q \quad t/m^2$$

$$q_2 = K \cdot \gamma_s \cdot H + q_1 = 0.513 \cdot H + 0.27 \cdot q \quad ''$$

5 − 2 sectional force of parapet

CASE 1 (HA)

$$S = 1/2 \times (0.28 + 1.48) \times 2.335 = 2.05^{t}$$

$$M = 2.05 \times 1/3 \times 2.335 \times \frac{2 \times 0.28 + 1.48}{0.28 + 1.48} = 1.85^{tm}$$

CASE 2 (HB)

$$S = 1/2 \times (0.45 + 1.68) \times 2.335 = 2.49^{t}$$

$$M = 2.49 \times 1/3 \times 2.335 \times \frac{2 \times 0.45 + 1.68}{0.45 + 1.68} = 2.35^{tm}$$

CASE 3

$$S = 10.97 \times 0.27 = 2.96^{t/m}$$

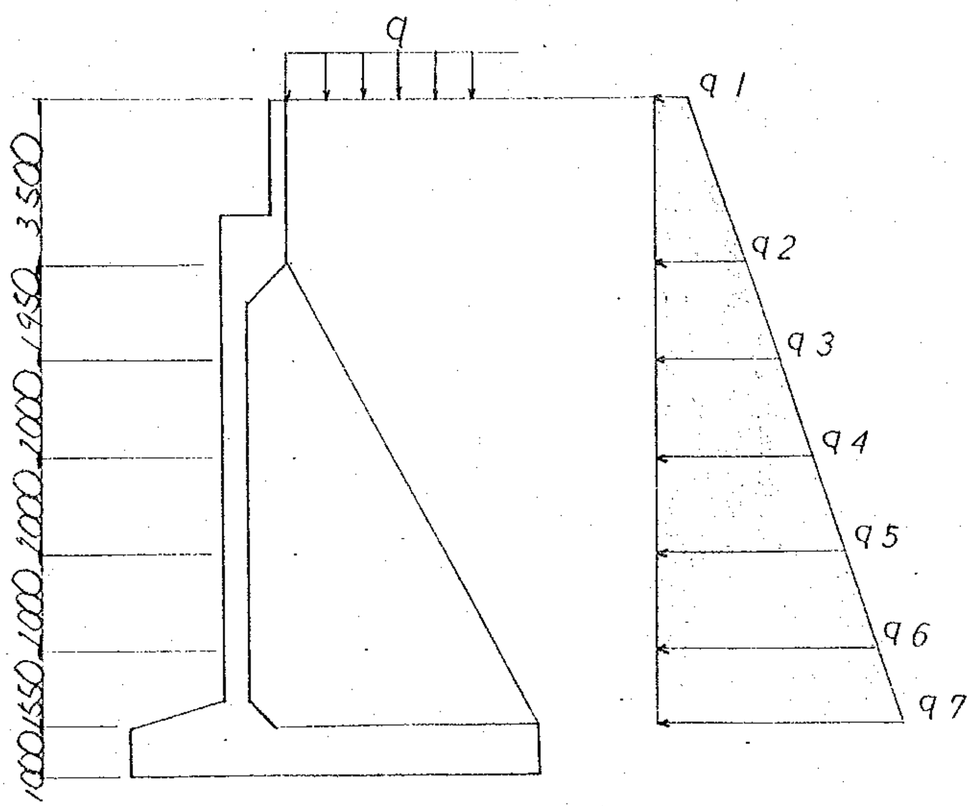
$$M = 2.96 \times 2.095 = 6.20^{tm}$$

5 - 3 list of stresses   σc.σs.τ : working stress.
σca,σsa,τa : Permissible stress.

	case 1	case 2				
M	1.85	2.35				
N	—	—				
S	2.05	2.49				
b	100	100				
h	23	23				
d'	7	7				
As	D16 @ 125 16.08	→				
As'	—	—				
f/d	0	0				
M'/bd²	3.50	4.44				
S/bd	0.89	1.08				
n·P	0.1049	→				
C	6.24	→				
S	10.86	→				
Z	1.14	→				
σc	22	28				
σs	570	724				
τ	1.01	1.23				
σca	83	103				
σsa	2346	2933				
τa	2.35	2.94				

§ 6 CALCULATION OF WALL SECTION

6-1 dimension and loading

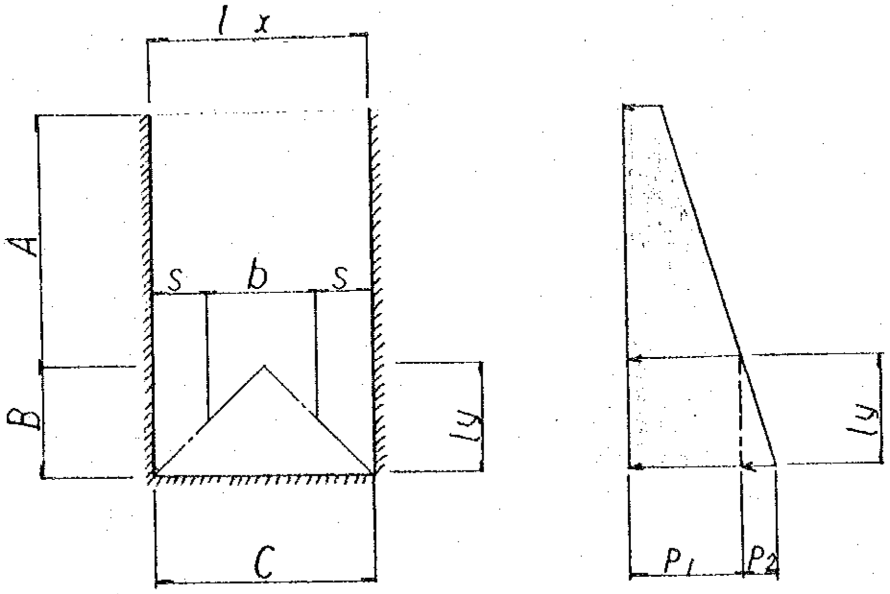


	q 1	q 2	q 3	q 4	q 5	q 6	q 7
HA loading	0.18	2.08	3.08	4.10	5.13	6.15	6.95
HB loading	0.45	2.25	3.25	4.27	5.30	6.33	7.12

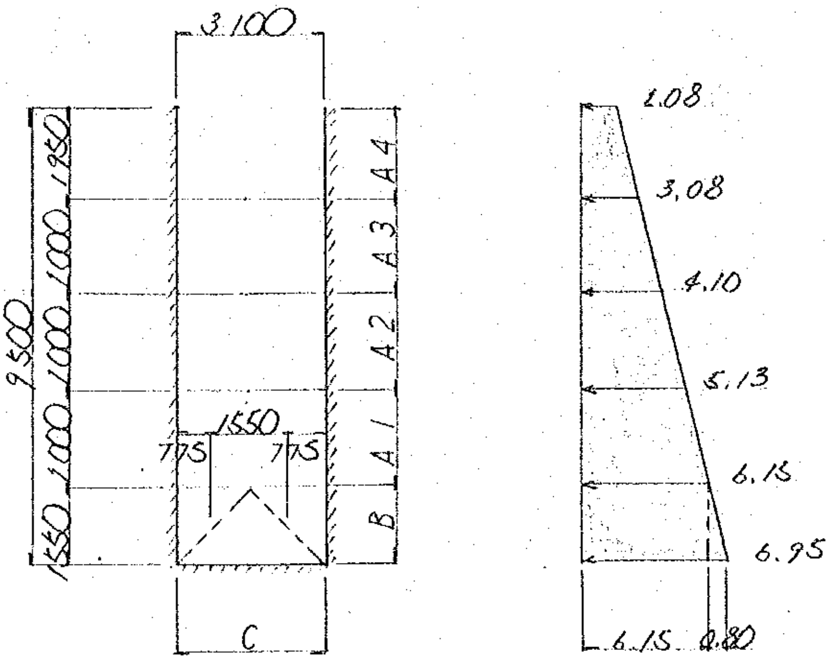
$$q_1 = q \cdot K \qquad = 0.27 \cdot q \quad t/m^2$$

$$q_x = K \cdot \gamma_s \cdot H_x + q_1 \quad = 0.513 \cdot H_x + 0.27 \cdot q \quad ''$$

6-2 sectional force of wall



	A	B	C
M (tm)	$\frac{p \cdot lx^2}{10}$	$\frac{p \cdot s^2}{6 \cdot lx}(2 \cdot lx + b)$	$\frac{1}{2}(\frac{p_1}{2} + \frac{p_2}{6}) ly^2$
S (t)	$\frac{p \cdot lx}{2}$	$p \cdot s$	$(p_1 + \frac{p_2}{2}) ly$



	M	(tm)	S	(t)
C − C	$\frac{1}{2}\times(\frac{6.15}{2}+\frac{0.80}{6})\times1.55^2$	3.85	$(6.15+\frac{0.80}{2})\times1.55$	10.15
B − B	$\frac{6.55\times0.775^2}{6\times3.10}\times(2\times3.10+1.55)$	1.64	6.55×0.775	5.08
A1 − 1	$\frac{6.15\times3.10^2}{10}$	5.91	$\frac{6.15\times3.10}{2}$	9.53
A2 − 2	$\frac{5.13\times3.10^2}{10}$	4.93	$\frac{5.13\times3.10}{2}$	7.95
A3 − 3	$\frac{4.10\times3.10^2}{10}$	3.94	$\frac{4.10\times3.10}{2}$	6.36
A4 − 4	$\frac{3.08\times3.10^2}{10}$	2.96	$\frac{3.08\times3.10}{2}$	4.77

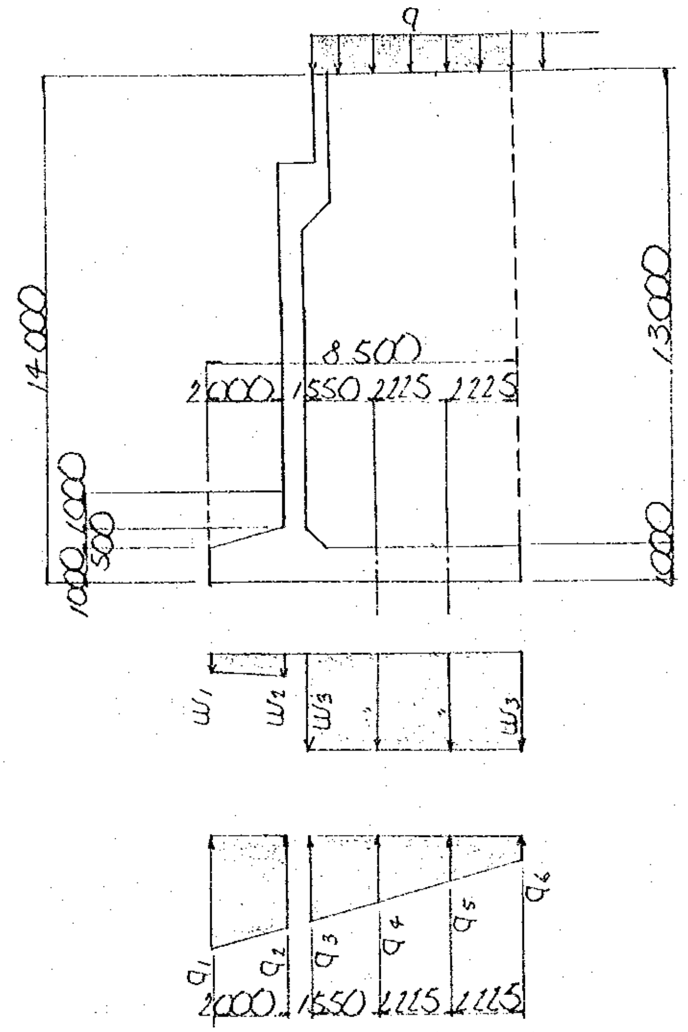
6 - 3 list of stresses

σ_c, σ_s, τ : working stress.
$\sigma_{ca}, \sigma_{sa}, \tau_a$: Permissible stress.

	As min = b·d·0.15% = 6.45 cm²					
	C - C	B - B	A1 - 1	A2 - 2	A3 - 3	A4 - 4
M	3.85	1.64	5.91	4.93	3.94	2.96
N	—	—	—	—	—	—
S	10.15	5.08	9.53	7.95	6.36	4.77
b	100	→				
h	43	→				
d'	7	→				
As	※D16 C 250 8.04	※ →		※	※	※ →
As'	—	—	—	—	—	—
f/d			0			
M'/bd^2			3.20			
S/bd			2.22			
n·P			0.0280			
C			10.22			
S			38.36			
Z			1.08			
σ_c			33			
σ_s			1839			
τ			2.40			
σ_{ca}	83	→				
σ_{sa}	2346	→				
τ_a	2.35	→				

§ 7 CALCULATION OF FOOTING SECTION

7-1 . dimenston and loading



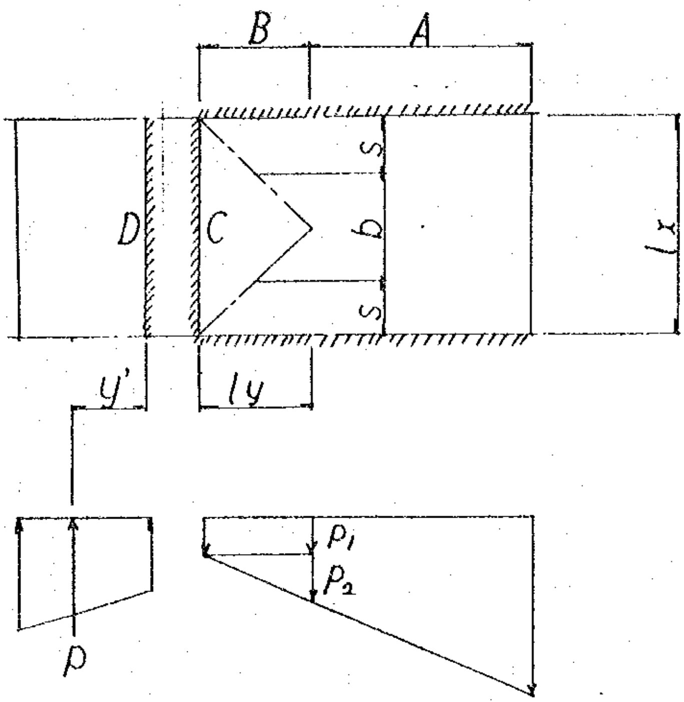
$w_1 = 1.00 \times 2.41 + 1.50 \times 1.9 \qquad = 5.26\ t/m^2$

$w_2 = 1.50 \times$ 〃 $+ 1.00 \times$ 〃 $\qquad = 5.52$ 〃

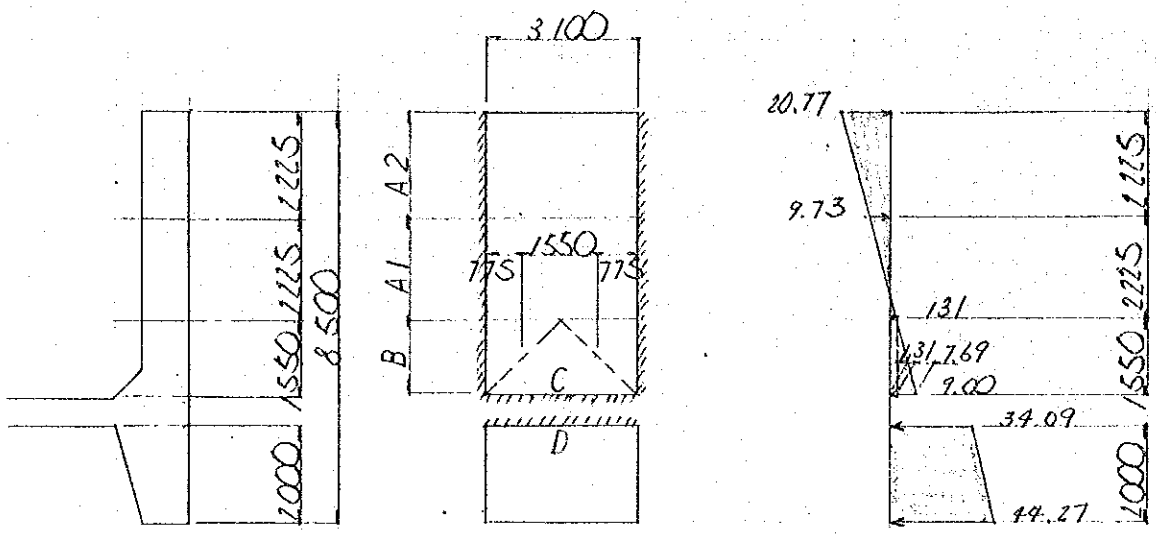
$w_3 = 1.00 \times$ 〃 $+ 13.00 \times$ 〃 $+ q \quad = 27.11 + q$ 〃

	q_1	q_2	q_3	q_4	q_5	q_6
HA loading	49.53	39.61	37.13	29.44	18.40	7.36
HB loading	51.34	40.57	37.88	29.53	17.54	5.56

7-2 sectional force of footing



	A	B	C	D
(tm) M	$\frac{p \cdot lx^2}{10}$	$\frac{p \cdot s^2}{6 \cdot lx}(2 \cdot lx + b)$	$\frac{1}{2}(\frac{p_1}{2} + \frac{p_2}{6})ly^2$	$p \cdot y'$
(t) S	$\frac{p \cdot lx}{2}$	$p \cdot s$	$(p_1 + \frac{p_2}{2}) \cdot ly$	p



	M	(tm)	S	(t)
D − D	$78.36 \times \frac{2.00}{3} \times \left(\frac{2 \times 1.00 + 1.50}{1.00 + 1.50}\right)$	73.14	$\frac{1}{2} \times (34.09 + 44.27) \times 2.00$	78.36
C − C	$\frac{1}{2} \times \left(\frac{1.31}{2} + \frac{7.69}{6}\right) \times 1.55^2$	2.33	$\left(1.31 + \frac{7.69}{2}\right) \times 1.55$	7.99
B − B	$\frac{5.16 \times 0.775^2}{6 \times 3.10} \times (2 \times 3.10 + 1.55)$	1.29	5.16×0.775	4.00
A1 − 1	$\frac{9.73 \times 3.10^2}{10}$	9.35	$\frac{9.73 \times 3.10}{2}$	15.08
A2 − 2	$\frac{20.77 \times 3.10^2}{10}$	19.96	$\frac{20.77 \times 3.10}{2}$	32.19
A3 − 3	———	——	———	——

7 - 3 list of stresses σc . σs . τ : working stress .
σca, σsa, τa : Permissible stress.

	※As min = b·d·0.15 % = 13.50 mm²					
	D − D	C − C	B − B	A1 − 1	A2 − 2	
M	23.14	2.33	1.29	9.35	19.96	
N	———	———	———	———	———	
S	18.36	7.99	4.00	15.08	32.19	
b	100	→	→	→	→	
h	140	90	→	→	→	
d'	10	10	→	→	→	
As	D20 @ 125 25.12	D16 @ 125 ※ 16.08	→ ※	→ ※	D16 @ 125 16.08	
As'	———	———	———	———	———	
f/d	0	|	|	|	0	
M'/bd²	3.73	|	|	|	2.46	
S/bd	5.60	|	|	|	3.58	
n·P	0.0269	|	|	|	0.0268	
C	10.90	|	|	|	10.92	
S	39.93	|	|	|	40.10	
Z	1.07	|	|	|	1.07	
σc	39	|	|	|	26	
σs	2235	|	|	|	1982	
τ	5.60	|	|	|	3.6	
σca	83	→	→	→	→	
σsa	2346	→	→	→	→	
τa	2.35	→	→	→	→	

Check for stirrups.

Sect D-D

$$\tau = \frac{S}{b \cdot d} \cdot Z = \frac{78.36 \times 10^3}{100 \times 140} \times 1.07 = 5.99\ kg/cm^2 > \tau_a = 2.35\ kg/cm^2$$

$S' = S - S_c$

$S_c = \tau_a \cdot b \cdot d \cdot 1/Z = 2.35 \times 100 \times 140 \times 1/1.07 = 30.75 \times 10^3\ kg$

$S' = (78.36 - 30.75) \times 10^3 = 47.61 \times 10^3\ kg$

$$Req\ A_v = \frac{S' \times a}{\sigma_{sa} \cdot d} \times Z = \frac{47.61 \times 10^3 \times 25}{1780 \times 140} \times 1.07 = 5.11\ cm^2$$

Φ 20 - ctc 250 $n = 2$

$A_s = 3.14 \times 2 = 6.28\ cm^2 > Req\ A_v = 5.11\ cm^2$

Sect A_{2-2}.

$$\tau = \frac{S}{b \cdot d} \cdot Z = \frac{32.19 \times 10^3}{100 \times 90} \times 1.07 = 3.83\ kg/cm^2 > \tau_a = 2.35\ kg/cm^2$$

$S' = S - S_c$

$S_c = \tau_a \cdot b \cdot d \cdot 1/Z = 2.35 \times 100 \times 90 \times 1/1.07 = 19.77 \times 10^3\ kg$

$S' = (32.19 - 19.77) \times 10^3 = 12.42 \times 10^3\ kg$

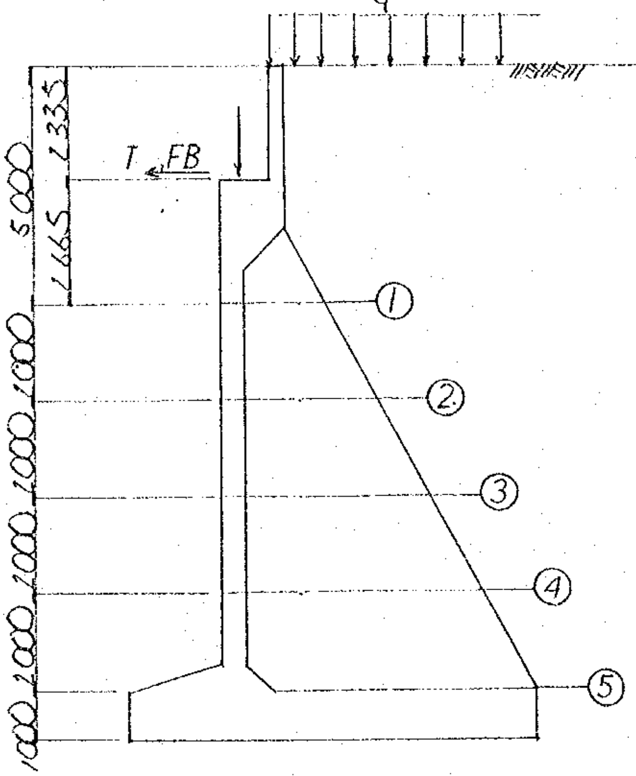
$$Req\ A_v = \frac{S' \times a}{\sigma_{sa} \cdot d} \cdot Z = \frac{12.42 \times 10^3 \times 25}{1780 \times 90} \times 1.07 = 2.07\ cm^2$$

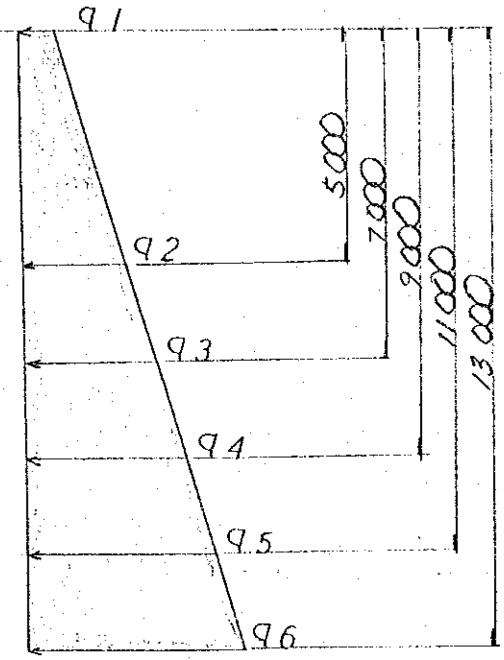
Φ 16 - ctc 250 $n = 2$

$A_s = 2.01 \times 2 = 4.02 > Req\ A_v = 2.07\ cm^2$

§ 8 CALCULATION OF BUTTRESS SECTION

8 - 1 dimenston and loading





$$q = (K \cdot \gamma_s \cdot H + q \cdot K) \cdot l$$

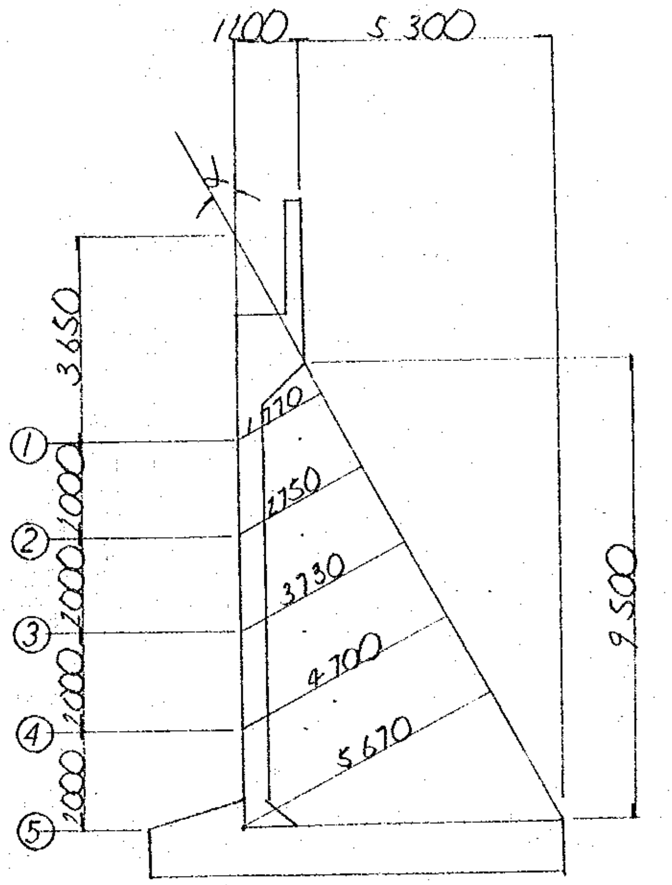
	F B (t)	T (t)	FB + T (t)	(FB+T) l / B (t)
HA loading	25.80	27.58	53.38	16.38
HA loading	38.20	27.58	65.78	20.19

	q 1	q 2	q 3	q 4	q 5	q 6	q 7
HA loading	0.85	8.80	11.98	15.16	18.34	21.52	——
HB loading	1.39	9.34	12.52	15.70	18.88	22.06	——

8 − 2 sectional force of buttress

		HA loading			HB loading		
		H (t)	y (m)	H·y (tm)	H (t)	y (m)	H·y (tm)
1-1	FB · T	16.38	2.665	43.65	20.19	2.665	53.81
	Pa	24.13	1.813	43.75	26.83	1.813	48.64
	Σ	40.51		87.40	47.02		102.45
2-2	FB · T	16.38	4.665	76.41	20.19	4.665	94.19
	Pa	44.91	2.488	111.74	48.69	2.488	121.14
	Σ	61.29		188.15	68.88		215.33
3-3	FB · T	16.38	6.665	109.17	20.19	6.665	134.57
	Pa	72.05	3.159	227.61	76.91	3.159	242.96
	Σ	88.43		336.78	97.10		377.53
4-4	FB · T	16.38	8.665	141.93	20.19	8.665	174.95
	Pa	105.55	3.829	404.15	111.49	3.829	426.90
	Σ	121.93		546.08	131.68		601.85
5-5	FB · T	16.38	10.665	174.69	20.19	10.665	215.33
	Pa	145.41	4.498	654.05	152.43	4.498	685.63
	Σ	161.79		828.74	172.62		900.96

8 − 3 calculation of members



$\tan\alpha = \frac{5.30}{9.50} = 0.558$

$\alpha = 29°9'$

$\sin 29°9' = 0.487$

$H = h \cdot \sin\alpha$

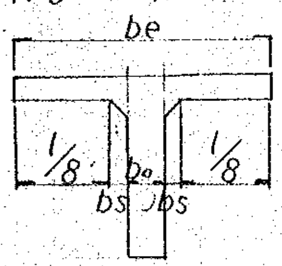
$H1 = 3.65 \times 0.487 = 1.77$ m

$H2 = 5.65 \times$ 〃 $= 2.75$ 〃

$H3 = 7.65 \times$ 〃 $= 3.73$ 〃

$H4 = 9.65 \times$ 〃 $= 4.70$ 〃

$H5 = 11.65 \times$ 〃 $= 5.67$ 〃

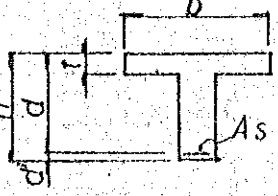


$be = 60 + 2 \times (30 + 38) = 196$ cm

8 - 4 list of stresses

σ_c, σ_s, τ : working stress.
σ_{ca}, σ_{sa}, τ_a : Permissible stress.

		※(As) min = b · d · 0.15%				
		1 - 1	2 - 2	3 - 3	4 - 4	5 - 5
M	tm	87.40	188.15	336.78	546.08	828.74
S	t	40.51	61.29	88.43	121.93	161.79
b	cm	196	→	→	→	→
t	〃	50	→	→	→	→
d	〃	167	265	358	455	552
A s	cm²	3 - D32 ※(15.03) 24.12	5 - D32 ※(13.85) 40.20	5/1 > D32 ※(32.22) 48.24	5/3 > D32 ※(40.95) 64.32	5/5 > D32 ※(49.68) 80.40
P		0.0007	0.0008	0.0007	0.0007	0.0007
t/d		0.30	0.19	0.14	0.11	0.091
K		0.178	0.149	0.135	0.138	0.144
j		1.109	0.960	0.955	0.957	0.961
σ_s	kg/cm²	1956	1839	2092	1950	1943
σ_c	〃	28	21	22	21	22
τ	〃	4.09	3.85	4.11	4.47	4.88
σ_{sa}	〃	2346	→	→	→	→
σ_{ca}	〃	83	→	→	→	→
τ_a	〃	8.2	→	→	→	→



8-5 check for tie bers

1) wall and buttress

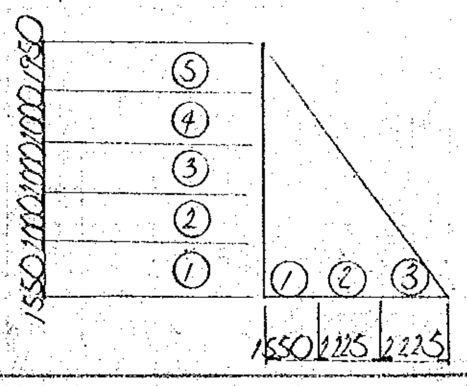
$$A_s = \frac{S}{\sigma_{sa}} \quad (cm^2)$$

		S (t)	As (cm^2)	As'	(cm^2)
section	1 — 1	5.08	2.16	D16 ctc150	8.04
	2 — 2	9.53	4.06	↓	↓
	3 — 3	7.95	3.39	↓	↓
	4 — 4	6.36	2.71	↓	↓
	5 — 5	4.77	2.03	↓	↓

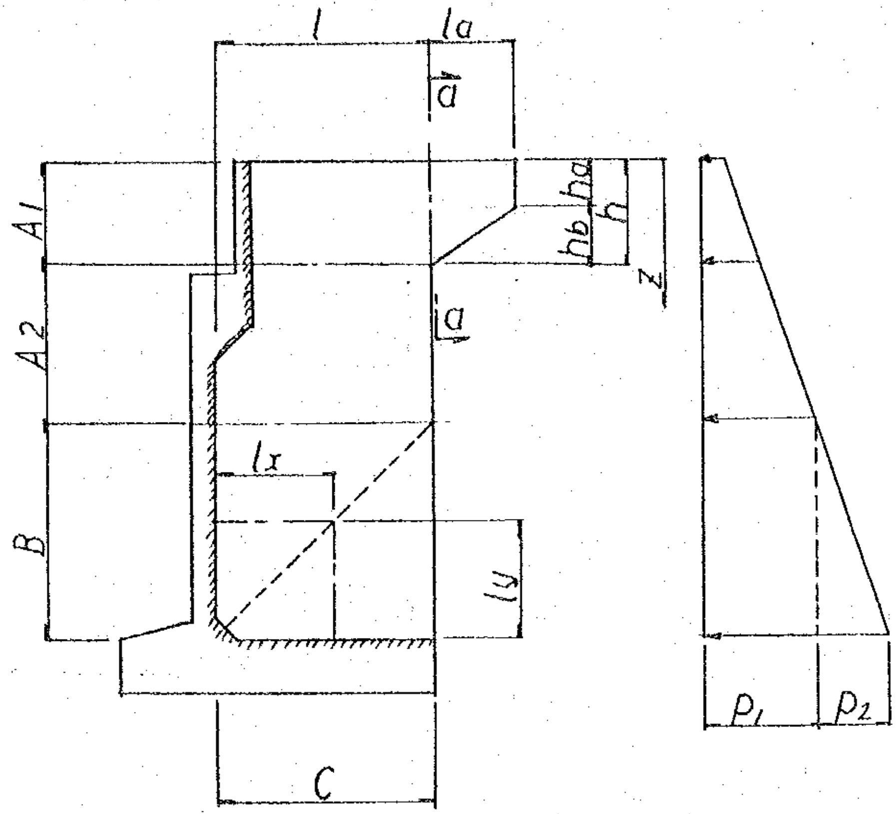
2) footing and buttress

$$A_s = \frac{S}{\sigma_{sa}} \quad (cm^2)$$

		S (t)	As (cm^2)	As'	(cm^2)
section	1 1	4.00	1.71	D16 ctc150	8.04
	2 2	15.08	6.43	D16 ctc150	8.04
	3 3	32.19	13.72	D16 ctc125	16.08



§ 9 CALCULATION OF WING SECTION



		S (t)	M (tm)
a–a	$0 < z < h_a$	$(q+\gamma\cdot z)\cdot K\cdot l_a$	$(q+\gamma\cdot z)\cdot K\cdot \frac{l_a^2}{2}$
	$h_a < z < h$	$(q+\gamma\cdot z)\cdot K\cdot l_a\cdot \frac{h-z}{h_b}$	$(q+\gamma\cdot z)\cdot K\cdot \frac{l_a^2}{2}\cdot\left(\frac{h-z}{h_b}\right)^2$

$$M_{max}\ (h_a < z < h) \longrightarrow z = \frac{\gamma\cdot h - 2\cdot q}{3\gamma}\ (m)$$

$q = 1.02$ t/m²

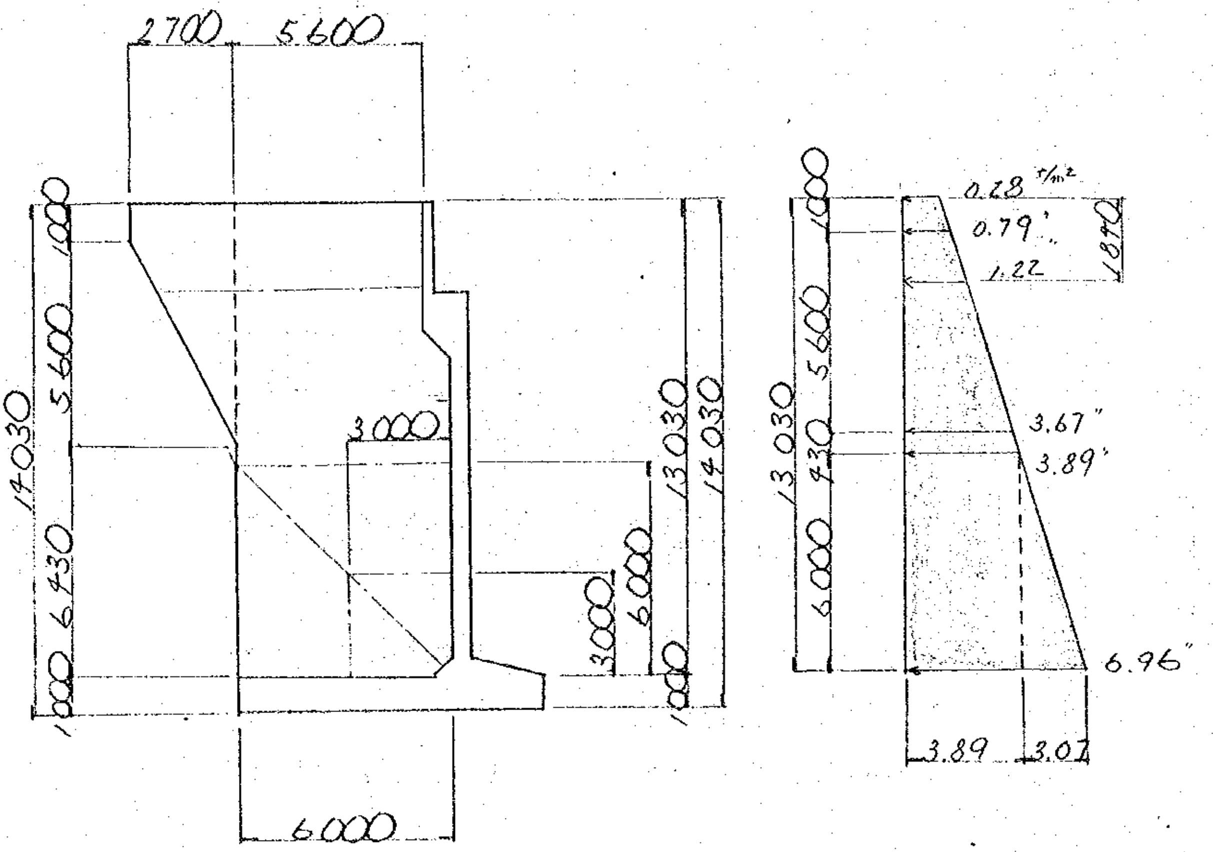
$K = 0.27$

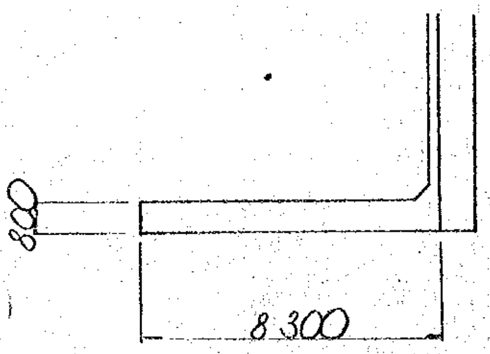
$\gamma = 1.9$ t/m³

	M (t)	S (tm)
A1 − 1	$\frac{1}{2} p \cdot l^2 + Ma + Sa \cdot l$	$p \cdot l + Sa$
A2 − 2	$\frac{1}{2} \cdot p \cdot l^2$	$p \cdot l$
B − B	$\frac{1}{2} \cdot p \cdot l_x^2$	$p \cdot l_x$
C − C	$(\frac{p_1}{2} + \frac{p_2}{6})\, l_y^2$	$(p_1 + \frac{p_2}{2}) \cdot l_y$

(B-LINE - 2 A I L)

9 — I dimension and loading





		$\bar{x}$ (m)	M (t m)		S (t)	
a – a	1 – 1	1.00	$(1.02+1.9\times1.00)\times0.27\times1.70^2\times 1/2$	2.87	$(1.02+1.9\times1.00)\times0.27\times2.70$	2.13
	2 – 2	1.00 ~6.50	$(1.02+1.9\times1.84^{*})\times0.27\times\frac{2.70^2}{2}\times\left(\frac{6.60-1.84}{5.60}\right)^2$	3.21	$(1.02+1.9\times1.84)\times0.27\times2.70\times\left(\frac{6.60-1.84}{5.60}\right)$	2.80
A 1		0 ~6.60	$\frac{1}{2}\times1.22\times6.00^2+3.21+2.80\times6.00$	41.97	$1.22\times6.00+2.80$	10.12
A 2	1 – 1	6.60	$\frac{1}{2}\times3.67\times6.00^2$	66.06	3.67×6.00	22.02
	2 – 2	7.03	$\frac{1}{2}\times3.89\times6.00^2$	70.02	3.89×6.00	23.34
B – B		7.03 ~13.03	$\frac{1}{2}\times\frac{3.89+6.96}{2}\times3.00^2$	24.41	$\frac{3.89+6.96}{2}\times3.00$	16.28
C – C		13.03	$\left(\frac{3.89}{2}+\frac{3.07}{6}\right)\times3.00^2$	22.11	$\left(3.89+\frac{3.07}{2}\right)\times3.00$	16.28

$$z^{*}=\frac{1.9\times6.60-2\times1.02}{3\times1.9}=1.84^{m}$$

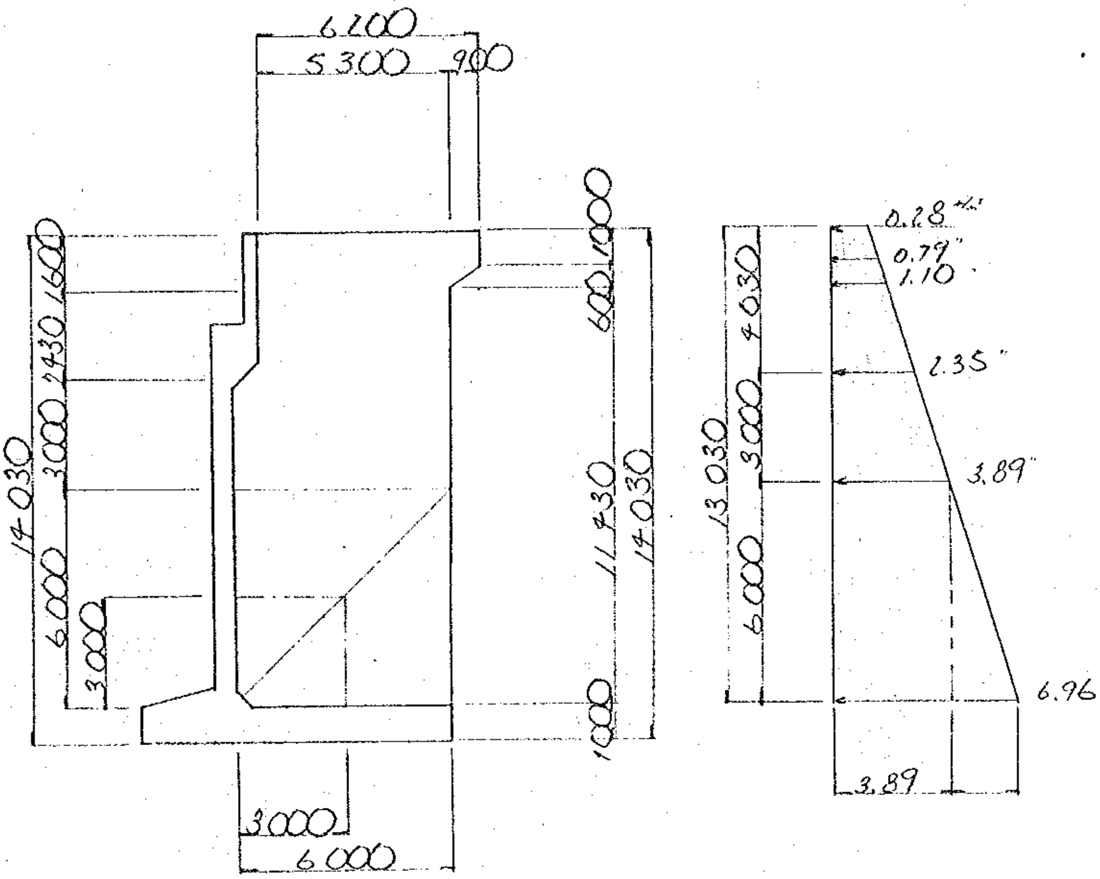
9 - 2 list of stresses $\sigma_c . \sigma_s . \tau$: working stress.

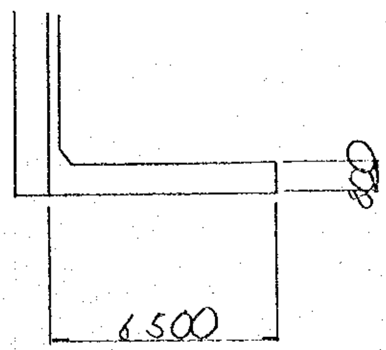
$\sigma_{ca}, \sigma_{sa}, \tau_a$: Permissible stress.

	※ $As_{min} = b \cdot d \cdot 0.15\% = 10.95\ cm^2$					
	a - a	A_1	A_2 1-1	A_2 2-2	B	C
M	3.21	41.97	66.06	70.02	24.41	21.11
N	―	―	―	―	―	―
S	1.80	10.12	22.02	23.34	16.28	16.28
b	100	→				
h	73	→				
d'	7	→				
As	D20 @ 250 ※ 12.56	D25 / D20 > @ 125 32.20	D25 / D32 > @ 125 51.80	→	D25 @ 250 19.64	D16 @ 125 16.08
As'	―	―	―	―	―	―
f/d		0	0	0	0	0
M'/bd^2		8.45	12.40	13.14	4.58	3.96
S/bd		1.43	3.02	3.19	2.23	2.23
n·P		0.0662	0.1064	0.1064	0.033	0.033
C		7.33	6.21	6.21	9.57	9.57
S		16.83	10.71	10.71	32.78	32.78
Z		1.11	1.14	1.14	1.08	1.08
σ_c		62	77	82	44	38
σ_s		2133	1991	2110	2252	1948
τ		1.6	3.4	3.2	2.4	2.4
σ_{ca}	83	→				
σ_{sa}	2346	→				
τ_a	2.35	3.47	3.47	→	2.35	→

(B-LINE-2 A2 R)

9 - 3 dimension and loading





		$\bar{z}$ (m)	M (tm)		S (t)	
a-a	1 − 1	1.00	$(1.02 + 1.9 \times 1.00) \times 0.27 \times 0.90^2 \times 1/2$	0.32	$(1.02 + 1.9 \times 1.00) \times 0.27 \times 0.90$	0.71
	2 − 2	—	—	—	—	—
A 1		1.00 ~1.60	$\frac{1}{2} \times 1.10 \times 5.30^2$	15.45	1.10×5.30	5.83
A 2	1 − 1	7.03	$\frac{1}{2} \times 2.35 \times 6.00^2$	42.30	2.35×6.00	14.10
	2 − 2	7.03	—	70.02	—	23.34
B − B		7.03 ~13.30	—	24.41	—	16.28
C − C		13.30	—	22.11	—	16.28

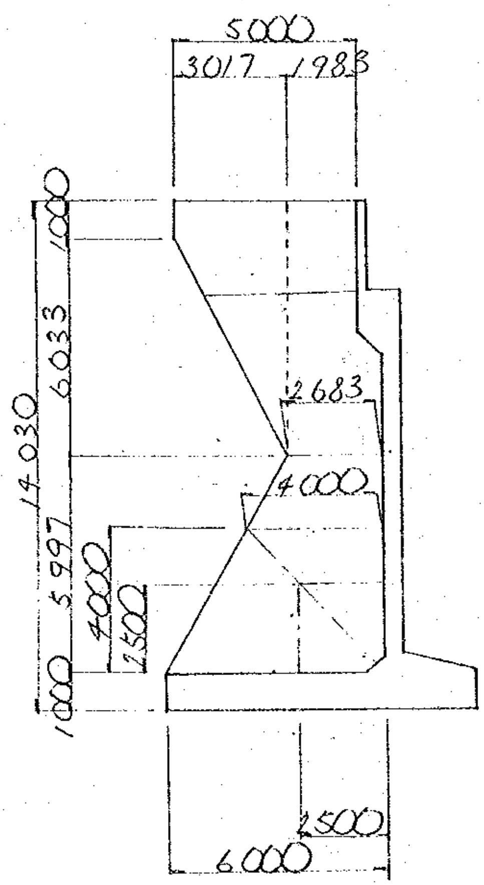
$$\bar{z}' = \frac{1.9 \times 1.60 - 2 \times 1.02}{3 \times 1.9} = 0.18 < 1.00$$

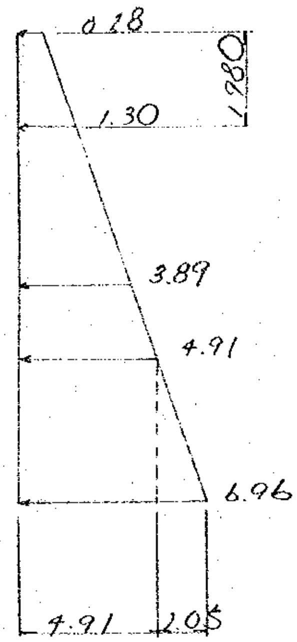
9 - 4 list of stresses σ_c, σ_s, τ : working stress.
$\sigma_{ca}, \sigma_{sa}, \tau_a$: Permissible stress.

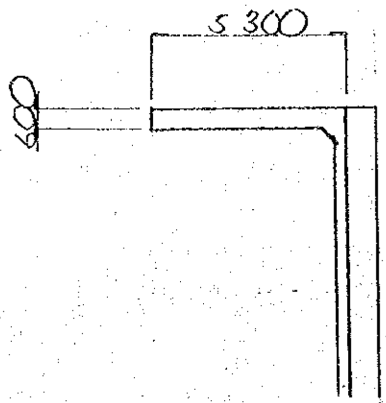
	※ $As_{min} = b \cdot d \cdot 0.15\% = 10.95$ cm^2					
	a - a	A_1	A_2 1-1	A_2 2-2	B	C
M	0.32	15.45	42.30	70.02	24.41	22.11
N	———	———	———	———	———	———
S	0.71	5.83	14.10	23.34	16.28	16.28
b	100	→				
h	73	→				
d'	7	→				
As	D20 @ 250 ※ 12.56	※ →	D25/D20 > @ 125 32.20	D25/D32 > @ 125 51.80	D25 @ 250 19.64	D16 @ 125 16.08
As'	———	———	———	———	———	———
f/d	0	0	0	0	0	0
M'/bd²	|	|	7.94	13.14	4.58	4.15
S/bd	|	|	1.93	3.20	2.23	2.23
n·P	|	|	0.0662	0.1064	0.033	0.033
C	|	|	7.33	6.21	9.57	9.57
S	|	|	16.83	10.71	32.78	32.78
Z	|	|	1.11	1.14	1.08	1.08
σ_c	|	|	58	82	44	40
σ_s	|	|	2004	2111	2252	2040
τ	|	|	2.1	3.1	2.4	2.4
σ_{ca}	83	→				
σ_{sa}	2346	→				
τ_a	2.35	→	3.47	→	2.35	→

(A-LINE-2 A1 R)

9 — 5 dimension and loading







		z (m)	M (tm)		S (t)	
a-a	1-1	1.00	$(1.02+1.9\times1.00)\times0.27\times3.017^2\times 1/2$	3.59	$(1.02+1.9\times1.00)\times0.27\times3.017$	2.38
a-a	2-2	1.00 ~ 7.03	$(1.02+1.9\times1.98)\times0.27\times\frac{3.017^2}{2}\times\left(\frac{7.033-1.98}{6.033}\right)^2$	4.12	$(1.02+1.9\times1.98)\times0.27\times3.017\times\frac{7.033-1.98}{6.033}$	3.26
A 1		1.00 ~ 7.03	$\frac{1}{2}\times1.30\times1.983^2+4.12+3.26\times1.983$	13.14	$1.30\times1.983+3.26$	5.84
A 2	1-1	7.033	$\frac{1}{2}\times3.89\times2.683^2$	14.00	3.89×2.683	10.44
A 2	2-2	9.033	$\frac{1}{2}\times4.91\times4.00^2$	39.28	4.91×4.00	19.64
B-B		9.033 ~ 13.03	$\frac{1}{2}\times\frac{4.91+6.96}{2}\times2.50^2$	18.55	$\frac{4.91+6.96}{2}\times2.50$	14.84
C-C			$\left(\frac{4.91}{2}+\frac{2.05}{6}\right)\times2.50^2$	17.48	$\left(4.91+\frac{2.05}{2}\right)\times2.50$	14.84

$$z^* = \frac{1.9\times7.033-2\times1.02}{3\times1.9} = 1.98\ \text{m}$$

9-6 list of stresses σ_c, σ_s, τ : working stress.
$\sigma_{ca}, \sigma_{sa}, \tau_a$: Permissible stress.

※ $A_s\ min = b \cdot d \cdot 0.15\% = 7.95$

	a-a	A_1	A_2 1-1	A_2 2-2	B	C
M	4.12	13.14	14.00	39.28	18.55	17.48
N	—	—	—	—	—	—
S	3.26	5.84	10.44	19.64	14.84	14.84
b	100	→				
h	53	→				
d'	7	→				
As	D16@250 ※8.04	D16@125 16.08	→	D25@125 39.28	D25@250 19.64	D16@125 16.08
As'	—	—	—	—	—	—
f/d		0	0	0	0	0
M'/bd^2		5.18	4.98	13.98	6.60	6.22
S/bd		1.37	1.97	3.71	2.80	2.80
n·P		0.0355	0.0355	0.1112	0.0455	0.0455
C		9.29	9.29	6.12	8.40	8.40
S		30.52	30.52	10.28	23.07	23.07
Z		1.08	1.08	1.14	1.00	1.00
σ_c		48	46	82	56	53
σ_s		2339	2281	2156	2330	2247
τ		1.48	2.1	3.4	3.0	3.0
σ_{ca}	83	→				
σ_{sa}	2346	→				
τ_a	2.35	3.47	→			