社会開発協力部報告書

No. 3

AFRICAN DEVELOPMENT BANK

GOVERNMENT OF MAURITIUS

BEAU BASSIN - PORT LOUIS LINK ROAD

CULCULATION NOTE

FOR

SUBSTRUCTURES

2

SEPTEMBER 1980

Japan International Cooperation Agency

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80-100

CONTENTS

4. Motorway Junction Bridge (Piers)

CONTENT

§§ 1. DESIGN CONDITIONS

§§ 1. DESIGN CONDITIONS

1 Pier type

T Pier with circular column

height $H = 19.00^m$, 14.80^m, 15.80^m

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 σ_{su} = 410 N/mm² = 4180 kg/cm²

permissible tensile stress σ_{sa} = 230 N/mm² = 2340 kg/cm²

permissible tensile stress in shera reinforcement σ_{sa} = 175 N/mm² = 1780 kg/cm²

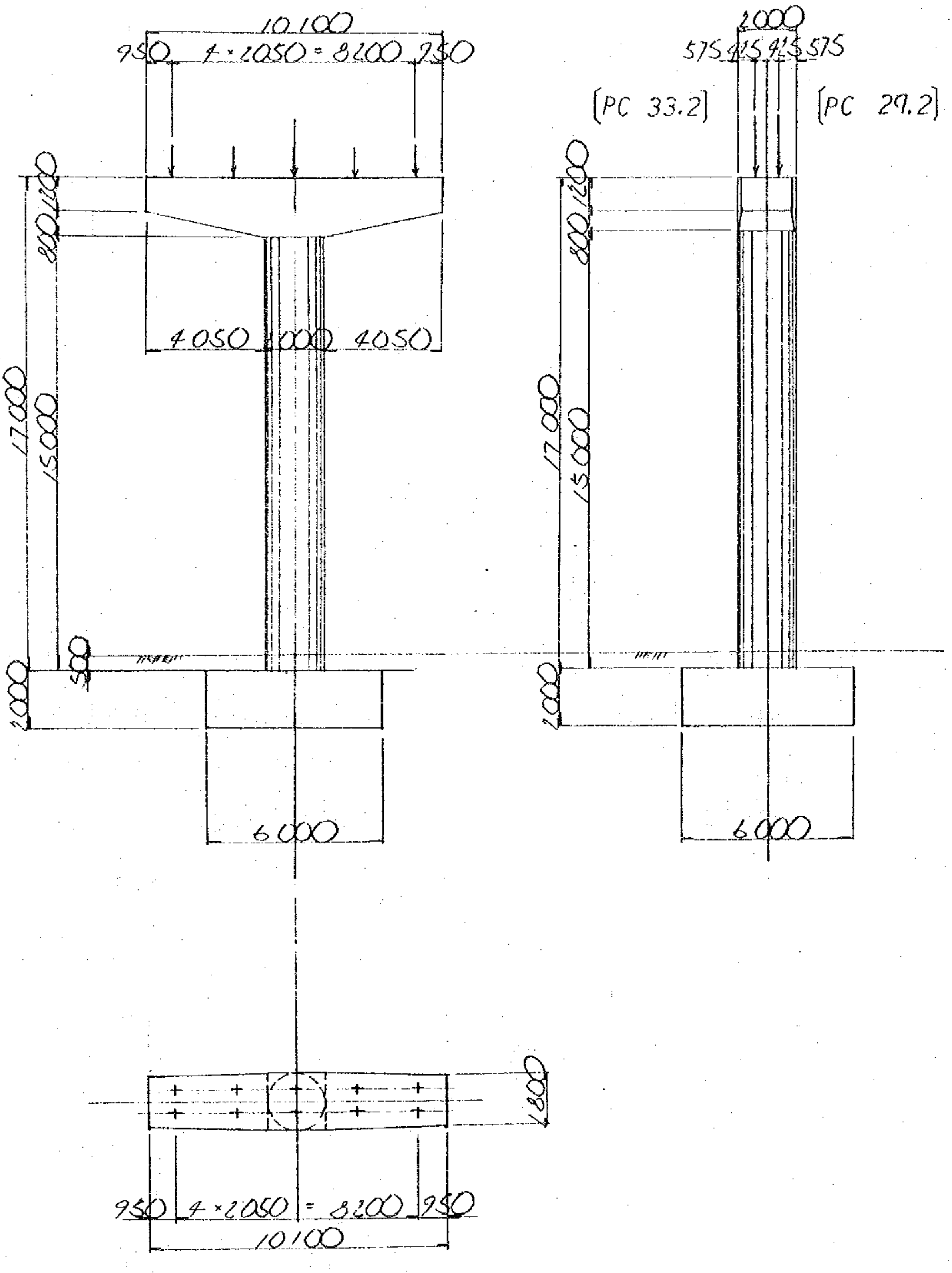
6 Permissible increase in basic working stresses

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 = 19.00 m

A - L - 2	P 1
B - L - 2	P 1
E - RAMP	P 1

§ 1 STRUCTURAL FIGURE



§ 2 REACTION OF SUPERSTRUCTURE

2-1 whole reaction of superstructure

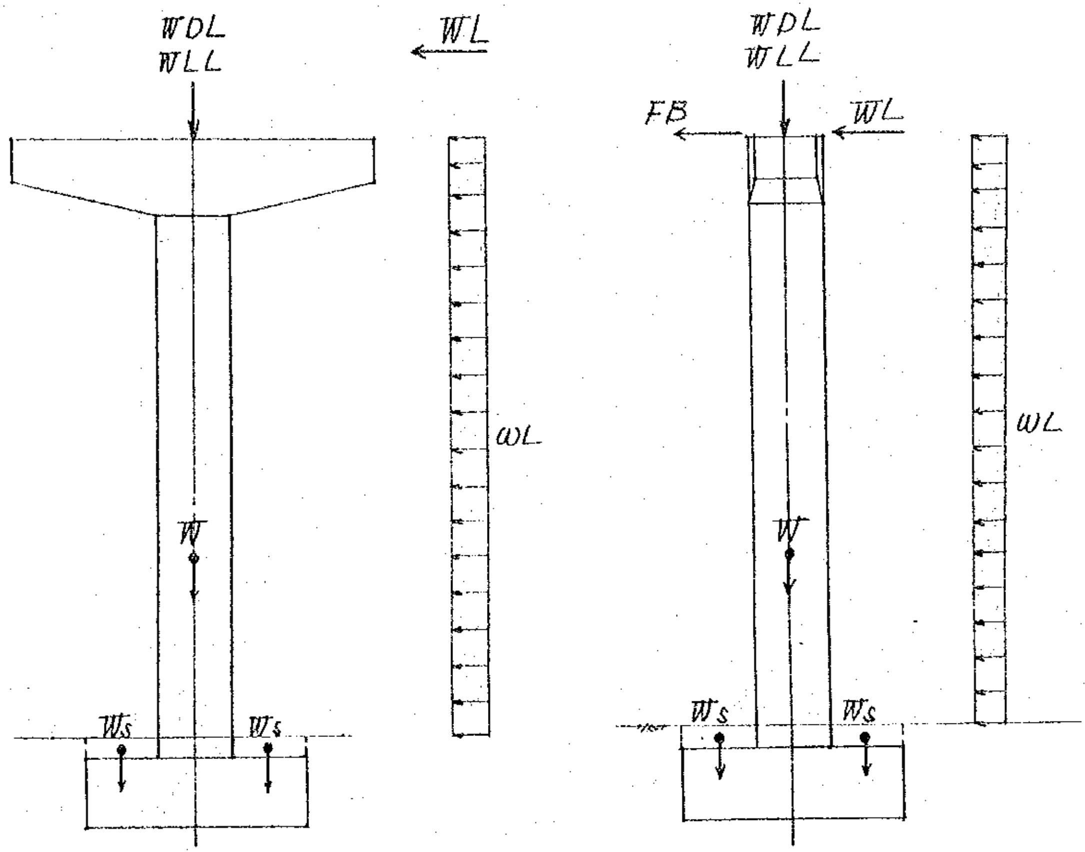
dead load of deck		296.1	266.7
H. A live load		138.0	100.4
H. B live load		102.3	67.2
crowd load		———	
longitudinal forces	under H.A	12.90	
	under H.B	19.10	

2-2 reaction per each girder

		G 1	G 2	G 3	G 4	G 5
dead load of deck		114.7	116.5	118.1	116.5	114.7
live load	H A	63.8	60.7	58.2	60.7	63.8
	H B	63.5	57.3	62.2	57.3	63.5
TOTAL	H A	178.5	177.2	176.3	177.2	178.5
	H B	178.2	174.1	180.8	174.1	178.2

§ 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 or fraction

W : self weight

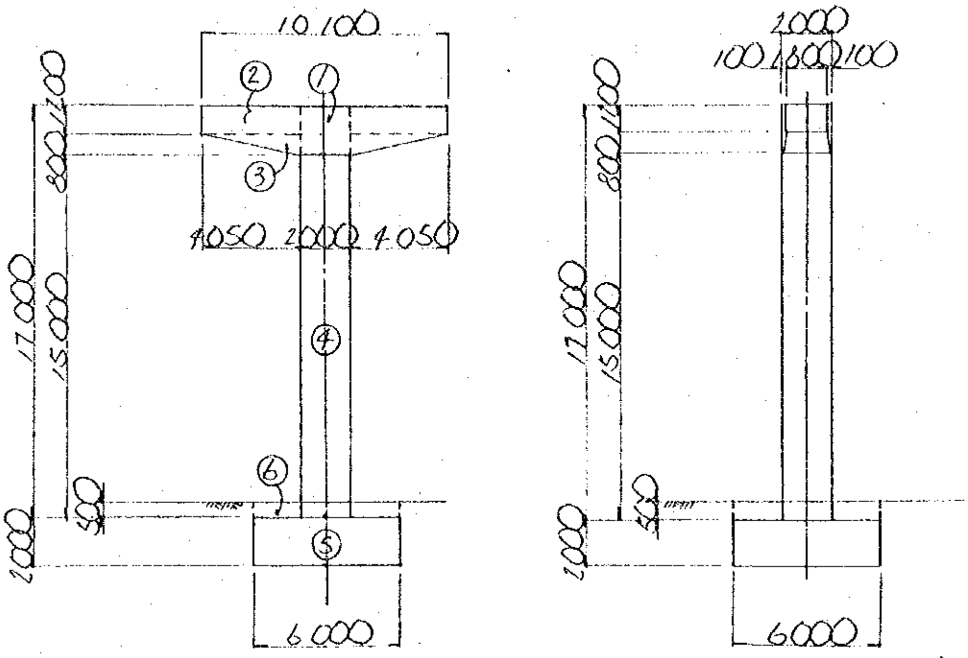
Ws : weight of soil

WL : wind load on the superstructure

wL : wind load on the pier

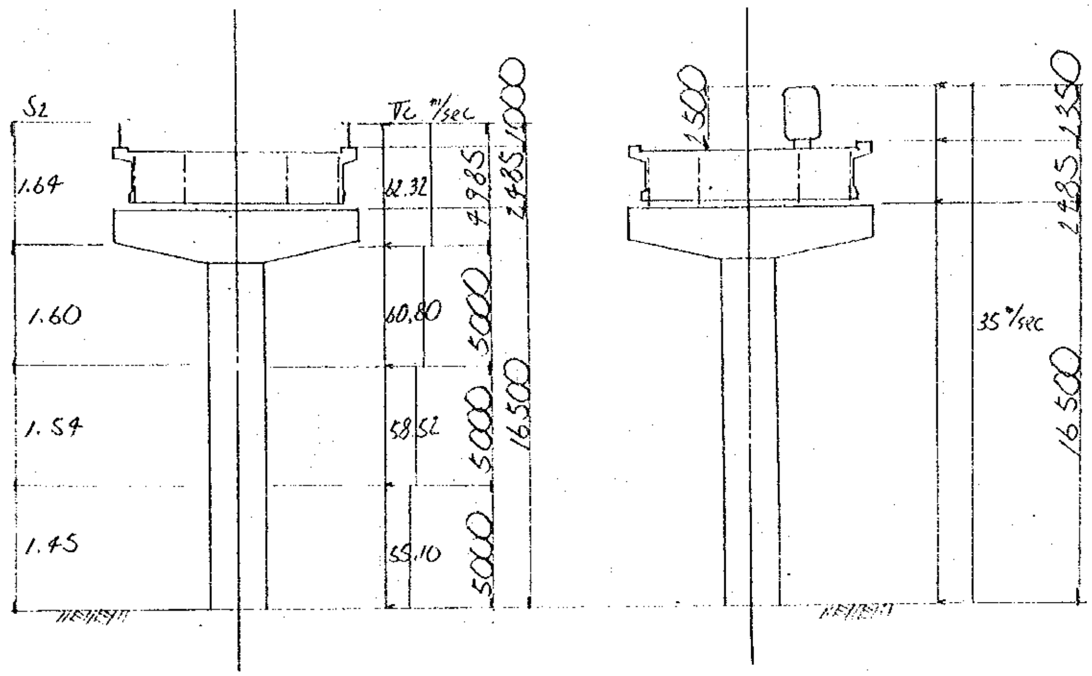
B : buoyancy

3 - 2 self weight and weight of soil



		N (t)
①	2.00 × 2.00 × 2.00 × 2.41	19.28
②	{1/2 × (1.80 + 2.00) × 4.05 × 1.20} × 2 × 2.41	44.51
③	{1/6 × 0.80 × 4.05 × (2 × 2.00 + 1.80)} × 2 × 2.41	15.10
④	π/4 × 2.00² × 15.00 × 2.41	113.57
⑤	6.00 × 6.00 × 2.00 × 2.41	173.52
⑥	(6.00 × 6.00 − π/4 × 2.00²) × 0.50 × 1.9	31.22
		397.20

3-3 wind pressure



wind gust speed

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

case 1 (without live load)

$$V_c = 38 \times 1.0 \times 1.0 \times S_2 = 38 \cdot S_2 \; \text{m/sec}$$

case 2 (with live load)

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

(A) transverse wind load

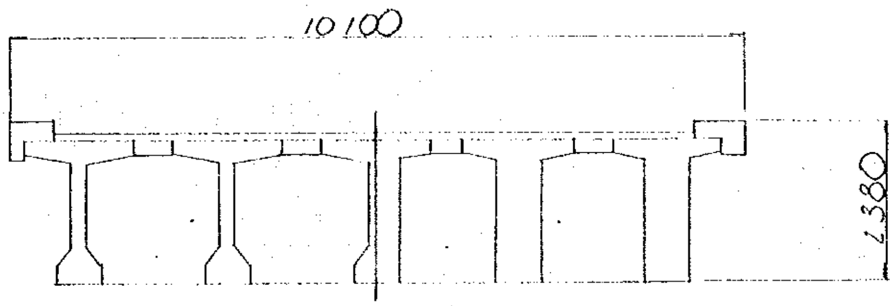
(A-1) for superstructures

$$Pt = q \cdot A \cdot Cd \quad (t)$$

$$q = 0.613 \cdot Vc^2 \times 0.102 \quad (kg/m^2)$$

Cd : drag coefficient

A : loading area (m^2)



case 1

$$q = 0.613 \times 62.32^2 \times 0.102 \times 10^{-3} = 0.24 \; t/m^2$$

$$A = 2.38 \times 1/2 \times (34.00 + 30.00) = 76.16 \; m^2$$

$$Cd = 1.38 \quad (b/d = 10.10/2.38 = 4.24)$$

$$Pt = 0.24 \times 76.16 \times 1.38 = 25.22 \; t$$

case 2

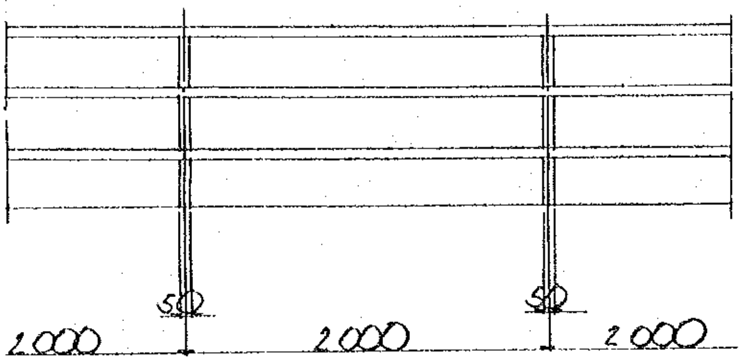
$$q = 0.613 \times 35^2 \times 0.102 \times 10^{-3} = 0.077 \; t/m^2$$

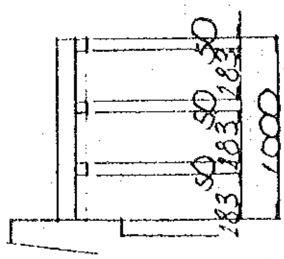
$$A = 4.73 \times 1/2 \times (34.00 + 30.00) = 151.36$$

$$Cd = 1.37 \quad (b/d = 10.10/2.50 = 4.04)$$

$$Pt = 0.077 \times 151.36 \times 1.37 = 15.97 \; t$$

(A - 2) for parapet





case 1

$$A = 0.05 \times 3 \times 32.00 + (1.00 - 0.05 \times 3) \times \frac{32.00}{2.00}$$

$$= 18.40 \ m^2$$

$$q = 0.613 \times 62.32^2 \times 0.102 \times 10^{-3} = 0.24 \ t/m^2$$

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

$$Pt = 0.24 \times 18.40 \times 1.1 = 4.86^{t}$$

(A − 3) for substructure

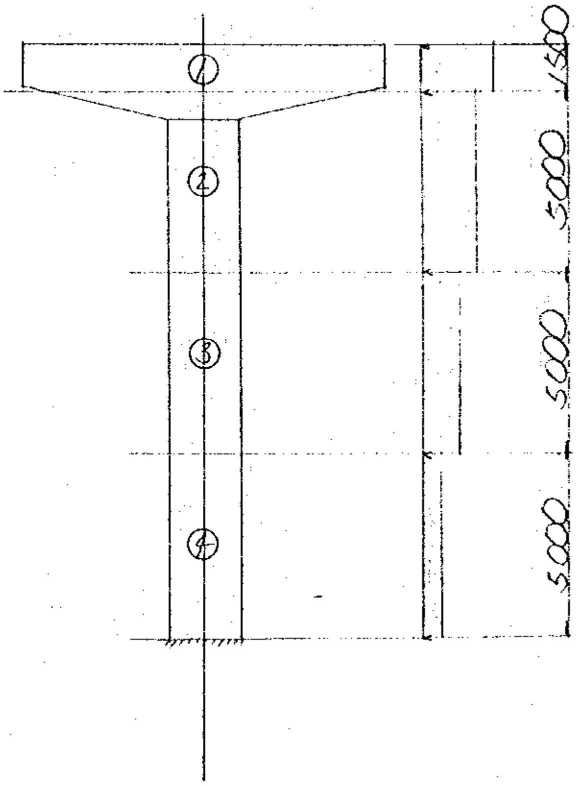
case 1

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

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

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

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



	V_c (m/sec)	q (t/m²)	t/b	C_d
①	62.32	0.24	> 4	1.1
②	60.80	0.23	○	1.2
③	58.52	0.21	○	1.2
④	55.10	0.19	○	1.2

	A (m^2)		Pt (t)	y (m)	Pt·y (tm)
①	2.00 × 1.50	3.00	0.79	18.250	14.42
②	2.00 × 5.00	10.00	2.76	15.000	41.40
③	〃	10.00	2.52	10.000	25.20
④	〃	10.00	2.28	5.000	11.40
Σ		33.00	8.35		92.42

case − 2

$$V_c = 35 \ ^{m}/_{sec}$$

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

$$A = 33.00 \ ^{m^2}$$

$$\bar{C}d = (1.10 \times 3.00 + 1.2 \times 30.00) \times 1/33.00 = 1.19$$

$$Pt = 0.077 \times 33.00 \times 1.19 = 3.02^{t}$$

(B) longitudinal wind load

(B - 1) for superstructure

case 1

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

$$= 0.25 \times 25.22 = 6.31^t$$

case 2

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

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

$$P_{LS} = 0.25 \times 0.077 \times (32.00 \times 2.38) \times 1.38$$

$$= 2.02^t$$

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

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

$$P_{LL} = 0.5 \times 0.077 \times (2.50 \times 32.00) \times 1.45$$

$$= 4.47^t$$

(B − 2) for palapet

for vertical members

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

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

$$A = 0.05 \times (1.00 - 3 \times 0.05) \times 32.00/2.00 = 0.68^{m^2}$$

$$P_{L1} = 0.8 \times 0.24 \times 0.68 \times 1.1 = 0.15^{t}$$

for horizontal members

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

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

$$A = 32.00 \times 0.05 \times 3 = 4.80^{m^2}$$

$$P_{L2} = 0.4 \times 0.24 \times 4.80 \times 1.1 = 0.51^{t}$$

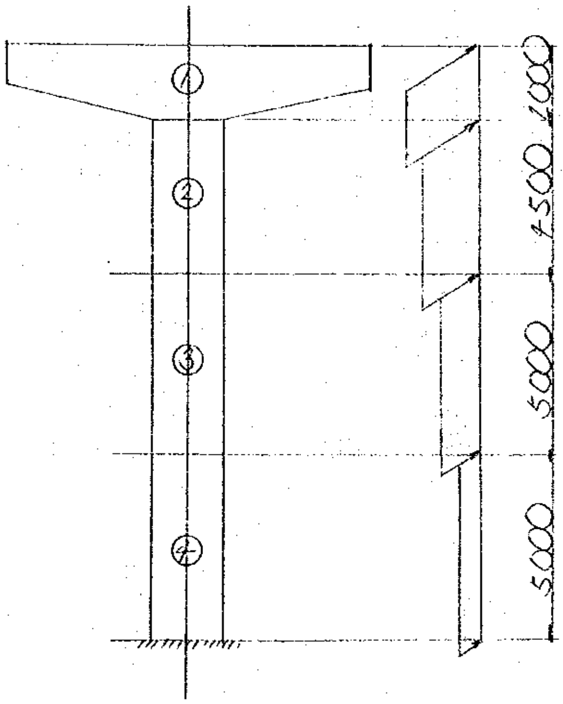
(B - 3) for substructure

case 1

$$V_c = U \cdot K_1 \cdot S_1 \cdot S_2$$
$$= 38 \times 1.0 \times 1.0 \times S_2 = 38 \cdot S_2 \quad m/sec$$

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

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



	V_c (m/sec)	q (t/m²)	t/b	Cd
①	62.32	0.24	$< \frac{1}{4}$	2.1
②	60.80	0.23	○	1.2
③	58.52	0.21	○	1.2
④	55.10	0.19	○	1.2

		A (m²)	Pt (t)	y (m)	Pt·y (tm)
①	10.10×1.20 + ½×(2.00+10.10)×0.80	16.96	8.55	18.000	153.90
②	2.00×4.50	9.00	2.48	14.750	36.58
③	2.00×5.00	10.00	2.52	10.000	25.20
④	〃	10.00	2.28	5.000	11.40
Σ		45.96	15.83		227.08

case 2

$$V_c = 35 \ ^{m}/_{sec}$$

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

$$A = 45.96^{m^2}$$

$$C_d = (2.1 \times 16.96 + 1.2 \times 29.00) \times {}^{1}/_{45.96} = 1.53$$

$$P_t = 0.077 \times 45.96 \times 1.53 = 5.41^{t}$$

$$y = \frac{16.96 \times 18.00 + 29.00 \times 9.75}{45.96} = 12.79^{m}$$

(C) vertical wind load

case 1

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

$A = 10.10 \times 32.00 = 323.20\ m^2$

$C_L = 0.4 \quad (b/d = 10.10 / 2.38 = 4.24)$

$$P_V = 0.24 \times 323.20 \times 0.4 = 31.03^{t}$$

case 2

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

$A = 323.20\ m^2$

$C_L = 0.4$

$$P_V = 0.077 \times 323.20 \times 0.4 = 9.95^{t}$$

§ 4 CALCULATION OF STABILITY

4 - 1 longitudinal direction

case 1 (HA loading)

	N (t)	x (m)	N·x (tm)	H (t)	y (m)	Hy (tm)
WDL. WLL	801.20	——	28.48	——	——	——
F B	——	——	——	12.90	19.000	245.10
W. Ws	397.20	——	——	——	——	——
TOTAL	1198.40		28.48	12.90		245.10

1) check for eccentricity

$$e = \frac{\Sigma N x + \Sigma H y}{\Sigma N} = \frac{28.48 + 245.10}{1198.40} = 0.23^{m}$$

$$< \frac{B}{6} = 1.00^{m}$$

2) soil reaction

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

$$= \frac{1198.40}{6.00 \times 6.00} \times \left(1 \pm \frac{6 \times 0.23}{6.00}\right) = \begin{cases} 40.91\ t/m^2 \\ 25.63 \end{cases} < 60\ t/m^2$$

3) check for sliding

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

$$F = \frac{0.6 \times 1198.40}{12.90} = 55.7 \quad > Fa = 1.5$$

case 2 (HB loading)

	N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL.WLL	732.30	—	27.41	—	—	—
F B	—	—	—	19.10	19.000	362.90
W, Ws	397.20	—	—	—	—	—
TOTAL	1129.50		27.41	19.10		362.90

1) check for eccentricity

$$e = \frac{27.41 + 362.90}{1129.50} = 0.35^{m} < \frac{B}{6}\ 1.25 = 1.25^{m}$$

2) soil reaction

$$q = \frac{1129.50}{6.00 \times 6.00} \times \left(1 \pm \frac{6 \times 0.35}{6.00}\right) = \begin{cases} 42.36^{t/m^2} \\ 20.39\ " \end{cases} < 75^{t/m^2}$$

3) check for sliding

$$F = \frac{0.6 \times 1129.50}{19.10} = 35.4 > Fa = 1.5 \cdot 1/1.25 = 1.2$$

case 3 (HA loading + wind B)

	N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL.WLL	801.20	—	28.48	—	—	—
F.B	—	—	—	12.90	19.000	245.10
W, Ws	397.20	—	—	—	—	—
wind pressure B-1	—	—	—	(2.02 + 4.47) 6.49	19.000	123.31
wind pressure B-3	—	—	—	5.41	12.790	69.19
TOTAL	1198.40	—	28.48	24.80		437.60

1) check for eccentricity

$$e = \frac{28.48 + 437.60}{1198.40} = 0.39^{m} < \frac{B}{6} \times 1.15 = 1.15^{m}$$

2) soil reaction

$$q = \frac{1198.40}{6.00 \times 6.00} \times \left(1 \pm \frac{6 \times 0.39}{6.00}\right) = \begin{cases} 46.27^{t/m^2} \\ 20.31 \end{cases} < 69.00^{t/m^2}$$

3) check for sliding

$$F = \frac{0.6 \times 1198.40}{24.80} = 29 \quad > Fa = 1.5 \times 1/1.15 = 1.3$$

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

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL, WLL		801.20	——	28.48	——	——	——
F. B		——	——	——	12.90	19.000	245.10
W. Ws		397.20	——	——	——	——	——
wind pressure (B)	B−1	——	——	——	6.49	19.000	123.31
	B−3	——	——	——	5.41		69.19
	C	9.95	——	——	——	——	——
wind pressure (A)	A−1	——	——	——	(7.99)	21.418	(171.13)
	A−3	——	——	——	(4.18)	——	(46.21)
TOTAL		1208.35		28.48	24.80 (12.17)		437.60 (217.34)

1) check for eccentricity

$$e = \frac{28.48 + 437.60}{1208.35} = 0.39 \text{ m} < \frac{B}{6} \times 1.15 = 1.15 \text{ m}$$

2) soil reaction

$$q = \frac{1208.35}{6.00 \times 6.00} \times \left(1 \pm \frac{6 \times 0.39}{6.00}\right) \pm \frac{6 \times 217.34}{6.00 \times 6.00^2} = \begin{cases} 52.70 \ t/m^2 \\ 14.43 \end{cases}$$

$$< 69.00 \ t/m^2.$$

3) check for sliding

$$F = \frac{0.6 \times 1208.35}{24.80} = 48 < Fa = 1.3$$

4 − 2 transverse direction

case 1 (HA loading)

	N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL	562.80	—	—	—	—	—
WLL	238.40	—	—	—	—	—
W . Ws	397.20	—	—	—	—	—
TOTAL	1198.40		—	—		—

1) check for eccentricity

$$e = \frac{0 + 0}{1198.40} = 0 \ ^{m} < \frac{B}{6} = 1.00 \ ^{m}$$

2) soil reaction

$$q = \frac{1198.40}{6.00 \times 6.00} = 33.29 \ t/m^2 < 60 \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 1198.40}{0} = \infty > F_a = 1.5$$

case 2 (wind loadig)

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL		562.80	—	—	—	—	—
W, Ws		397.20	—	—	—	—	—
wind pressere	A-1	—	—	—	25.22	20.295	511.84
	A-2	—	—	—	4.86	21.985	106.85
	A-3	—	—	—	8.35		92.42
TOTAL		960.00		—	38.43		711.11

1) check for eccentricity

$$e = \frac{0 + 711.11}{960.00} = 0.74^{m} < \frac{B}{6} \times 1.15 = 1.15^{m}$$

2) soil reaction

$$q = \frac{960.00}{6.00 \times 6.00} \times \left(1 \pm \frac{6 \times 0.74}{6.00}\right) = \begin{cases} 46.40 \ t/m^2 \\ 6.93 \ '' \end{cases} < 69. \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 960.00}{38.43} = 15.0 \quad > Fa = 1.5 \times 1/1.15 = 1.3$$

case 3 (HA loading + wind A)

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	HY (tm)
WDL		562.80	―	―	―	―	―
WLL		238.40	―	―	―	―	―
W , Ws		397.20	―	―	―	―	―
wind pressure	A-1	―	―	―	15.97	21.470	342.88
	A-3	―	―	―	3.02	10.750	32.47
TOTAL		1198.40		―	18.99		375.35

1) check for eccentricity

$$e = \frac{0 \quad + 375.35}{1198.40} = 0.31^{\ m} < \frac{B}{6} \times 1.15 = 1.15^{\ m}$$

2) soil reaction

$$q = \frac{1198.40}{6.00 \times 6.00} \times \left(1 \pm \frac{6 \times 0.31}{6.00}\right) = \begin{cases} 43.61 \ t/m^2 \\ 22.97 \ " \end{cases} < 69 \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 1198.40}{18.99} = 37.9 \qquad > Fa = 1.3$$

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

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL		562.80	—	—	—	—	—
WLL		238.40	—	—	—	—	—
W. Ws		397.20	—	—	—	—	—
wind pressure	A-1	—	—	—	15.97	—	342.88
	A-2	—	—	—	3.02	—	32.47
	C	9.95	—	—	—	—	—
TOTAL		1208.35		—	18.99		375.35

1) check for eccentricity

$$e = \frac{0 + 375.35}{1208.35} = 0.31^{m} < \frac{B}{6} \times 1.15 = 1.15^{m}$$

2) soil reaction

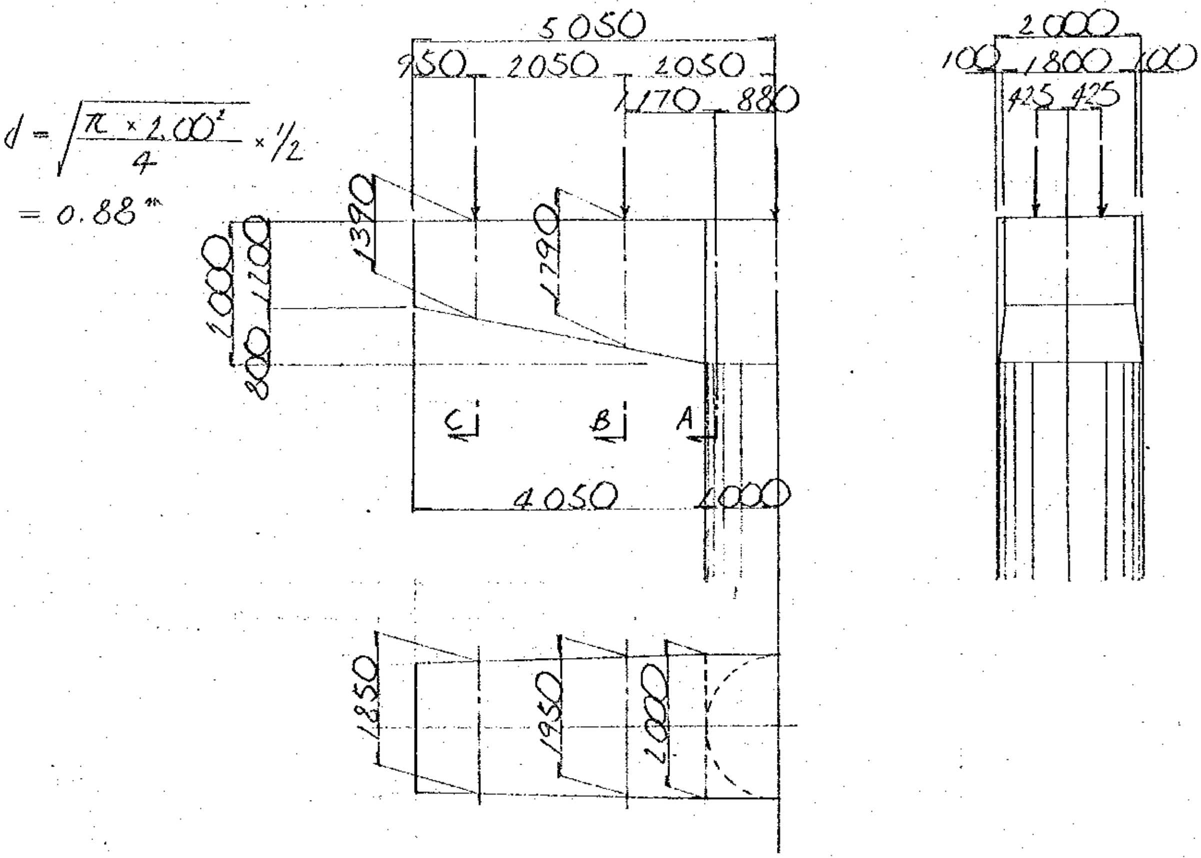
$$q = \frac{1208.35}{6.00 \times 6.00} \times \left(1 \pm \frac{6 \times 0.31}{6.00}\right) = \begin{cases} 43.97 \ t/m^2 \\ 23.16 \ " \end{cases} < 69 \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 1208.35}{18.99} = 38 \quad > F_a = 1.3$$

§ 5 CALCULATION OF BEAM SECTION

5-1 dimension of beam and load



		G1	G2	G3	G4	G5
WDL		114.7	116.5	118.1	116.5	114.7
WLL	H A	63.8	60.7	58.2	60.7	63.8
	H B	63.5	57.6	62.7	57.6	63.5
TOTAL	H A	178.5	177.2	176.3	177.2	178.5
	H B	178.2	174.1	180.8	174.1	178.2

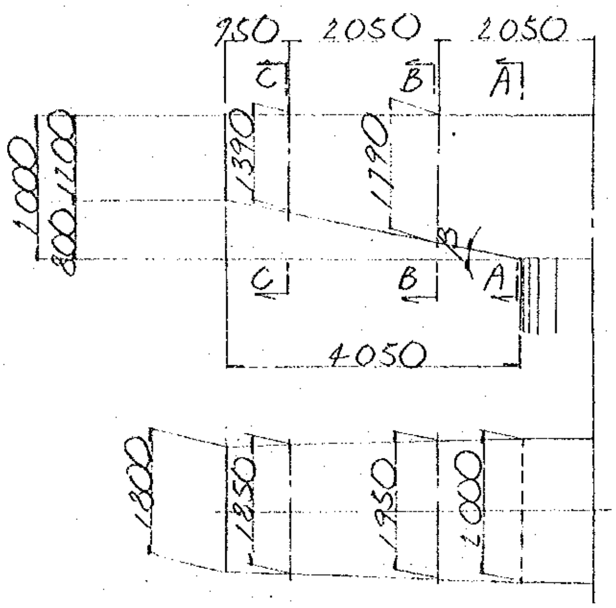
5-2 sectional force of beam (HA loding)

			S (t)	x (m)	M (tm)
A-A	W 1	0.12 × 2.00 × 2.00 × 2.41	1.16	0.060	0.01
	W 2	½ × (1.80 + 2.00) × 4.05 × 1.20 × 2.41	22.25	2.109	46.93
	W 3	⅙ × 0.80 × 4.05 × (2 × 2.00 + 1.80) × 2.41	7.55	1.447	10.92
	R 1	――――	177.20	1.170	207.32
	R 2	――――	178.50	3.220	574.77
	Σ		386.66		839.95
B-B	W 1	½ × (1.80 + 1.95) × 3.00 × 1.20 × 2.41	16.27	1.480	24.08
	W 2	⅙ × 0.59 × 3.00 × (2 × 1.95 + 1.80) × 2.41	4.05	0.987	4.00
	R 1	――――	(177.20)	0	0
	R 2	――――	178.50	2.050	365.93
	Σ		376.02 (198.82)		394.01
C-C	W 1	½ × (1.80 + 1.85) × 0.95 × 1.20 × 2.41	5.01	0.473	2.37
	W 2	⅙ × 0.19 × 0.95 × (2 × 1.85 + 1.80) × 2.41	0.40	0.315	0.13
	R 1		178.50	0	0
	Σ		183.91 (5.41)		2.50

5-3 list of stresses $\sigma_c . \sigma_s . \tau$: working stress.
$\sigma_{ca}, \sigma_{sa}, \tau_a$: Permissible stress.

	A-A	B-B	C-C			
M	839.95	394.01	2.50			
N	——	——	——			
S	386.66	376.02	183.91			
b	200	195	185			
h	185	164	129			
d'	15	15	10			
As	15/15 > D32 241.20	15 - D32 120.60	13 - D32 104.52			
As'	——	——	——			
f/d	0	0				
M'/bd²	12.27	7.51				
S/bd	10.45	11.76				
n·P	0.0978	0.0566				
C	6.39	7.77				
S	11.60	19.53				
Z	1.13	1.10				
σ_c	78	58				
σ_s	2136	2201				
τ	10.4	11.7				
σ_{ca}	83	——→				
σ_{sa}	2346	——→				
τ_a	8.2	——→				

5 - 4 check for stirrup



$\tan\beta = \frac{0.80}{4.05} = 0.198$

	M (tm)	S (t)	d (m)	$\frac{M}{d}(\tan\beta)$ (t)	Sh (t)
section A-A	839.95	386.66	1.850	89.90	296.76
〃 B-B	394.01	376.02	1.640	47.57	328.45
〃 C-C	2.50	183.91	1.290	0.38	183.53

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

	b (cm)	d (cm)	τa (kg/cm²)	Sc (t)	Sh' (t)
section A-A					
〃 B-B					
〃 C-C					

$$Sc = \tau a \cdot b \cdot d \cdot 10^{-3} \quad (t)$$

$$Sh' = Sh - Sc \quad (t)$$

check for stirrups

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

$$= \frac{328.45 \times 10^3}{195 \times 164} \times 1.10 = 11.30 > \tau a = 8.2$$

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

$$Sh' = Sh - Sc$$

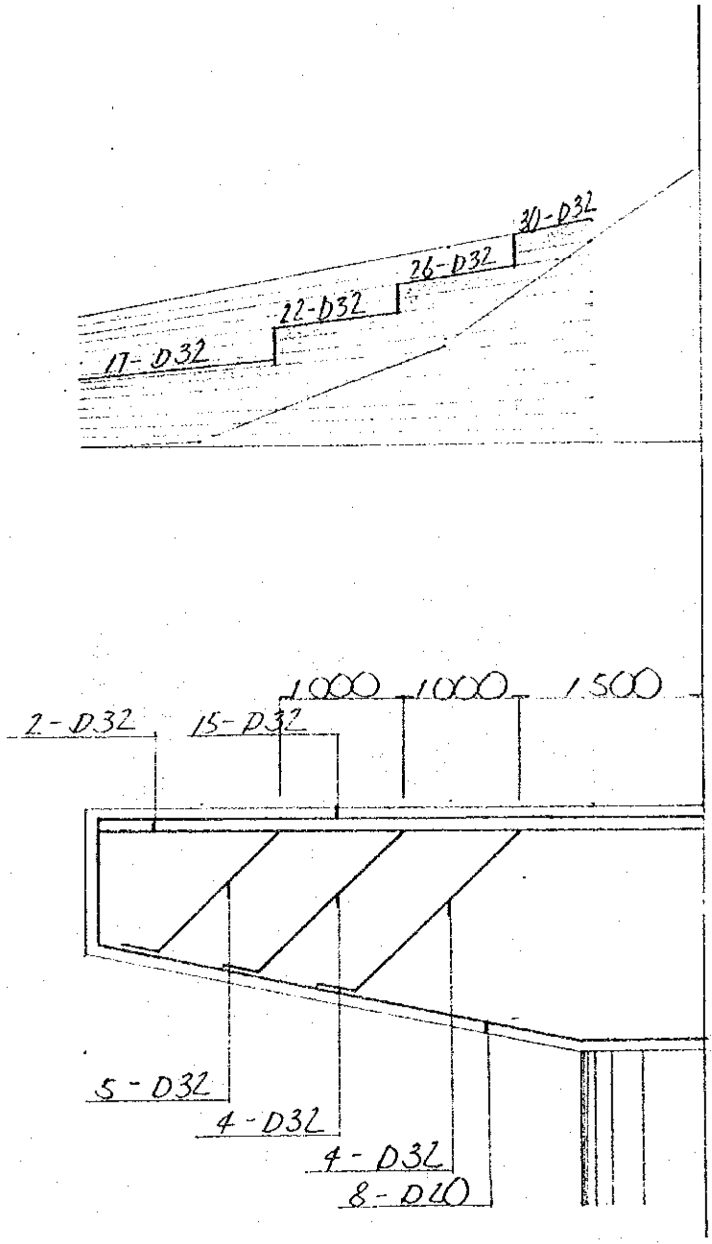
$$Sc = \tau a \times b \times d \times \frac{1}{Z}$$

$$= 0 \times \quad \times \quad \times \quad = 0$$

$$\text{req. } A_w = \frac{328.45 \times 10^3 \times 15}{1780 \times 164} \times 1.10 = 18.6 \ cm^2$$

Φ 20 - ctc 150 $n = 6$

Used $A_w = 3.14 \ cm^2 \times 6 = 18.84 \ cm^2 > \text{req. } A_w = 18.6 \ cm^2$

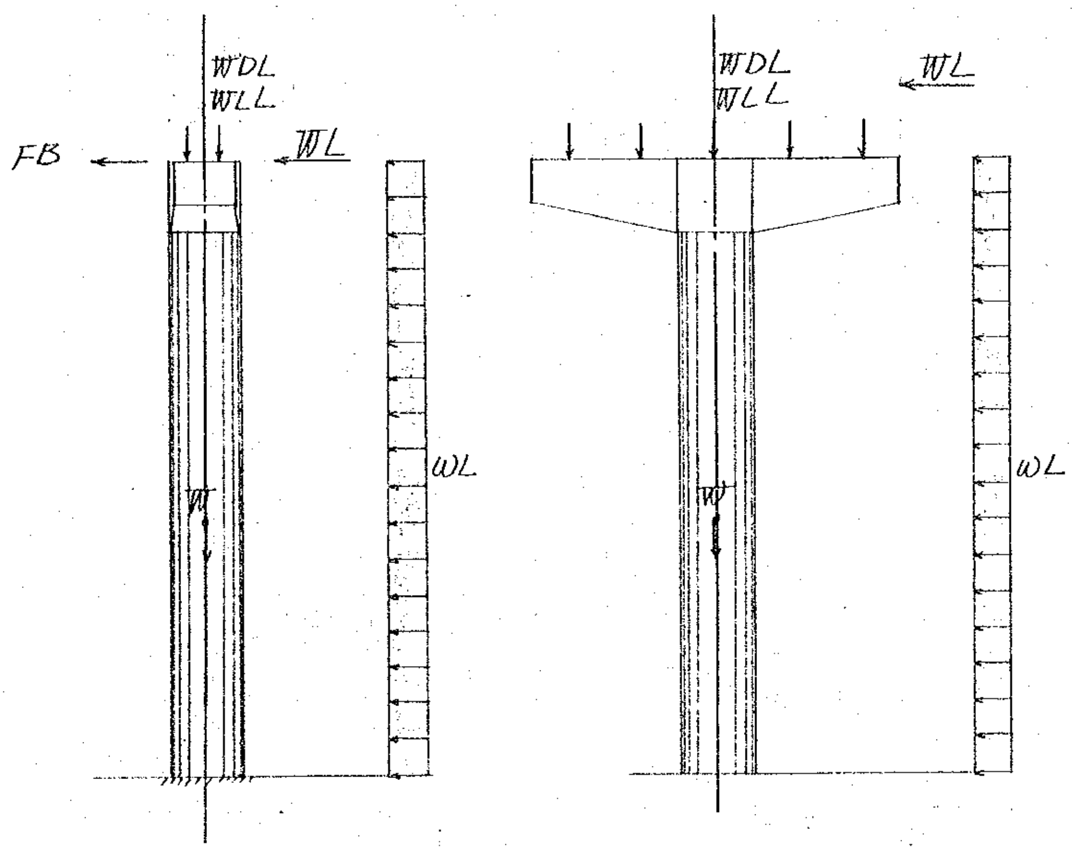


$$M_r = \frac{M}{\sigma_{sa} \cdot j \cdot d}$$

§ 6 CALCULATION OF COLUMN SECTION

6 - 1 dimension of column and load

longitudinal direction transverse direction

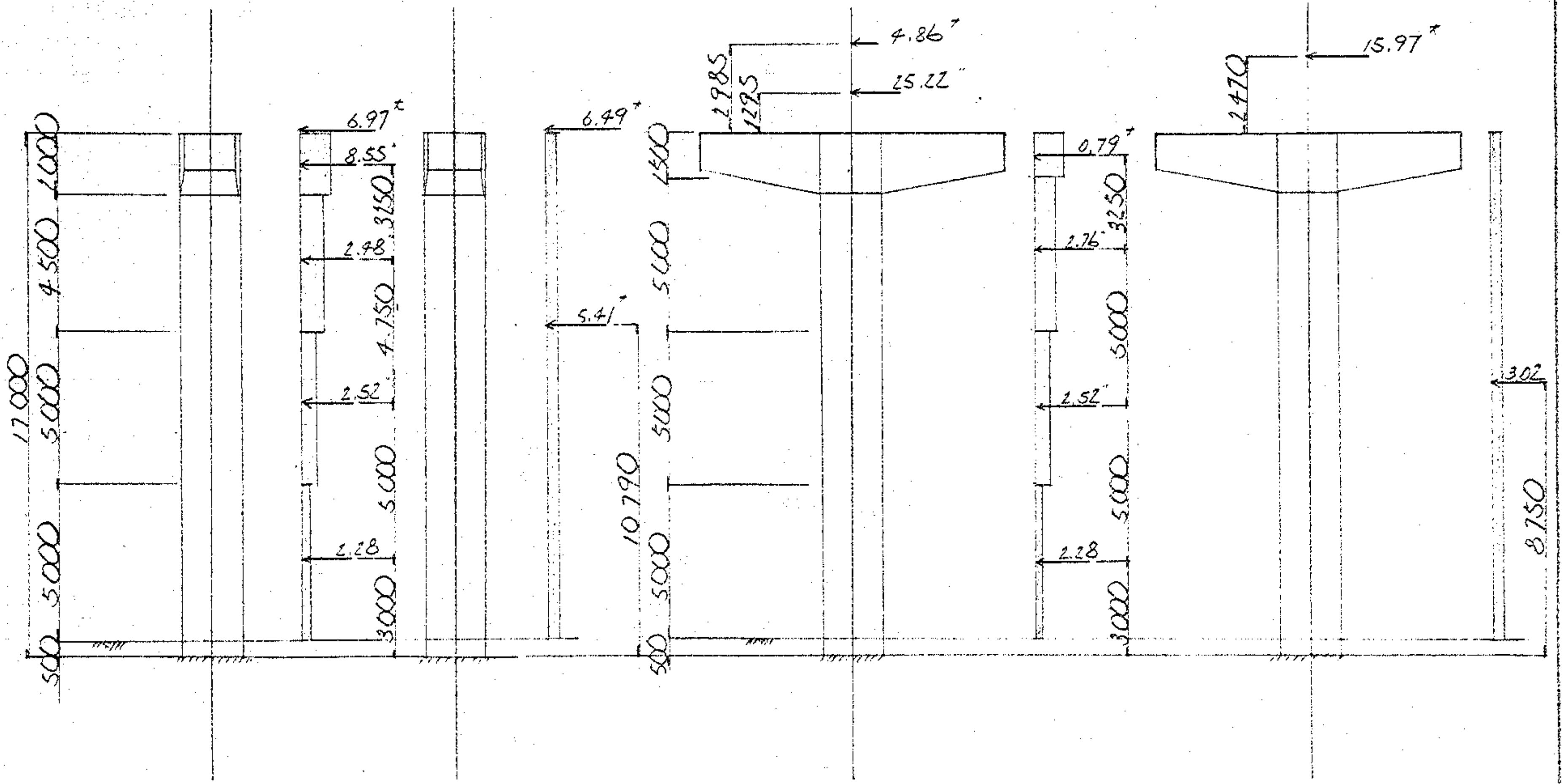


	HA loading		HB loading	
dead load of deck	296.1	266.7	296.1	266.7
live load	138.0	100.4	102.3	67.2
longitudinal forces	12.9		19.1	

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		562.80	—	12.50	—	—	—
	WLL		238.40	—	15.98	—	—	—
	FB		—	—	—	12.90	17.000	219.30
	W		192.46	—	—	—	—	—
			993.66		28.48	12.90		219.30
case 2 (wind)	WDL		562.80	—	12.50	—	—	—
	W		192.46	—	—	—	—	—
	wind	B1.2	—	—	—	6.97	17.000	118.49
		B-3	—	—	—	15.83	—	195.42
			755.26		12.50	22.80		313.91
	(α = 1.15)		(656.75)		(10.87)	(19.83)		(272.97)
case 3 (HA loading + wind)	WDL		562.80	—	12.50	—	—	—
	WLL		238.40	—	15.98	—	—	—
	FB		—	—	—	12.90	17.000	219.30
	W		192.46	—	—	—	—	—
	wind	B-1	—	—	—	6.49	17.000	110.33
		B-2	—	—	—	5.41	10.790	58.37
			993.66		28.48	24.80		388.00
	(α = 1.15)		(864.05)		(24.77)	(21.57)		(337.39)

2) transverse direction

			N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
case 1 (wind)	WDL		562.80	—	—	—	—	—
	W		192.46	—	—	—	—	—
	wind	A-1	—	—	—	25.22	18.295	461.40
		A-2	—	—	—	4.86	19.985	97.13
		A-3	—	—	—	8.35	—	75.72
	(α = 1.15)		755.26 (656.75)			38.43 (33.42)		634.25 (551.52)
case 2 (1/1 A loading + wind)	WDL		562.80	—	—	—	—	—
	WLL		238.40	—	—	—	—	—
	W		192.46	—	—	—	—	—
	wind	A-1	—	—	—	15.97	19.470	310.94
		A-3	—	—	—	3.02	8.750	26.43
	(α = 1.15)		993.66 (864.05)			18.99 (16.51)		337.37 (293.37)

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

	longitudinal direction			transvers direction	
	case 1	case 2	case 3	case 1	case 2
M	247.78	283.84	362.16	551.52	293.37
N	993.66	656.75	864.05	656.75	864.05
r	100	→	→	→	→
rs	90	→	→	→	→
As	56-D32 ctc 100 450.24	→	→	→	→
e		43.13	41.91	83.98	33.95
e/r		0.43	0.419	0.840	0.340
M'		940.59	1226.11	1208.27	1157.42
M'/r³		94.06	122.62	120.83	115.74
n P		0.215	0.215	0.215	0.215
rs/r		0.90	0.90	0.90	0.90
(C)		0.481	0.474	0.685	0.436
(S)		0.097	0.086	0.518	0.022
σ_c		45	58	82	51
σ_s		137	159	938	39
σ_{ca}	83	→	→	→	→
σ_{sa}	2346	→	→	→	→

※ $As_{min} = \pi/4 \times 200^2 \times 0.01 = 314.16$ (cm)²

6-4 check for buckling of column

$$Pa = \frac{1}{3} \times (0.85 \cdot \sigma_{ck} \cdot A_c + \sigma_{sy}' \cdot A_s)$$

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

$$h_e = (17.00 + 2.00) \times 2 \qquad = 38.00^{m}$$

$$Pa = 1/3 \times (0.85 \times 250 \times \pi/4 \times 200^2 + 2500 \times 450.24)$$

$$= 2600\,000^{kg} \qquad = 2600^{t}$$

$$\alpha = 1.45 - 0.03 \times 38.00 / 2.00$$

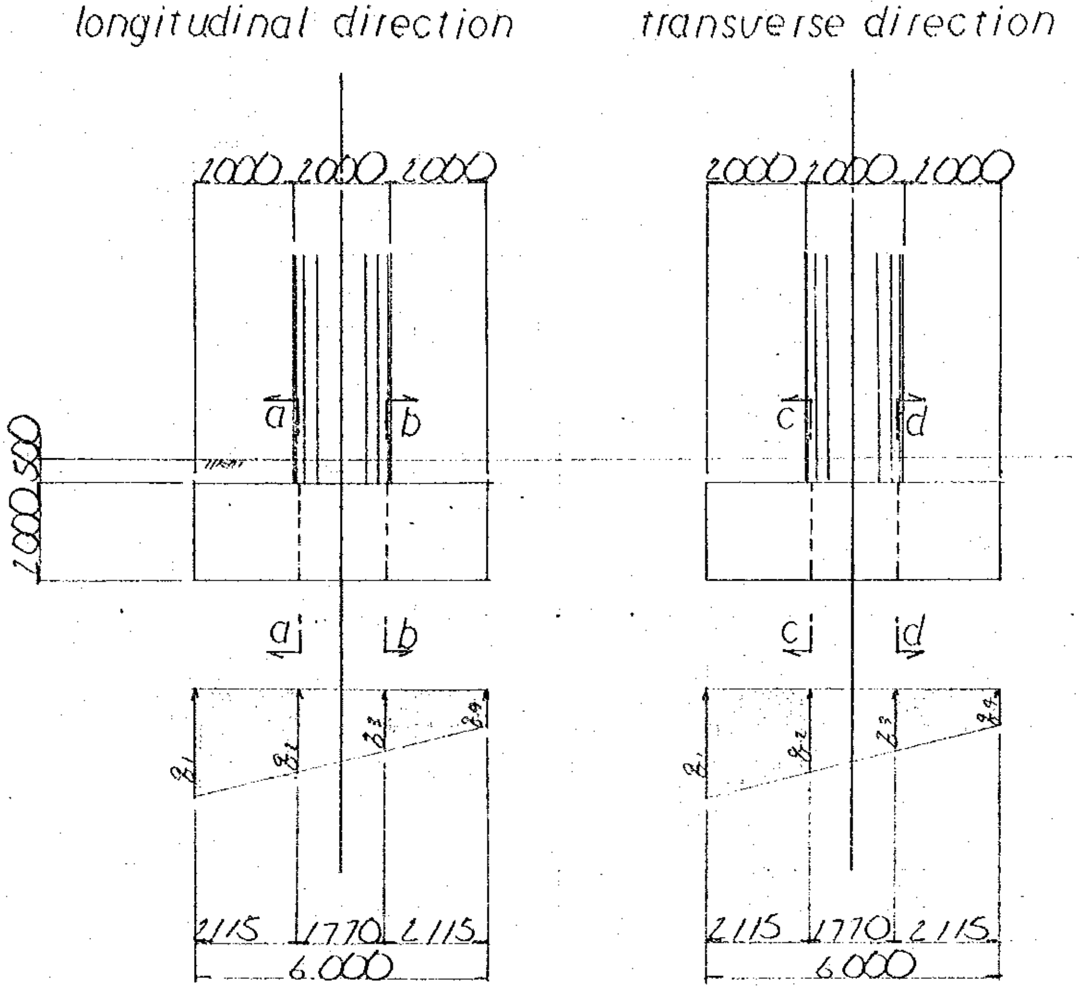
$$= 0.88$$

$$\therefore Paa = 2600 \times 0.88$$

$$= 2280^{t} \qquad > P_N = 993.66^{t}$$

§ 7 CALCULATION OF FOOTING SECTION

7-1 dimension and soil reaction



case	longitudinal direction				transverse direction			
	q_1	q_2	q_3	q_4	q_1	q_2	q_3	q_4
1	40.91	35.52	31.02	25.63	33.29	33.29	33.29	33.29
2	42.36	34.62	28.13	20.39	46.40	32.49	20.84	6.93
3	46.27	37.12	29.46	20.31	43.61	36.33	30.25	22.97
4	46.66	37.43	29.70	20.47	43.97	36.63	30.50	23.16

section a − a

			S (t)	x (m)	Sx (tm)
case 1	Wd	(2.00×2.41+0.50×1.9) ×2.115 × 6.00	73.22	1.058	77.47
	q	1/2×(40.91+35.52)×2.115×6.00	− 484.95	1.082	− 524.89
			− 411.73		− 447.42
case 2	Wd	———	73.22	———	77.47
	q	1/2×(42.36+34.62)×2.115×6.00	− 488.44	1.093	− 533.86
(α = 1.25)			415.22 (332.18)		456.39 (365.12)
case 3	Wd	———	73.22	———	77.47
	q	1/2×(46.27+37.12)×2.115×6.00	− 529.11	1.096	− 579.90
(α = 1.15)			455.89 (396.43)		502.43 (436.90)
case 4	Wd	———	73.22	———	77.47
	q	1/2×(46.66+29.70)×2.115×6.00	− 484.50	1.096	− 531.02
(α = 1.15)			411.28 (357.63)		453.55 (394.39)

section b − b

$M_{upper} = 0$

section c − c

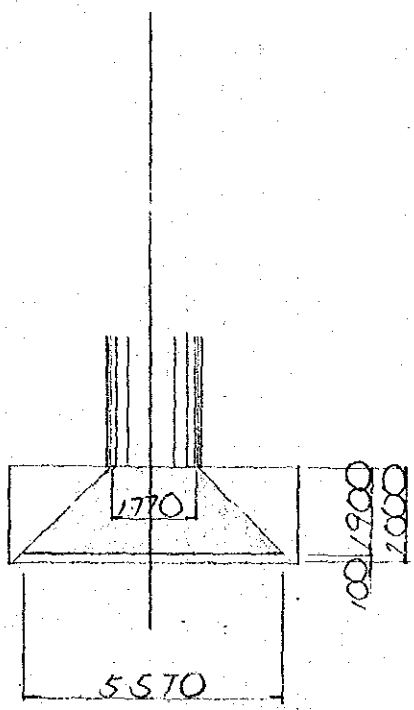
			S (t)	x (m)	Sx (tm)
case 1	wd	———	73.22	———	77.47
	q	33.29 × 2.115 × 6.00	- 422.45	1.058	- 446.95
			369.23		369.48
case 2 (α = 1.15)	wd	———	73.22	———	77.47
	q	½ × (46.40 + 32.49) × 2.115 × 6.00	- 500.56	1.120	- 560.62
			427.34		483.15
			(371.60)		(420.13)
case 3 (α = 1.15)	wd	———	73.22	———	77.47
	q	½ × (43.61 + 36.33) × 2.115 × 6.00	- 507.22	1.090	- 552.87
			433.99		475.40
			(377.39)		(413.39)
case 4 (α = 1.15)	wd	———	73.22	———	77.47
	q	½ × (43.97 + 36.63) × 2.115 × 6.00	- 511.41	1.089	- 557.23
			438.19		479.76
			(381.03)		(417.19)

section d − d

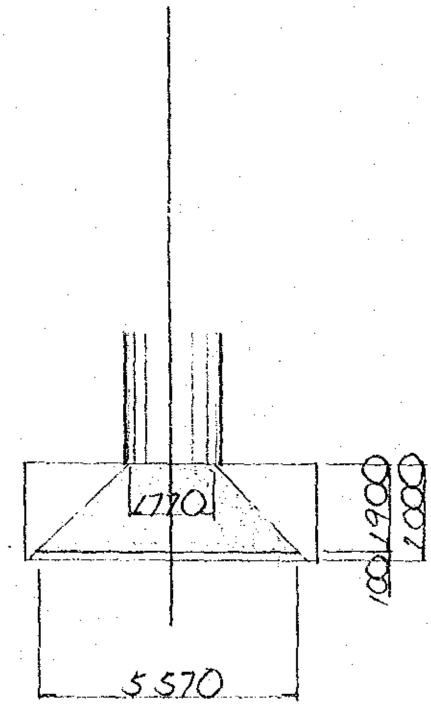
$M_{upper} = 0$

7 - 2 calculation of members

longitudinal direction



transverse direction



$$B_1 = 1.77 + 1.90 \times 2 = 5.57 \; m$$

$$B_2 = 1.77 + 1.90 \times 2 = 5.57 \; m$$

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	447.42			420.13		
N	——			——		
S	411.73			381.03		
b	557			557		
h	190			190		
d'	10			10		
As	D25 @ 150 116.18			D25 @ 150 116.18		
As'	——			——		
f/d	0			0		
M'/bd^2	2.23			2.09		
S/bd	3.89			3.60		
n·P	0.0165			0.0165		
C	12.78			12.78		
S	64.33			64.33		
Z	1.06			1.06		
σ_c	29			27		
σ_s	2147			2017		
τ	3.4			3.3		
σ_{ca}	83	→	→	→	→	
σ_{sa}	2346	→	→	→	→	
τ_a	2.35	→	→	→	→	

Check for stirrups

Sect a-a

$$\tau = \frac{S}{b \cdot d} \times Z = \frac{411.73 \times 10^3}{557 \times 190} \times 1.06 = 4.12 \ kg/cm^2 > \tau a = 2.35 \ kg/cm^2$$

$$S' = S - Sc$$

$$Sc = \tau a \cdot b \cdot d \cdot 1/Z = 2.35 \times 557 \times 190 \times 1/1.06 = 234.62 \times 10^3 \ kg$$

$$S' = (411.73 - 234.62) \times 10^3 = 177.11 \times 10^3 \ kg$$

$$Req\ Av = \frac{S' \times a}{\sigma sa \cdot d} \times Z = \frac{177.11 \times 10^3 \times 50}{1780 \times 190} \times 1.06 = 27.76 \ cm^2$$

$$Req\ Av / 1.0m = 27.76 / 5.57^m = 4.98 \ cm^2$$

As = Φ20 - ctc 50 $n = 2$

$$As = 3.14 \times 2 = 6.28 \ cm^2 > Req\ Av = 4.98 \ cm^2$$

Sect c-c

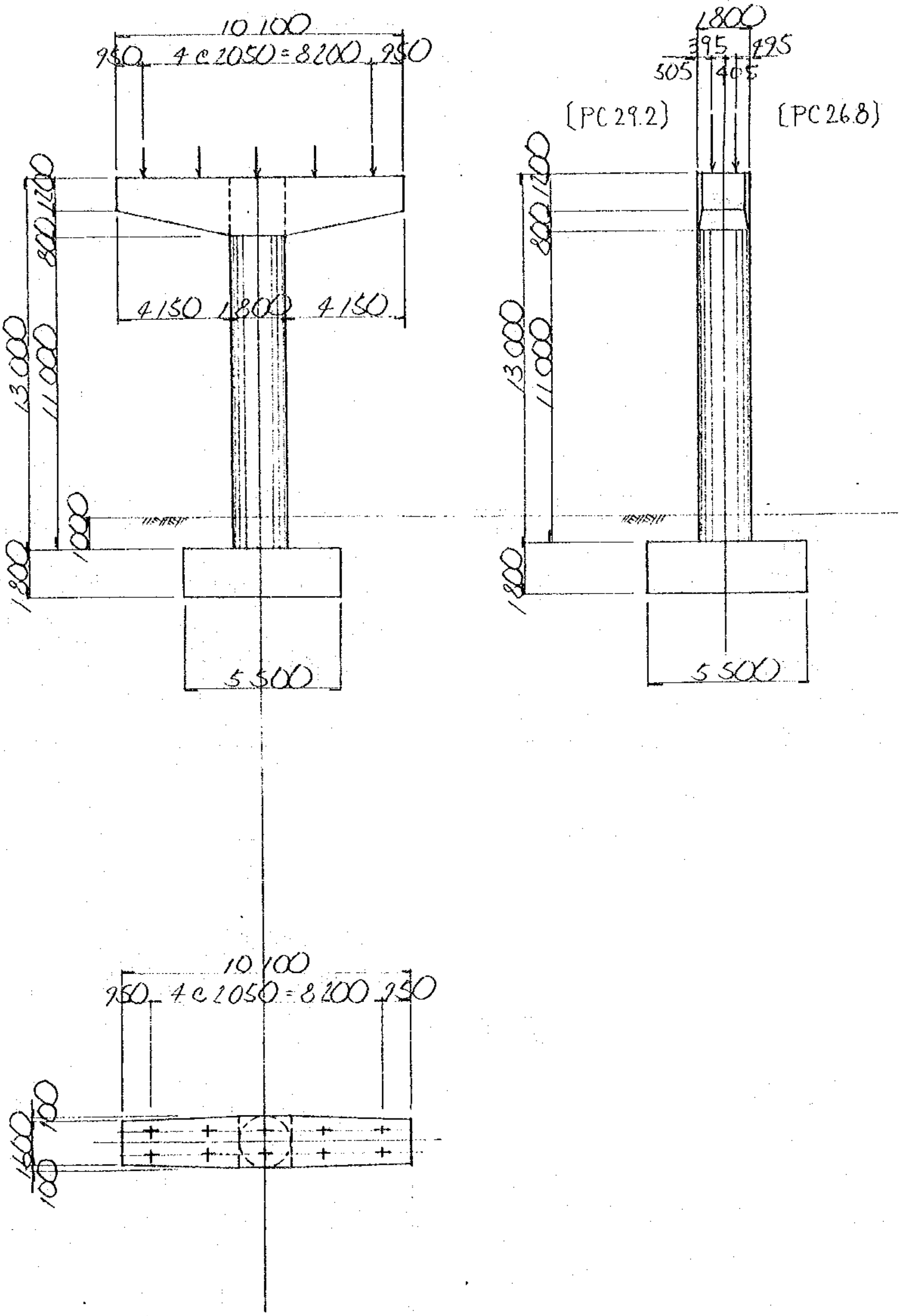
Refer to sect a-a

As = Φ20 - ctc 500

§§ 3 $H = 14.80$ m

A – L – 2 P 2
B – L – 2 P 2

§ 1 STRUCTURAL FIGURE



§ 2 REACTION OF SUPERSTRUCTURE

2-1 whole reaction of superstructure

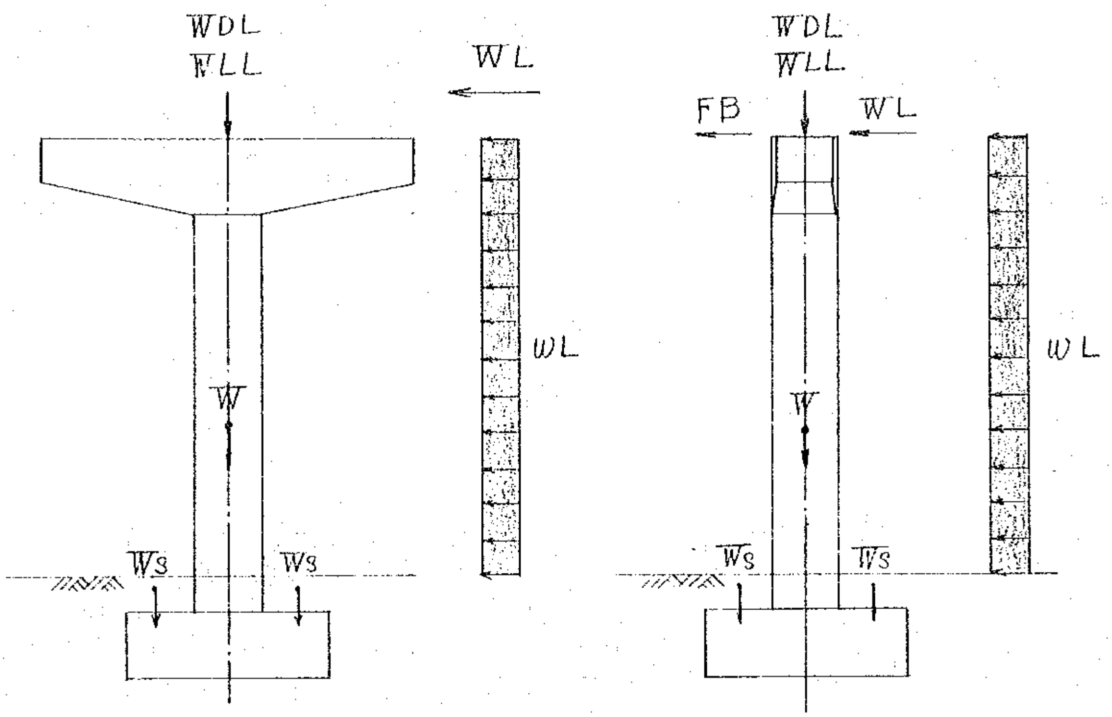
dead load of deck		221.6	248.0
H. A live load		128.6	94.9
H. B live load		99.1	66.4
crowd load		—	—
longitudinal forces	under H.A	12.9	
	under H.B	19.1	

2-2 reaction per each girder

		G 1	G 2	G 3	G 4	G 5
dead load of deck		104.3	106.3	107.7	106.3	104.3
live load	H A	59.8	57.7	54.5	57.7	59.8
	H B	62.1	54.3	57.3	54.3	62.1
TOTAL	H A	164.1	164.0	162.2	164.0	164.1
	H B	166.4	160.6	165.0	160.6	166.4

§ 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

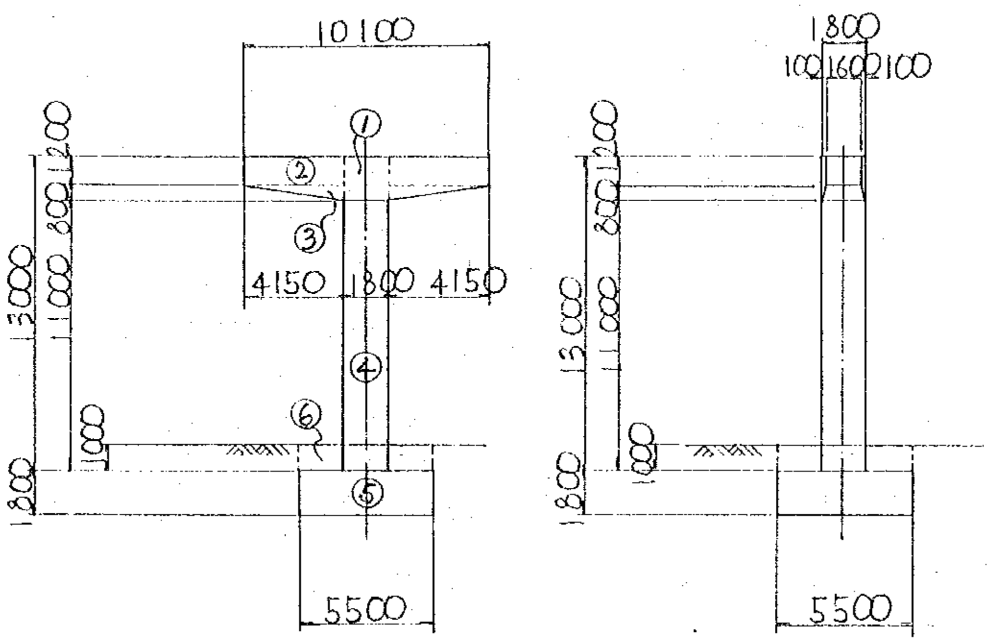
Ws : weight of soil

WL : wind load on the superstructure

wL : wind load on the pier

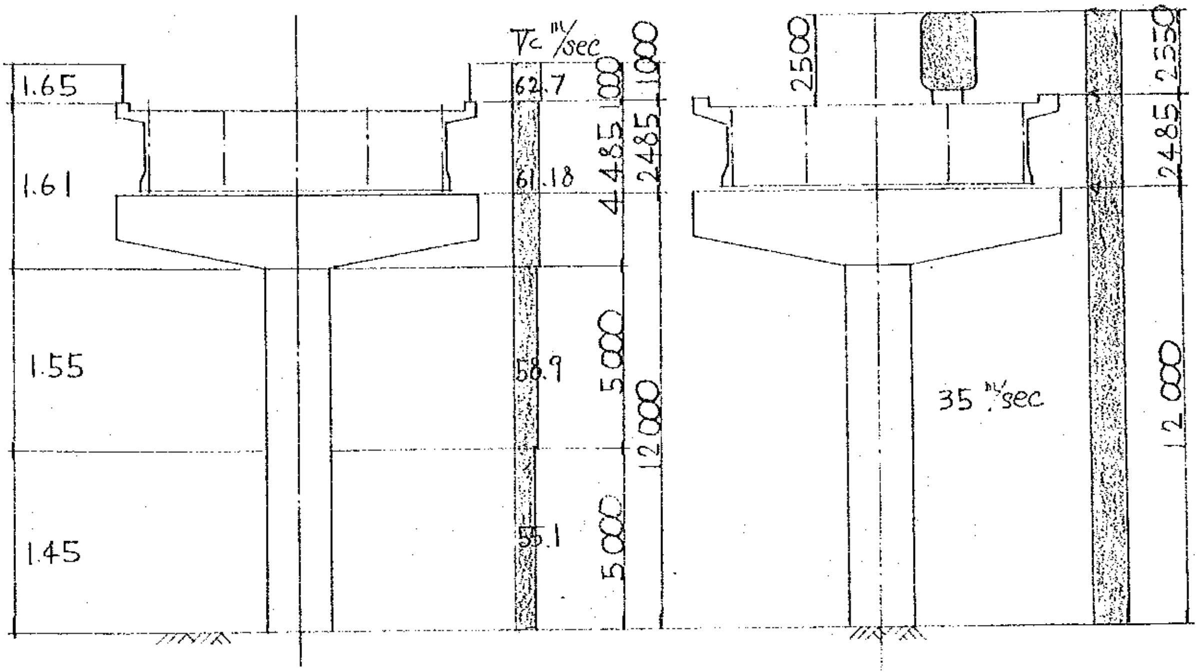
B : buoyancy

3 - 2 self weight and weight of soil



		N (t)
①	$1.80 \times 1.80 \times 2.00 \times 2.41$	15.62
②	$\{1/2 \times (1.60 + 1.80) \times 4.15 \times 1.20\} \times 2.41 \cdot 2$	40.81
③	$\{1/6 \times 0.80 \times 4.15 \times (2 \times 1.80 + 1.60)\} \times 2 \times 2.41$	13.87
④	$\pi/4 \times 1.80^2 \times 11.00 \times 2.41$	67.46
⑤	$5.50 \times 5.50 \times 1.80 \times 2.41$	131.22
⑥	$(5.50 \times 5.50 - \pi/4 \times 1.80^2) \times 1.00 \times 1.9$	52.64
		321.62

3-3 wind pressure



wind gust speed

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

case 1 (without live load)

$$V_c = 38 \times 1.0 \times 1.0 \times S_2 = 38 \cdot S_2 \; m/sec$$

case 2 (with live load)

$$V_c = 35.00 \; m/sec$$

(A) transverse wind load

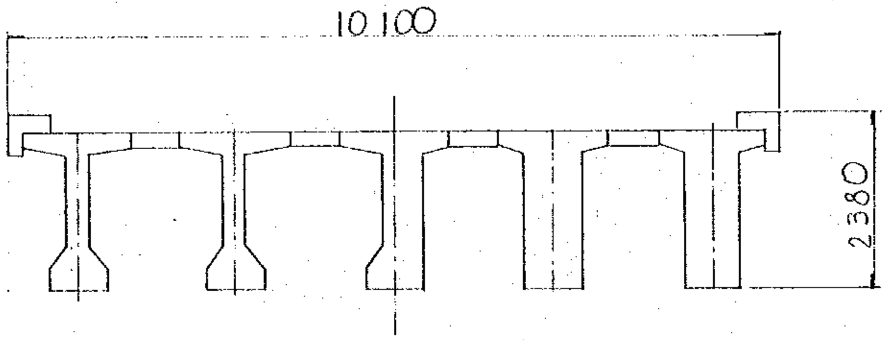
(A-1) for superstructures

$P_t = q \cdot A \cdot C_d$ (t)

$q = 0.613 \cdot V_c^2 \times 0.102$ (kg/m^2)

C_d : drag coefficient

A : loading area (m^2)



case 1

$q = 0.613 \times 61.18^2 \times 0.102 \times 10^{-3} = 0.23 \; t/m^2$

$A = 2.38 \times 1/2 \times (30.00 + 27.50) = 68.43 \; m^2$

$C_d = 1.38$ ($b/d = 10.10/2.38 = 4.24$)

$P_t = 0.23 \times 68.43 \times 1.38 = 21.72 \; t$

case 2

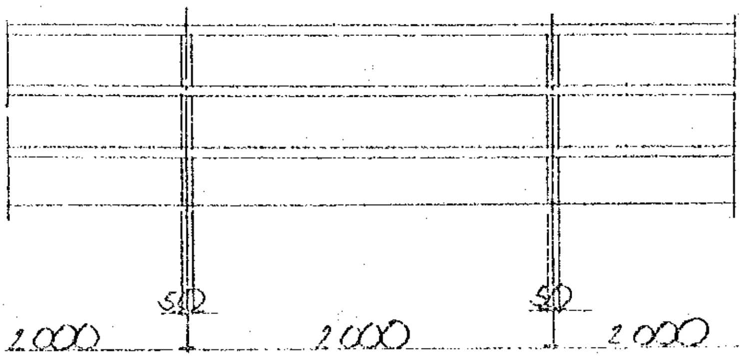
$q = 0.613 \times 35^2 \times 0.102 \times 10^{-3} = 0.077 \; t/m^2$

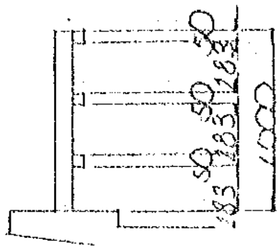
$A = 4.73 \times 1/2 \times (30.00 + 27.50) = 135.99$

$C_d = 1.37$ ($b/d = 10.10/2.50 = 4.04$)

$P_t = 0.077 \times 135.99 \times 1.37 = 14.35 \; t$

(A − 2) for parapet





case 1

$$A = 0.05 \times 3 \times 28.75 + (1.00 - 0.05 \times 3) \times \frac{28.75}{2.00}$$

$$= 16.53\ m^2$$

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

$Cd = 1.1$ (from table 8)

$$Pt = 0.25 \times 16.53 \times 1.1 = 4.55\ t$$

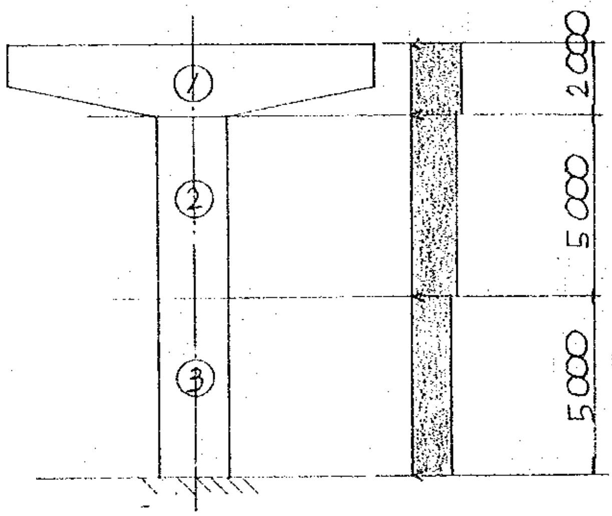
(A-3) for substructure

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	58.9	0.22	○	1.2
③	55.1	0.19	○	1.2

	A (m^2)		Pt (t)	y (m)	Pt·y (tm)
①	1.80 × 2.00	3.60	0.91	13.80	12.56
②	1.80 × 5.00	9.00	2.38	10.30	24.51
③	〃	9.00	2.05	5.30	10.87
		21.60	5.34		47.94

case - 2

$$V_c = 35 \ m/sec$$

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

$$A = 21.60 \ m^2$$

$$Cd = (1.1 \times 3.60 + 1.20 \times 18.0) \times 1/21.6 = 1.18$$

$$Pt = 0.077 \times 21.6 \times 1.18 = 1.96 \ t$$

$$y = \frac{3.60 \times 13.80 + 18 \times 7.80}{21.60} = 8.80 \ m$$

(B) longitudinal wind load

(B - 1) for superstructure

case 1

$P_{LS} = 0.25 \cdot P_t$

$= 0.25 \times 21.72 = 5.43^t$

case 2

$P_{LS} = 0.25 \cdot P_t$

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

$P_{LS} = 0.25 \times 0.077 \times (28.75 \times 2.38) \times 1.38$
$= 1.82^t$

$P_{LL} = 0.5 \cdot P_t$

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

$P_{LL} = 0.5 \times 0.077 \times (2.50 \times 28.75) \times 1.45$
$= 4.01^t$

(B − 2) for parapet

for vertical members

$$PL1 = 0.8 \cdot Pt$$

$$Pt = q \cdot A \cdot Cd \qquad Cd = 1.1$$

$$A = 0.05 \times (1.00 - 3 \times 0.05) \times 28.75/2.00 = 0.61^{m^2}$$

$$PL1 = 0.8 \times 0.25 \times 0.61 \times 1.1 = 0.13^{t}$$

for horizontal members

$$PL2 = 0.4 \cdot Pt$$

$$Pt = q \cdot A \cdot Cd \qquad Cd = 1.1$$

$$A = 28.75 \times 0.05 \times 3 = 4.31^{m^2}$$

$$PL2 = 0.4 \times 0.25 \times 4.31 \times 1.1 = 0.47^{t}$$

(B - 3) for substructure

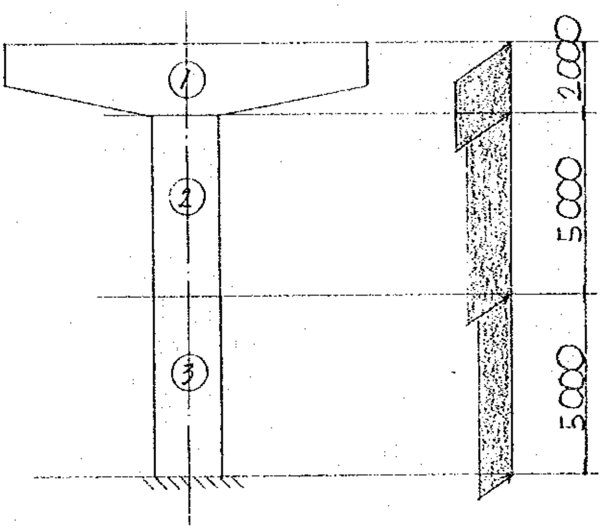
case 1

$$V_c = v \cdot k_1 \cdot S_1 \cdot S_2$$

$$= 38 \times 1.0 \times 1.0 \times S_2 = 38 \cdot S_2 \quad {}^{m}/_{sec}$$

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

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



	V_c (m/sec)	q (t/m²)	t/b	Cd
①	61.18	0.23	< 1/4	2.1
②	58.9	0.22	○	1.2
③	55.1	0.19	○	1.2

		A (m^2)	Pt (t)	y (m)	Pt·y (tm)
①	10.10 × 1.20 + ½ × (1.80 + 10.10) × 0.80	16.88	8.15	13.80	112.47
②	1.80 × 5.00	9.00	2.38	10.30	24.51
③	1.80 × 5.00	9.00	2.05	5.30	10.87
		34.88	12.58		147.85

case 2

$$V_c = 35 \ m/sec$$

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

$$A = 34.88 \ m^2$$

$$C_d = (2.1 \times 16.88 + 18.00 \times 1.2) \times 1/34.88 = 1.64$$

$$P_t = 0.077 \times 34.88 \times 1.64 = 4.40 \ t$$

$$y = \frac{16.88 \times 13.80 + 18.00 \times 7.80}{34.88} = 10.704 \ m$$

(C) vertical wind load

case 1

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

$$A = 10.10 \times 28.75 = 290.38^{m^2}$$

$$C_L = 0.4 \quad (b/d = 10.10/2.38 = 4.24)$$

$$P_V = 0.23 \times 290.38 \times 0.4 = 26.71^{t}$$

case 2

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

$$A = 290.38$$

$$C_L = 0.4$$

$$P_V = 0.077 \times 290.38 \times 0.4 = 8.94^{t}$$

§ 4 CALCULATION OF STABILITY

4 - 1 longitudinal direction

case 1 (HA loading)

	N (t)	x (m)	N·x (tm)	H (t)	y (m)	Hy (tm)
WDL, WLL	743.1	—	19.20	—	—	—
F B	—	—	—	12.90	14.80	190.92
W, Ws	321.62	—	—	—	—	—
TOTAL	1064.72		19.20	12.90		190.92

1) check for eccentricity

$$e = \frac{\Sigma N x + \Sigma H y}{\Sigma N} = \frac{19.20 + 190.92}{1064.72} = 0.20^{m}$$

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

2) soil reaction

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

$$= \frac{1064.72}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.20}{5.50}\right) = \begin{cases} 42.88 \, t/m^2 \\ 27.52 \end{cases} < 60 \, t/m^2$$

3) check for sliding

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

$$F = \frac{0.6 \times 1064.72}{12.90} = 49.52 \quad > F_a = 1.5$$

case 2 (wind loading)

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL		519.6	—	6.84	—	—	—
W, Ws		321.62	—	—	—	—	—
wind Plassure	B−1	—	—	—	5.43	14.8	80.36
	B−2	—	—	—	(0.13 + 0.47) 0.60	14.8	10.37
	B−3	—	—	—	12.58		147.85
TOTAL		841.22		6.84	18.61		238.58

1) check for eccentricity

$$e = \frac{6.84 + 238.58}{841.22} = 0.29^{m} < \frac{B}{6} \cdot 1.15 = 1.05^{m}$$

2) soil reaction

$$q = \frac{841.22}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.29}{5.50}\right) = \begin{cases} 36.61 \ t/m^2 \\ 19.01 \end{cases} < 69 \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 841.22}{18.61} = 45 \quad > Fa = 1.5 \cdot 1/1.15 = 1.3$$

case 3 (HA loading + wind B)

	N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL.WLL	743.1	—	19.20	—	—	—
F B	—	—	—	12.90	14.80	190.92
W , Ws	321.62	—	—	—	—	—
wind pressure B-1	—	—	—	(1.82+4.01) 5.83	14.80	86.28
wind pressure B-3	—	—	—	4.40	12.74	56.06
TOTAL	1064.72		19.20	23.13		333.26

1) check for eccentricity

$$e = \frac{19.20 + 333.26}{1064.72} = 0.33^{m} < \frac{B}{6} \cdot 1.15 = 1.05^{m}$$

2) soil reaction

$$q = \frac{1064.72}{550 \times 5.50} \cdot \left(1 \pm \frac{6 \times 0.33}{5.50}\right) = \begin{cases} 35.2 \ t/m^2 \\ 22.53 \ '' \end{cases} < 69.00 \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 1064.72}{23.13} = 28 > Fa = 1.5 \times 1/1.15 = 1.3$$

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

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL, WLL		743.1	——	19.20	——	——	——
F B		——	——	——	12.90	14.80	190.92
W . Ws		321.62	——	——	——	——	——
wind pressure (B)	B−1	——	——	——	5.83	14.80	86.28
	B−3	——	——	——	4.40	12.74	56.06
	C	8.94	——	——	——	——	——
wind pressure (A)	A−1	——	——	——	(7.18)	17.27	124.00
	A−3	——	——	——	(0.98)	8.80	8.62
TOTAL		1073.66		19.20	23.13 (8.16)		333.26 (132.62)

1) check for eccentricity

$$e = \frac{19.20 + 333.26}{1073.66} = 0.33\ ^{m} < \frac{B}{6} \times 1.15 = 1.05\ ^{m}$$

2) soil reaction

$$q = \frac{1073.66}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.33}{5.50}\right) \pm \frac{6 \times 131.62}{5.50 \times 5.50^2} = \begin{cases} 53.02\ t/m^2 \\ 17.97\ \text{"} \end{cases}$$

$< 69.00\ t/m^2$

3) check for sliding

$$F = \frac{0.6 \times 1073.66}{23.13} = 28 < F_a = 1.3$$

4 - 2 transverse direction

case 1 (H.A loading)

	N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL	519.6	—	—	—	—	—
WLL	223.5	—	—	—	—	—
W, Ws	321.62	—	—	—	—	—
TOTAL	1064.72		—	—		—

1) check for eccentricity

$$e = \frac{0 + 0}{1064.72} = 0^{m} < \frac{B}{6} = 0.92^{m}$$

2) soil reaction

$$q = \frac{1064.72}{5.50 \times 5.50} = 35.2\ t/m^2 < 60\ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 1064.72}{0} = \infty > F_a = 1.5$$

case 2 (wind loadig)

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL		519.6	—	—	—	—	—
W . Ws		321.62	—	—	—	—	—
wind pressere	A-1	—	—	—	21.72	16.095	349.58
	A-2	—	—	—	4.55	17.785	80.92
	A-3	—	—	—	5.34		47.94
TOTAL		841.22		—	31.61		478.44

1) check for eccentricity

$$e = \frac{0 + 478.44}{841.22} = 0.57^{m} < \frac{B}{6} \times 1.15 = \quad {}^{m}$$

2) soil reaction

$$q = \frac{841.22}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.57}{5.50}\right) = \begin{cases} 45.10 \ t/m^2 \\ 10.52 \ " \end{cases} < 69. \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 841.22}{31.61} = 16.0 \quad > Fa = 1.5 \times 1/1.15 = 1.3$$

case 3 (HA loading + wind A)

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL		519.6	——	——	——	——	——
WLL		223.5	——	——	——	——	——
W . Ws		321.62	——	——	——	——	——
wind pressure	A-1	——	——	——	14.35	17.27	247.82
	A-3	——	——	——	1.96	8.80	17.25
TOTAL		1064.72		——	16.31		265.07

1) check for eccentricity

$$e = \frac{0 + 265.07}{1064.72} = 0.25^{m} < \frac{B}{6} \times 1.15 = 1.05^{m}$$

2) soil reaction

$$q = \frac{1064.72}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.25}{5.50}\right) = \begin{cases} 44.8 \ t/m^2 \\ 25.6 \ " \end{cases} < 69 \ t/m^2$$

3) check for sliding

$$F = \frac{0.6 \times 1064.72}{16.31} = 39 \quad > F_a = 1.3$$

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

		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
WDL		519.6	—	—	—	—	—
WLL		223.5	—	—	—	—	—
W . Ws		321.62	—	—	—	—	—
wind pressure	A-1	—	—	—	14.35	—	247.82
	A-2	—	—	—	1.96	—	17.25
	C	8.94	—	—	—	—	—
TOTAL		1073.66		—	16.31		265.07

1) check for eccentricity

$$e = \frac{0 + 265.07}{1073.66} = 0.25^{m} < \frac{B}{6} \times 1.15 = 1.05^{m}$$

2) soil reaction

$$q = \frac{1073.66}{5.50 \times 5.50} \times \left(1 \pm \frac{6 \times 0.25}{5.50}\right) = \begin{cases} 45.17 \ t/m^2 \\ 25.81 \end{cases} < 69 \ t/m^2$$

3) check for sliding

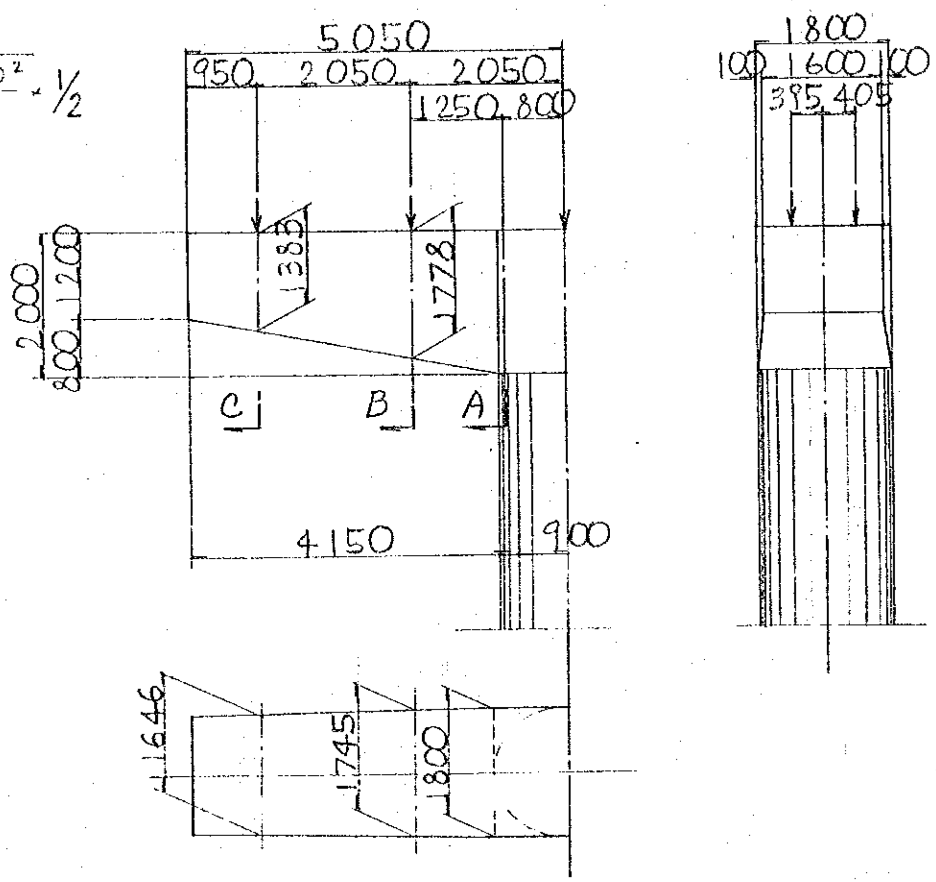
$$F = \frac{0.6 \times 1073.66}{16.31} = 39 \quad > F_a = 1.3$$

§ 5 CALCULATION OF BEAM SECTION

5-1 dimension of beam and load

$$d = \sqrt{\frac{\pi \times 1.80^2}{4} \times \frac{1}{2}}$$

$= 0.80$



		G 1	G 2	G 3	G 4	G 5
WDL		104.3	106.3	107.7	106.3	104.3
WLL	H A	59.8	57.7	54.5	57.7	59.8
	H B	62.1	54.3	57.3	54.3	62.1
TOTAL	H A	164.1	164.0	162.2	164.0	164.1
	H B	166.4	160.6	165.0	160.6	166.4

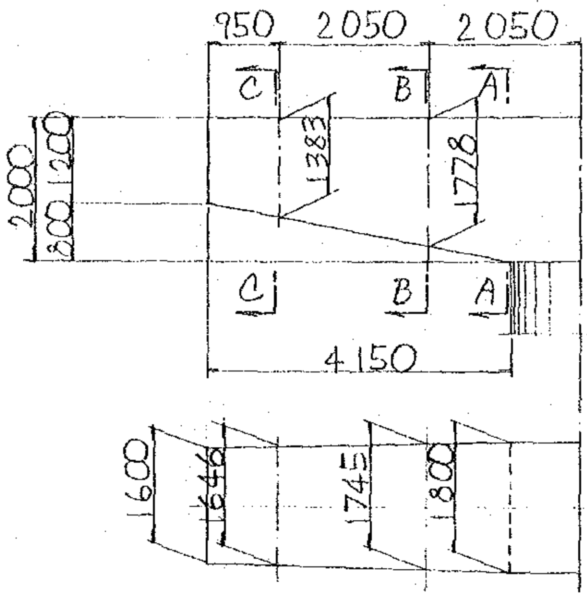
5-2 sectional force of beam (HA loding)

			S (t)	χ (m)	M (tm)
A - A	W 1	0.10 × 1.80 × 1.80 × 2.41	0.78	0.05	0.04
	W 2	½ × (1.60 + 1.80) × 4.15 × 1.20 × 2.41	20.40	2.134	43.53
	W 3	1/6 × 0.80 × 4.15 × (2 × 1.80 + 1.60) × 2.41	6.93	1.457	10.10
	R 1	————	164.0	1.25	205.0
	R 2	————	164.1	3.30	541.53
	Σ		356.21		800.2
B - B	W 1	½ × (1.60 + 1.745) × 3.00 × 1.20 × 2.41	14.51	1.478	21.45
	W 2	1/6 × 0.578 × 3.00 × (2 × 1.745 + 1.60) × 2.41	3.55	0.986	3.50
	R 1	————	(164.0)	0	0
	R 2	————	164.1	2.05	336.41
	Σ		346.16 (182.16)		361.36
C - C	W 1	½ × (1.60 + 1.646) × 0.95 × 1.20 × 2.41	4.46	0.473	2.11
	W 2	1/6 × 0.183 × 0.95 × (2 × 1.646 + 1.60) × 2.41	0.34	0.315	0.11
	R 1	————	164.1	0	0
	Σ		168.9 (4.80)		2.22

5 – 3 list of stresses σ_c . σ_s . τ : working stress .
σ_{ca}, σ_{sa}, τ_a : Permissible stress .

	A – A	B – B	C – C			
M	800.2	361.36	2.22			
N	——	——	——			
S	356.21	346.16	168.9			
b	180	174	164			
h	185	168	128			
d'	15	10	10			
As	14, 14 > D32 225.12	14 – D32 112.56	12 – D32 96.48			
As'	——	——	——			
f/d	0	0	|			
M'/bd^2	12.99	7.36	|			
S/bd	10.70	11.84	|			
n·P	0.1014	0.0578	|			
C	6.31	7.71	|			
S	11.21	19.16	|			
Z	1.14	1.11	|			
σ_c	82	57	|			
σ_s	2184	2115	|			
τ	12	13	|			
σ_{ca}	83	——→	——→			
σ_{sa}	2346	——→	——→			
τ_a	8.2	——→	——→			

5 - 4 check for stirrup



$$\tan\beta = \frac{0.80}{4.15} = 0.193$$

	M (tm)	S (t)	d (m)	$\frac{M}{d}(\tan\beta)$ (t)	Sh (t)
section A-A	800.2	356.21	1.850	83.38	272.83
〃 B-B	361.36	346.16	1.680	41.46	319.9
〃 C-C	2.22	168.9	1.280	0.33	168.57

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

	b (cm)	d (cm)	Za (kg/cm²)	Sc (t)	Sh' (t)
section A-A					
〃 B-B					
〃 C-C					

~~$Sc = Za \cdot b \cdot d \cdot 10^{-3}$ (t)~~

~~$Sh' = Sh - Sc$ (t)~~

check for stirrups

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

$$= \frac{319.90 \times 10^3}{175 \times 168} \times 1.11 = 12.10 > \tau_a = 8.2$$

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

$$Sh' = Sh - Sc$$

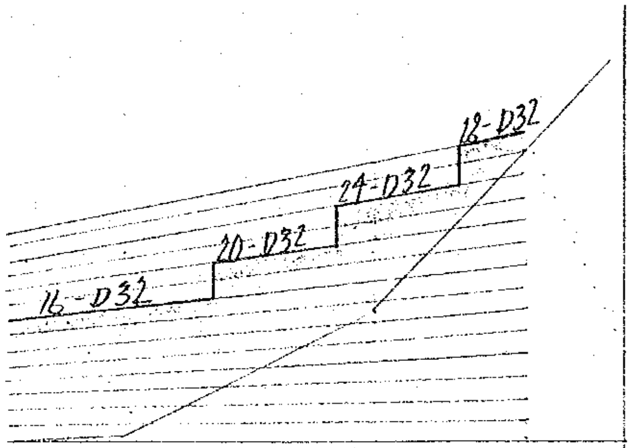
$$Sc = \tau_a \times b \times d \times \frac{1}{z}$$

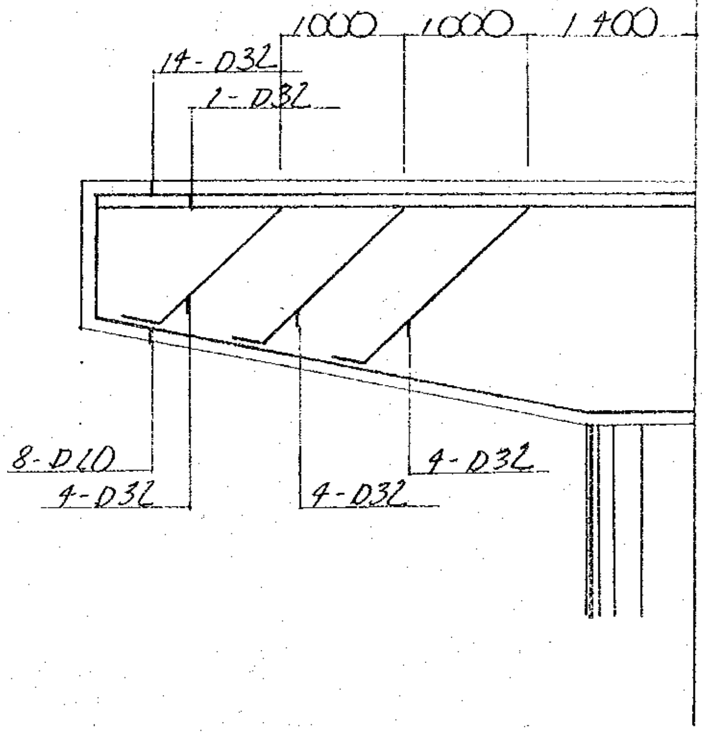
$$= 0 \times \quad \times \quad \times \text{——} = 0$$

$$req.\ A_w = \frac{319.90 \times 10^3 \times 15}{1780 \times 168} \times 1.11 = 17.81\ cm^2$$

Φ 20 - ctc 150 $\quad n = 6$

Used $A_w = 3.14 \times 6 = 18.84\ cm^2 > req.\ A_w = 17.81\ cm^2$

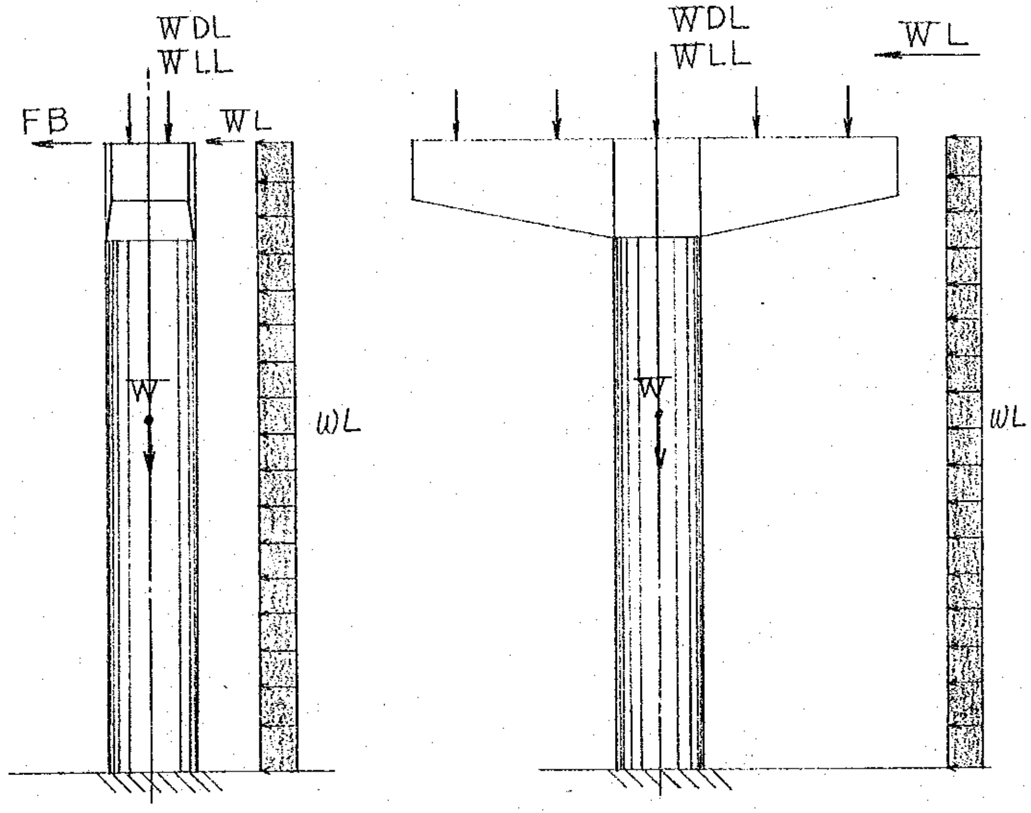

18-D32
24-D32
20-D32
16-D32


1000
1000
1400
14-D32
2-D32
8-D20
4-D32
4-D32
4-D32

§ 6 CALCULATION OF COLUMN SECTION

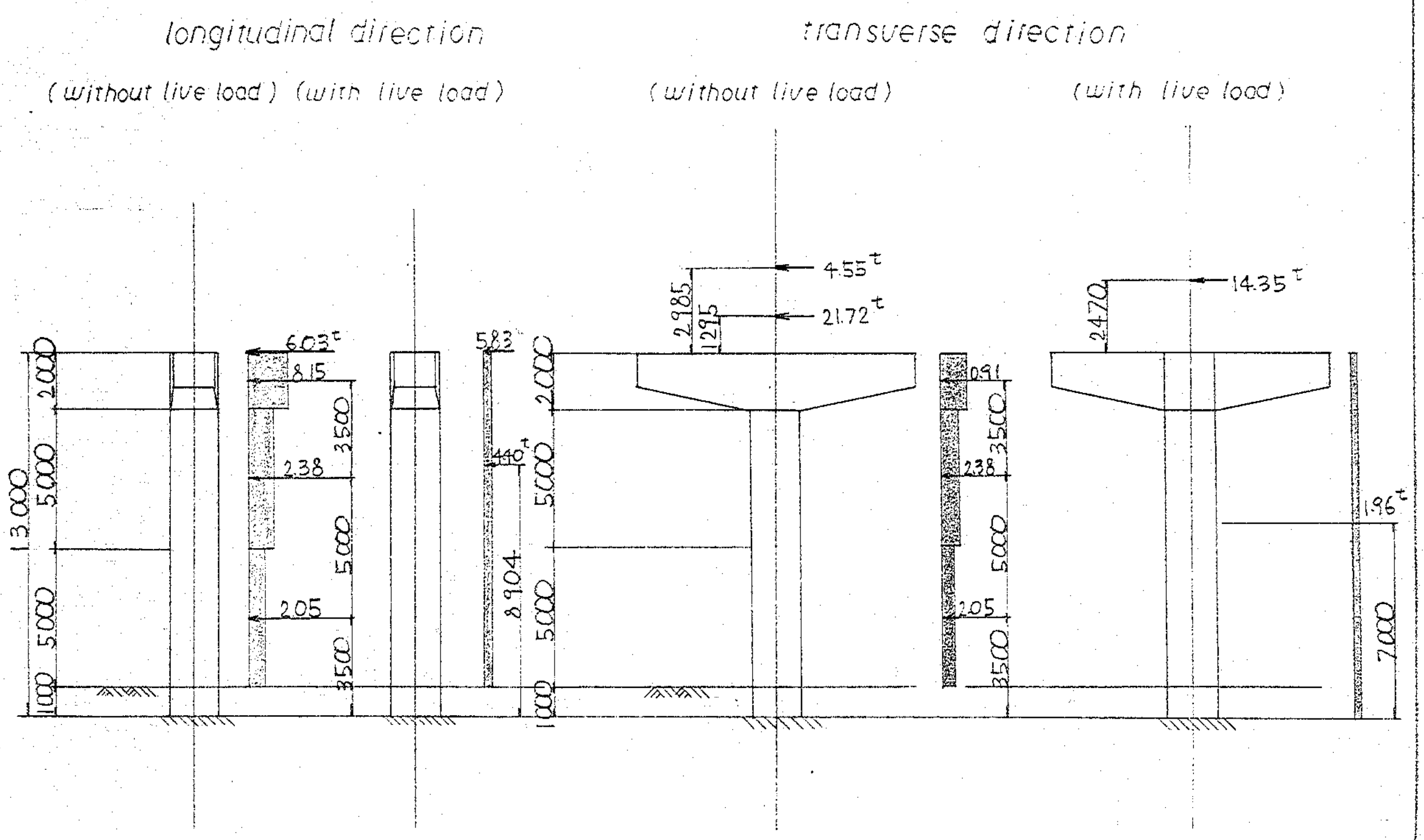
6 - 1 dimension of column and load

longitudinal direction   transverse direction



	HA loading		HB loading	
dead load of deck	271.6	248.0	271.6	248.0
live load	128.6	94.9	99.1	66.4
longitudinal forces	12.9		19.1	

wind load


longitudinal direction
(without live load) (with live load)
transverse direction
(without live load)
(with live load)
6.03t
8.15
2.38
2.05
5.83
4.40t
8904
13000
2000
5000
5000
1000
3500
5000
3500
4.55t
21.72t
2985
1295
14.35t
2470
0.91
2.38
2.05
1.96t
7000

6 − 2 sectional force of column

1) longitudinal direction

Case	Load		N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
case 1 (HA loading)	WDL		519.6	—	6.84	—	—	—
	WLL		223.5	—	12.36	—	—	—
	FB		—	—	—	12.90	13.00	167.70
	W		137.76	—	—	—	—	—
			880.86		19.20	12.90		167.70
case 2 (wind)	WDL		519.6	—	6.84	—	—	—
	W		137.76	—	—	—	—	—
	wind	B-1,2	—	—	—	6.03	13.00	78.39
		B-3	—	—	—	12.58	—	125.21
			657.36		6.84	18.61		203.6
	(α = 1.15)		(571.62)		(5.95)	(16.18)		(177.04)
case 3 (HA loading + wind)	WDL		519.6	—	6.84	—	—	—
	WLL		223.5	—	12.36	—	—	—
	F B		—	—	—	12.90	13.00	167.70
	W		137.76	—	—	—	—	—
	wind	B-1	—	—	—	5.83	13.00	75.79
		B-2	—	—	—	4.40	8.904	39.18
			880.86		19.20	23.13		282.67
	(α = 1.15)		(765.97)		(16.70)	(20.11)		(245.8)

2) transverse direction

			N (t)	x (m)	Nx (tm)	H (t)	y (m)	Hy (tm)
case 1 (wind)	WDL		519.6	—	—	—	—	—
	W		137.76	—	—	—	—	—
	wind	A-1	—	—	—	21.72	14.295	310.49
		A-2	—	—	—	4.55	15.985	72.73
		A-3	—	—	—	5.34	—	38.33
	(α = 1.15)		657.36 (571.62)			31.61 (27.49)		421.55 (366.57)
case 2 (II A loading + wind)	WDL		519.6	—	—	—	—	—
	WLL		223.5	—	—	—	—	—
	W		137.76	—	—	—	—	—
	wind	A-1	—	—	—	14.35	15.47	221.99
		A-3	—	—	—	1.96	7.00	13.72
	(α = 1.15)		880.86 (765.97)			16.31 (14.18)		235.71 (204.97)

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	186.9	182.99	262.5	366.57	204.97
N	880.86	571.62	765.97	571.62	765.97
r	90	→	→	→	→
r_s	80	→	→	→	→
As	36 - D32 ctc 140 289.44	→	→	→	→
e		32.01	34.27	64.13	
e/r		0.36	0.38	0.71	
M'		697.45	952	881.03	
M'/r^3		95.67	130.57	120.85	
n p		0.1706	0.1706	0.1706	
r_s/r		0.90	0.90	0.90	
[C]		0.46	0.48	0.68	
[S]		0.0406	0.0618	0.448	
σ_c		45	63	82	
σ_s		58	121	812	
σ_{ca}	83	→	→	→	→
σ_{sa}	2346	→	→	→	→

6-4 check for buckling of column

$$P_a = \frac{1}{3} \times (0.85 \cdot f_{ck} \cdot A_c + f_{sy}' \cdot A_s)$$

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

$$h_e = (13.00 + 1.80) \times 2 = 29.60^{m}$$

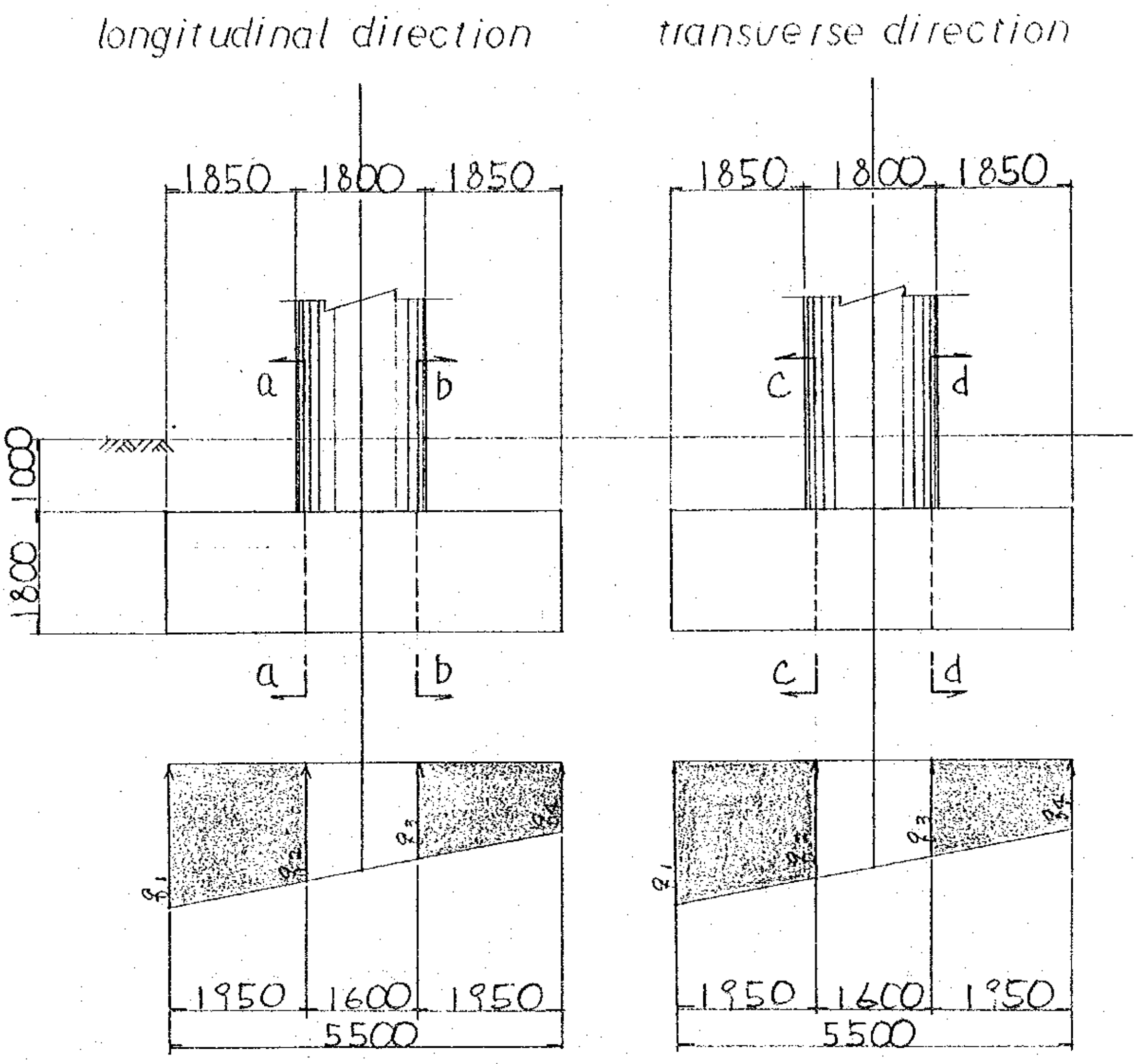
$$P_a = 1/3 \times (0.85 \times 250 \times \pi/4 \times 180^2 + 2500 \times 289.44)$$
$$= 2044.000^{kg} \quad 2044^{t}$$

$$\alpha = 1.45 - 0.03 \times 29.60/1.8$$
$$= 0.96$$

$$\therefore P_{aa} = 2044 \times 0.96$$
$$= 1962.24^{t} \quad > P_N = 880.86$$

§ 7 CALCULATION OF FOOTING SECTION

7-1 dimension and soil reaction



case	longitudinal direction				transverse direction			
	q_1	q_2	q_3	q_4	q_1	q_2	q_3	q_4
1	42.88	37.43	32.97	27.52	35.2	35.2	35.2	35.2
2	36.61	30.37	25.25	19.01	45.1	32.84	22.78	10.52
3	35.20	30.71	27.02	22.53	44.8	37.99	32.41	25.6
4	48.27	39.21	31.78	22.72	45.17	38.31	32.67	25.81

section A — A

			S (t)	x (m)	Sx (tm)
case 1	wd	(1.80 × 2.41 + 1.00 × 1.9) × 1.95 × 5.50	66.90	0.975	65.23
	q	½×(42.88+37.43)×1.95×5.50	-430.66	0.997	-429.37
			363.76		364.14
case 2 (α = 1.15)	wd	————	66.9	——	65.23
	q	½×(36.61+30.37)×1.95×5.50	-359.18	1.01	-362.77
			292.28 (254.16)		297.54 (258.73)
case 3 (α = 1.15)	wd	————	66.9	——	65.23
	q	½×(35.2+30.71)×1.95×5.50	-353.44	0.997	-352.38
			286.54 (249.17)		287.15 (249.70)
case 4 (α = 1.15)	wd	————	66.9	——	65.23
	q	½×(48.27+39.21)×1.95×5.50	-469.11	1.01	-473.80
			402.21 (349.75)		408.57 (355.28)

section B — B

M upper = 0

section c − c

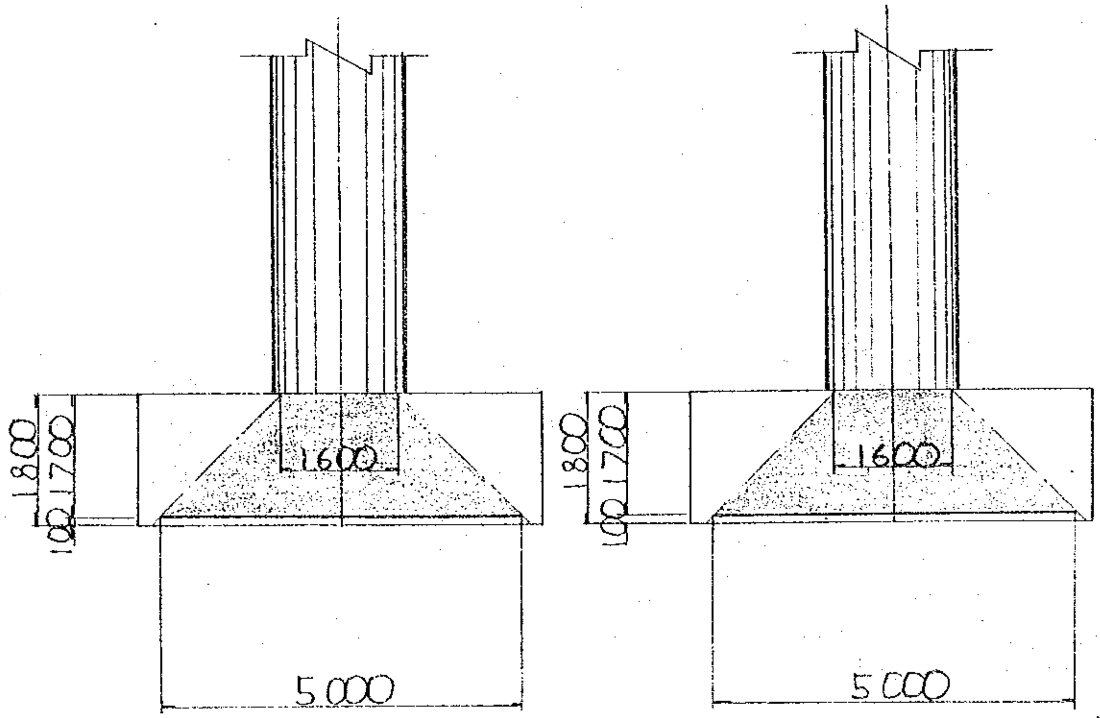
			S (t)	x (m)	Sx (tm)
case 1	wd	————	66.9	——	65.23
	q	35.2 × 1.95 × 5.50	−377.52	0.975	−368.08
			310.62		302.85
case 2 (α = 1.15)	wd	————	66.9	——	65.23
	q	½×(45.1+32.84)×1.95×5.50	−417.95	1.026	−428.82
			351.05 (305.26)		363.59 (316.17)
case 3 (α = 1.15)	wd	————	66.9		65.23
	q	½×(44.8+37.99)×1.95×5.50	−443.96	1.002	−444.85
			377.06 (327.88)		379.62 (330.10)
case 4 (α = 1.15)	wd	————	66.9		65.23
	q	½×(45.17+38.31)×1.95×5.50	−447.66	1.002	−448.56
			380.76 (331.10)		383.33 (333.33)

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	364.14			333.33		
N	———			———		
S	363.76			331.10		
b	500			500		
h	170			170		
d′	10			10		
As	D25 @150 106.76			D25 @150 106.76		
As′	———			———		
f/d	0			0		
M′/bd²	2.52			2.31		
S/bd	4.28			3.90		
n·P	0.0188			0.0188		
C	12.07			12.07		
S	56.52			56.52		
Z	1.06			1.06		
σ_c	30			29		
σ_s	2136			1956		
τ	4.5			4.1		
σ_{ca}	83	→	→	→	→	
σ_{sa}	2346	→	→	→	→	
τ_a	2.35	→	→	→	→	

Check for stirrups.

Sect a-a

$$\tau = \frac{S}{b \cdot d} \times Z = \frac{363.76 \times 10^3}{500 \times 170} \times 1.06 = 4.54\ kg/cm^2 < \tau_a = 2.35\ kg/cm^2$$

$$S' = S - S_c$$

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

$$S' = (363.76 - 188.44) \times 10^3 = 175.32 \times 10^3$$

$$Req\ A_v = \frac{S' \times a}{\sigma_{sa} \cdot d} \times Z = \frac{175.32 \times 10^3 \times 50}{1780 \times 170} \times 1.06 = 30.71\ cm^2$$

$$Req\ A_v / m = 30.71 / 5.0 = 6.14$$

Used A_v = Φ20 - ctc 500 $n = 2$

$$A_v = 3.14 \times 2 = 6.28 > Req\ A_v = 6.14\ cm^2$$

Sect c-c

A_v = Φ20 - ctc 500 $n = 2$