AFRICAN DEVELOPMENT BANK

GOVERNMENT OF MAURITIUS

BEAU BASSIN - PORT LOUIS LINK ROAD

CALCULATION NOTE

RETAINING WALL

BRIDGE OF FRONTAGE ROAD

SEPTEMBER 1980

Japan International Cooperation Agency

CONTENTS

1. Retaining Wall of Motorway Junction

CONTENT

§§ 1. DESIGN CONDITIONS

§ 1. DESIGN CONDITIONS

1 Retaining wall type

cantilever Type Height = 7.5, 9.0, 9.5, 11.1 and 11.7 meters

coulerfort Type Height = 12.7 m

2. foundation type

Spread footing

3 unit weight of reinforced concrete and soil

reinforced concrete 2.41 $^{ton}/_{m^3}$

soil 1.90 $^{ton}/_{m^2}$

4 bearing capacity

permissible bearing capacity σ_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 σ_{ca} = 85 $^{kg}/_{cm^2}$

permissible shear stress τ_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

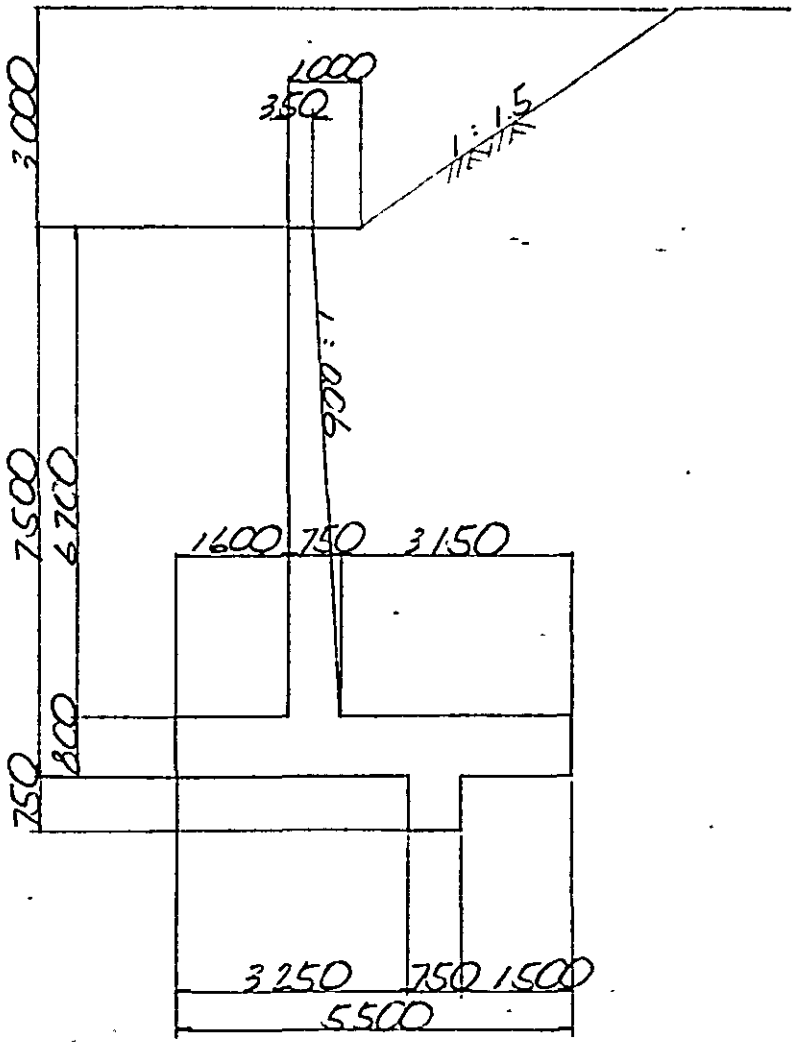
specified characteristic stress	$\sigma_{su} = 410\ N/mm^2 = 4180\ kg/cm^2$
permissible tensile stress	$\sigma_{sa} = 230\ N/mm^2 = 2\,340\ kg/cm^2$
permissible tensile stress in shera reinforcement	$\sigma_{sa} = 175\ N/mm^2 = 1780\ kg/cm^2$

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

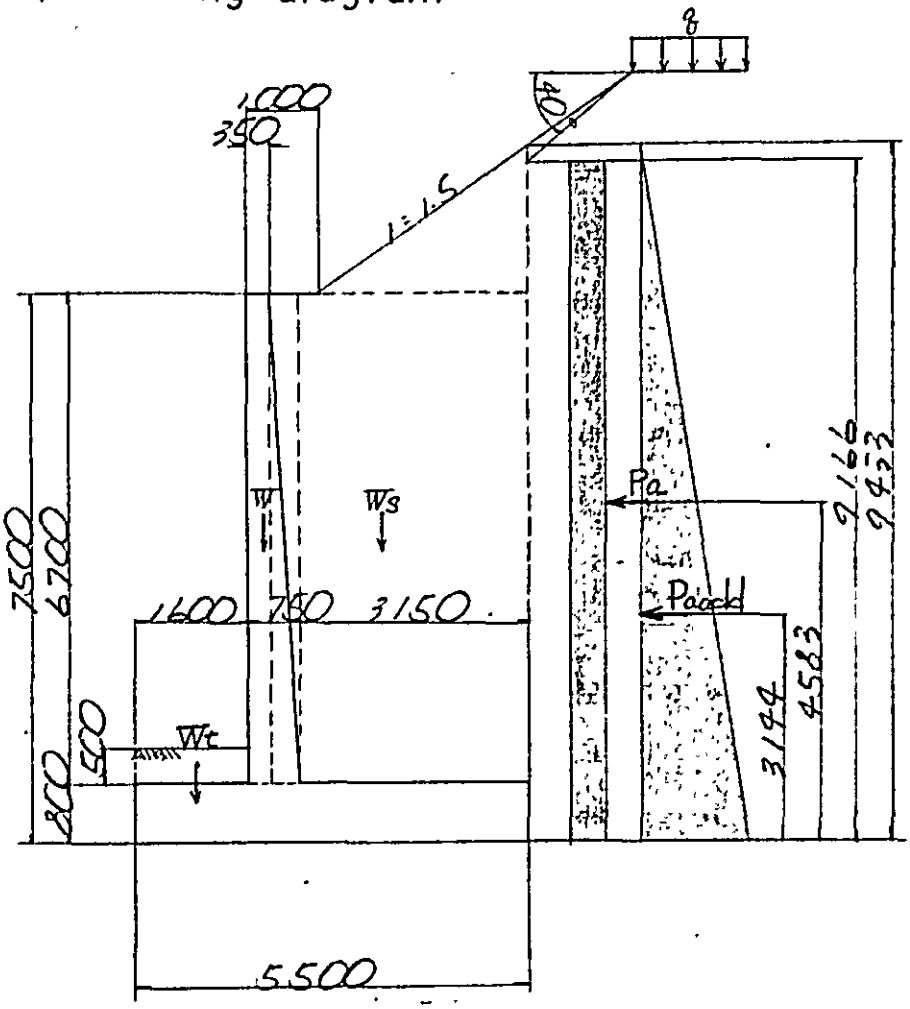
§§ 2 H = 7.50 m

§ 1 STRUCTURAL FIGURE



§ 2. CALCULATION OF LOAD

2-1 loading diagram



W : self weight

Ws : weight of soil

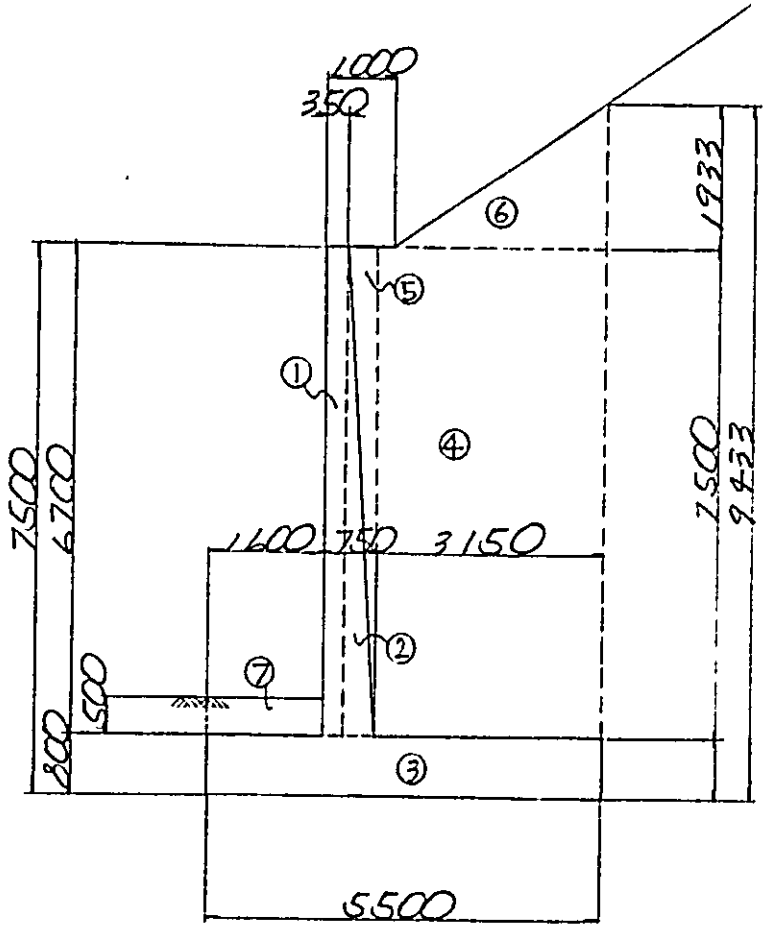
Wt : fill on toe

Ws add : weight of surcharge

P_A : active pressure

P_A add : surcharge

2-2 self weight & weight of soil



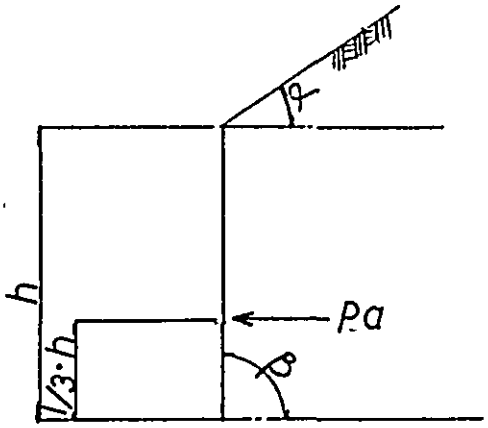
		N (t)	x (m)	N·x (tm)
①	0.35 × 6.70 × 2.41	5.65	1.775	10.03
②	½ × 6.70 × 0.40 × 2.41	3.23	2.083	6.73
③	0.80 × 5.50 × 2.41	10.60	2.75	29.15
④	6.70 × 3.15 × 1.9	40.10	3.925	157.39
⑤	½ × 6.70 × 0.40 × 1.9	2.55	2.217	5.65
⑥	½ × 2.90 × 1.933 × 1.9	5.33	4.533	24.16
⑦	0.50 × 1.60 × 1.9	1.52	0.80	1.22
Σ		68.98		234.33

$$e = \frac{B}{2} - \bar{x} = \frac{5.50}{2} - \frac{234.33}{68.98} = -0.647\ m$$

2-3 earth pressure

unit weight of soil $\gamma s = 1.9$

angle of internal friction $\phi = 35°$



$$K = \left(\frac{\cos\phi}{a+1}\right)^2$$

$$a = \sqrt{\sin\phi - 1/2 \tan\alpha \cdot \sin 2\phi}$$

$$a = \sqrt{\sin 35° - 1/2 \times \tan 0 \times \sin 2 \times 35°}$$

$$= \sqrt{0.574^2 - 1/2 \times 0 \times 2 \times 0.574}$$

$$= 0.574$$

$$K = \left(\frac{\cos 35°}{0.574 + 1}\right)^2$$

$$= \left(\frac{0.819}{1.574}\right)^2$$

$$= 0.27$$

(1) active pressure

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

$$= 1/2 \times 0.27 \times 1.9 \times 9.433^2 = 22.82 \ t/m$$

$$y = 1/3 \times 9.433 = 3.144 \ m$$

(2) active pressure due to surcharge

under H.A surcharge

$$q = 1.032 \times 1.9 + 1.02 = 2.98 \ t/m^2$$

$$q_h = q \cdot K \cdot H$$

$$= 2.98 \times 0.27 \times 9.166 = 7.37 \ t/m$$

$$y = 1/2 \times 9.166 = 4.583 \ m$$

2-4 weight of surcharge

under H.A $q = 1.02 \ t/m^2$

$x = \quad m$

§ 3 CALCULATION OF STABILITY

	N (t)	x (m)	N·x (tm)	H (t)	y (m)	H·y (tm)
W. Ws, Wt	68.98		-234.33	—	—	—
Ws·add	—	—	—	—	—	—
Pa	—	—	—	22.82	3.144	71.75
Pa·add	—	—	—	7.37	4.583	33.78
TOTAL	68.98		-234.33	30.19		105.53

1) check for eccentric

$$x = \frac{Nx + Hy}{\Sigma N} = \frac{-234.33 + 105.53}{68.98} = 1.87 \text{ m}$$

$$e = \frac{B}{2} - x = \frac{5.50}{2} - 1.87 = 0.88 \text{ m}$$

$0.88 < \frac{B}{6} = 0.92$

2) soil reaction

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

$$= \frac{68.98}{5.50} \times \left(1 \pm \frac{6 \times 0.88}{5.50}\right) = \begin{cases} 24.58 \\ 0.50 \end{cases} \text{ t/m}$$

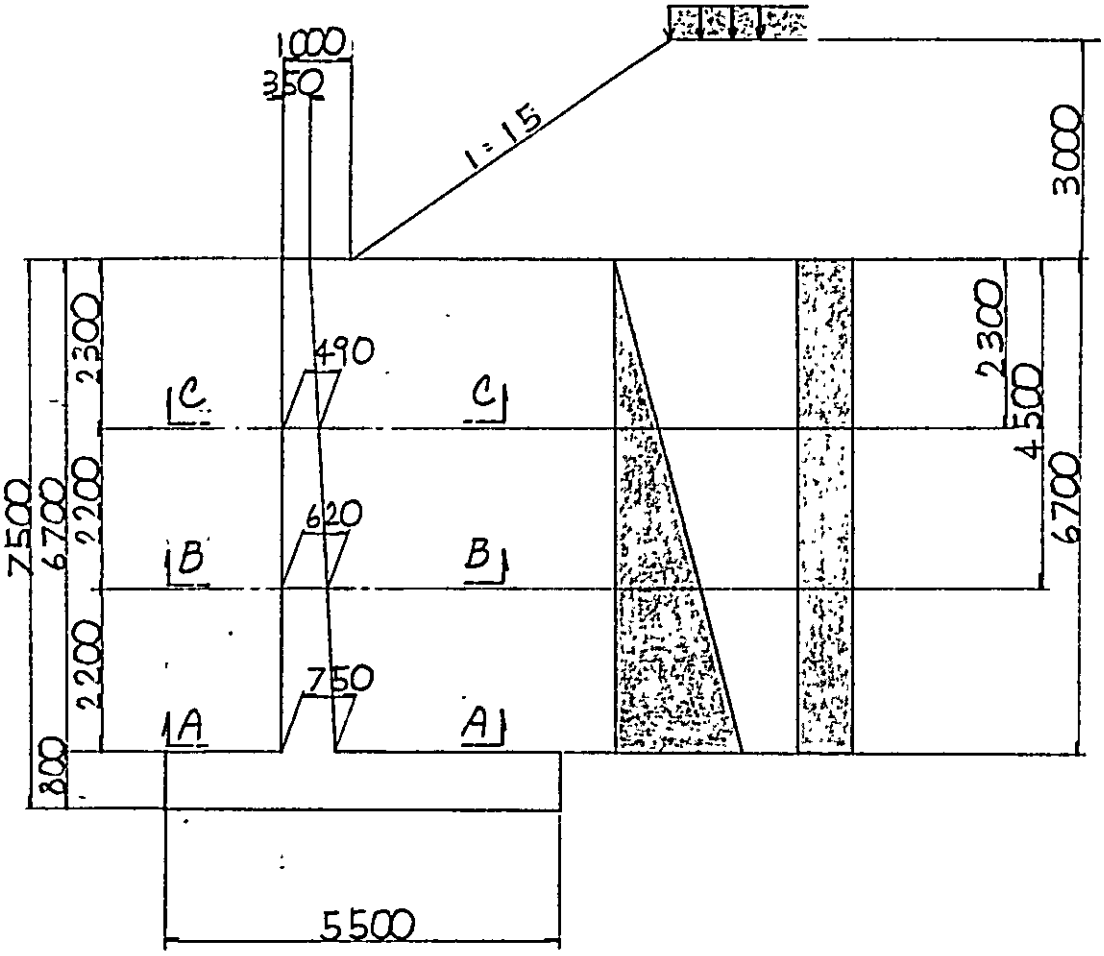
3) check for sliding

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

$$F = \frac{Hu}{H} = \frac{68.98 \times 0.6}{30.19} = 1.40 < 1.5$$

§ 4 CALCULATION OF WALL SECTION

4 - 1 dimension and loading



$$q = q_{HA} + \gamma_s \cdot h$$

$$= 1.02 + 1.9 \times 3.00 = 6.72 \ t/m^2$$

$$Pa\,add = q \cdot K \cdot Hx$$

$$= 6.72 \times 0.27 \times Hx = 1.8144 \cdot Hx \ t/m$$

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

$$= \frac{1}{2} \times 1.9 \times 0.27 \times Hx^2 = 0.2565 \cdot Hx^2 \ t/m$$

4-2 sectional force of wall

section A-A

		H (t)	y (m)	H·y (t·m)
Pa	0.2565×6.70^2	11.51	2.233	25.70
Pa add	1.8144×6.70	12.16	3.35	40.74
TOTAL		23.67		66.44

section B-B

		H (t)	y (m)	H·y (tm)
Pa	0.2565×4.50^2	5.19	1.50	7.79
Pa add	1.8144×4.50	8.16	2.25	18.36
TOTAL		13.35		26.15

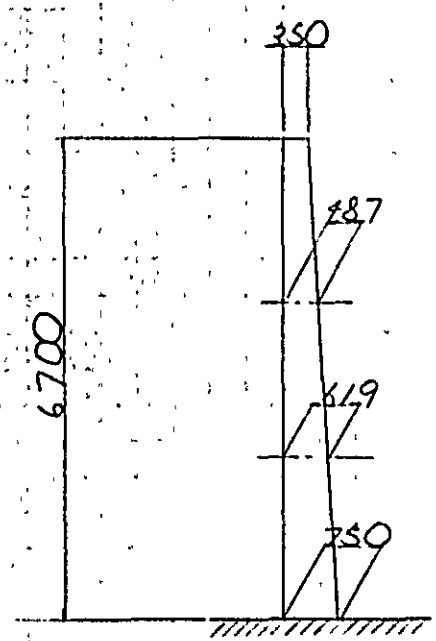
section C-C

		H (t)	y (m)	H·y (tm)
Pa	0.2565×2.30^2	0.59	0.767	0.45
Pa add	1.8144×2.30	4.17	1.15	4.80
TOTAL		4.76		5.25

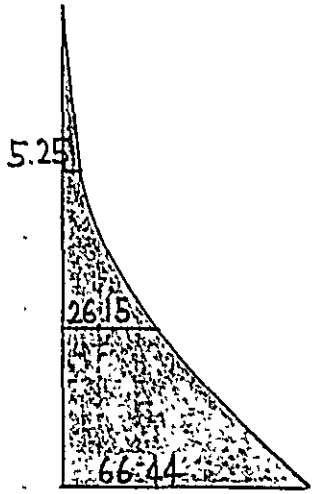
4 - 3 list of stresses $\sigma c, \sigma s, \tau$: working stress.

$\sigma ca, \sigma sa, \tau a$: Permissible stress.

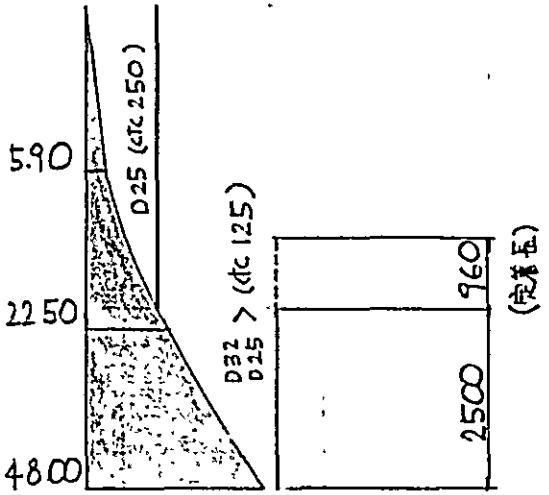
	A - A	B - B	C - C			
M	66.44	26.15	5.25			
N	—	—	—			
S	23.67	13.35	4.76			
b	100	100	100			
h	68	55	42			
d'	7	7	7			
As	D32 D25 @125 51.80	D32 D25 @125 51.80	D25@250 19.64			
As'	D20@250 12.56	D20@250 12.56	D20@250 12.56			
t/d	0	0	0			
M'/bd^2	14.37	8.64	2.98			
S/bd	3.48	2.43	1.13			
n.P	0.1143	0.1413	0.0701			
C	5.58	5.17	6.90			
S	9.90	8.09	15.88			
Z	1.14	1.16	1.13			
σc	80	45	21			
σs	2133	1049	709			
τ	3.4	2.8	1.3			
σca	83	83	83			
σsa	2346	2346	2346			
τa	3.47	3.47	3.47			



(moment)



(As)



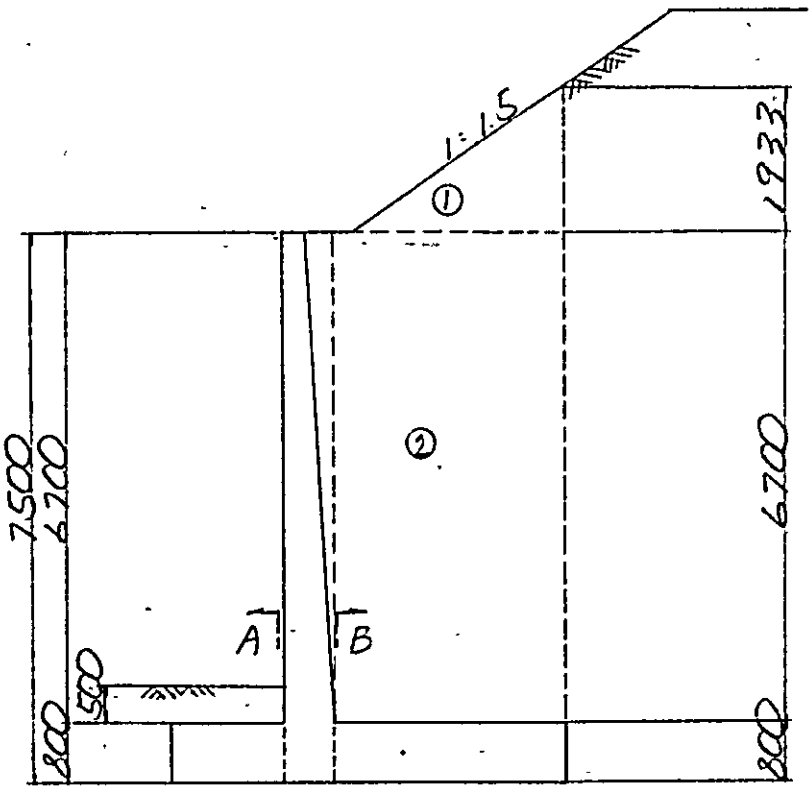
$$As = \frac{M}{\sigma sa \cdot j \cdot d}$$

$\sigma sa = 1346\ kg/m^2$

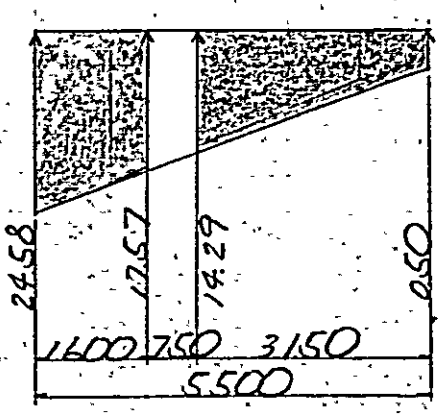
$j = 0.875$

§ 5 CALCULATION OF FOOTING SECTION

5 - 1 dimenston and loading



A B



5 - 2 sectional force of footing

section A - A

		S (t)	x (m)	S·x (tm)
W	1.60 × 0.80 × 2.41	3.08	0.80	2.46
Wt	1.60 × 0.50 × 1.9	1.52	0.80	1.22
q	-½ × (24.58+17.57) × 1.60	-33.72	0.844	-28.46
TOTAL		-29.12		-24.78

section B - B

			S (t)	x (m)	S·x (tm)
W		3.15 × 0.80 × 2.41	6.07	1.575	9.56
W s	①	½ × 2.90 × 1.933 × 1.9	5.33	2.183	11.64
	②	3.15 × 6.70 × 1.90	40.10	1.575	63.16
q		½ × (14.29+0.50) × 3.15	-23.29	1.085	-25.27
TOTAL			28.21		59.09

5 - 3 list of stresses $\sigma c, \sigma s, \tau$: working stress.

$\sigma ca, \sigma sa, \tau a$: permissible stress.

	A - A	B - B				
M	24.78	59.09				
N	—	—				
S	29.12	28.21				
b	100	100				
h	70	70				
d'	10	10				
As	D20×@125 D16 20.6	D32×@125 D20 44.72				
As'	—	—				
f'_c/d	—	—				
M'/bd^2	5.06	12.06				
S/bd	4.16	4.03				
n·P	0.0441	0.0958				
C	8.53	6.43				
S	24.78	11.83				
Z	1.09	1.13				
σc	43	78				
σs	1880	2139				
τ	4.1	4.0				
σca	83	83				
σsa	2346	2346				
τa	2.35	2.35				

check for stirrups

$$\tau = \frac{S_h}{b \cdot d} \cdot Z$$

$$= \frac{29.12 \times 10^3}{100 \times 70} \times 1.09 = 4.53 > \tau_a = 2.35$$

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

$$S_h' = S_h - S_c$$

$$S_c = \tau_a \times b \times d \times \frac{1}{Z}$$

$$= 2.35 \times 100 \times 70 \times \frac{1}{1.09} = 15092 \ kg$$

$$S_h' = (29.12 - 15.09) \times 10^3 = 14.03 \times 10^3 \ kg$$

$$\text{req. } A_w = \frac{14.03 \times 10^3 \times 30}{1780 \times 70} \times 1.09 = 3.68 \ cm^2$$

Φ 16 - ctc 300 $n = 2$

Used $A_w = 2.01 \times 2 = 4.02 > \text{req. } A_w = 3.68$

check for stirrups

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

$$= \frac{28.21 \times 10^3}{100 \times 70} \times 1.13 = 4.55 > \tau_a = 2.35$$

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

$$Sh' = Sh - Sc$$

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

$$= 2.35 \times 100 \times 70 \times \frac{1}{1.13} = 14\,560$$

$$Sh' = (26.21 - 14.56) \times 10^3 = 13.65 \times 10^3 \ kg$$

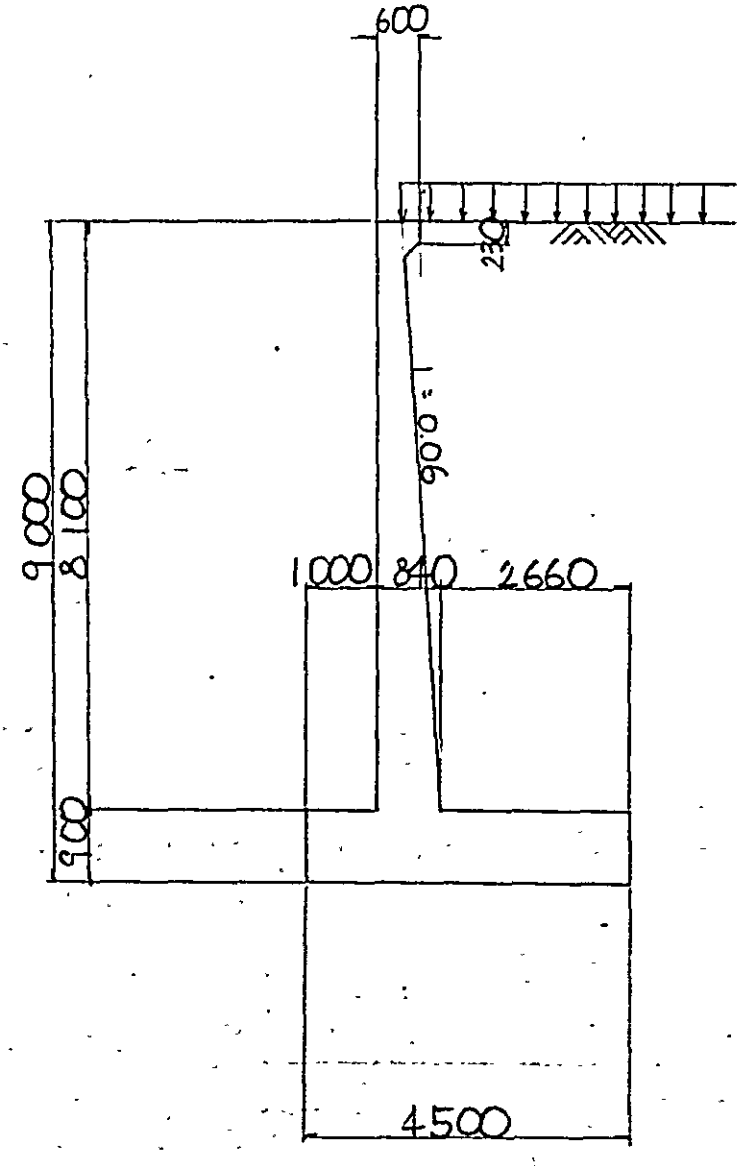
$$\text{req. } A_w = \frac{13.65 \times 10^3 \times 30}{1780 \times 70} \times 1.13 = 3.71 \ cm^2$$

Φ 16 - ctc 300 $n = 2$

Used $A_w = 2.01 \times 2 = 4.02 \ cm^2 > \text{req. } A_w = 3.71 \ cm^2$

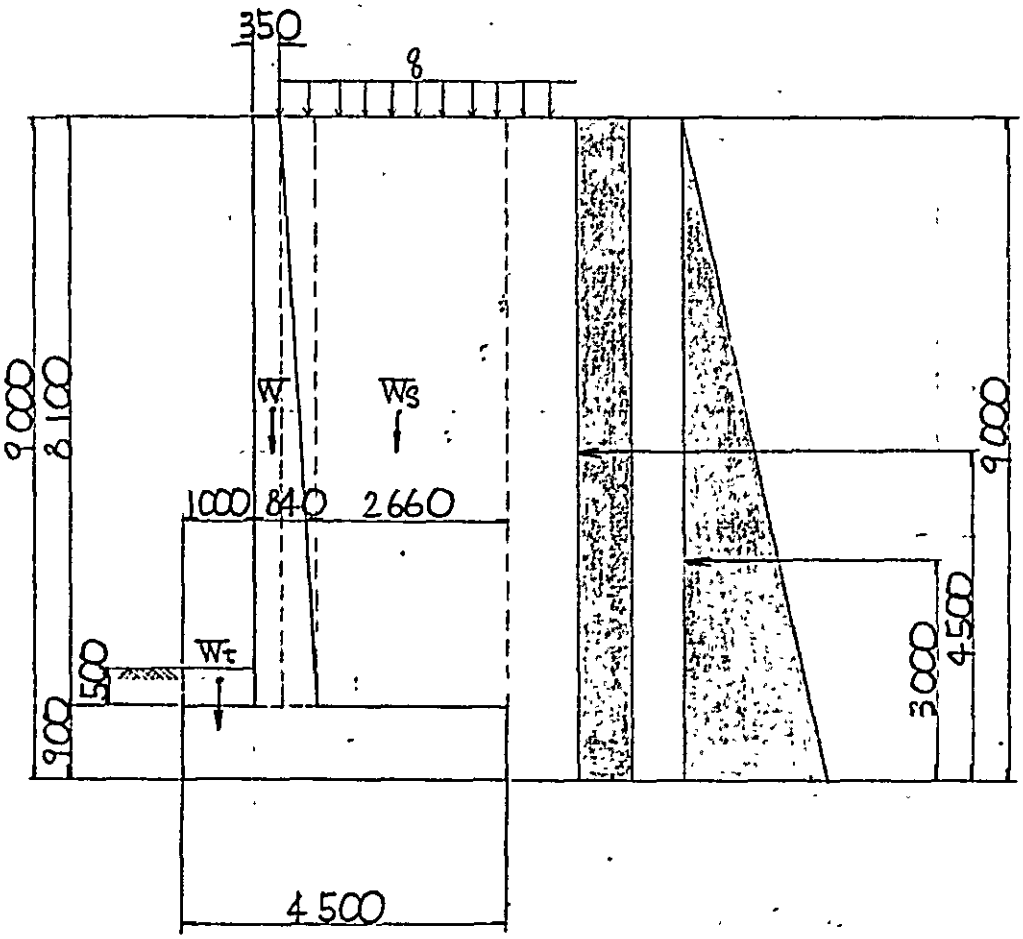
§§ 3 $H = 900^{m}$

§ 1. STRUCTURAL FIGURE



§ 2. CALCULATION OF LOAD

2-1 loading diagram



W : self weight

Ws : weight of soil

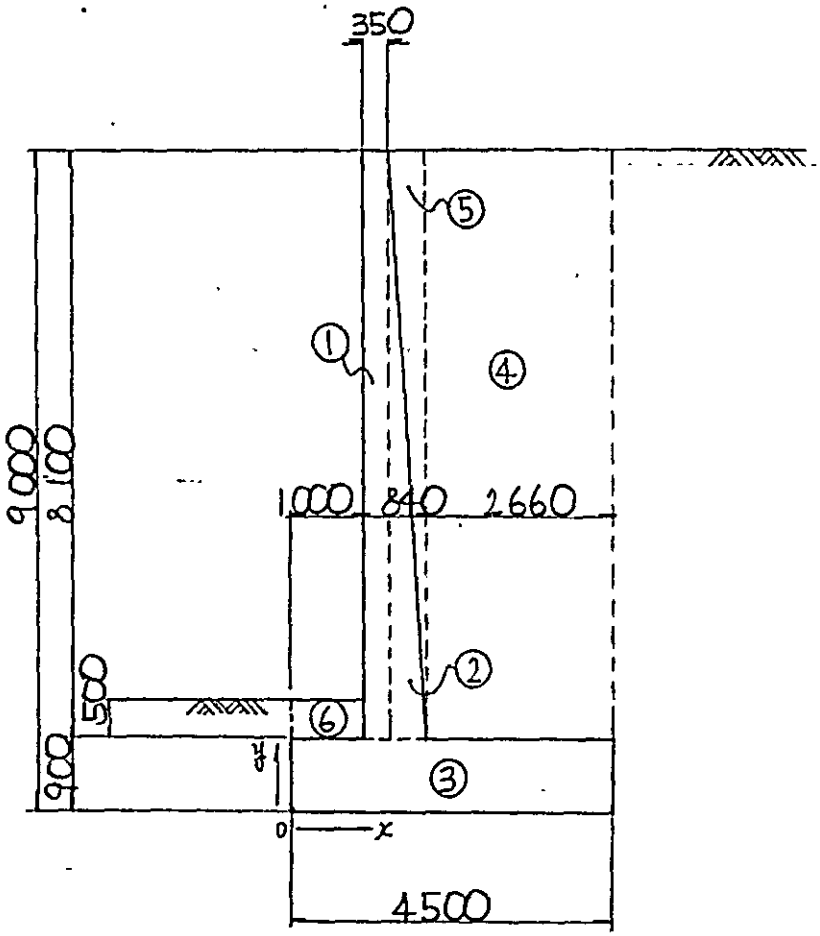
Wt : fill on toe

Ws add: weight of surcharge

P_A : active pressure

P_A add : surcharge

2-2 self weight & weight of soil



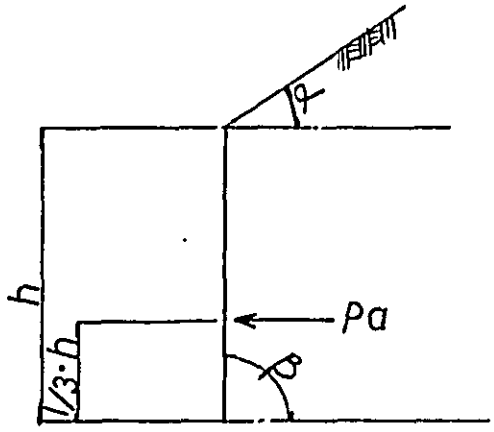
		N (t)	x (m)	N·x (tm)
①	0.35 × 8.10 × 2.41	6.83	1.175	8.03
②	½ × 0.49 × 8.10 × 2.41	4.78	1.513	7.23
③	0.90 × 4.50 × 2.41	9.76	2.25	21.96
④	2.66 × 8.10 × 1.9	40.94	3.17	129.78
⑤	½ × 0.49 × 8.10 × 1.9	3.77	1.677	6.32
⑥	0.50 × 1.00 × 1.9	0.95	0.50	0.48
Σ		67.03		173.80

$$e = \frac{B}{2} - \bar{x} = \frac{4.50}{2} - \frac{173.80}{67.03} = -0.343\ m$$

2-3 earth pressure

unit weight of soil $\gamma s = 1.9$

angle of internal friction $\phi = 35°$



$$K = \left(\frac{\cos\phi}{a+1}\right)^2$$

$$a = \sqrt{\sin\phi - 1/2 \tan\alpha \cdot \sin 2\phi}$$

$$a = \sqrt{\sin 35° - 1/2 \times \tan 0 \times \sin 2 \times 35°}$$

$$= \sqrt{0.574^2 - 1/2 \times 0 \times 2 \times 0.574}$$

$$= 0.574$$

$$K = \left(\frac{\cos 35°}{0.574 + 1}\right)^2$$

$$= \left(\frac{0.819}{1.574}\right)^2$$

$$= 0.27$$

(1) active pressure

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

$$= 1/2 \times 0.27 \times 1.9 \times 9.00^2 = 20.78 \ t/m$$

$$y = 1/3 \times 9.00 = 3.00 \ m$$

(2) active pressure due to surcharge

under H.A surcharge

$$q = 1.02 \ t/m^2$$

$$q_h = q \cdot K \cdot H$$

$$= 1.02 \times 0.27 \times 9.00 = 2.48 \ t/m$$

$$y = 1/2 \times 9.00 = 4.50 \ m$$

2-4 weight of surcharge

under H.A $q = 1.02 \ t/m^2$

$x = 3.15 \ m$

§ 3 CALCULATION OF STABILITY

	N (t)	x (m)	N·x (tm)	H (t)	y (m)	H·y (tm)
W. Ws, Wt	67.03		-173.80	—	—	—
Ws·add	3.21	2.925	9.39	—	—	—
Pa	—	—	—	20.78	3.00	62.34
Pa·add	—	—	—	2.48	4.50	11.16
TOTAL	70.24		-183.19	23.26		73.50

1) check for eccentric

$$x = \frac{Nx + Hy}{\Sigma N} = \frac{-183.19 + 73.5}{70.24} = 1.56 \ m$$

$$e = \frac{B}{2} - x = \frac{4.50}{2} - 1.56 = 0.69 \ m$$

$$< \frac{B}{6} = 0.75^{m}$$

2) soil reaction

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

$$= \frac{70.24}{4.50} \times \left(1 \pm \frac{6 \times 0.69}{4.50}\right) = \begin{cases} 29.97 \ t/m \\ 1.25 \end{cases}$$

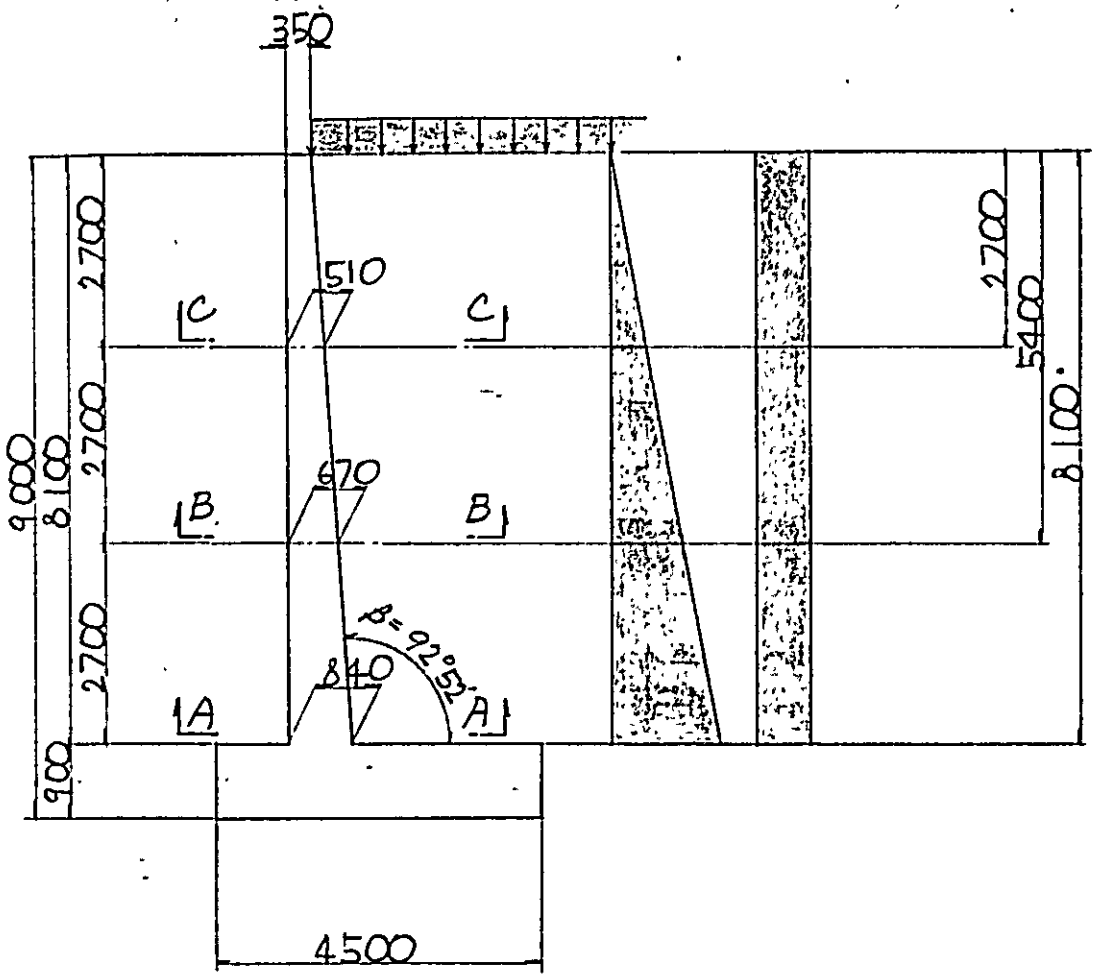
3) check for sliding

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

$$F = \frac{Hu}{H} = \frac{70.24 \times 0.6}{23.26} = 1.81 > 1.5$$

§ 4 CALCULATION OF WALL SECTION

4 - 1 dimension and loading



$$K = \left[\frac{\sin(\beta-\phi)}{(a+1)\sin\beta}\right]^2 \frac{1}{\sin^2\beta} \qquad a = \sqrt{\frac{\sin\phi\,\sin(\phi-\delta)}{\sin\beta\,\sin(\beta-\delta)}}$$

$$a = \sqrt{\frac{\sin 35°\sin(35°-0)}{\sin 92°52'\sin(92°52'-0)}} = 0.574$$

$$K = \left[\frac{\sin(92°52'-35°)}{(0.574+1)\sin 92°52'}\right]^2 \times \frac{1}{\sin^2 92°52'} = 0.29$$

$$P_{aH} = 1/2 \cdot K \cdot \delta_s \cdot H^2 \cdot \cos(\beta-90°) = 1/2 \times 0.29 \times 1.9 \times H^2 \times 0.9987 = 0.2751 H^2$$

$$P_{a\,add\,H} = q \cdot K \cdot H \cdot \cos(\beta-90°) = 1.02 \times 0.29 \times H \times 0.9987 = 0.2954 H$$

4-2 sectional force of wal

section A-A

		H (t)	y (m)	H·y (t·m)
Pa	0.2751×8.10^2	18.05	2.70	48.74
Pa add	0.2954×8.10	2.39	4.05	9.68
TOTAL		20.44		58.42

section B-B

		H (t)	y (m)	H·y (t·m)
Pa	0.2751×5.40^2	8.02	1.80	14.44
Pa add	0.2954×5.40	1.60	2.70	4.32
TOTAL		9.62		18.76

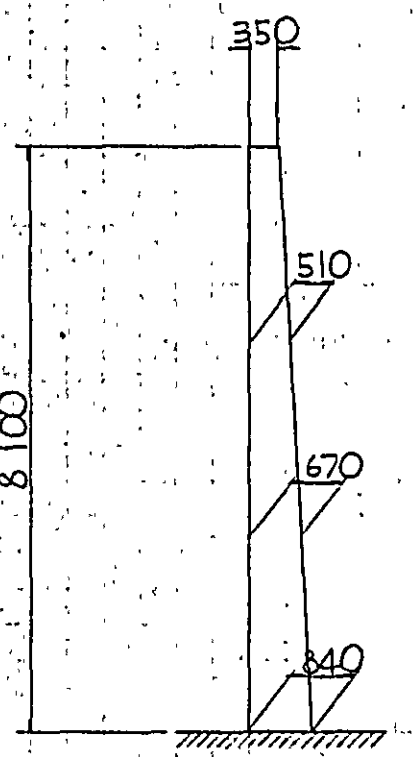
section C-C

		H (t)	y (m)	H·y (t·m)
Pa	0.2751×2.70^2	2.01	0.90	1.81
Pa add	0.2954×2.70	0.80	1.35	1.08
TOTAL		2.81		2.89

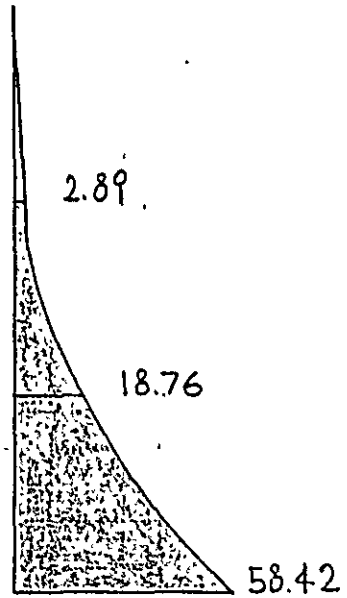
4 - 3 list of stresses $\sigma c, \sigma s, \tau$: working stress.

$\sigma ca, \sigma sa, \tau a$: Permissible stress.

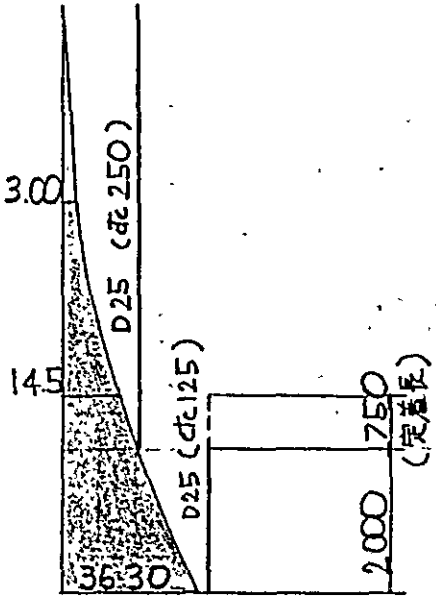
	A - A	B - B	C - C			
M	58.42	18.76	2.89			
N	—	—	—			
S	20.44	9.62	2.81			
b	100	100	100			
h	77	60	44			
d'	7	7	7			
As	D25@125 39.28	D25@250 19.64	D25@250 19.64			
As'	D12@250 4.52	D12@250 4.52	D12@250 4.52			
t/d	0	0	0			
M'/bd^2	9.85	5.21	1.49			
S/bd	2.65	1.60	0.64			
n.P	0.0765	0.0491	0.067			
C	6.75	7.91	7.02			
S	14.59	22.32	16.60			
Z	1.12	1.10	1.12			
σc	67	41	10			
σs	2157	1745	372			
τ	3.0	1.8	0.7			
σca	83	83	83			
σsa	2346	2346	2346			
τa	3.47	2.35	2.35			



(moment)



(As)

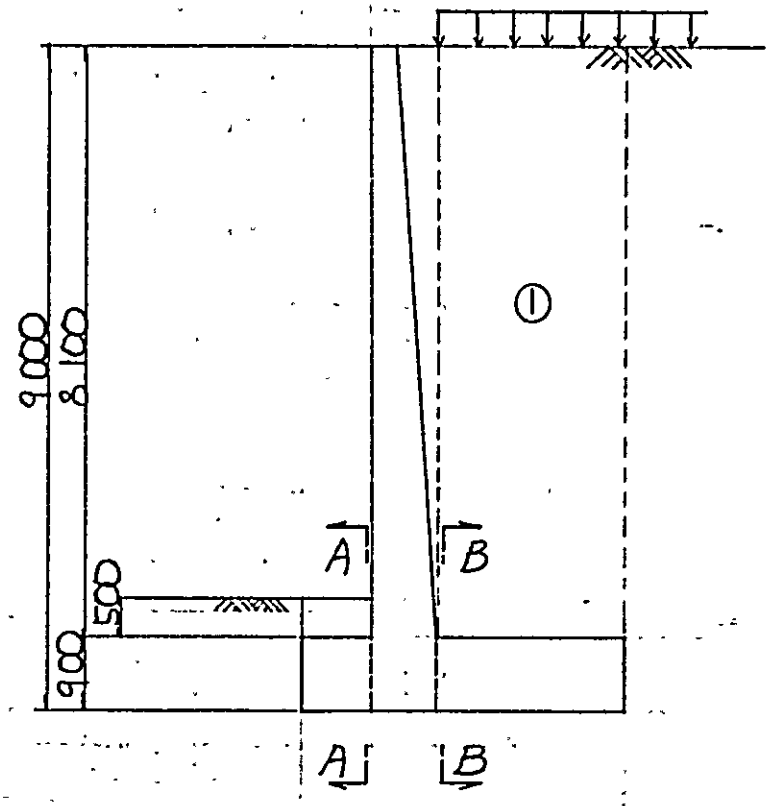


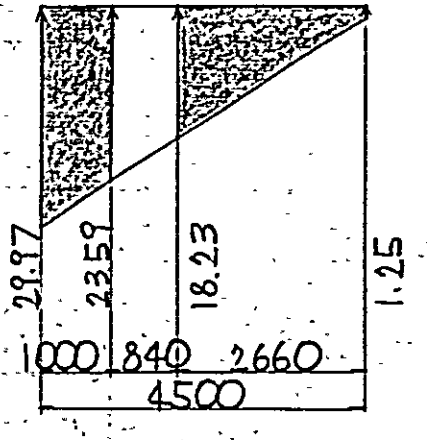
$$A = \frac{M}{\sigma_{sa} \cdot j \cdot d}$$

$\sigma_{sa} = 2346\ ^{kg/cm^2}$ $j = 0.875$

§ 5 CALCULATION OF FOOTING SECTION

5-1 dimenston and loading





5 - 2 sectional force of footing

section A - A

		S (t)	x (m)	S·x (tm)
W	0.90 × 1.00 × 2.41	2.17	0.50	1.09
Wt	0.50 × 1.00 × 1.9	0.95	0.50	0.48
q	½ × (23.59 + 29.97) × 1.00	-26.78	0.52	-13.93
TOTAL		-23.66		-12.36

section B - B

		S (t)	x (m)	S·x (tm)
W	0.90 × 2.66 × 2.41	5.77	1.33	7.67
Ws ①	8.10 × 2.66 × 1.9	40.94	1.33	54.45
Ws add	1.02 × 2.66	2.71	1.33	3.60
q	½ × (1.25 + 18.23) × 2.66	-25.91	0.944	-24.46
TOTAL		23.51		41.26

5-3 list of stresses σ_c, σ_s, τ : working stress.

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

	A-A	B-B				
M	12.36	41.26				
N	—	—				
S	23.66	23.51				
b	100	100				
h	80	80				
d'	10	10				
As	D16 @ 125 16.08	D20 @ 125 25.12				
As'	—	—				
f/d	—	—				
M'/bd^2	1.93	6.45				
S/bd	2.96	2.94				
n.P	0.0151	0.0471				
C	13.28	8.23				
S	70.26	23.28				
Z	1.06	1.10				
σ_c	26	54				
σ_s	2035	2251				
τ	3.1	3.2				
σ_{ca}	83	83				
σ_{sa}	2346	2346				
τ_a	2.35	2.35				

Check for stirrups.

Sect A-A

$$\tau = \frac{S}{b \cdot d} \cdot z = \frac{23.66 \times 10^3}{100 \times 80} \times 1.06 = 3.13 \ kg/cm^2 < \tau_a = 2.35 \ kg/cm^2$$

$$S' = S - S_c$$

$$S_c = \tau_a \cdot b \cdot d \cdot 1/z = 2.35 \times 100 \times 80 \times 1/1.06 = 17.74 \times 10^3 \ kg$$

$$S' = (23.66 - 17.74) \times 10^3 = 5.92 \times 10^3 \ kg$$

$$\text{Req } A_v = \frac{S' \times a}{\sigma_{sa} \cdot d} \times z = \frac{5.92 \times 10^3 \times 60}{1780 \times 80} \times 1.06 = 2.64 \ cm^2$$

Used A_v = ϕ16 - c/c 600 mm n = 2

$$A_s = 2.01 \times 2 = 4.02 \ cm^2 > \text{Req } A_v = 2.64 \ cm^2$$

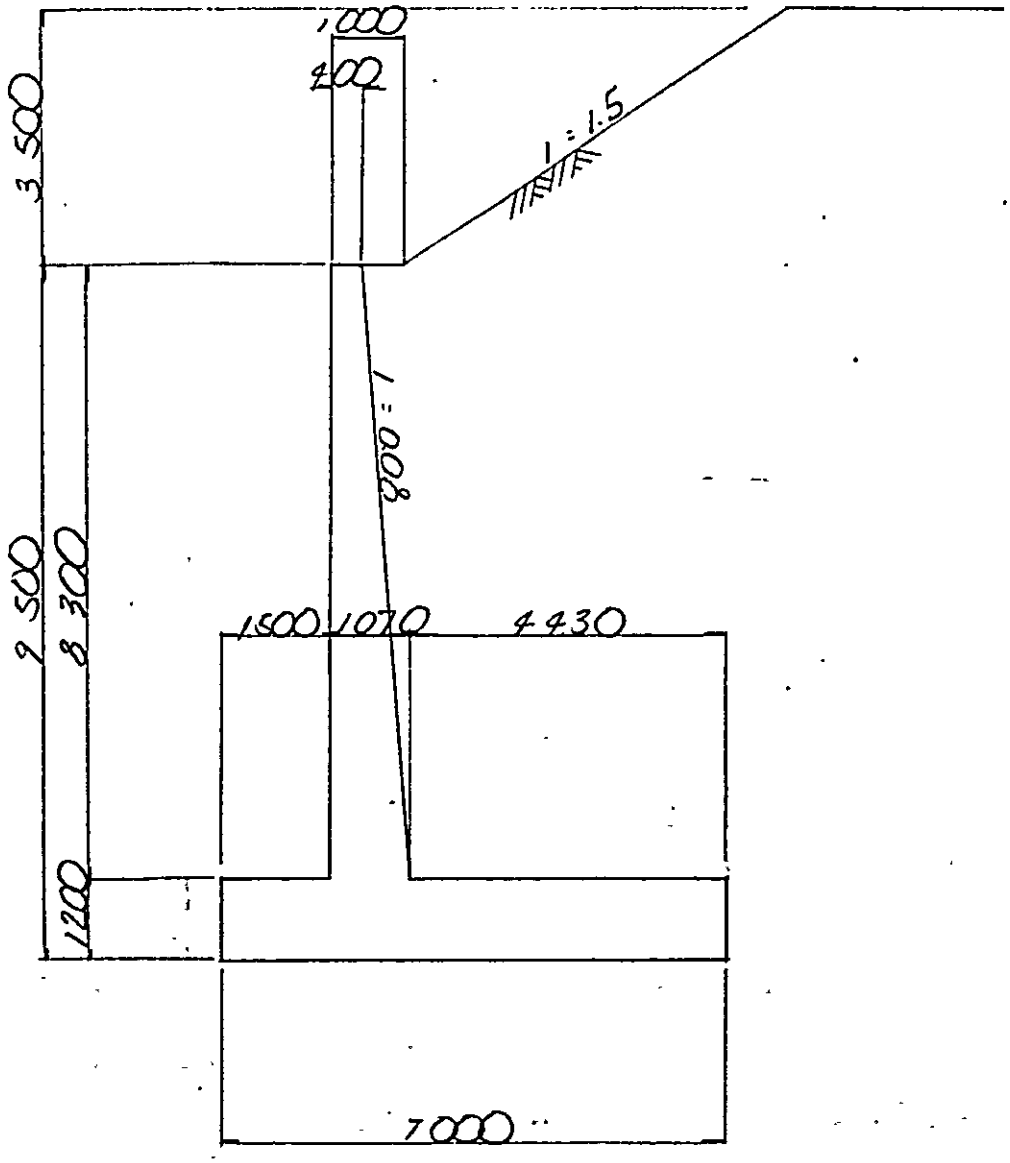
Sect B-B

Refer to Sect A-A

Used A_v = ϕ16 - c/c 600 n = 2 /100 cm

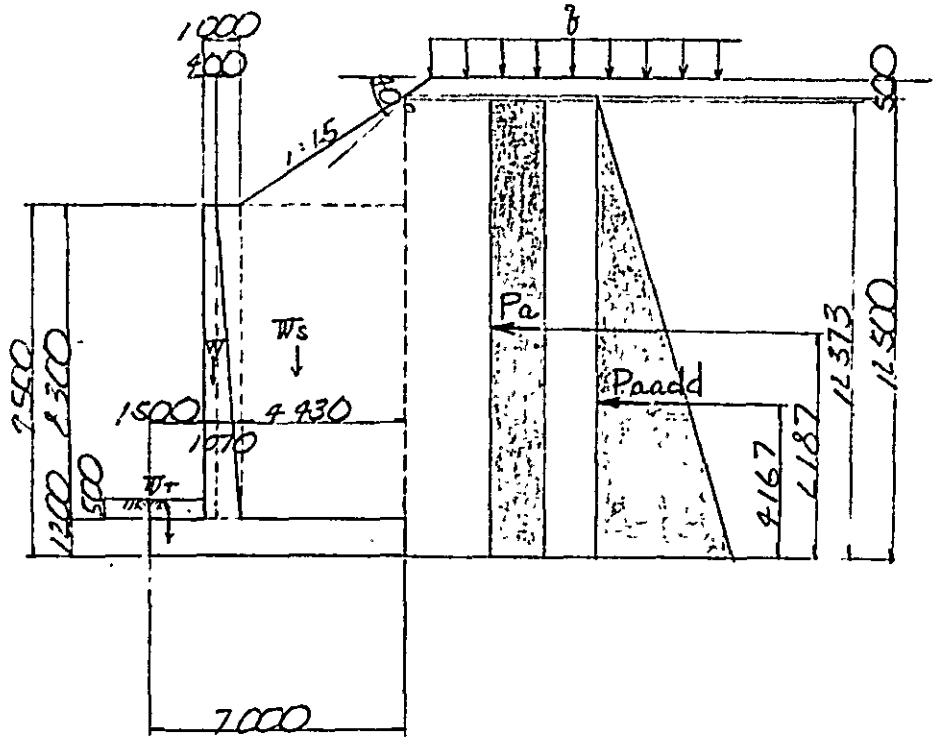
§§ 4 $H = 9.50^{m}$

§ 1 STRUCTURAL FIGURE



§ 2. CALCULATION OF LOAD

2-1 loading diagram



W : self weight

Ws : weight of soil

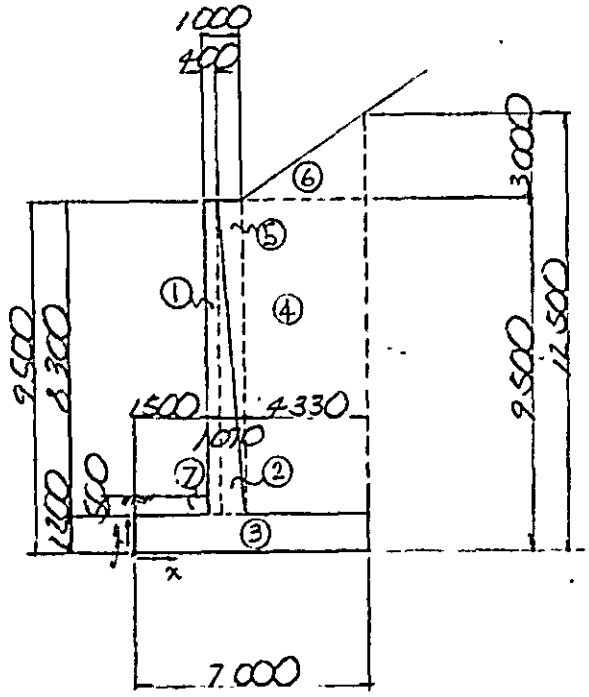
Wt : fill on toe

Ws add : weight of surcharge

PA : active pressure

PA add : surcharge

2-2 self weight & weight of soil

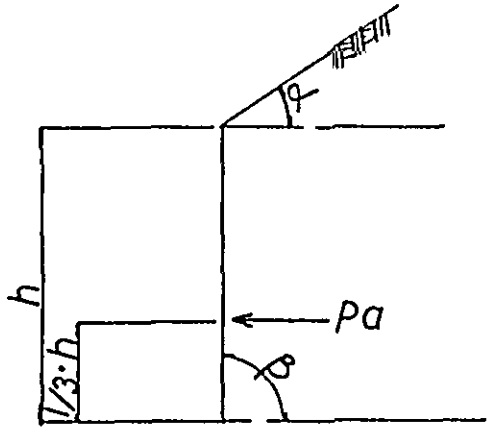


		N (t)	x (m)	N·x (tm)
①	0.40×8.40×2.41	8.10	1.700	13.77
②	½×0.67×8.40×2.41	6.78	2.123	14.39
③	7.00×1.10×2.41	18.56	3.500	64.96
④	4.43×8.40×1.9	66.98	4.785	320.50
⑤	½×0.67×8.40×1.9	5.06	2.347	11.88
⑥	½×4.50×3.00×1.9	12.15	5.500	66.83
⑦	0.50×1.50×1.9	1.35	0.750	1.01
Σ		118.98		493.34

2-3 earth pressure

unit weight of soil $\gamma s = 1.9$

angle of internal friction $\phi = 35°$



$$K = \left(\frac{\cos\phi}{a+1}\right)^2$$

$$a = \sqrt{\sin\phi - 1/2 \tan\delta \sin 2\phi}$$

$$a = \sqrt{\sin 35° - 1/2 \times \tan 0 \times \sin 2 \cdot 35°}$$

$$= \sqrt{0574^2 - 1/2 \times 0 \times 2 \times 0574}$$

$$= 0574$$

$$K = \left(\frac{\cos 35°}{0574 + 1}\right)^2$$

$$= \left(\frac{0.819}{1574}\right)^2$$

$$= 10\,2.7$$

(1) active pressure

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

$$= 1/2 \times 0.27 \times 1.9 \times 12.50^2 = 37.97 \ t/m$$

$$y = 1/3 \times 12.50 = 4.167 \ m$$

(2) active pressure due to surcharge

under H.A surcharge

$$q = 1.02 + 0.50 \times 1.9 = 1.95 \ t/m^2$$

$$q_h = q \cdot K \cdot H$$

$$= 1.95 \times 0.27 \times 12.373 = 6.51 \ t/m$$

$$y = 1/2 \times 12.373 = 6.187 \ m$$

2-4 weight of surcharge

under H.A $q = 1.02 \ t/m^2$

$x = \quad m$

§ 3 CALCULATION OF STABILITY

	N (t)	x (m)	N·x (tm)	H (t)	y (m)	H·y (tm)
W. Ws. Wt	118.98		-493.34	—	—	—
Ws·add	—	—	—	—	—	—
Pa	—	—	—	37.97	4.167	158.22
Pa·add	—	—	—	6.51	6.187	40.28
TOTAL	118.98		-493.34	44.48		198.50

1) check for eccentric

$$x = \frac{Nx + Hy}{\Sigma N} = \frac{-493.34 + 198.50}{118.98} = 2.48 \text{ m}$$

$$e = \frac{B}{2} - x = \frac{7.00}{2} - 2.48 = 1.02 \text{ m}$$

2) soil reaction $< \frac{B}{6} = 1.16$ m

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

$$= \frac{118.98}{7.00} \times \left(1 \pm \frac{6 \times 1.02}{7.00}\right) = \begin{cases} 31.86 \\ 2.14 \end{cases} \text{ t/m}$$

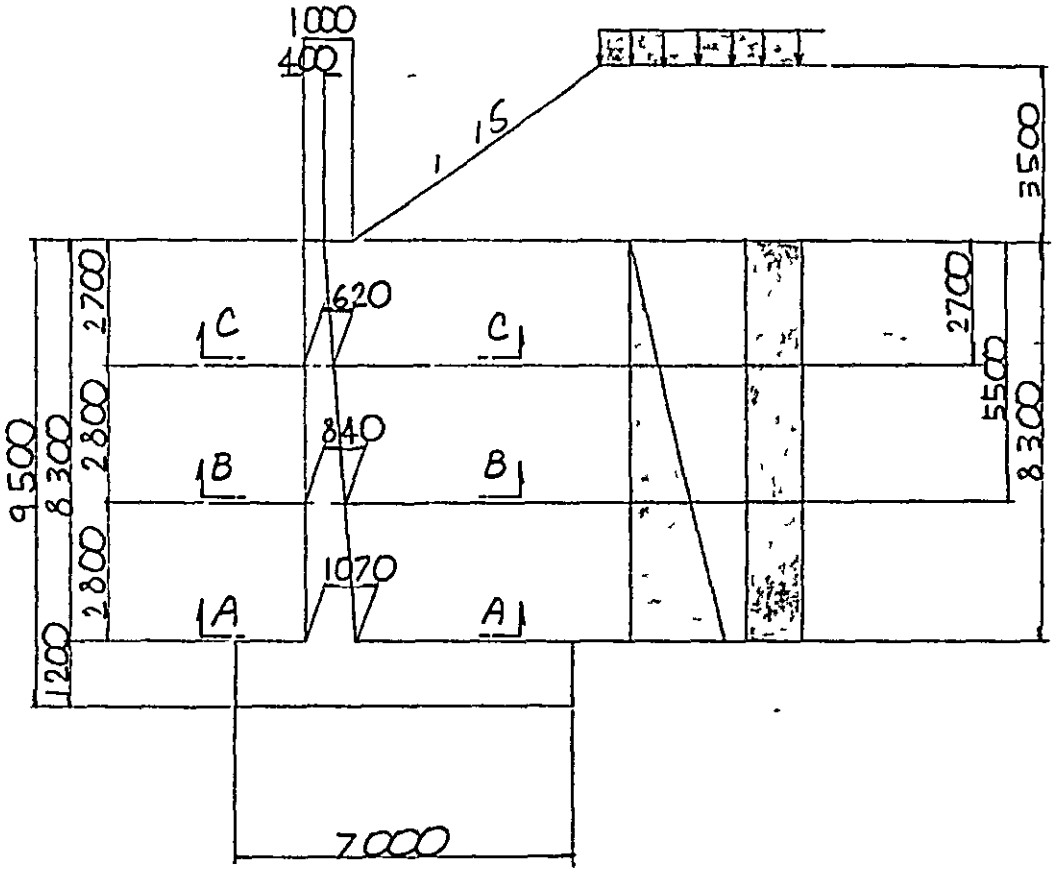
3) check for sliding

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

$$F = \frac{Hu}{H} = \frac{118.98 \times 0.6}{44.48} = 1.60 > 1.5$$

§ 4 CALCULATION OF WALL SECTION

4 - 1 dimension and loading



$$q = q_{HA} + \gamma_s h$$
$$= 1.02 + 1.9 \times 3.50 = 7.67 \ t/m^2$$

$$P_{a\,add} = q \cdot K \cdot H_x$$
$$= 7.67 \times 0.27 \times H_x = 2.071 \cdot H_x \ t/m$$

$$P_a = \frac{1}{2} \gamma_s \cdot K \cdot H_x^2$$
$$= \frac{1}{2} \times 1.9 \times 0.27 \times H_x^2 = 0.2565 \cdot H_x^2 \ t/m$$

4-2 sectional force of wall

section A-A

		H (t)	y (m)	H·y (t·m)
Pa	0.2565×8.30^2	17.67	2.767	48.89
Pa add	2.071×8.30	17.19	4.15	71.34
TOTAL		34.86		120.23

section B-B

		H (t)	y (m)	H·y (tm)
Pa	0.2565×5.50^2	7.76	1.833	14.22
Pa add	2.071×5.50	11.39	2.750	31.32
TOTAL		19.15		45.54

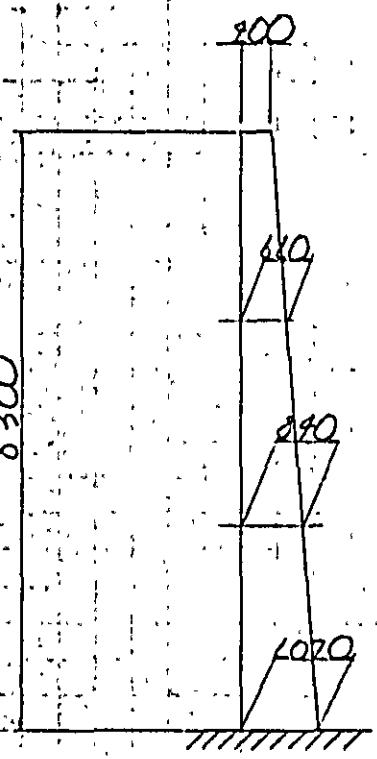
section C-C

		H (t)	y (m)	H·y (tm)
Pa	0.2565×2.70^2	1.87	0.90	1.68
Pa add	2.071×2.70	5.59	1.35	7.55
TOTAL		7.46		9.23

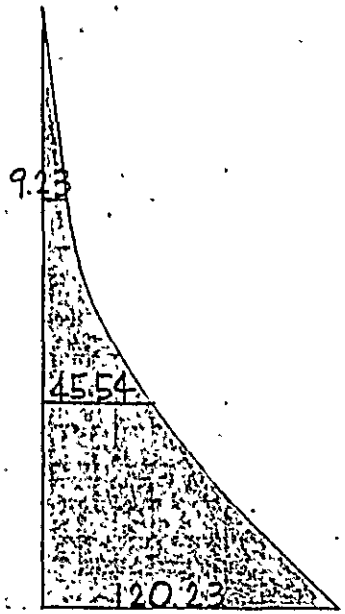
4-3 list of stresses σ_c, σ_s, τ : working stress.

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

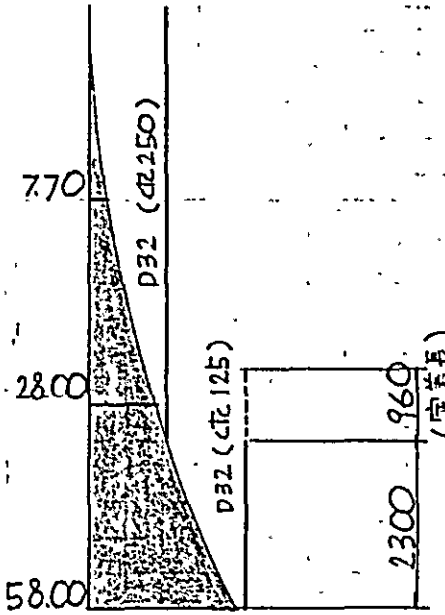
	A - A	B - B	C - C			
M	120.23	45.54	9.23			
N	—	—	—			
S	34.86	19.15	7.46			
b	100	100	100			
h	100	77	55			
d'	7	7	7			
As	D32 @125 64.32	D32 @ 250 32.16	D32 @ 250 32.16			
As'	D12 @ 250 4.52	D12 @ 250 4.52	D12 @ 250 4.52			
t/d	0	0	0			
M'/bd^2	12.02	7.68	3.05			
S/bd	3.49	2.49	1.36			
n.P	0.0965	0.0649	0.0877			
C	6.27	7.25	6.40			
S	11.70	17.66	12.82			
Z	1.13	1.11	1.13			
σ_c	75	56	20			
σ_s	2111	2034	586			
τ	3.4	2.8	1.5			
σ_{ca}	83	83	83			
σ_{sa}	2346	2346	2346			
τ_a	3.47	3.47	3.47			



(moment)



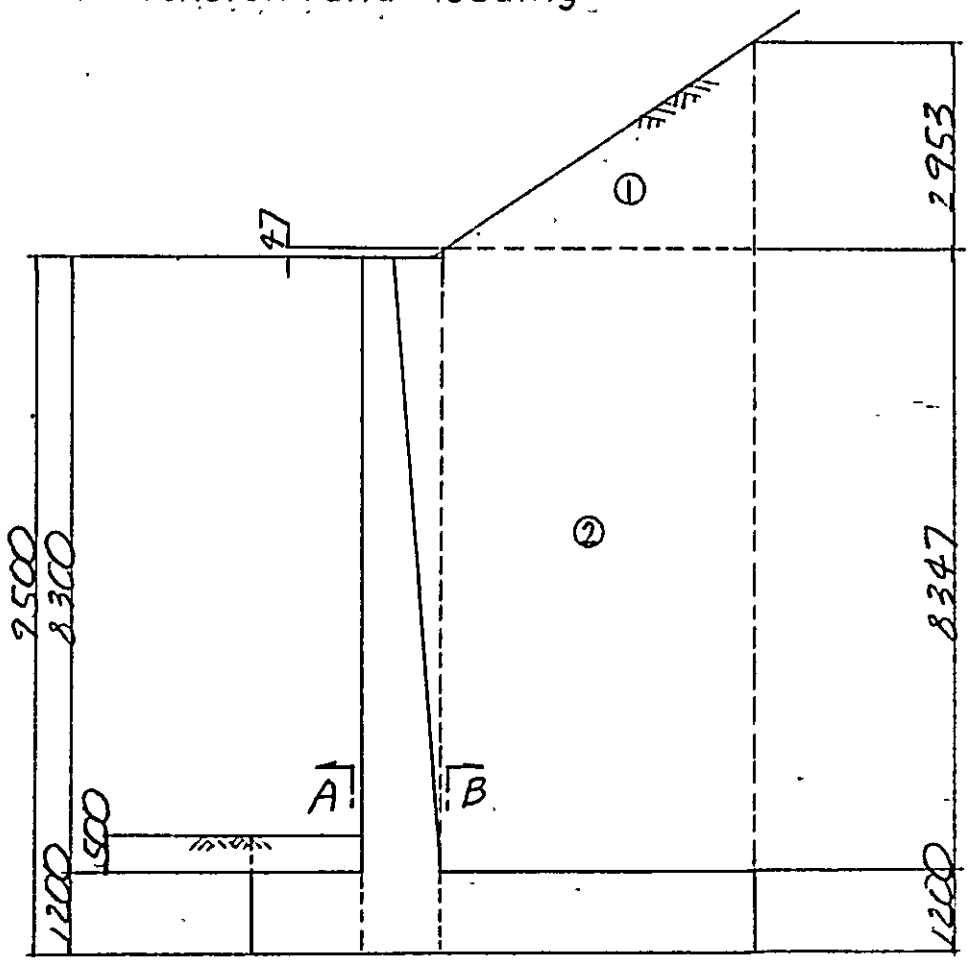
(As)

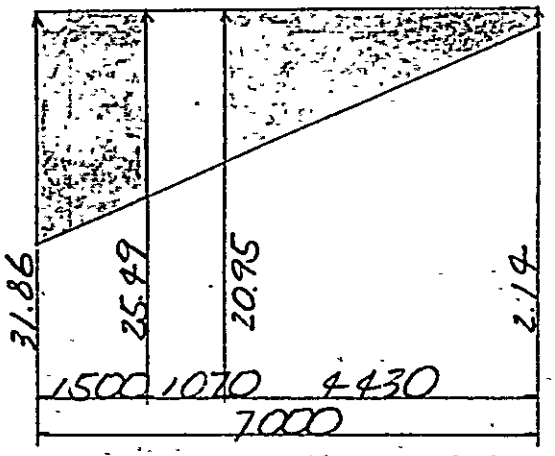


$$As = \frac{M}{\sigma sa \cdot j \cdot d} \qquad \sigma sa = 2346\ kg/cm^2 \qquad j = 0.875$$

§ 5 CALCULATION OF FOOTING SECTION

5 - 1 dimenston and loading





5-2 sectional force of footing

section A - A

		S (t)	x (m)	S·x (tm)
W	1.10 × 1.50 × 2.41	3.98	0.75	2.99
Wt	0.50 × 1.50 × 1.9	1.43	0.75	1.07
q	½ × (25.49 + 31.86) × 1.50	-43.01	0.778	-33.46
TOTAL		37.60		29.40

section B - B

			S (t)	x (m)	S·x (tm)
W		1.10 × 4.43 × 2.41	11.74	2.215	26.00
Ws	①	½ × 4.43 × 2.953 × 1.9	12.43	3.023	37.58
	②	4.43 × 8.447 × 1.9	71.10	2.215	157.49
q		½ × (2.14 + 20.95) × 4.43	-51.14	1.614	-82.54
TOTAL			44.13		138.53

5 - 3 list of stresses $\sigma c . \sigma s . \tau$: working stress .

$\sigma ca, \sigma sa, \tau a$: Permissible stress.

	A - A	B - B				
M	29.40	138.53				
N	—	—				
S	37.60	44.13				
b	100	100				
h	110	110				
d'	10	10				
As	D16 > d 125 D20 20.60	D32 @ 125 64.32				
As'	—	—				
f/d	—	—				
M'/bd²	2.43	11.45				
S/bd	3.42	4.01				
n.P	0.0268	0.0877				
C	10.42	6.63				
S	40.18	12 86				
Z	1.07	1.13				
σc	25	76				
σs	1464	2208				
τ	3.4	4.0				
σca	83	83				
σsa	2346	2346				
τa	2.35	3.47				

Check for stirrups

Sect. A-A.

$$\tau = \frac{S}{b \cdot d} \cdot Z = \frac{37.60 \times 10^3}{100 \times 110} \times 1.07 = 3.66 \ kg/cm^2 < \tau_a = 2.35 \ kg/cm^2$$

$S' = S - S_c$

$$S_c = \tau_a \cdot b \cdot d \cdot 1/Z = 2.35 \times 100 \times 110 \times 1/1.07 = 24.16 \times 10^3 \ kg$$

$$S' = (37.60 - 24.16) \times 10^3 = 13.44 \times 10^3 \ kg$$

$$\text{Req } A_v = \frac{S' \times a}{\sigma_{sa} \cdot d} \times Z = \frac{13.44 \times 10^3 \times 50}{1780 \times 110} \times 1.07 = 3.67 \ cm^2$$

Used $A_v = \phi 16 - c.t.c. \ 500^{mm}$ $n = 2$

$A_s = 2.01 \times 2 = 4.02 \ cm^2 > \text{Req } A_v = 3.67$

Sect. B-B.

$$\tau = \frac{S}{b \cdot d} Z = \frac{44.13 \times 10^3}{100 \times 110} \times 1.13 = 4.53 \ kg/cm^2 < 3.47 \ kg/cm^2$$

$S' = S - S_c$

$$S_c = \tau_a \cdot b \cdot d \cdot 1/Z = 3.47 \times 100 \times 110 \times 1/1.13 = 33.78 \times 10^3 \ kg$$

$$S' = (44.13 - 33.78) \times 10^3 = 10.35 \times 10^3 \ kg$$

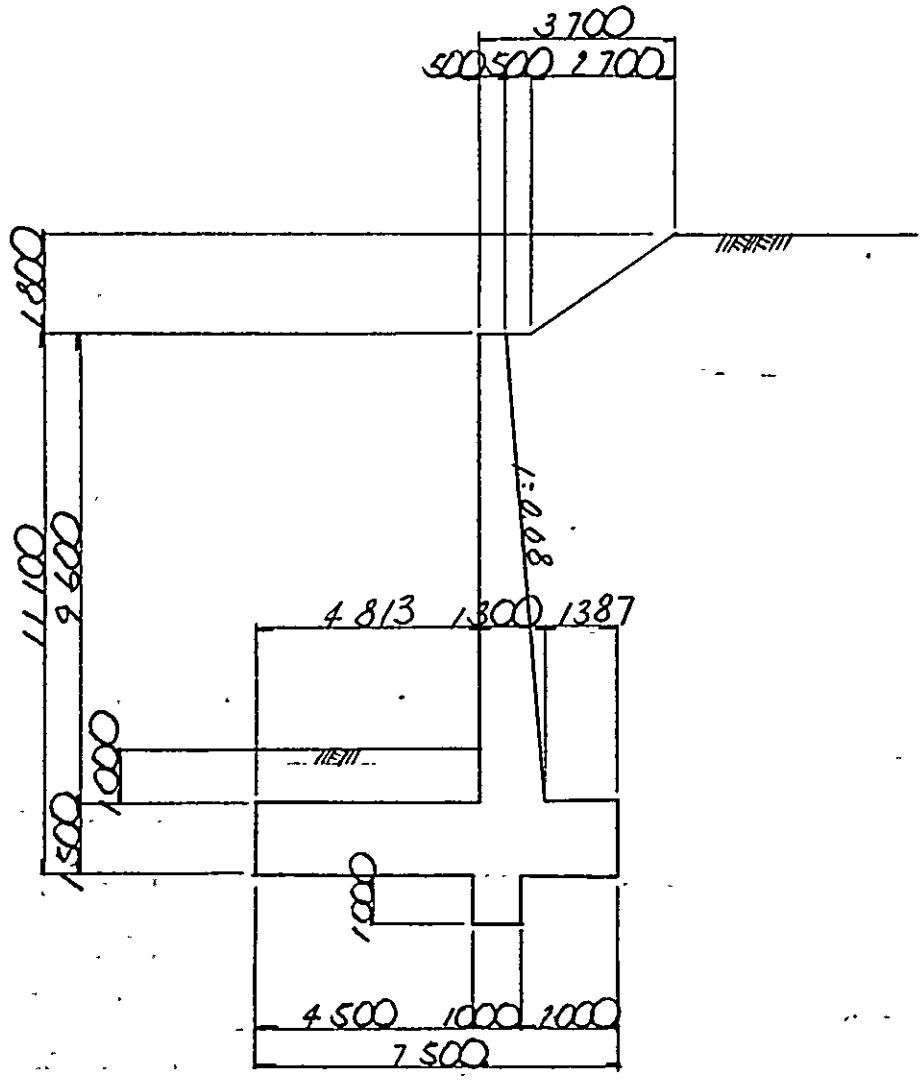
$$\text{Req } A_v = \frac{S' \times a}{\sigma_{sa} \cdot d} \times Z = \frac{10.35 \times 10^3 \times 50}{1780 \times 110} \times 1.13 = 3.0 \ cm^2$$

Used $A_s = \phi 16 - c.t.c. \ 500$ $n = 2$

$A_s = 4.02 \ cm^2 > \text{Req } A_s = 3.00 \ cm^2$

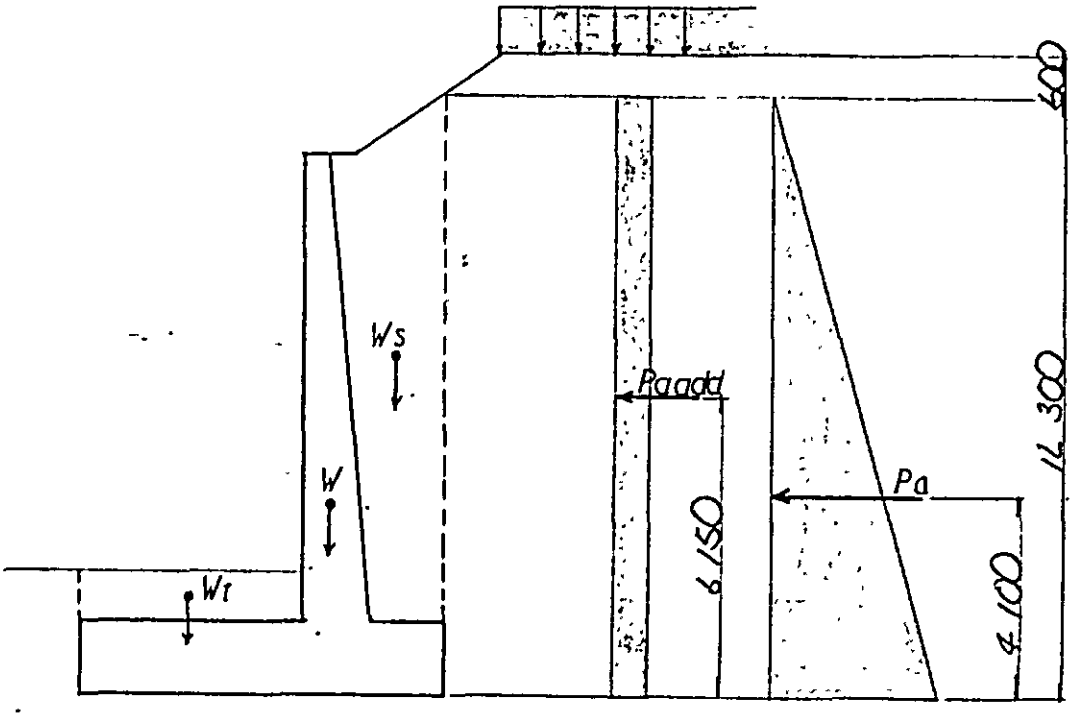
§§ 5 $H = 11.10^{m}$

§ 1. STRUCTURAL FIGURE



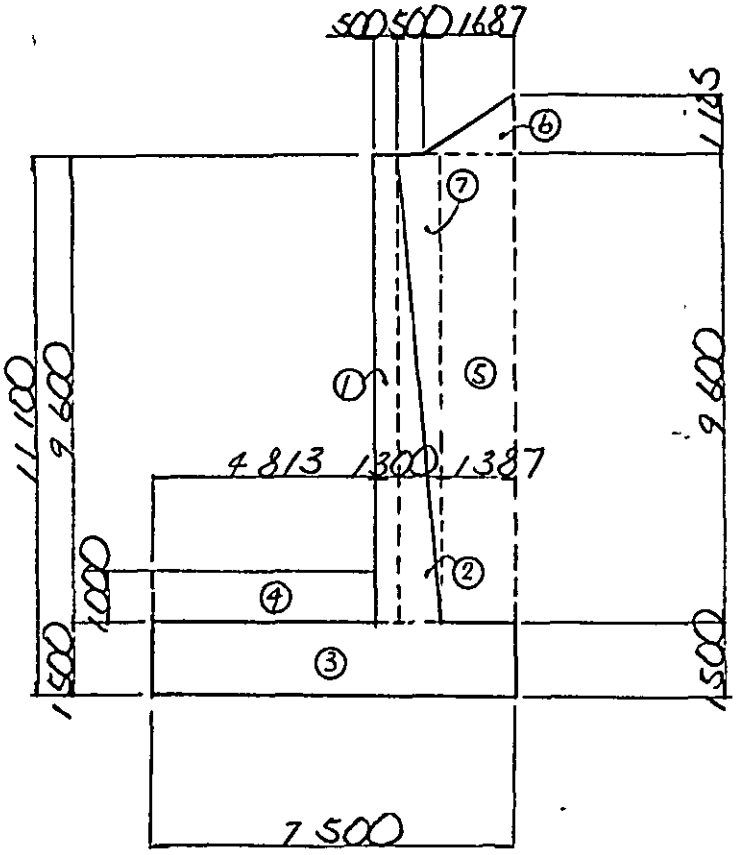
§ 2. CALCULATION OF LOAD

2-1 loading diagram



W : self weight
Ws : weight of soil
Wt : fill on toe
Ws add : weight of surcharge
P_A : active pressure
P_A add : surcharge

2-2 self weight & weight of soil

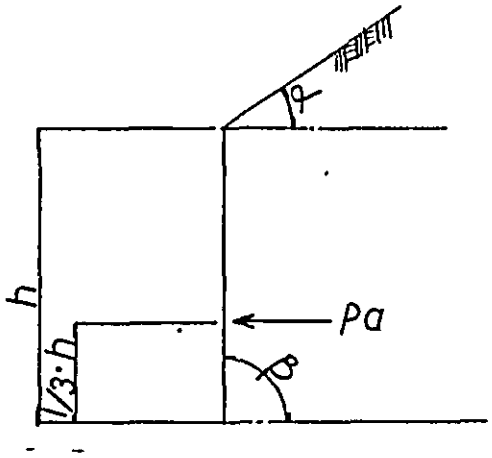


		N (t)	x (m)	N·x (tm)
①	0.50×7.60×2.41	11.57	5.063	58.57
②	½×0.80×9.60×2.41	9.15	5.580	51.64
③	7.50×1.50×2.41	27.11	3.750	101.67
④	4.813×1.00×1.9	9.14	2.407	22.01
⑤	1.387×9.60×1.9	15.30	6.807	172.21
⑥	½×1.687×1.125×1.9	1.80	6.938	12.59
⑦	½×0.80×9.60×1.9	7.30	5.846	42.65
Σ		91.47		461.34

2-3 earth pressure

unit weight of soil $\gamma s = 1.9$

angle of internal friction $\phi = 35°$



$$K = \left(\frac{\cos\phi}{a+1}\right)^2$$

$$a = \sqrt{\sin\phi - 1/2 \tan\alpha \cdot \sin 2\phi}$$

$$a = \sqrt{\sin 35°^2 - 1/2 \times \tan 0 \times \sin 2 \times 35°}$$

$$= \sqrt{0.573^2 - 1/2 \times 0 \times 2 \times 0.9396}$$

$$= 0.573$$

$$K = \left(\frac{\cos 35°}{0.573 + 1}\right)^2$$

$$= \left(\frac{0.819}{\quad}\right)^2$$

$$= 0.271$$

(1) active pressure

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

$$= 1/2 \times 0.271 \times 1.9 \times 12.30^2 = 38.95 \ t/m$$

$$y = 1/3 \times 12.30 = 4.100 \ m$$

(2) active pressure due to surcharge

under H.A surcharge

$$q = 0.60 \times 1.9 + 1.02 = 1.16 \ t/m^2$$

$$q_h = q \cdot K \cdot H$$

$$= 1.16 \times 0.271 \times 12.30 = 3.87 \ t/m$$

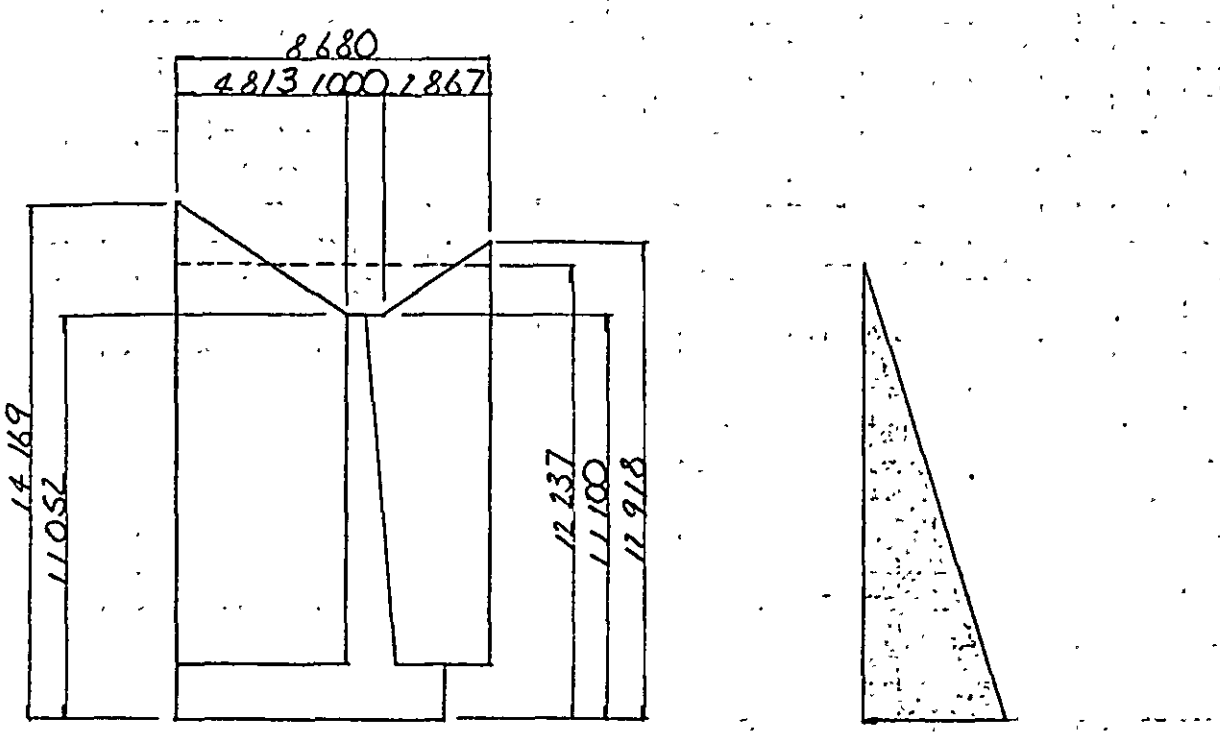
$$y = 1/2 \times 12.30 = 6.150 \ m$$

2-4 weight of surcharge

under H.A $q = 1.02 \ t/m^2$

$x = 0 \ m$

2-5 active pressure of longitudinal direction



$$h' = \frac{\frac{1}{2}\times(11.052+14.169)\times 4.813 + 11.100\times 1.00 + \frac{1}{2}\times(11.100+12.918)\times 2.867}{8.680}$$

$$= 12.237^{m}$$

$$Pa = \frac{1}{2}\times 1.9\times 0.27\times 12.237^{2} \qquad = 38.41\ ^{t/m}$$

$$M = 38.41\times 12.237\times \frac{1}{3} \qquad = 156.67\ ^{t\cdot m/m}$$

§ 3 CALCULATION OF STABILITY

	N (t)	x (m)	N·x (tm)	H (t)	y (m)	H·y (tm)
W. Ws. Wt	91.47	——	461.34	——	——	——
Ws·add	——	——	——	——	——	——
Pa	——	——	——	38.95	4.100	159.70
Pa·add	——	——	——	3.87	6.150	23.80
TOTAL	91.47		461.34	42.82		183.50

1) check for eccentric

$$x = \frac{Nx + Hy}{\Sigma N} = \frac{461.34 - 183.50}{91.47} = 3.04 \ m$$

$$e = \frac{B}{2} - x = \frac{7.500}{2} - 3.04 = 0.71 \ m$$

2) soil reaction $< \frac{B}{6} = 1.25$ m

$$q = \frac{\Sigma N}{B}\left(1 \pm \frac{6 \cdot e}{B}\right) \pm \frac{6M}{L^2}$$

$$= \frac{91.47}{7.50} \times \left(1 \pm \frac{6 \times 0.71}{7.50}\right) \pm \frac{6 \times 156.67}{11.50^2}$$

$$= \begin{cases} 26.23 \ t/m^2 \\ -1.84 \end{cases} < 60.00 \ t/m^2$$

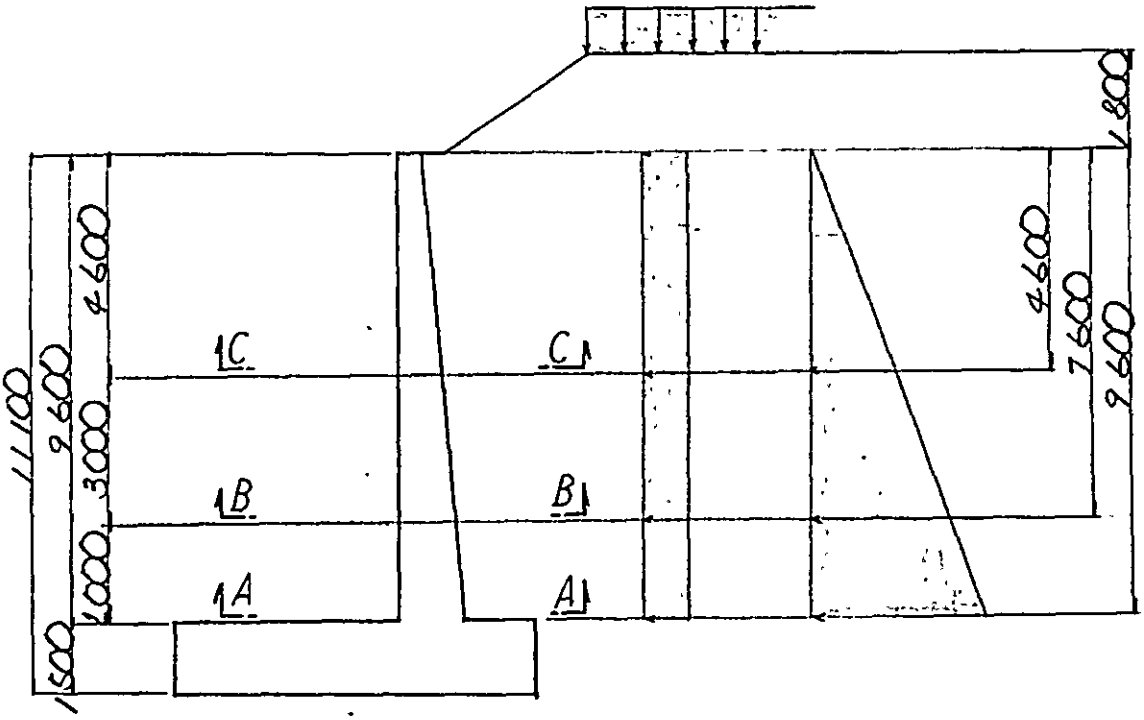
3) check for sliding

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

$$F = \frac{Hu}{H} = \frac{91.47 \times 0.6}{42.82} = 1.28 < 1.5$$

§ 4 CALCULATION OF WALL SECTION

4 - 1 dimension and loading



$$q = q_{HA} + \gamma_s \cdot h$$
$$= 1.02 + 1.9 \times 1.80 = 3.49 \ t/m^2$$

$$Pa\,add = q \cdot K \cdot Hx$$
$$= 3.49 \times 0.27 \times Hx = 0.942 \cdot Hx \ t/m$$

$$Pa = \frac{1}{2} \cdot \gamma_s \cdot K \cdot Hx^2$$
$$= \frac{1}{2} \times 1.9 \times 0.27 \times Hx^2 = 0.257 \cdot Hx^2 \ t/m$$

4-2 sectional force of wal

section A-A

		H (t)	y (m)	H·y (t·m)
Pa	0.942×9.60	9.04	4.800	43.41
Pa add	0.257×9.60^2	23.68	3.200	75.79
TOTAL		32.72		119.20

section B-B

		H (t)	y (m)	H·y (tm)
Pa	0.942×7.60	7.16	3.800	27.20
Pa add	0.257×7.60^2	14.84	2.533	37.60
TOTAL		22.00		64.80

section C-C

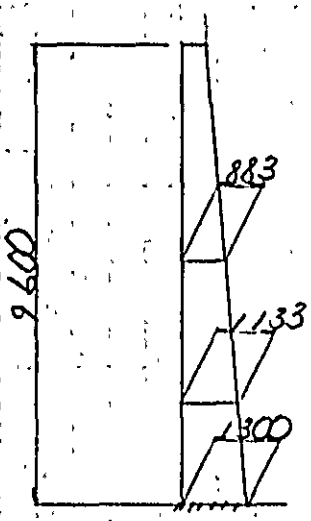
		H (t)	y (m)	H·y (tm)
Pa	0.942×4.60	4.33	2.300	9.97
Pa add	0.257×4.60^2	5.44	1.533	8.34
TOTAL		9.77		18.31

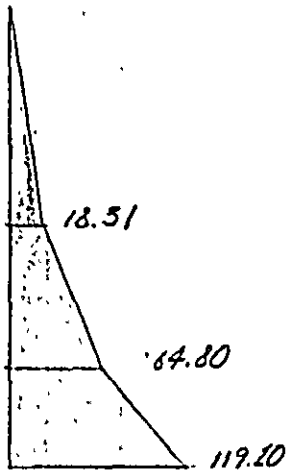
4 - 3 list of stresses . σc . σs . τ : working stress .

σca, σsa, τa : Permissible stress.

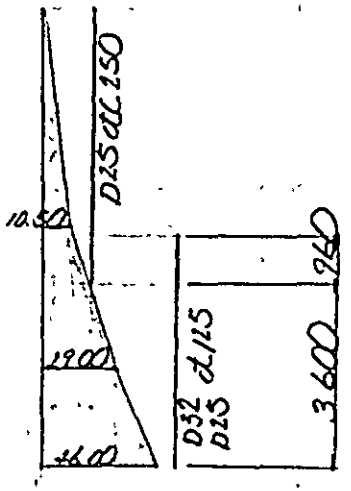
	A - A	B - B	C - C			
M	119.20	64.80	18.31			
N	—	—	—			
S	32.72	22.00	9.77			
b	100	100	100			
h	123	104	80			
d'	7	7	7			
As	D32 D25 dt125 51.80	D32 D25 dt125 51.80	D25 dt150 19.64			
As'	D12 dt250 4.52	——→	——→			
f/d	0	0	0			
M'/bd²	7.88	5.99	2.86			
S/bd	2.66	2.12	1.22			
n·P	0.0407	0.0747	0.0368			
C	7.29	6.85	8.87			
S	17.52	14.93	19.42			
Z	1.11	1.12	1.09			
σc	57	41	25			
σs	2070	1341	1263			
τ	2.9	2.3	1.3			
σca	83	——→	——→			
σsa	2364	——→	——→			
τa	3.47	3.47	2.35			

(moment)





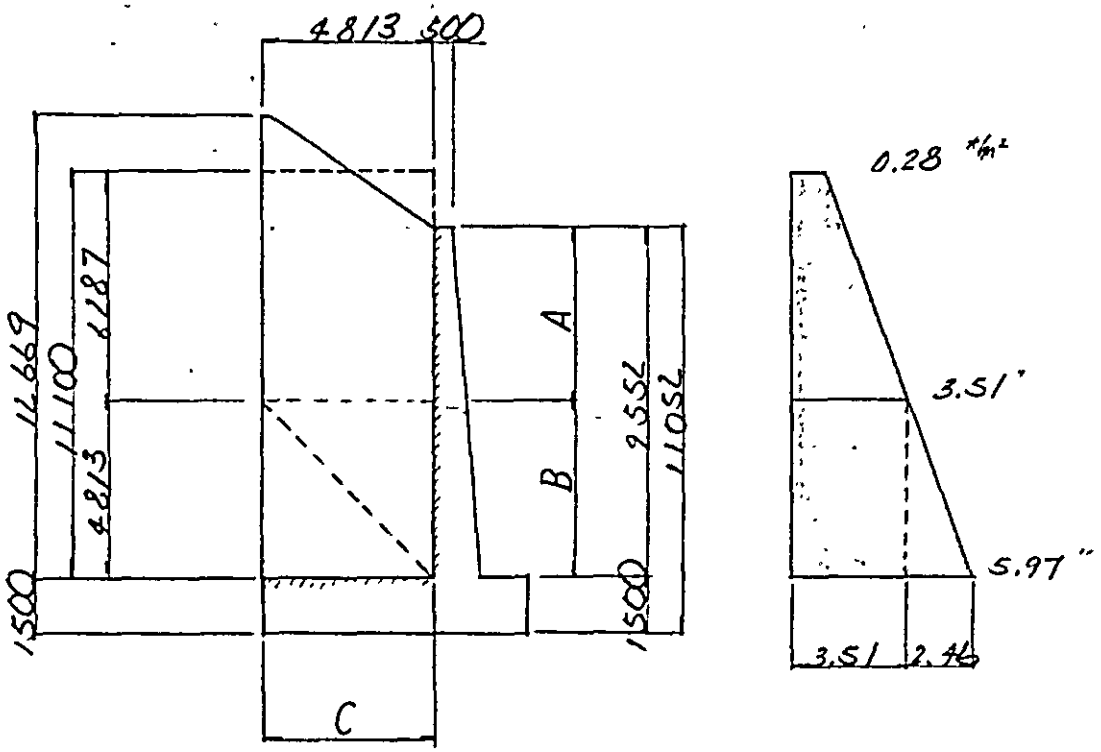
(As)



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

$\sigma_{sa} = 2346$ kg/cm² $j = 0.875$

4-4 dimension and loading



$q_1 = 1.02 \times 0.27 = 0.28$ t/m²

$q_2 = 1.9 \times 0.27 \times 6.287 + 0.28 = 3.51$ "

$q_3 = 1.9 \times 0.27 \times 11.10 + 0.28 = 5.97$ "

4 - 5 sectional force of wall

$$M_A = 1/2 \times 3.51 \times 4.813^2 = 40.65 \ t\cdot m$$

$$S_A = 3.51 \times 4.813 = 16.89 \ t$$

$$M_B = \frac{1/2 \times (3.51 + 5.97)}{2} \times (4.813 \times 1/2)^2 = 13.73 \ t\cdot m$$

$$S_B = 1/2 \times (3.51 + 5.97) \times 4.813 \times 1/2 = 11.41 \ t$$

$$M_C = \left(\frac{3.51}{2} + \frac{2.46}{6} \right) \times (4.813 \times 1/2)^2 = 12.54 \ t\cdot m$$

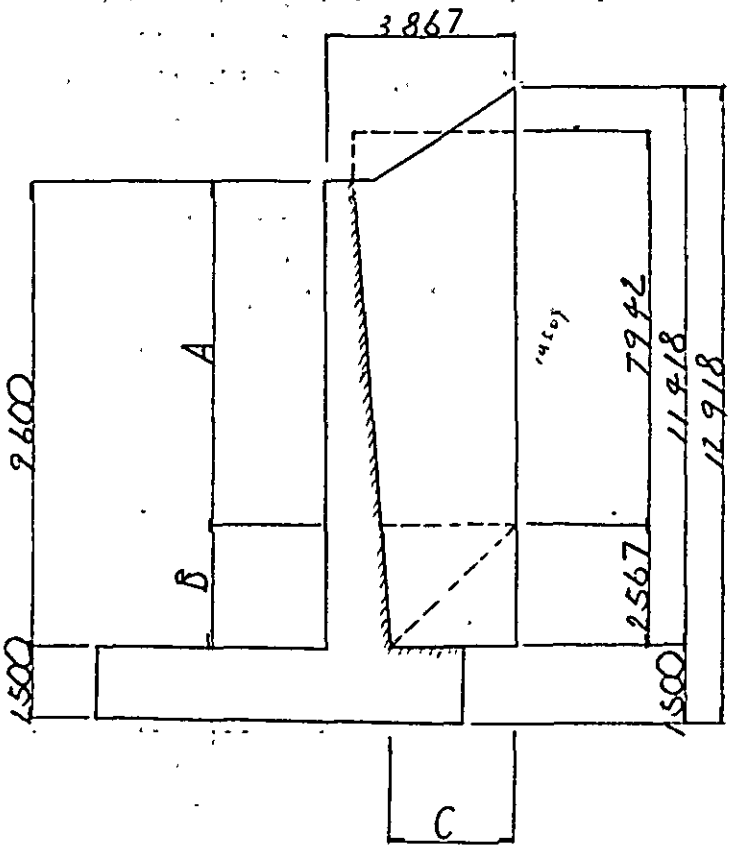
$$S_C = \left(3.51 + \frac{2.46}{2} \right) \times 4.813 \times 1/2 = 11.41 \ t$$

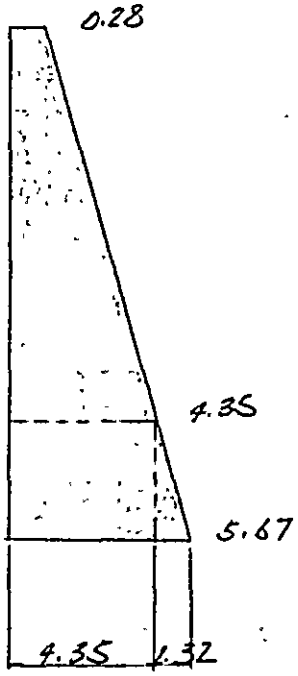
4 - 6 list of stresses $\sigma c, \sigma s, \tau$: working stress.

$\sigma ca, \sigma sa, \tau a$: Permissible stress.

	A - A	B - B	C - C			
M	40.65	13.73	12.54			
N	———	———	———			
S	16.89	11.41	11.41			
b	100	100	100			
h	53	53	53			
d'	7	7	7			
As	D25 dc 125 39.28	D10 dc 150 12.56	D20 dc 250 12.56			
As'	D16 dc 250 8.04	D12 dc 250 4.52	——→			
f/d	0	0	0			
M'/bd²	14.47	4.89	4.46			
S/bd	3.19	2.15	2.15			
n.P	0.1112	0.0355	0.0355			
C	5.91	8.95	8.95			
S	10.23	30.99	30.99			
Z	1.15	1.09	1.09			
σc	81	44	40			
σs	2221	1236	2041			
τ	3.4	2.4	2.4			
σca	83	——→	——→			
σsa	2346	——→	——→			
τa	3.47	2.4	2.4			

4 - 7 . dimension and loading





$q_1 = 1.02 \times 0.27 = 0.28$ t/m²

$q_2 = 1.9 \times 7.942 \times 0.27 + 0.28 = 4.35$ "

$q_3 = 1.9 \times 10.509 \times 0.27 + 0.28 = 5.67$ "

4-8 sectional force of wall

$M_A = 1/2 \times 4.35 \times 2.967^2 = 19.15$ t·m

$S_A = 4.35 \times 2.967 = 12.91$ t

$M_B = \frac{1/2 \times (4.35 + 5.67)}{2} \times (2.967 \times 1/2)^2 = 5.51$ t·m

$S_B = 1/2 \times (4.35 + 5.67) \times (2.967 \times 1/2) = 7.43$ t

$M_C = \left(\frac{4.35}{2} + \frac{1.32}{6}\right) \times (2.967 \times 1/2)^2 = 5.27$ t·m

$S_C = \left(4.35 + \frac{1.32}{2}\right) \times 2.967 \times 1/2 = 7.43$ t

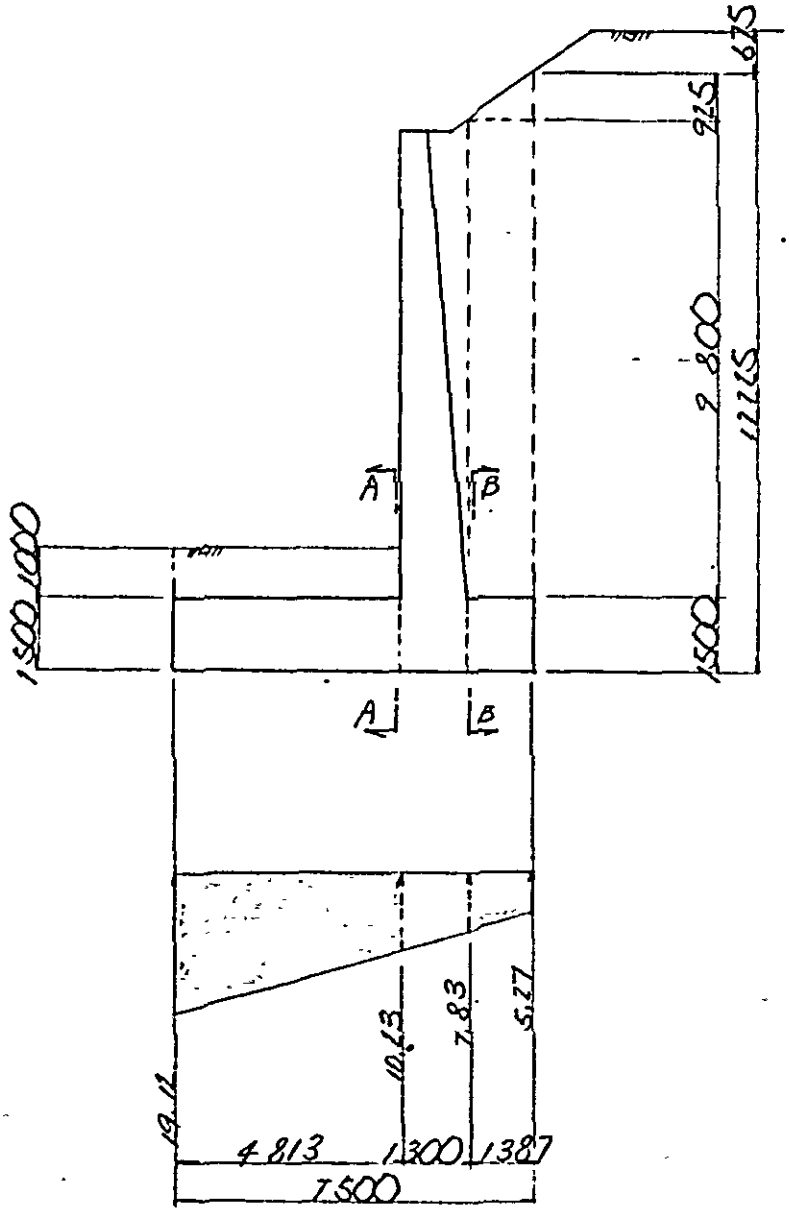
4 - 9 list of stresses $\sigma c . \sigma s . \tau$: working stress .

$\sigma ca, \sigma sa, \tau a$: permissible stress.

	A - A	B - B	C - C			
M	19.15	5.51	5.27			
N	———	———	———			
S	12.91	7.43	7.43			
b	100	——→	——→			
h	43	——→	——→			
d'	7	——→	——→			
As	D20 @c125 25.12	D16 @c250 8.04	——→			
As'	D12 @c250 4.52	——→	——→			
f/d	0	0	0			
M'/bd²	10.37	2.98	2.85			
S/bd	3.00	1.72	1.73			
n.P	0.0876	0.0280	0.0280			
C	6.38	9.87	9.87			
S	12.84	38.90	38.90			
Z	1.14	1.09	1.09			
σc	66	29	28			
σs	1995	1717	1642			
τ	3.4	1.9	1.9			
σca	83	——→	——→			
σsa	2.346	——→	——→			
τa	3.47	2.4	2.4			

§ 5 CALCULATION OF FOOTING SECTION

5 - 1 dimenston and loading



5 - 2 sectional force of footing

section A - A

		S (t)	x (m)	S·x (tm)
W	4.813 × 1.50 × 2.41	17.40	2.407	41.88
Wt	4.813 × 1.00 × 1.9	9.14	2.407	22.01
q	1/2 × (10.23 + 19.12) × 4.813	- 70.63	2.649	- 187.12
TOTAL		- 44.09		- 123.23

section B - B

			S (t)	x (m)	S·x (tm)
W		1.387 × 1.50 × 2.41	5.01	0.694	3.48
W s	①	1.387 × 9.80 × 1.9	25.83	0.694	17.93
	②	1/2 × 1.387 × 0.925 × 1.9	1.22	0.925	1.13
q		1/2 × (7.83 + 5.27) × 1.387	- 9.09	0.648	- 5.89
TOTAL			22.97		16.65

5 - 3. list of stresses $\sigma c, \sigma s, \tau$: working stress.

$\sigma ca, \sigma sa, \tau a$: Permissible stress.

	A - A	B - B				
M	123.23	16.65				
N	——	——				
S	44.09	22.97				
b	100	⟶				
h	140	⟶				
d'	10	⟶				
As	D32 D25 @125 51.80	D10 @125 25.12				
As'	D16 @250 ⋯ 8.04	D26 @250 19.64				
f/d	0	0				
M'/bd²	6.28	1.36				
S/bd	3.15	1.64				
n·P	0.0555	0.0086				
C	7.60	15.86				
S	19.89	121.36				
Z	1.11	1.06				
σc	48	22				
σs	1872	2311				
τ	3.4	1.7				
σca	83	83				
σsa	2346	2346				
τa	2.35	2.35				

Check for stirrups

Sect. A-A

$$\tau = \frac{S}{b \cdot d} \cdot Z = \frac{44.09 \times 10^3}{100 \times 140} \times 1.11 = 3.50 \ kg/cm^2 > \tau_a = 2.35$$

$$S' = S - Sc$$

$$Sc = \tau_a \cdot b \cdot d \cdot 1/Z = 2.35 \times 100 \times 140 \times 1/1.11 = 29.64 \times 10^3 \ kg$$

$$S' = (44.09 - 29.64) \times 10^3 = 14.45 \times 10^3 \ kg$$

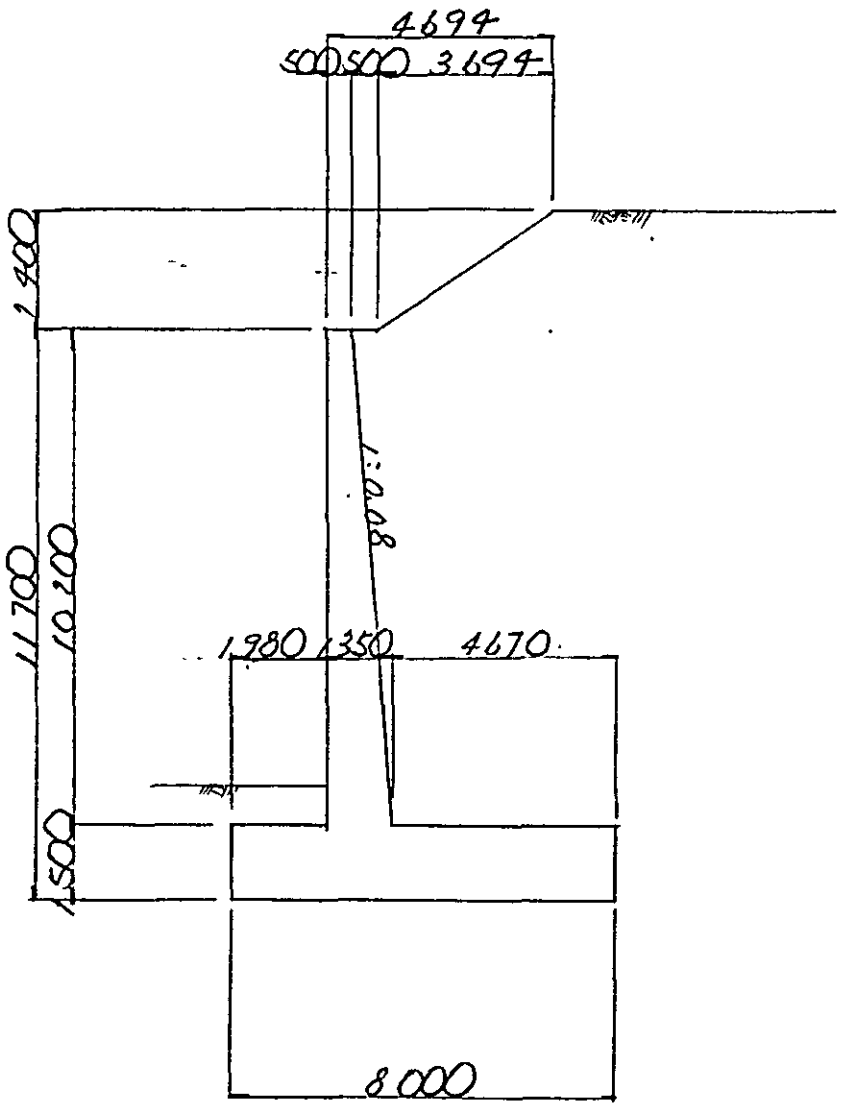
$$Req\ Av = \frac{S' \times a}{\sigma sa \cdot d} \times Z = \frac{14.45 \times 10^3 \times 50}{1780 \times 140} \times 1.11 = 3.2 \ cm^2$$

Used Av = Φ16 - c/c 500 n = 2

$$Av = 2.01 \times 2 = 4.02 \ cm^2 > Req\ Av = 3.2 \ cm^2$$

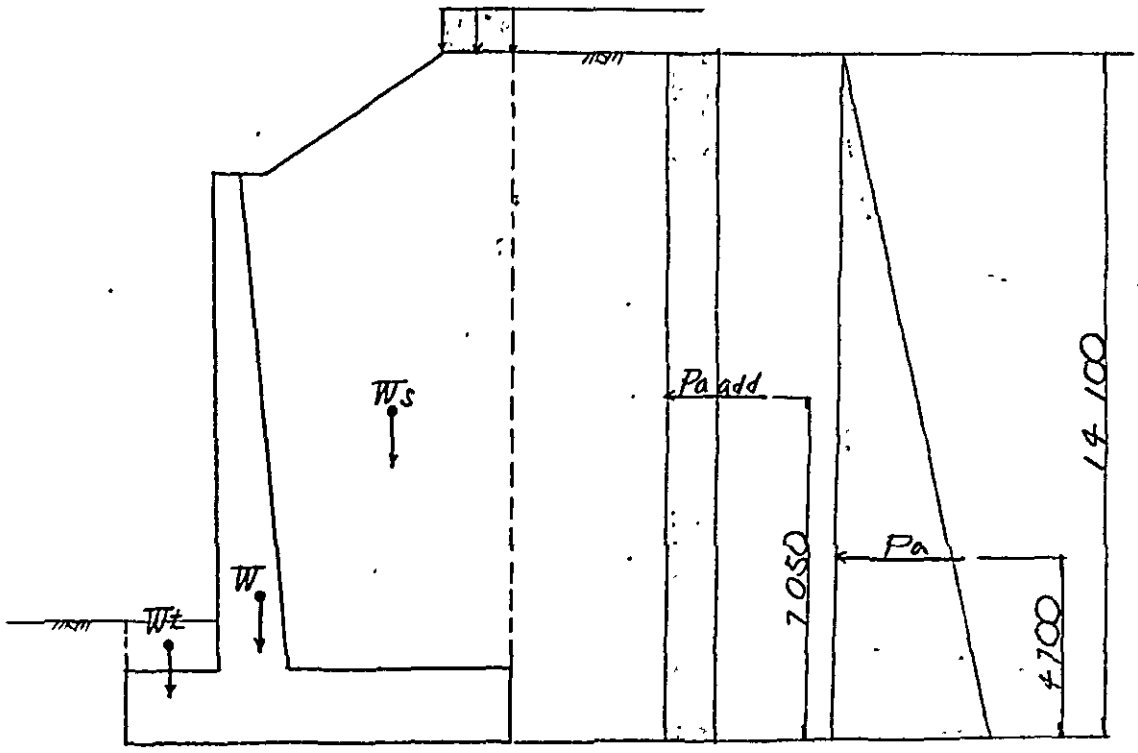
§§ 6 $H = 11.70$ m

§ 1. STRUCTURAL FIGURE



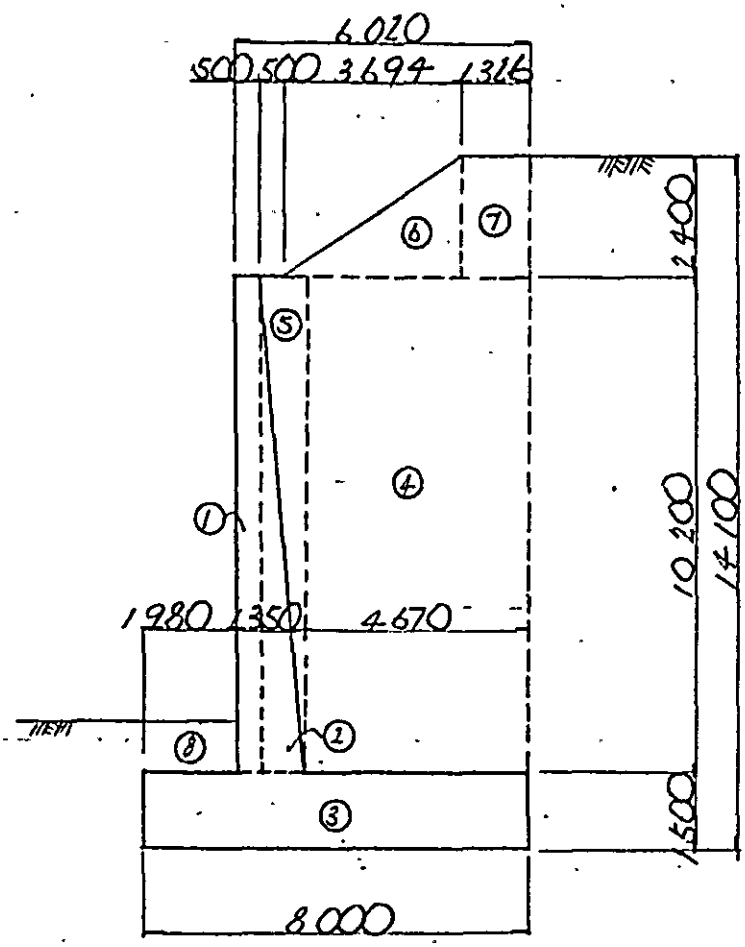
§ 2. CALCULATION OF LOAD

2-1 loading diagram



W : self weight
Ws : weight of soil
Wt : fill on toe
Ws add : weight of surcharge
P_A : active pressure
P_A add : surcharge

2-2 self weight & weight of soil

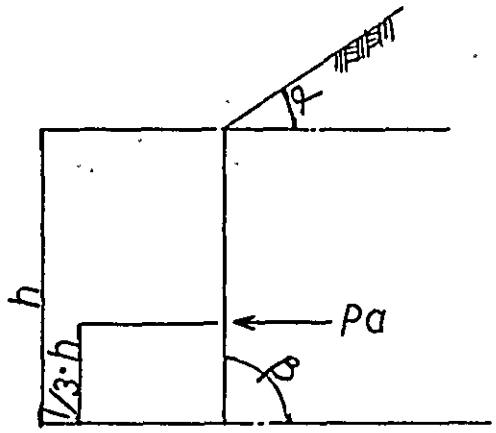


		N (t)	x (m)	N·x (tm)
①	0.50 × 10.20 × 2.41	12.29	2.230	27.41
②	1/2 × 0.82 × 10.20 × 2.41	10.08	2.753	27.75
③	8.00 × 1.50 × 2.41	28.92	4.000	115.68
④	4.70 × 10.20 × 1.9	91.09	5.650	514.66
⑤	1/2 × 0.82 × 10.20 × 1.9	7.95	3.027	24.06
⑥	1/2 × 3.694 × 2.40 × 1.9	8.42	5.443	45.83
⑦	1.326 × 2.40 × 1.9	6.05	7.337	44.39
⑧	1.98 × 1.00 × 1.9	3.76	0.990	3.72
Σ		168.56		803.50

2-3 earth pressure

unit weight of soil $\gamma s = 1.9$

angle of internal friction $\phi = 35°$



$$K = \left(\frac{\cos\phi}{a+1}\right)^2$$

$$a = \sqrt{\sin\phi - 1/2 \tan\alpha \cdot \sin 2\phi}$$

$$a = \sqrt{\sin 35^{\circ 2} - 1/2 \times \tan 0 \times \sin 2 \times 35^{\circ}}$$

$$= \sqrt{0.574 - 1/2 \times 0 \times 2 \times 0.9397}$$

$$= 0.574$$

$$K = \left(\frac{\cos 35^{\circ}}{0.574 + 1}\right)^2$$

$$= \left(\frac{0.819}{1.574}\right)^2$$

$$= 0.271$$

(1) active pressure

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

$$= 1/2 \times 0.27 \times 1.9 \times 14.10^2 = 50.99 \ t/m$$

$$y = 1/3 \times 14.10 = 4.700 \ m$$

(2) active pressure due to surcharge

under H.A surcharge

$$q = 1.02 \ t/m^2$$

$$q_h = q \cdot K \cdot H$$

$$= 1.02 \times 0.27 \times 14.10 = 3.88 \ t/m$$

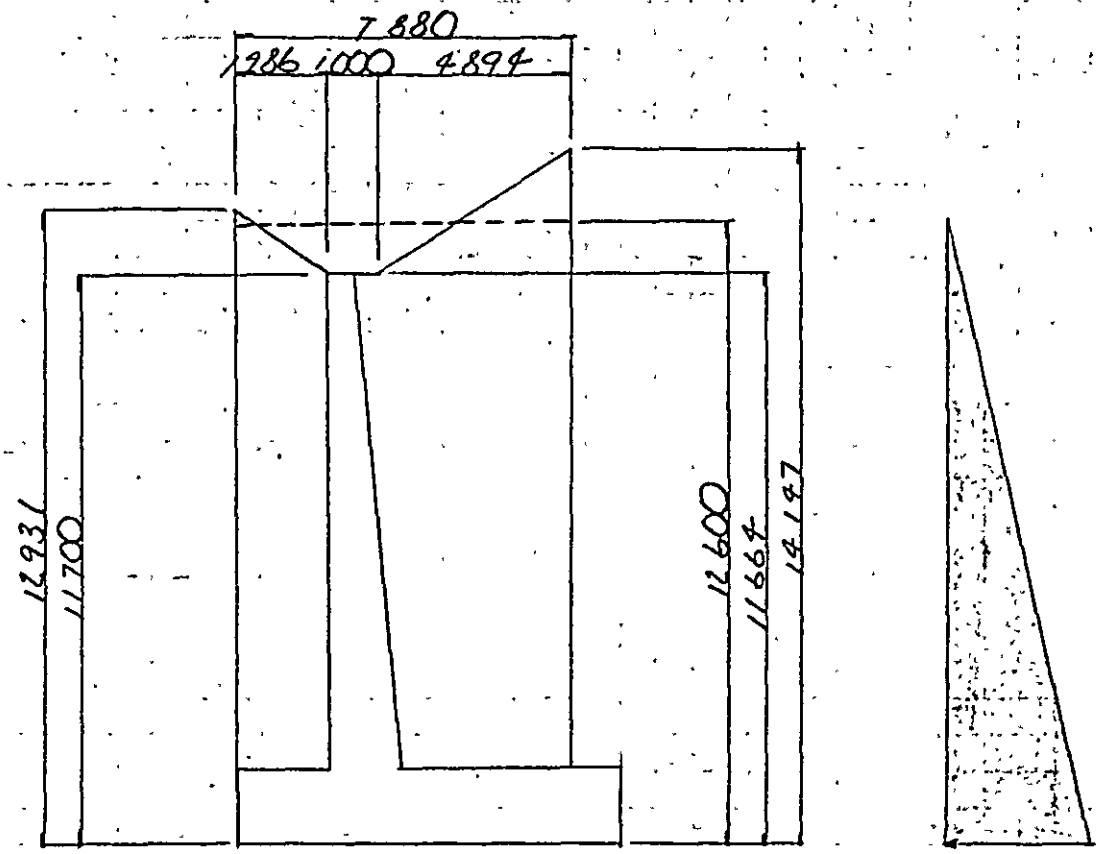
$$y = 1/2 \times 14.10 = 7.050 \ m$$

2-4 weight of surcharge

under H.A $q = 1.02 \ t/m^2$

$x = 1.326 \ m$

2-5 active pressure of longitudinal direction



$$h' = \frac{1/2 \times (12.931 + 11.700) \times 1.986 + 11.700 \times 1.00 + 1/2 \times (11.664 + 14.197) \times 4.894}{7.880}$$

$$= 12.60^{m}$$

$$Pa = 1/2 \times 1.9 \times 0.27 \times 12.60^{2} = 40.72^{t}$$

$$M = 40.72 \times 12.600 \times 1/3 = 171.02^{t\cdot m}$$

§ 3 CALCULATION OF STABILITY

	N (t)	x (m)	N·x (tm)	H (t)	y (m)	H·y (tm)
W. Ws. Wt	168.56	——	803.50	——	——	——
Ws·add	1.35	7.339	9.91	——	——	——
Pa	——	——	——	50.99	4.700	239.65
Pa·add	——	——	——	3.88	7.050	27.35
TOTAL	169.91		813.41	54.87		267.00

1) check for eccentric

$$x = \frac{Nx + Hy}{\Sigma N} = \frac{813.41 - 267.00}{169.91} = 3.216 \ ^{m}$$

$$e = \frac{B}{2} - x = \frac{8.00}{2} - 3.216 = 0.784 \ ^{m}$$

$$< \frac{B}{6} = 1.33 \ ^{m}$$

2) soil reaction

$$q = \frac{\Sigma N}{B}\left(1 \pm \frac{6 \cdot e}{B}\right) \pm \frac{6M}{L^2}$$

$$= \frac{169.91}{8.00} \times \left(1 \pm \frac{6 \times 0.784}{8.00}\right) \pm \frac{6 \times 171.02}{11.00^2}$$

$$= \begin{cases} 42.21 \ t/m^2 \\ 0.27 \ " \end{cases} < 60.00 \ t/m^2$$

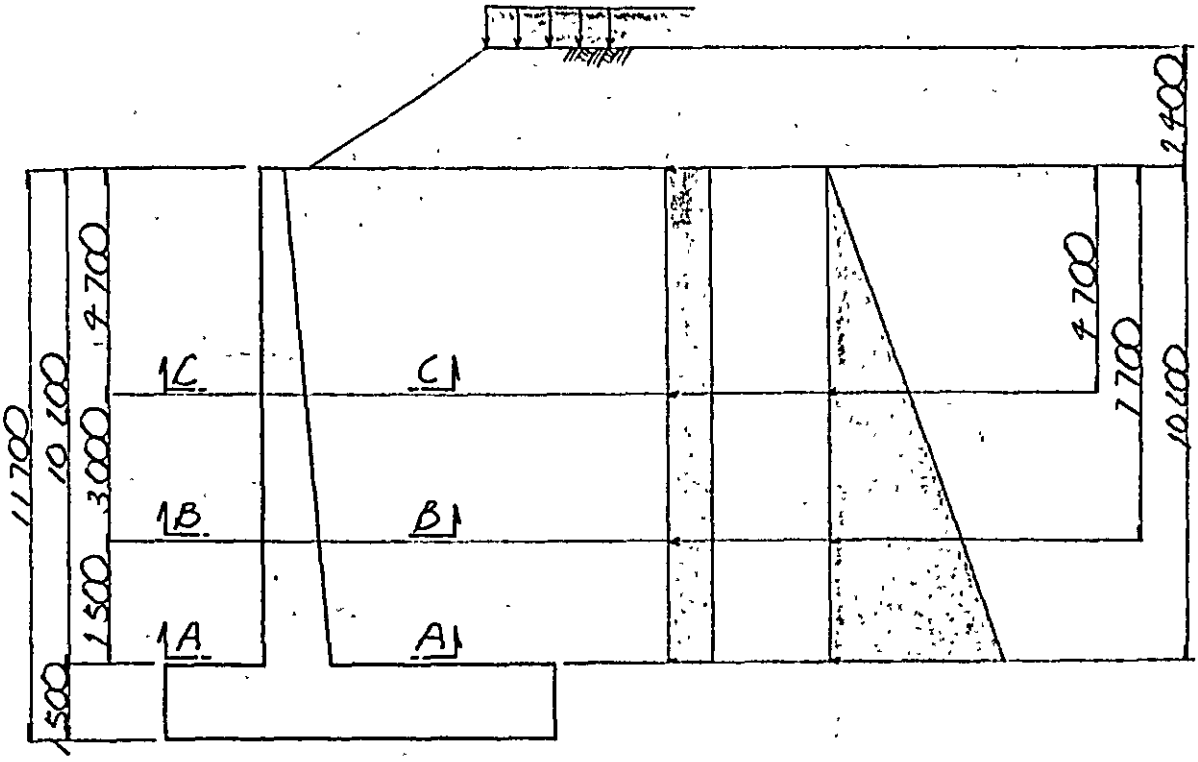
3) check for sliding

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

$$F = \frac{Hu}{H} = \frac{169.91 \times 0.6}{54.87} = 1.86 > 1.5$$

§ 4 CALCULATION OF WALL SECTION

4 - 1. dimension and loading



$$q = q_{HA} + \gamma_s \cdot h$$

$$= 1.02 + 1.9 \times 1.40 = 5.58 \ t/m^2$$

$$Pa_{add} = q \cdot K \cdot Hx$$

$$= 5.58 \times 0.27 \times Hx = 1.51 \cdot Hx \ t/m$$

$$Pa = 1/2 \cdot \gamma_s \cdot K \cdot Hx^2$$

$$= 1/2 \times 1.9 \times 0.27 \times Hx^2 = 0.257 \cdot Hx^2 \ t/m$$

4-2 sectional force of wal

section A-A

		H (t)	y (m)	H·y (t·m)
Pa	0.257×10.200^2	26.74	3.400	90.92
Pa add	1.51×10.200	15.40	5.100	78.54
TOTAL		42.14		169.46

section B-B

		H (t)	y (m)	H·y (t·m)
Pa	0.257×7.70^2	15.24	2.567	39.11
Pa add	1.51×7.70	11.63	3.850	44.76
TOTAL		26.87		83.87

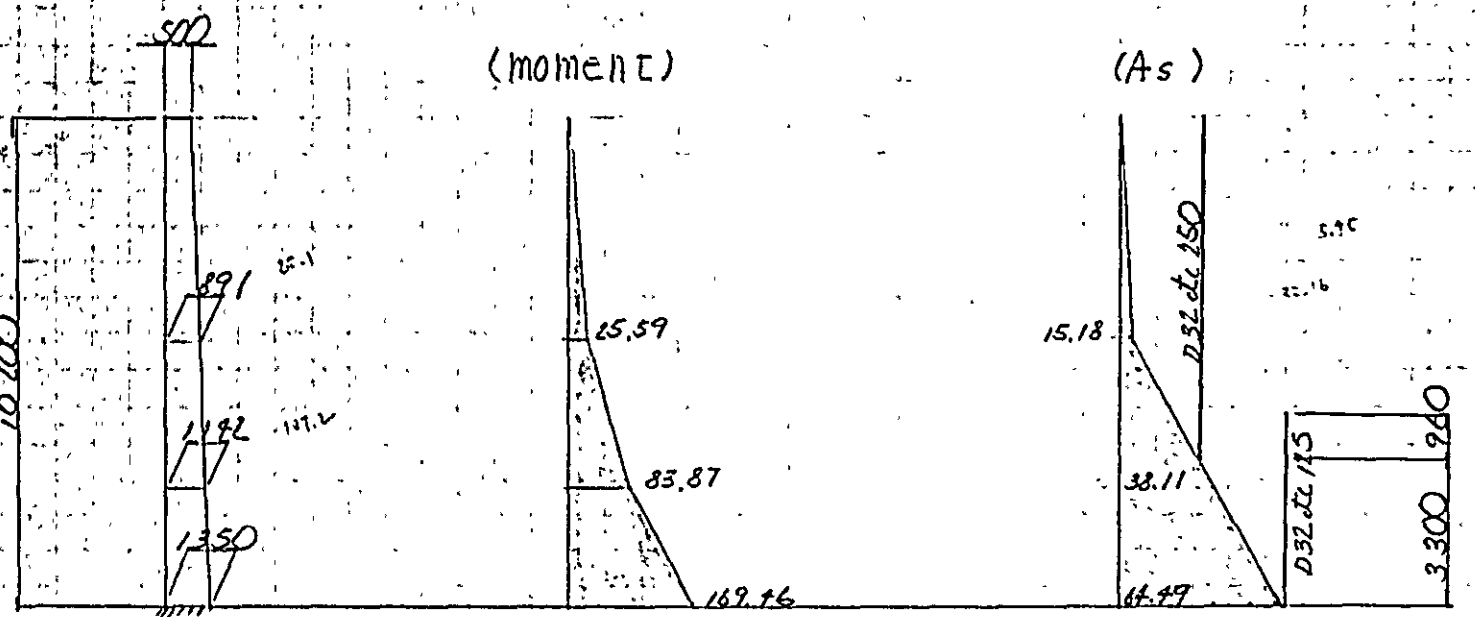
section C-C

		H (t)	y (m)	H·y (t·m)
Pa	0.257×4.70^2	5.68	1.567	8.90
Pa add	1.51×4.70	7.10	2.350	16.69
TOTAL		12.78		25.59

4-3 list of stresses $\sigma c, \sigma s, \tau$: working stress.

$\sigma ca, \sigma sa, \tau a$: Permissible stress.

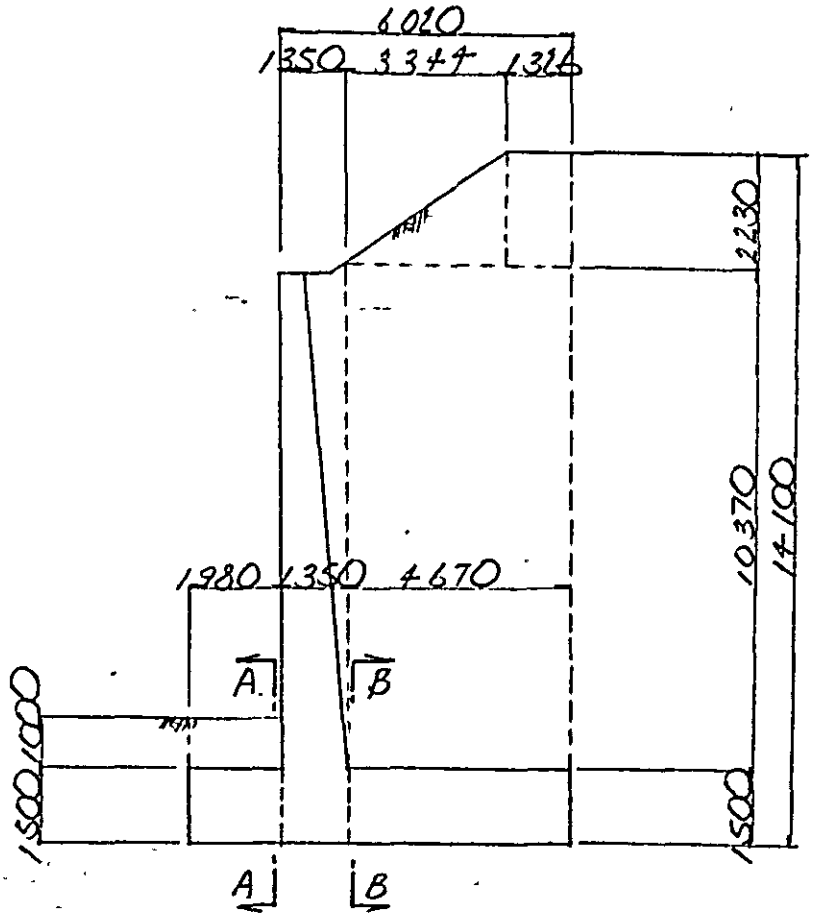
	A - A	B - B	C - C			
M	169.46	83.87	25.59			
N	———	———	———			
S	42.14	26.87	12.78			
b	100	100	100			
h	128	107	82			
d'	7	7	7			
As	D32 dc 125 64.32	D32 dc 125 64.32	D32 dc 250 41.08			
As'	D12 dc 250 4.52	———	——→			
f/d	0	0	0			
M'/bd^2	10.34	7.33	3.81			
S/bd	3.29	2.51	1.56			
n·P	0.0754	0.0902	0.0751			
C	6.85	6.42	6.80			
S	14.80	12.98	14.84			
Z	1.12	1.13	1.12			
σc	71	47	26			
σs	2296	1371	847			
τ	3.3	2.8	1.7			
σca	83	———→	———→			
σsa	2346	———→	———→			
τa	3.47	3.47	3.47			

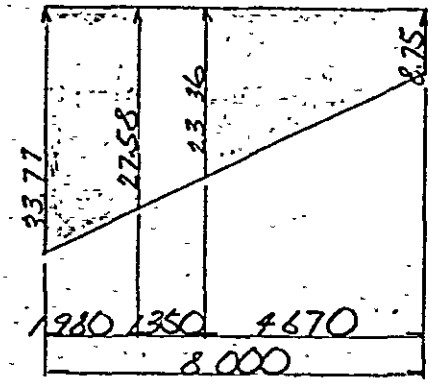


$$A_s = \frac{M}{\sigma_{sa} \cdot j \cdot d} \qquad \sigma_{sa} = 2346 \ kg/cm^2 \qquad j = 0.875$$

§ 5 CALCULATION OF FOOTING SECTION

5 - 1 dimenston and loading





5-2 sectional force of footing

section A - A

		S (t)	x (m)	S·x (tm)
W	1.98 × 1.50 × 2.41	7.16	0.990	7.09
Wt	1.98 × 1.00 × 1.9	3.76	0.990	3.72
q	1/2 × (33.77 + 27.58) × 1.98	- 60.74	1.023	- 62.13
TOTAL		49.82		51.32

section B - B

			S (t)	x (m)	S·x (tm)
W		4.67 × 1.50 × 2.41	16.88	2.335	39.41
Ws	①	4.67 × 10.37 × 1.9	92.01	2.335	214.84
	②	1.326 × 2.23 × 1.9	5.62	4.007	22.52
	③	1/2 × 3.344 × 2.23 × 1.9	7.08	2.129	15.78
Ws add		1.02 × 1.326	1.35	4.007	5.41
q		- 1/2 × (23.36 + 8.75) × 4.67	- 74.98	1.981	- 148.54
TOTAL			47.96		149.42

5-3 list of stresses $\sigma c, \sigma s, \tau$: working stress.

$\sigma ca, \sigma sa, \tau a$: Permissible stress.

	A-A	B-B				
M	51.32	149.42				
N	——	——				
S	49.82	47.96				
b	100	⟶				
h	140	⟶				
d'	10	⟶				
As	D20 dc 125 15.12	D32 D25 > dc 125 51.80				
As'	D 25 dc 250 19.64	D20 dc 250 12.56				
f/d	0	0				
M'/bd^2	2.62	7.62				
S/bd	3.56	3.43				
n·P	0.0269	0.0555				
C	9.65	7.98				
S	39.78	19.81				
Z	1.08	1.11				
σc	25	57				
σs	1563	2266				
τ	3.5	3.4				
σca	83	83				
σsa	2346	⟶				
τa	2.35	3.47				

Check for stirrups

Sect. A-A

$$\tau = \frac{S}{b \cdot d} \times Z = \frac{49.82 \times 10^3}{100 \times 140} \times 1.08 = 3.84 \ kg/cm^2 > \tau_a = 2.35 \ kg/cm^2$$

$$S' = S - Sc$$

$$Sc = \tau_a \cdot b \cdot d \cdot 1/Z = 2.35 \times 100 \times 140 \times 1/1.08 = 31.36 \times 10^3 \ kg$$

$$S' = (49.82 - 31.36) \times 10^3 = 18.46 \times 10^2 \ kg$$

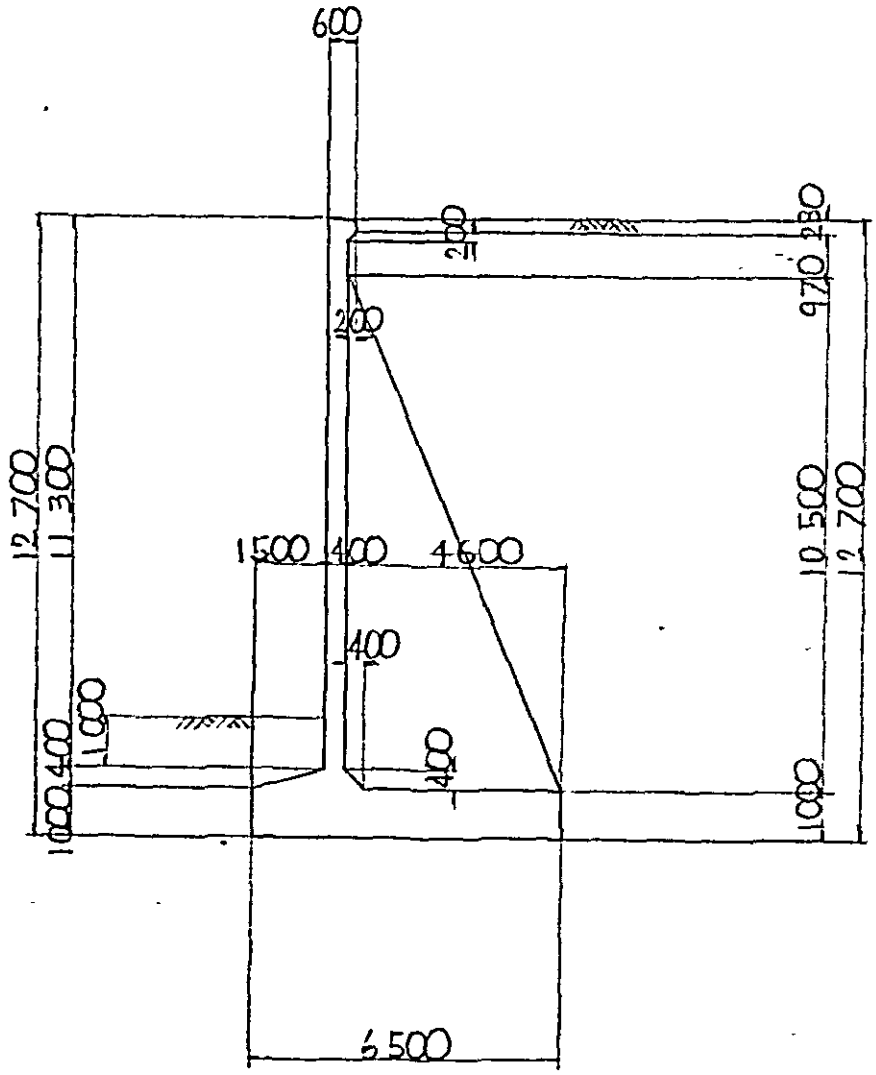
$$\text{Req } Av = \frac{S' \times a}{\sigma_{sa} \cdot d} Z = \frac{18.46 \times 10^3 \times 50}{1780 \times 140} \times 1.08 = 4.0 \ cm^2$$

Used $Av = \phi 16$ - ctc 500 $n = 2$

$$Av = 2.01 \times 2 = 4.02 \ cm^2 > \text{Req } Av = 4.0 \ cm^2$$

§§ 7 $H = 12.70$ m

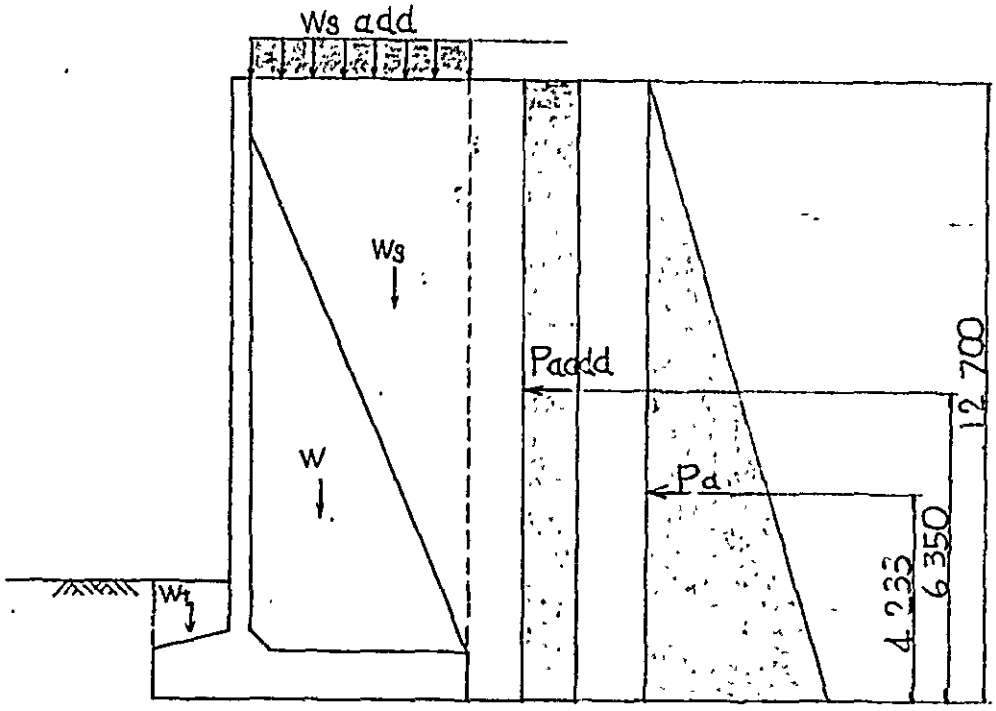
§ 1 STRUCTURAL FIGURE



buttress span $l = 3.50^{m}$

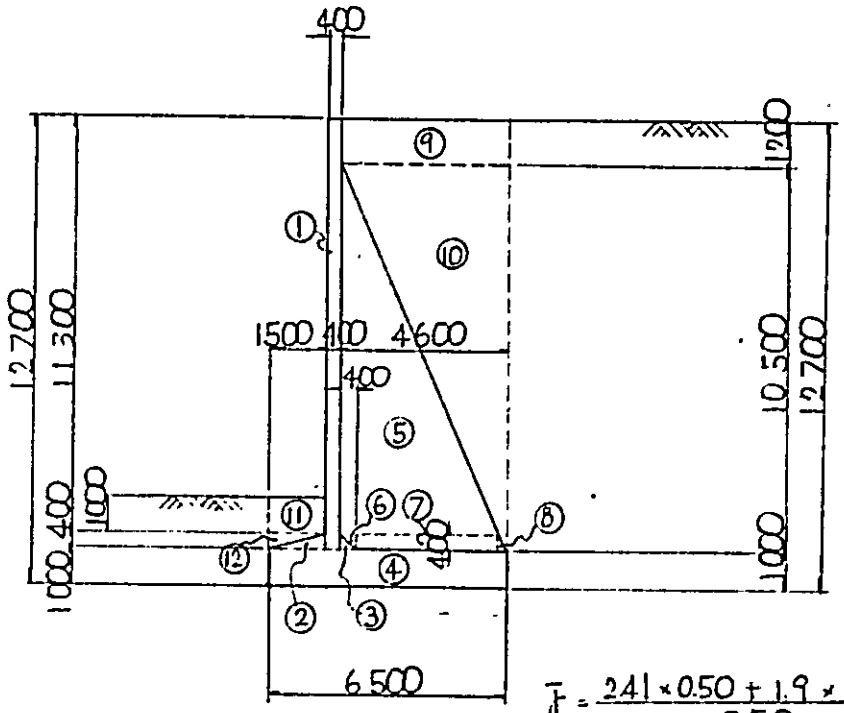
§ 2 CALCULATION OF LOAD

2-1 loading diagram



W : self weight
Ws : weight of soil
Wt : fill on toe
Ws add : weight of surcharge
P_A : active pressure
P_A add : surcharge

2－2 self weight and weight of soil



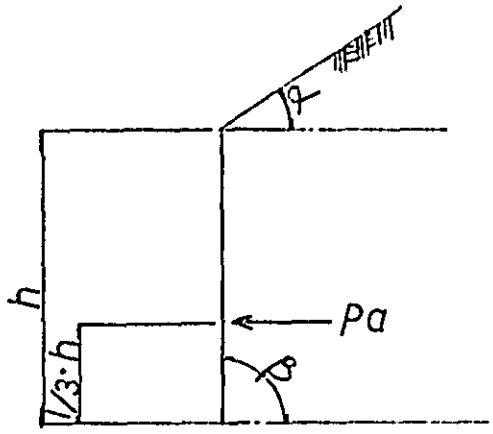
$$\bar{\gamma} = \frac{2.41 \times 0.50 + 1.9 \times 3.00}{3.50} = 1.97\ t/m^3$$

		N (t)	x (m)	N·x (tm)
①	0.40×11.70×3.50×2.41	39.48	1.70	67.12
②	½×0.40×1.50×2.41	0.72	1.00	0.72
③	½×0.40×0.40×2.41	0.19	2.033	0.39
④	6.50×1.00×3.50×2.41	54.83	3.25	178.20
⑤	½×4.425×10.10×3.50×1.97	154.08	3.435	515.22
⑥	½×0.40×0.40×3.50×1.97	0.55	2.167	1.19
⑦	4.025×0.40×3.50×1.97	11.10	4.313	47.87
⑧	½×0.40×0.175×3.5×1.97	0.24	6.383	1.53
⑨	4.60×1.20×3.50×1.90	36.71	4.20	154.18
⑩	½×4.60×10.50×3.50×1.9	160.60	4.967	797.70
⑪	1.00×1.50×3.50×1.9	9.98	0.75	7.49
⑫	½×1.50×0.40×3.50×1.9	2.00	0.57	1.14
Σ		470.48		1772.75

2-3 earth pressure

unit weight of soil $\gamma s = 1.9$

angle of internal friction $\phi = 35^\circ$



$$K = \left(\frac{\cos\phi}{a+1}\right)^2$$

$$a = \sqrt{\sin\phi - 1/2 \tan\alpha \cdot \sin 2\phi}$$

$$a = \sqrt{\sin^2 35^\circ - 1/2 \times \tan 0^\circ \times \sin 2 \cdot 35^\circ}$$

$$= \sqrt{0.574^2 - 1/2 \times 0 \times 2 \times 0.574}$$

$$= 0.574$$

$$K = \left(\frac{\cos 35^\circ}{0.574 + 1}\right)^2$$

$$= \left(\frac{0.819}{1.574}\right)^2$$

$$= 0.27$$

(1) active pressure

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

$$Pa = 1/2 \times 0.27 \times 1.9 \times 12.70^2 \times 3.50 = 144.80 \ t/m$$

$$y = 1/3 \times 12.70 = 4.233 \ m$$

(2) active pressure due to surcharge

under H.A surcharge

$$q = 1.02 \ t/m^2$$

$$q_h = q \cdot K \cdot H$$

$$= 1.02 \times 0.27 \times 12.70 \times 3.50 = 12.24 \ t/m$$

$$y = 1/2 \times 12.70 = 6.35 \ m$$

2-4 weight of surcharge

under H.A $q = 1.02 \ t/m^2$

$x = 4.60 \ m$

§ 3. CALCULATION OF STABILITY

	N (t)	x (m)	N·x (tm)	H (t)	y (m)	H·y (tm)
W. Ws, Wt	470.48		1772.75	—	—	—
Ws·add	4.69	4.20	19.70	—	—	—
Pa	—	—	—	144.80	4.233	612.94
Pa·add	—	—	—	12.24	6.35	77.72
TOTAL	475.17		1792.45	157.04		690.66

1) check for eccentric

$$x = \frac{Nx - Hy}{\Sigma N} = \frac{1792.45 - 690.66}{475.17} = 2.32 \ m$$

$$e = \frac{B}{2} - x = \frac{650}{2} - 2.32 = 0.93 \ m$$

$$< \frac{B}{6} = 1.08 \ m$$

2) soil reaction

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

$$= \frac{475.17}{6.50 \times 3.50} \times \left(1 \pm \frac{6 \times 0.93}{6.50}\right) = \begin{cases} 38.82 \\ 2.96 \end{cases} \ t/m^2$$

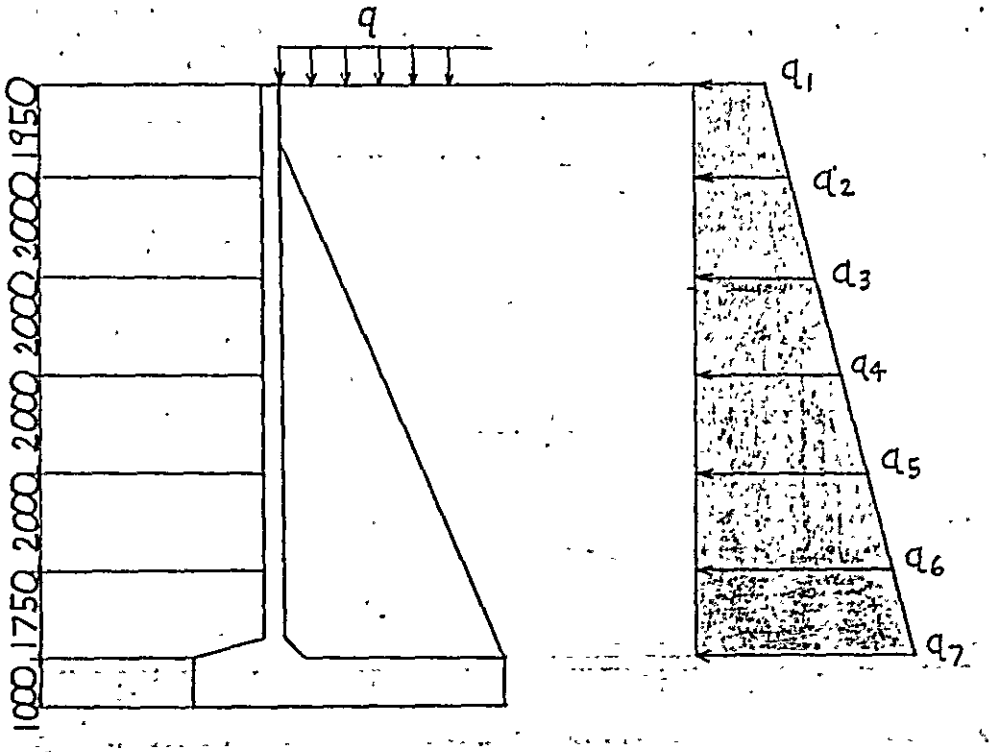
3) check for sliding

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

$$F = \frac{Hu}{H} = \frac{475.17 \times 0.6}{157.04} = 1.9 > 1.5$$

§ 4 CALCULATION OF WALL SECTION

4-1 dimension and loading.

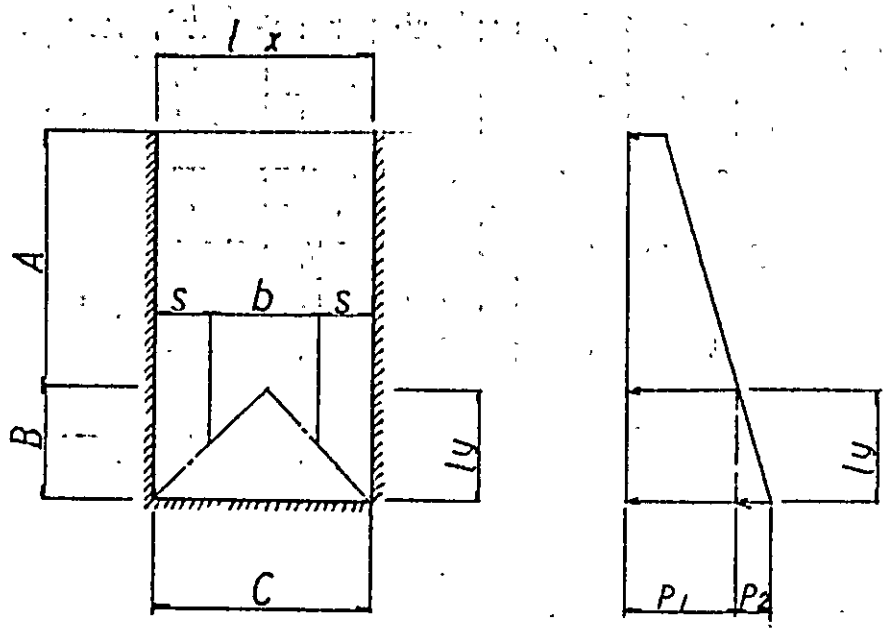


	q1	q2	q3	q4	q5	q6	q7
HA loading	0.28	1.26	2.31	3.33	4.36	5.38	6.28

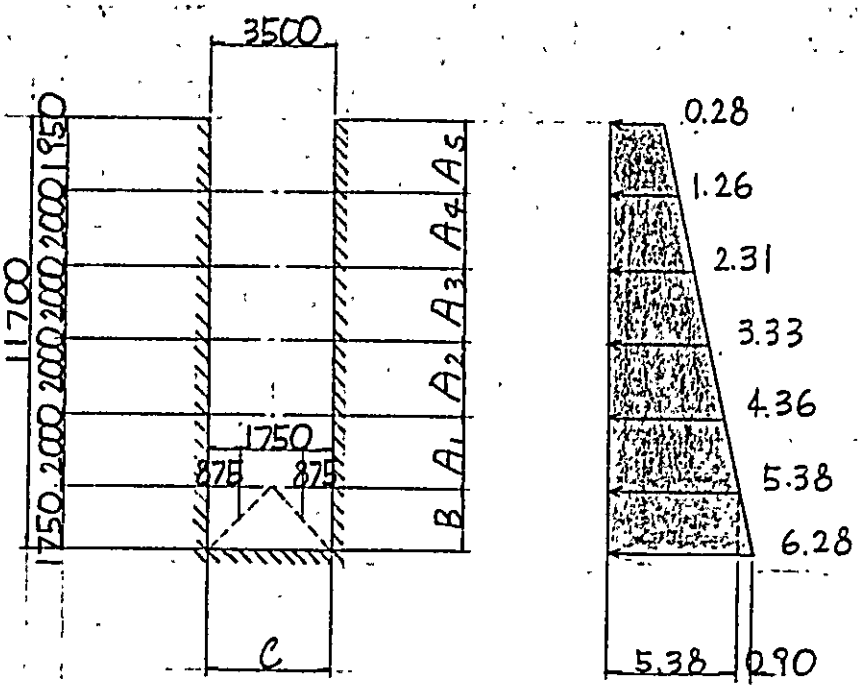
$q_1 = q \cdot K_a = 0.27 q$ t/m²

$q_{x_1} = K_a \cdot \gamma_s \cdot H_x + q_1 = 0.513 \cdot H_x + 0.27 \cdot q$

4-2. 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	$\frac{1}{2}\times(\frac{5.38}{2}+\frac{0.90}{6})\times 1.75^2$	4.35	$(5.38+\frac{0.90}{2})\times 1.75$	10.20
B−B	$\frac{5.83+0.875}{6\times 3.50}(2\times 3.50+1.75)$	2.13	5.83×0.875	5.10
A1−1	$\frac{5.38\times 3.50^2}{10}$	6.59	$\frac{5.38\times 3.50}{2}$	9.42
A2−2	$\frac{4.36\times 3.50^2}{10}$	5.34	$\frac{4.36\times 3.50}{2}$	7.63
A3−3	$\frac{3.33\times 3.50^2}{10}$	4.08	$\frac{3.33\times 3.50}{2}$	5.83
A4−4	$\frac{2.31\times 3.50^2}{10}$	2.83	$\frac{2.31\times 3.50}{2}$	4.04

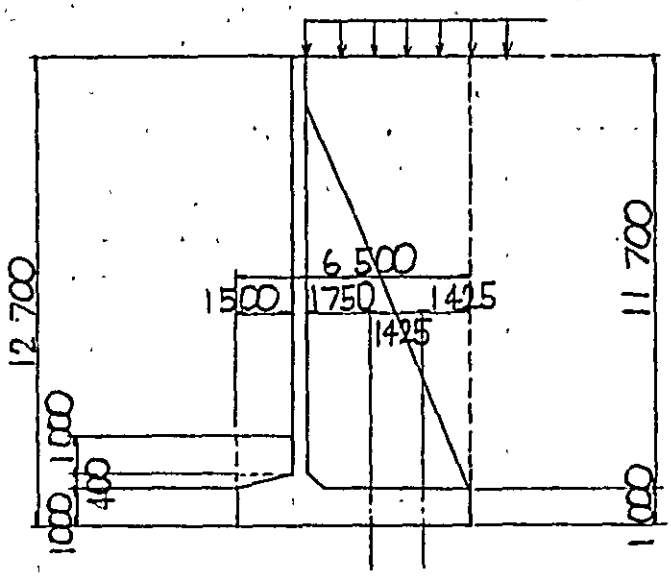
4-3 list of stresses $\sigma c, \sigma s, \tau$: working stress.

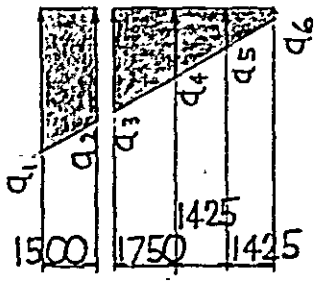
$\sigma ca, \sigma sa, \tau a$: Permissible stress.

	C-C	B-B	A1-1	A2-2	A3-3	A4-4
M	4.35	2.13	6.59	5.34	4.08	2.83
N	—	—	—	—	—	—
S	10.20	5.10	9.42	7.63	5.83	4.04
b	100	→	→	→	→	→
h	33	→	→	→	→	→
d'	7	→	→	→	→	→
As	D16 @ 250 8.04	D16 @ 250 8.04	D16 @ 125 16.08	D16 @ 250 8.04	D16 @ 250 8.04	D16 @ 250 8.04
As'	—	—	—	—	—	—
t/d	0	0	0	0	0	0
M'/bd^2	3.99	1.96	6.05	4.90	3.75	2.60
S/bd	3.09	1.55	2.85	2.31	1.77	1.22
n.P	0.0365	0.0365	0.0731	0.0365	0.0365	0.0365
C	9.19	9.19	7.07	9.19	9.19	9.19
S	29.72	29.72	15.30	29.72	29.72	29.72
Z	1.09	1.09	1.12	1.09	1.09	1.09
σc	37	18	43	45	34	24
σs	1781	872	1388	2186	1670	1159
τ	3.4	1.7	3.2	2.5	1.9	1.3
σca	83	→	→	→	→	→
σsa	2346	→	→	→	→	→
τa	3.5	→	3.47	2.4	→	→

8.5 CALCULATION OF FOOTING SECTION

5-1 dimenston and loading





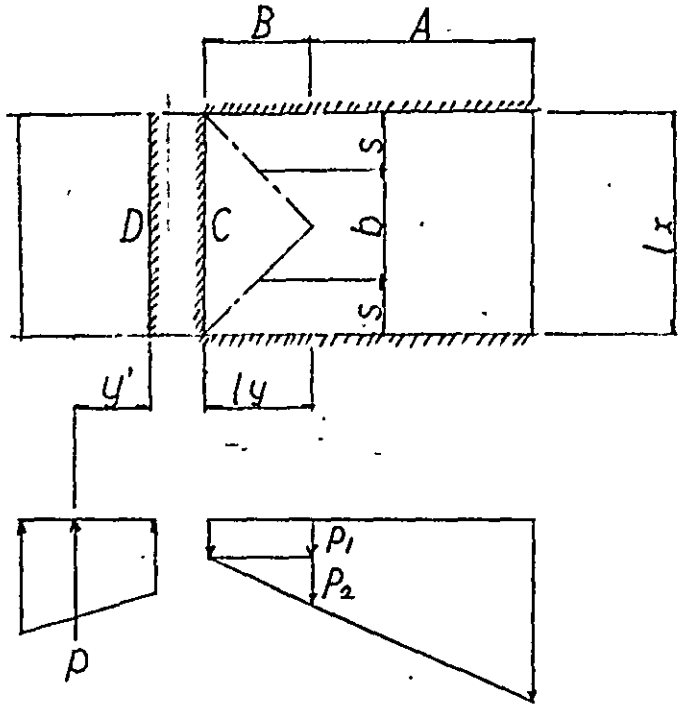
$w_1 = 1.00 \times 2.41 + 1.40 \times 1.9 = 5.07$ t/m²

$w_2 = 1.40 \times \cdot + 1.00 \times \cdot = 5.27$ "

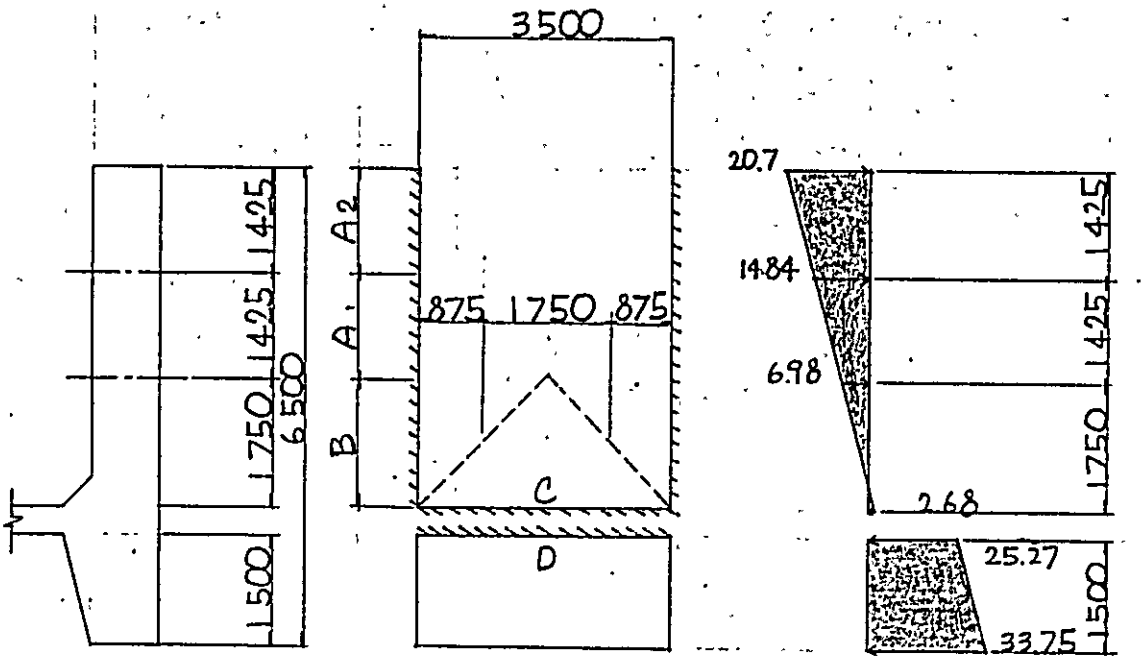
$w_3 = 1.00 \times \cdot + 11.70 \times \cdot + 1.02 = 25.66$ "

	q 1	q 2	q 3	q 4	q 5	q 6
HA loading	38.82	30.54	28.34	18.68	10.82	2.96

5-2 sectional force of footing



	A	B	C	D
(tm) M	$\frac{p \cdot lx^2}{10}$	$\frac{p \cdot s}{6 \cdot lx}(2 \cdot lx + b)$	$\frac{1}{2}(\frac{p_1}{2} + \frac{p_2}{6})ly^2$	$p \cdot y'$
(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	$44.27 \times \frac{1.50}{3} \times \left(\frac{25.27+2\times33.75}{25.27+33.75}\right)$	34.79	$\frac{1}{2} \times (25.27+33.75) \times 1.50$	44.27
C − C	$\frac{1}{2} \times \left(\frac{0}{2}+\frac{6.98}{6}\right) \times 1.75^2$	1.78	$\left(0+\frac{6.98}{2}\right) \times 1.75$	6.11
B − B	$\frac{3.49 \times 0.875^2}{6 \times 3.50} \times (2 \times 3.50+1.75)$	1.11	3.49×0.875	3.05
A1 − 1	$\frac{14.84 \times 3.50^2}{10}$	18.18	$\frac{14.84 \times 3.50}{2}$	25.97
A2 − 2	$\frac{20.7 \times 3.50^2}{10}$	25.36	$\frac{20.7 \times 3.50}{2}$	36.23
A3 − 3				

5-3 list of stresses $\sigma c, \sigma s, \tau$: working stress.

$\sigma ca, \sigma sa, \tau a$: Permissible stress.

	D-D	C-C	B-B	A_1-1	A_2-2	
M	34.79	1.78	1.11	18.18	25.36	
N	—	—	—	—	—	
S	44.27	6.11	3.05	25.97	36.23	
b	100	—	—	—	→	
h	130	90	—	—	→	
d'	10	10	—	—	→	
As	D20@125 25.12	D16@125 16.08	D16@125 16.08	D16@125 16.08	D16@125 16.08	
As'	—	—	—	—	—	
f/d	0	0	0	0	0	
M'/bd^2	2.06	0.22	0.14	2.24	3.13	
S/bd	3.41	0.68	0.34	2.89	4.03	
n·P	0.029	0.0268	0.0268	0.0268	0.0268	
C	10.09	10.42	10.42	10.42	10.42	
S	37.15	40.10	40.1	40.1	40.1	
Z	1.08	1.07	1.07	1.07	1.07	
σc	21	2	1	23	33	
σs	1147	132	82	1350	1883	
τ	3.7	0.7	0.4	3.1	4.3	
σca	83	—	—	—	—	→
σsa	2346	—	—	—	—	→
τa	2.35	—	—	—	—	→

Check for stirrups

Sect D-P

$$\tau = \frac{S}{b \cdot d} \times Z = \frac{44.27 \times 10^3}{100 \times 130} \times 1.08 = 3.68 \ kg/cm^2 > \tau_a = 2.35 \ kg/cm^2$$

$S' = S - S_c$

$S_c = \tau_a \cdot b \cdot d \cdot 1/Z = 2.35 \times 100 \times 130 \times 1/1.08 = 28.29 \times 10^3 \ kg$

$S' = (44.27 - 28.29) \times 10^3 = 15.98 \times 10^3 \ kg$

$$\text{Req } A_v = \frac{S' \times a}{\sigma_{sa} \cdot d} Z = \frac{15.98 \times 10^3 \times 50}{1780 \times 130} \times 1.08 = 3.7 \ cm^2$$

Used A_v = ϕ16 - ctc 500 $n = 2$

$A_v = 2.01 \times 2 = 4.02 \ cm^2 > \text{Req } A_v = 3.7$

Sect A2 - A2

$$\tau = \frac{S}{b \cdot d} \times Z = \frac{36.23 \times 10^3}{100 \times 90} \times 1.07 = 4.31 \ kg/cm^2 > \tau_a = 2.35$$

$S' = S - S_c$

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

$S' = (36.23 - 19.77) \times 10^3 = 16.46 \times 10^3 \ kg$

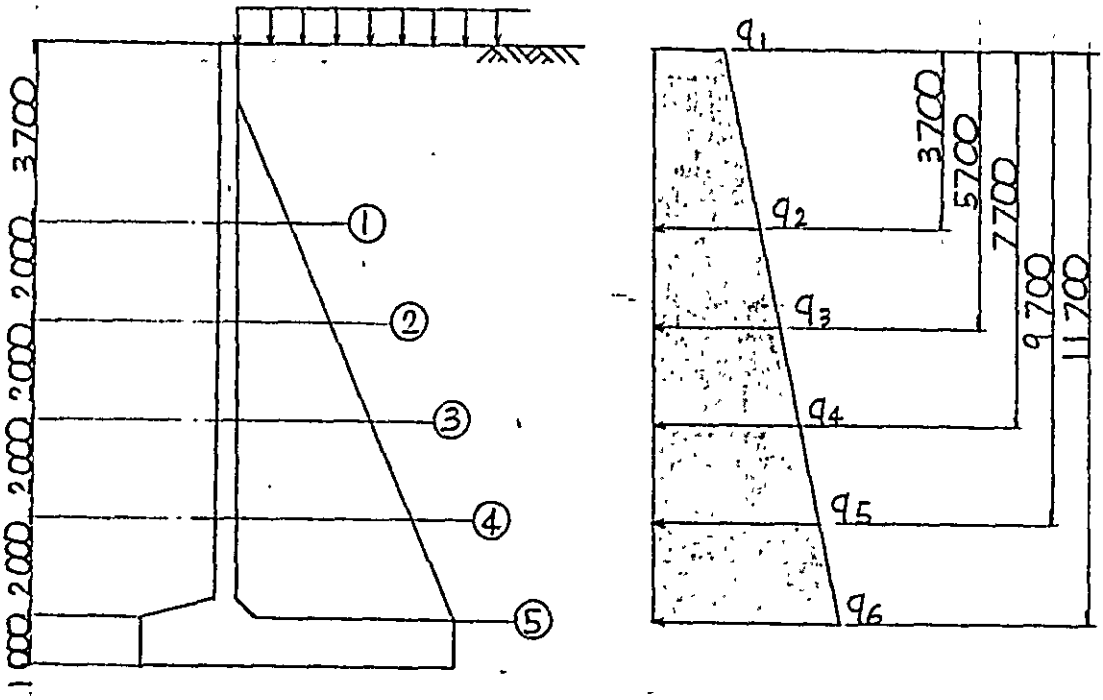
$$\text{Req } A_v = \frac{S' \times a}{\sigma_{sa} \cdot d} \times Z = \frac{16.46 \times 10^3 \times 25}{1780 \times 90} \times 1.07 = 2.75 \ cm^2$$

Used A_v = ϕ16 - ctc 250 $n = 2$

$A_v = 2.01 \times 2 = 4.02 > \text{Req } A_v = 2.75 \ cm^2$

§ 6 CALCULATION OF BUTTRESS SECTION

6-1 dimenston and loading



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

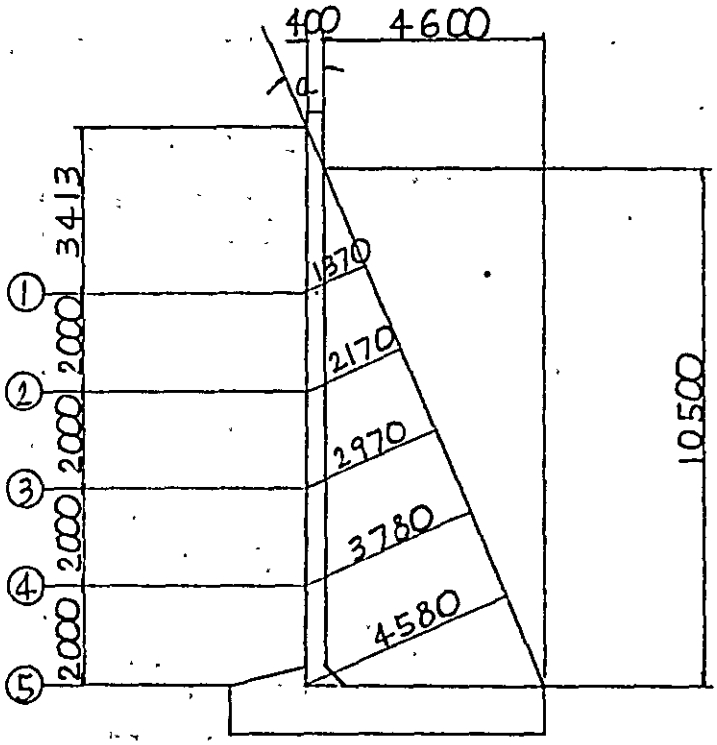
$$q = 1.796 \cdot H + 0.964$$

	q_1	q_2	q_3	q_4	q_5	q_6
HA loading	0.96	7.61	11.20	14.79	18.39	21.98

6 – 2 sectiona force of buttress

		HA loading		
		H (t)	y (m)	H·y (tm)
1——1	Pa	15.85	1.371	21.73
2——2	Pa	34.66	2.05	71.05
3——3	Pa	60.64	2.723	165.12
4——4	Pa	93.85	3.394	318.53
5——5	Pa	134.20	4.063	545.25

6 – 3 calculation of members

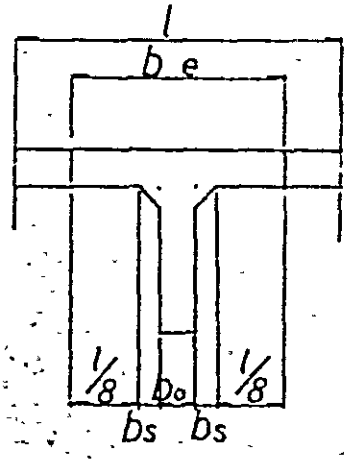


$$\tan\alpha = \frac{4.60}{10.50} = 0.438$$

$$\alpha = 23°39'$$

$$H = h \cdot \sin\alpha$$

$$= 0.401 \cdot h$$



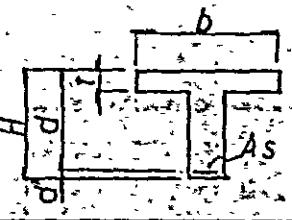
$$\therefore be = b_o + 2\left(b_s + \frac{l}{8}\right) = 50 + 2 \times (30 + 44) \text{ cm.}$$

$$= 198$$

6-4 list of stresses σ_c, σ_s, τ : working stress.

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

		1—1	2—2	3—3	4—4	5—5
M	tm	21.73	71.05	165.12	318.53	545.25
S	t	15.85	34.66	60.64	93.85	134.20
b	cm	198	———	———	———	———
t	"	40	———	———	———	———
d	"	127	207	287	363	443
As	cm^2	2-D32 16.08	4-D32 32.16	4-D32 32.16	$\begin{matrix}4\\2\end{matrix}$ > D32 48.24	$\begin{matrix}4\\4\end{matrix}$ > D32 64.32
P		0.0006	0.0008	0.0006	0.0007	0.0007
t/d		0.32	0.19	0.14	0.11	0.09
K		0.181	0.150	0.126	0.138	0.145
j		1.196	0.962	0.959	0.957	0.961
σ_s	kg/cm^2	889	1109	1866	1901	1990
σ_c	"	13	13	18	20	22
τ	"	250	335	4.23	5.17	6.06
σ_{sa}	"	2346	———	———	———	———
σ_{ca}	"	83	———	———	———	———
τ_a	"	8.2	———	———	———	———



6-5 check for tie bers

1) wall and buttress

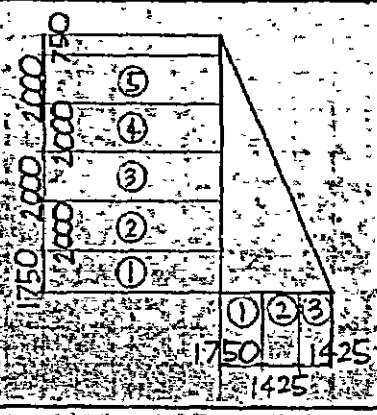
$$As = \frac{S}{\sigma sa} \quad (cm^2)$$

		S (t)	As (Cm²)	As' (Cm²)	
section	1—1	5.10	2.17	D16 @c 250	8.04
	2—2	9.42	4.02		
	3—3	7.63	3.25		
	4—4	5.83	2.49		
	5—5	4.04	1.72		

2) footing and buttress

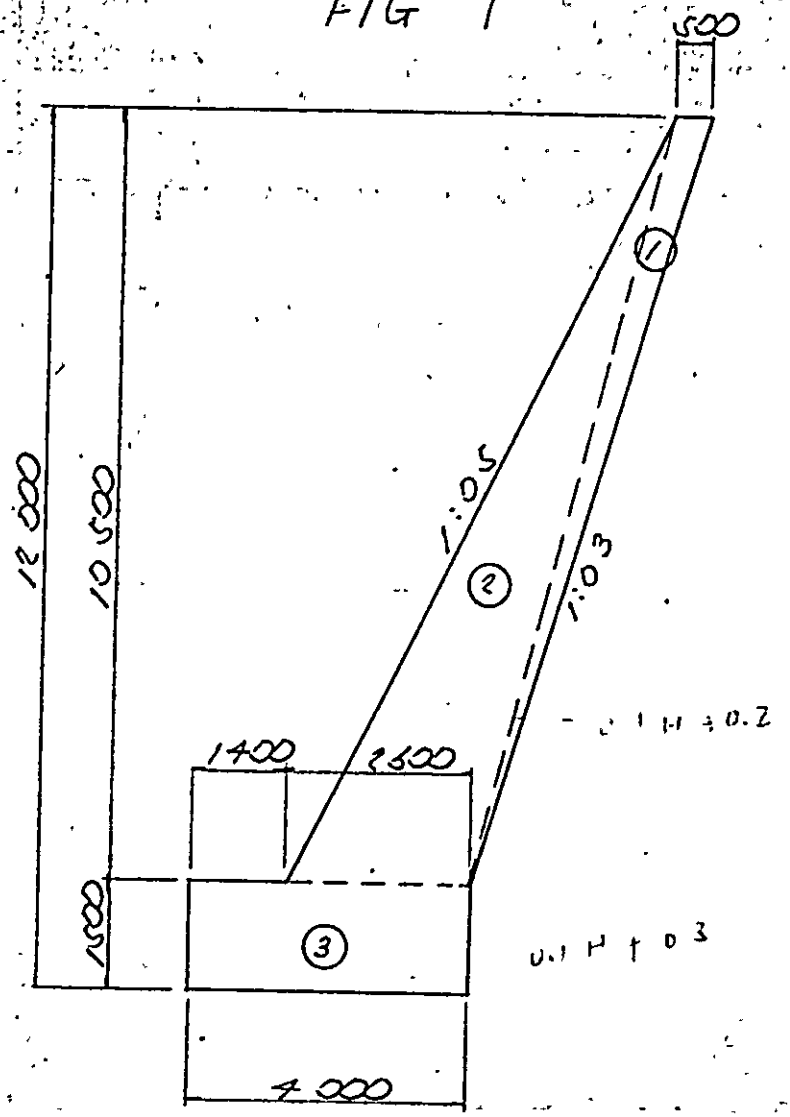
$$As = \frac{S}{\sigma sa} \quad (cm^2)$$

		S (t)	As (Cm²)	As' (Cm²)	
section	1 1	3.05	1.30	D16 @c 250	8.04
	2 2	25.97	11.07	D16 @c 125	16.08
	3 3	36.23	15.44	D16 @c 125	16.08



2. Retaining Wall of Main Road

FIG 1



	AREA	UNIT WEIGHT	WEIGHT	X	Y	WX	WY
1	2.625 m^2	2.3 t/m^3	6.04	5.067	8.500	30.60	51.34
2	13.650	"	31.40	4.017	5.000	126.13	157.00
3	6.000	"	13.80	2.000	0.750	27.60	10.35
Σ			51.24			184.33	218.69

$$X_0 = \frac{184.33}{51.24} = 3.597$$

SUR CHANGE

SUR CHANGE 1.66 t/m²

CONVERTED HEIGHT BY SURCHARGE

$$h = \frac{q}{\gamma} = \frac{1.66}{2.0} = 0.83\ m$$

EARTH PRESSURE

$$P_H = 1/2 \cdot K_H \cdot H^2$$

$$P_V = 1/2 \cdot K_V \cdot H^2$$

$P_H = 1/2 \times 0.28 \times 12.83^2 = 23.05$

$P_V = 1/2 \times 0 \times 12.83^2 = 0$

STABILITY

	V	H	X	Y	VX	HY
WALL	51.24		3.597		184.31	
EARTH PRESSURE		23.05		4.750		109.49
TOTAL	51.24	23.05			184.31	109.49

STABILITY FOR TURN OVER

$$X_1 = \frac{\Sigma VX - \Sigma HY}{\Sigma V} = \frac{184.31 - 109.49}{51.24} = 1.460$$

$X_1 = 1.46 > B/3 = 1.33$ 安定している。

STABILITY FOR BEARING

$$e_1 = \frac{B}{2} - x_1 = \frac{4.00}{2} - 1.46 = 0.54$$

$$B/6 = 0.667 > e_1 = 0.54$$

$$\left.\begin{matrix} q_{max} \\ q_{min} \end{matrix}\right\} = \frac{\Sigma V}{B}\left(1 \pm \frac{6e_1}{B}\right)$$

$$= \frac{51.24}{4.00}\left(1 \pm \frac{6 \times 0.54}{4.00}\right)$$

$q_{max} = 23.19\ t/m^2$

$q_{min} = 2.43\ t/m^2$

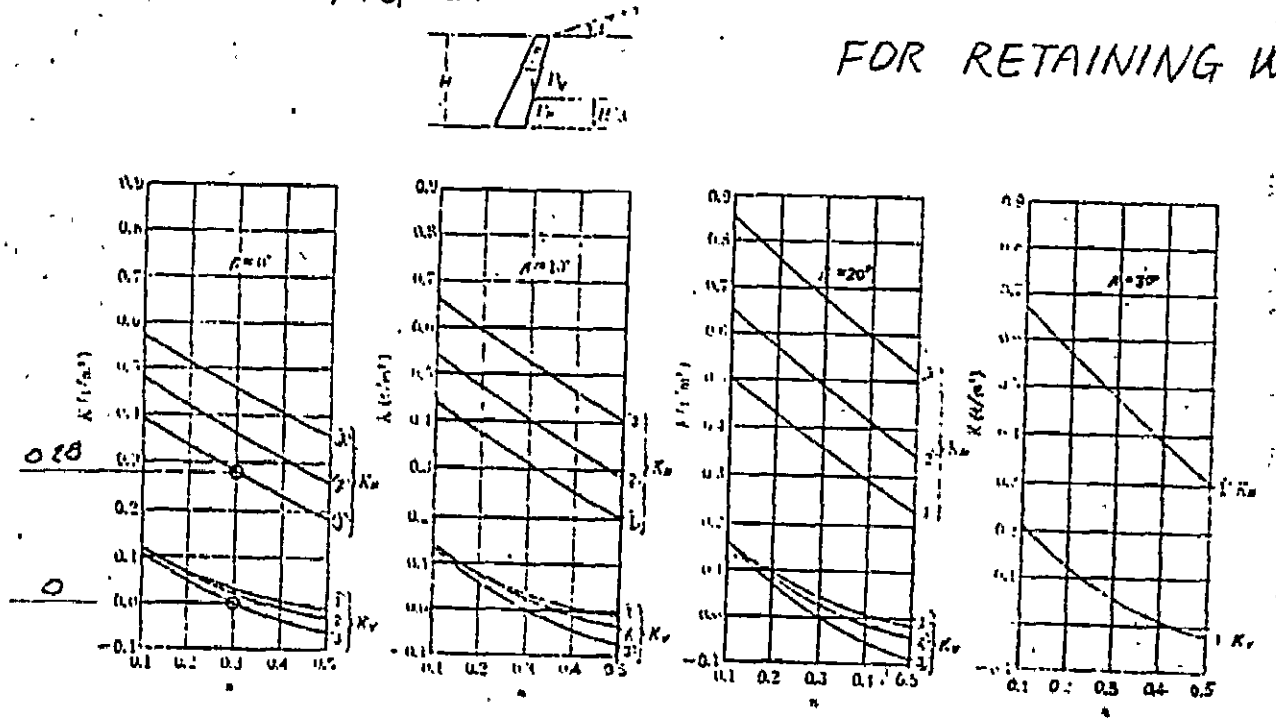
STABILITY FOR SLIDING

$$H_u = V \tan\phi_B$$

$$= 51.24 \times 0.6 = 30.74$$

$$F = \frac{30.74}{23.07} = 1.33 > 1.3$$ 安定している

FIG 2. EARTH PRESSURE DIAGRAM FOR RETAINING WALL DESIGN



NOTE : NUMBER OF LINE SHOWS KIND OF BACK FILL SOIL

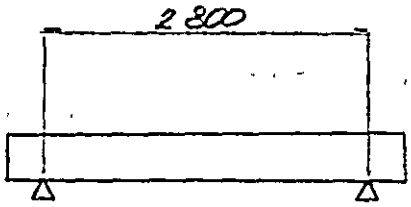
① GRAVEL, GRAVELLY SOIL

② SANDY SOIL

③ SILT. COHESIVE SOIL (LL < 50%)

3. Frontage Road Bridges

DESIGN OF SLAB



a. BENDING MOMENT BY LIVE LOAD (T - LOAD)

LENGTH OF BRIDGE $\ell \leq 10^{M}$

LIVE LOAD : T-20 (BRIDGE DESIGN MANUAL OF JAPANESE ROAD ASSOCIATION)

$Me = 1.8\ell + 0.5 \ ^{t/M}$ (INCLUDING INPACT)

$Me = (1.8\ell + 0.5) \times 0.7$

$= (1.8 \times 2.80 + 0.5) \times 0.7 = 3.878 \ ^{t.m/M}$

b. BENDING MOMENT BY DEAD LOAD

$Md = \frac{1}{8} w.\ell^2$

$= \frac{1}{8} \times (0.30^{m} \times 2.4^{t/m^3}) \times 2.80^2 = 0.706 \ ^{t.m/M}$

c. COMPOSITE STRESS

$M = Me + Md$

$= 3.878 + 0.706 = 4.584 \ ^{t.m/M}$

SEAR FORCE

BEARING FORCE (PER 50^{cm})

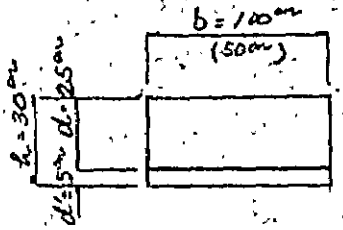
$R = Re + Rd$

$= 5.6 (1+1.3) + \frac{1}{2} \times 0.30 \times 2.4 \times 2.80 \times 0.50 = 7.784^{t}$

$S = R = 7.784 \ t$

d. SECTION FORCE

AREA OF STEEL BAR = As



$$As = \frac{M}{\sigma sa \cdot j \cdot d}$$

$$= \frac{4.584 \times 10^5}{1400 \times 7/8 \times 25} = 14.97\ cm^2 < 016\text{-}dtc125 = 16.09\ cm^2$$

PERMISSIBLE STRESS OF REINFORCEMENT

$\sigma sa = 1400\ kg/cm^2$

$$\tau = \frac{S}{b \cdot j \cdot d}$$

$$= \frac{7.784 \times 10^3}{50 \times 7/8 \times 25} = 7.12\ kg/cm^2 < \tau a = 9\ kg/cm^2$$