Vol. 2

M.J B-RAMP BR. P_2 Pier

(P.S.C.I E, F-RAMP P_2 Pier)

※ フーチングは M-GRAMP P_2 Pier
の設計に準ずる

(P -)

§ 1 DESIGN CONDITIONS

1 Pier type

Rigid-frame pier

hight H = m

2 Foundation type

footing foundation

3 Unit weight of reinforced concrete

2.4?7 t/m^3

4 Allowable stresses of reinforced concrete

1.) concrete (grade 25 , BS 54??)

cube strength at 28 days σk = 255 kg/cm^2

bending stress σa = 85

direct stress σa = 64.3

shear stress a = ?.2

2.) reinforcement (hot rolled high yield bars, BS 4449)

specified characteristic strength

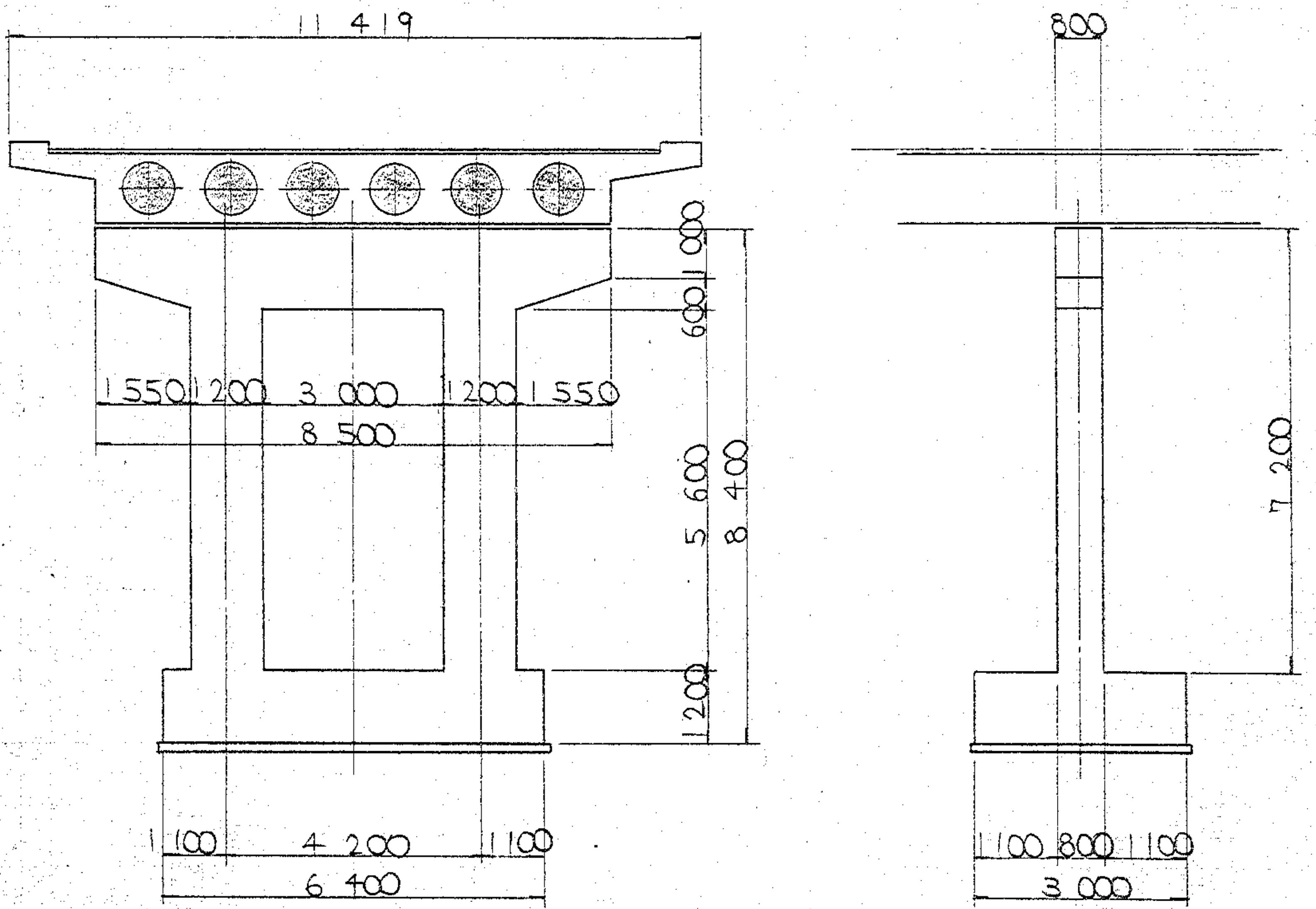
su = 4 18? kg/cm^2

permissible tensile stress

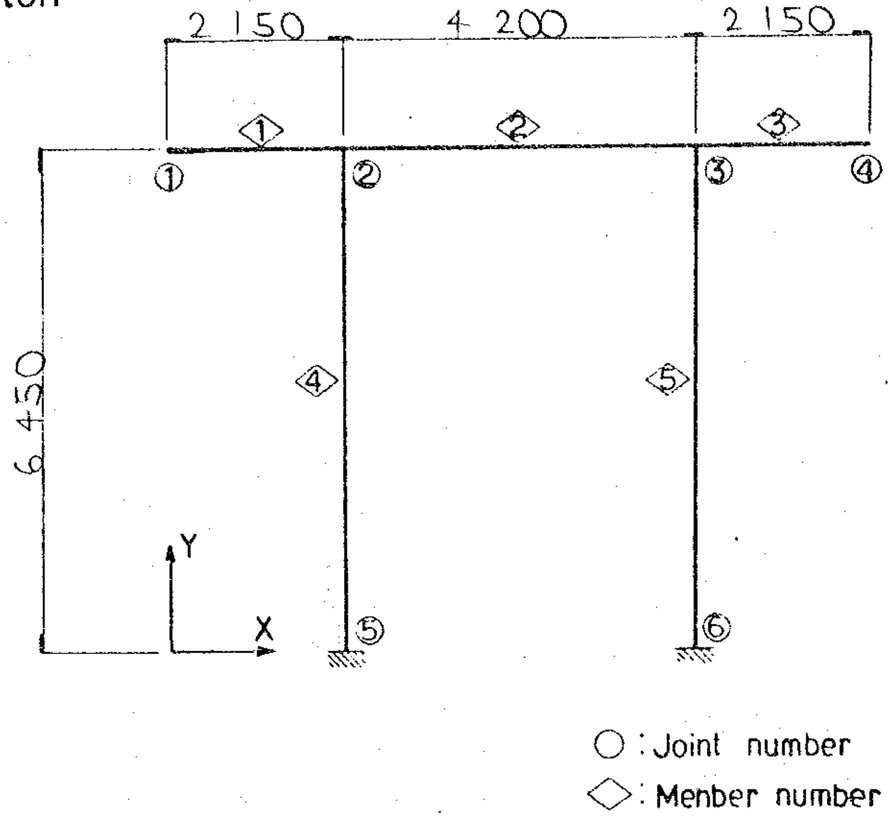
sa = 2 34? kg/cm^2

modular ratio n = 15

§ 2 GENERAL DIMENSION



Skeleton



Coordinates

(m)

	X	Y		X	Y
①	0.0	6.45	④	8.50	6.45
②	2.15	6.45	⑤	2.15	0.0
③	6.35	6.45	⑥	6.35	0.0

Modulus of elasticity of concrete

$Ec = 26\ kN/mm^2$

$= 2.65 \times 10^6\ t/m^2$

member	section B x H	area of section A (m^2)	moment of inertia I (m^4)
⟨1⟩	0.80 × 1.25	1.00	0.1302
⟨2⟩	0.80 × 1.50	1.20	0.2250
⟨3⟩	0.80 × 1.25	1.00	0.1302
⟨4⟩	0.80 × 1.20	0.96	0.1152
⟨5⟩	0.80 × 1.20	0.96	0.1152

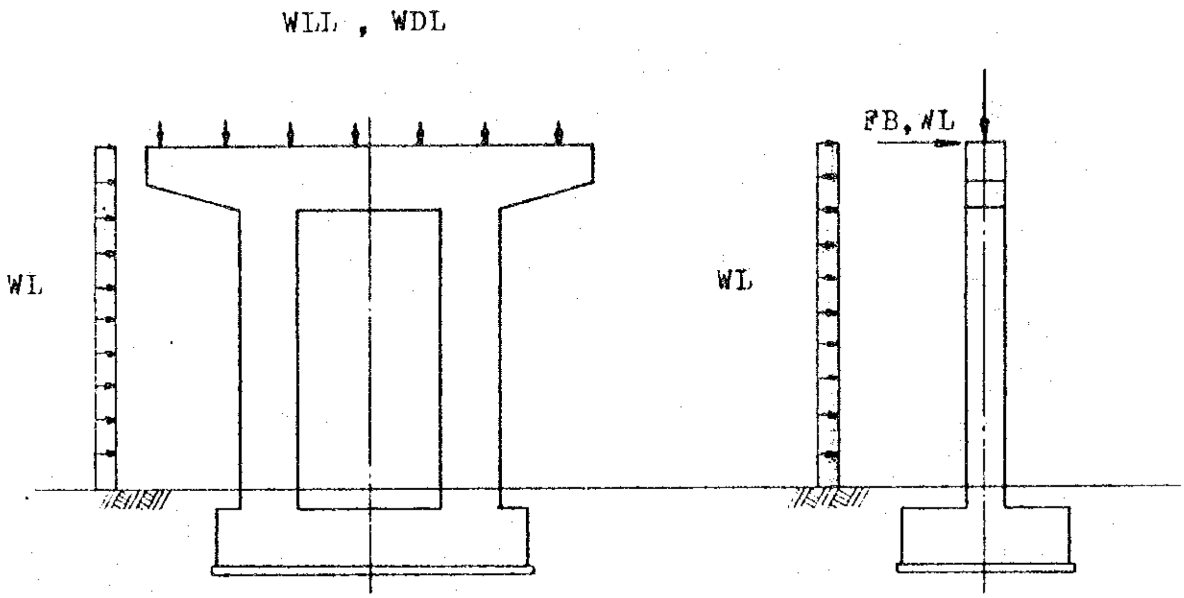
§ 3 CALCULATION OF LOADS

1.) Loading case and increase in basic stresses

No.	base load case	mark
1	dead load of deck	WDL
2	max reaction under HA	WLL(A)
3	max reaction under HB	WLL(B)
4	HA braking	FB(A)
5	HB braking	FB(B)
6	Self weight	W
7	temperture charge and drying schrinkage	FT & FS
8	wind	WL

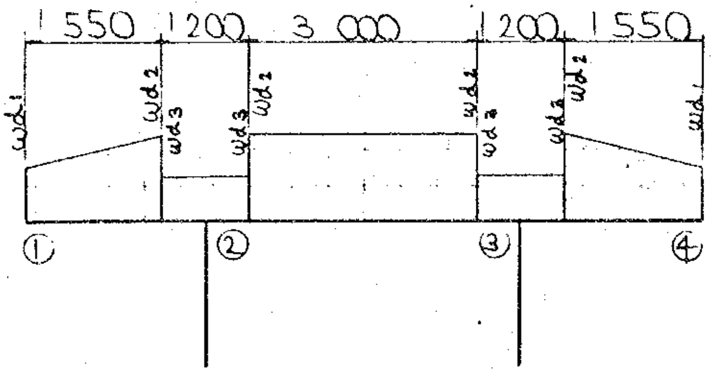
case	load combination	increase in basic stresses
1	1, 6, 7	1.00
2	1, 6, 7, 8	1.00
3	1, 2, 6, 7	1.00
4	1, 3, 6, 7	1.25
5	1, 2, 6, 7, 8	1.15
6	1, 3, 6, 7, 8	1.30
7	1, 2, 4, 6, 7	1.00
8	1, 3, 5, 6, 7	1.25
9	1, 2, 4, 6, 7, 8	1.15
10	1, 3, 5, 6, 7, 8	1.30
11	1, 6, 7, 8	1.00

2.) Loading diagram



3) Dead load

(a) beam



wd1 = 1.00 × 0.80 × 2.407 = 1.93 t/m

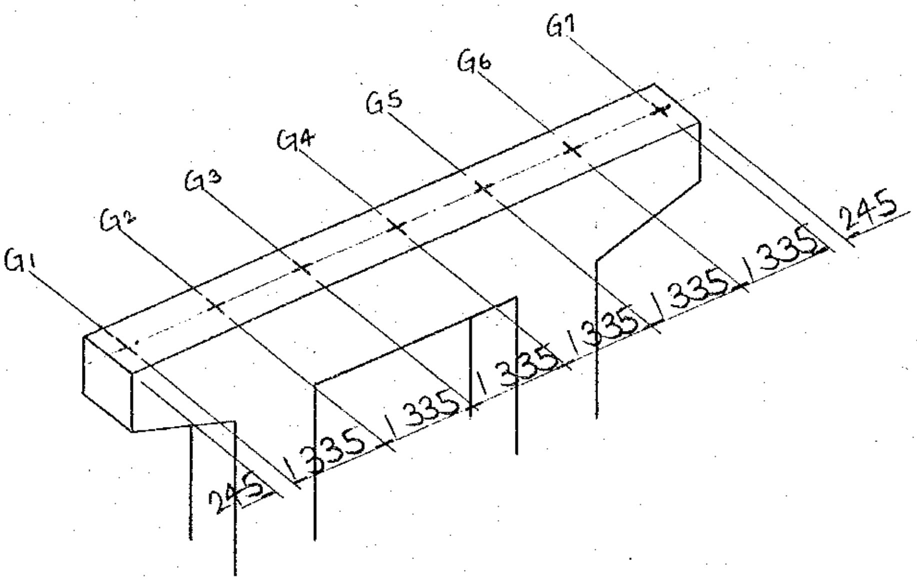
wd2 = 1.50 × 0.80 × 2.407 = 2.89 t/m

wd3 = 0.75 × 0.80 × 2.407 = 1.44 t/m

(b) column

pw = 1.20 × 0.80 × 2.407 = 2.31 t/m

4) Reaction



	G-1	G-2	G-3	G-4	G-5	G-6	G-7
Dead load	59.3	28.1	45.7	42.8	50.1	11.6	97.7
HA load	59.1	35.3	38.1	34.4	37.4	36.2	80.1
HB load	81.4	41.1	38.2	33.6	36.0	40.4	109.8

5.) Temperture change and Drying schrinkage

temperture change -12 +20 deg.

drying schrinkage -20 deg.

6.) Wind Load (transverse)

(a) For superstructure

Vc = 38 x 1.0 x 1.0 x 1.56 = 59.3 m/sec. > 35 m/sec.

Unloaded

Pt = q・A・Cd

$q = 0.613 \times 59.3^2 \times 0.102 = 219.9\ kg/m^2$

$A = 1.38 \times 17.2 = 23.7\ m^2$

Cd = 1.2

$Pt = 219.9 \times 23.7 \times 1.2 = 6254\ kg$

$= 6.3\ ton$

Live loaded

Pt = q・A・Cd

$q = 0.613 \times 35^2 \times 0.102 = 76.6\ kg/m^2$

$A = 3.73 \times 17.2 = 64.2\ m^2$

Cd = 1.40

$Pt = 76.6 \times 64.2 \times 1.40 = 6885\ kg$

$= 6.9\ ton$

(b) For safety fences

Vc = 38 x 1.0 x 1.0 x 1.56 = 59.3 m/sec.

Pt = q・A・Cd

$q = 219.9\ kg/m^2$

$A = (0.150 \times 17.2 + 0.850 \times 0.05 \times \frac{17.2}{2}) \times 2 = 5.89\ m^2$

Cd = 1.1

$Pt = 219.9 \times 5.89 \times 1.1 = 1425\ kg$

$= 1.4\ t$

(c) For Pier

$Vc = 38 \times 1.0 \times 1.0 \times 1.56 = 59.3$ m/sec.

Unloaded

$q = 0.613 \times 59.3^2 \times 0.102 = 219.9\ kg/m^2$

$A1 = 0.80 \times 6.70 = 5.36\ m^2$

$A2 = 0.80 \times 5.20 = 4.16\ m^2$

$Cd = 1.7$

$Pt = 219.9 \times (5.36 + 4.16) \times 1.7 = 3359\ kg$

$= 3.4\ ton$

Live loaded

$q = 0.613 \times 35^2 \times 0.102 = 76.6\ kg/m^2$

$A = A1 + A2 = 9.52\ m^2$

$Cd = 1.7$

$Pt = 76.6 \times 9.52 \times 1.7 = 1240^{kg} = 1.2\ ton$

(d) Table of Wind load (transverce)

(ton)

	unloaded	live loaded
super-structure	6.3	6.9
safety fences	1.4	——
Pier	3.4	1.2

7.) Longitudinal force

(a) due to breaking

HA ——— 25.8 ton

HB ——— 38.3 ton

(b) due to Wind

for superstructure

unloaded PLS = 0.25 Pt = 0.25 × 6.3

= 1.6 ton

live loaded PLL = 0.5 Pt

Pt = 76.6×(2.5×17.2)×1.40

= 4.6 ton

PLL = 0.5 × 4.6 = 2.3 ton

PLS = 0.25 Pt

Pt = 76.6 × (3.73 − 2.5) × 17.2 × 1.2

= 1.9 ton

PLS = 0.25 × 1.9 = 0.5 ton

for safety fences

vertical member

PL = 0.8 Pt

Pt = $219.9 \times (0.85 \times 0.05 \times \frac{17.2}{2} \times 2) \times 1.1$

= 177 kg = 0.18 ton

PL = 0.8 × 0.18 = 0.14 ton

longitudinal member

PL = 0.4 Pt

Pt = 219.9 × (0.15 × 17.2 × 2) × 1.1

= 1248 kg = 1.2 ton

PL = 0.4 × 1.2 = 0.48 ton

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for Pier

Vc = 59.3 m/sec.

unloaded

q = 219.9 kg/m²

A1= 8.50×1.50−1.55×0.50 = 12.0 m²

A2= 5.20×1.20×2 = 12.5 m²

Cd1= 2.1

Cd2= 2.2

Pt1= 219.9×12.0×2.1 = 5.5 ton

Pt2= 219.9×12.5×2.2 = 6.0 ton

live loaded

q = 76.6 kg/m²

A1= 12.0 m²

A2= 12.5 m²

Cd1= 2.1

Cd2= 2.2

Pt1= 76.6×12.0×2.1 = 1.9 ton

Pt2= 76.6×12.5×2.2 = 2.1 ton

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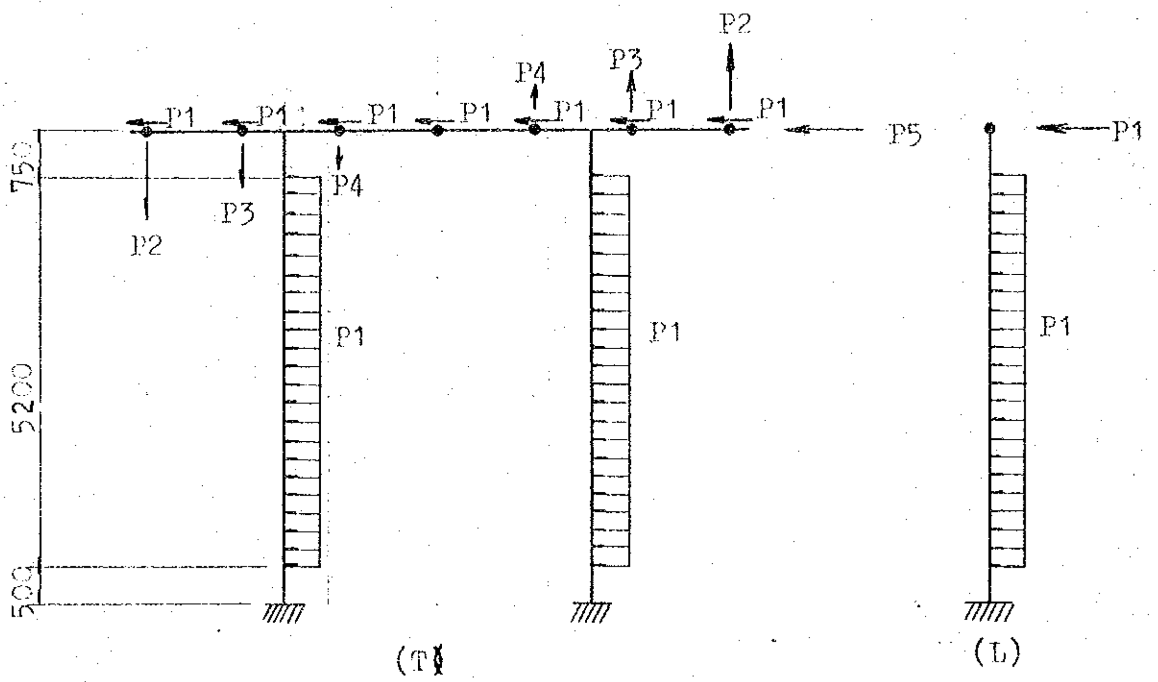
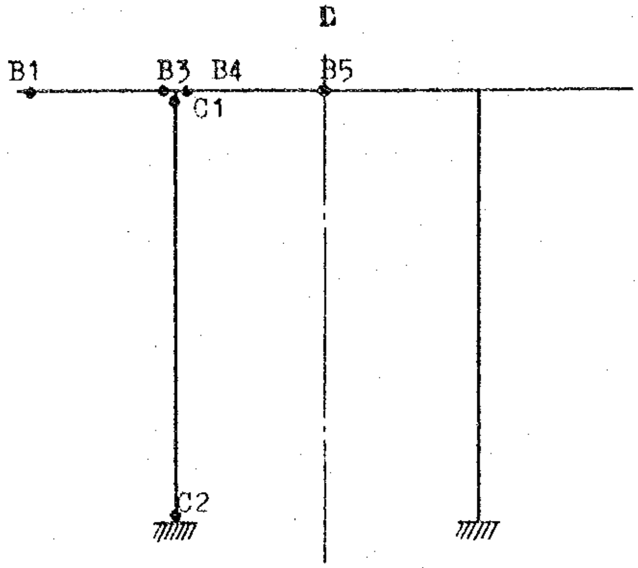
8) Wind loading diagram



		For Place	unloaded	live loaded
(T)	P1	superstructure safety fences	1.10 ton	0.99 ton
	P2	superstructure safety fences	0.83 ton	1.39 ton
	P3	superstructure safety fences	0.55 ton	0.93 ton
	P4	superstructure safety fences	0.28 ton	0.46 ton
	P5	Pier	0.28 ton	0.16 ton
	P1	Pier	0.30 t/m	0.10 t/m
(L)	P1	superstructure safety fences	3.86 ton	2.35 ton
	P1	Pier	0.58 t/m	0.20 t/m

§ 4 ACTING FORCE TABLE

1.) due to transverse force



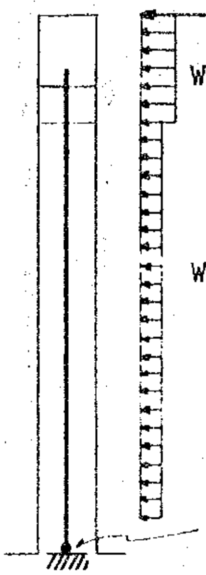
			case	M (tm)	N (ton)	S (ton)	
B1	M max	+	3	-0.238	0	178.294	
		-					
	N max	+					
		-	2	-0.157	-1.380	·97.364	
	S max	+	3	-0.238	0	178.294	
		-					
B2	M max	+					
		-					
	N max	+					
		-					
	S max	+					
		-					
B3	M max	+					
		-	3	-234.732	0	181.535	
	N max	+					
		-	2	-129.118	-1.380	100.605	
	S max	+					
		-	3	-234.732	0	181.535	

			case	M (tm)	N (ton)	S (ton)	
B4	M max.	+					
		-	3	-310.084	9.501	-180.985	1.00
	N max.	+	3	-240.203	31.933	-98.261	"
		-					
	S max.	+					
		-	3	-275.687	21.945	-180.985	1.00
B5	M max.	+	3	34.866	13.938	-51.657	"
		-	3	-139.942	19.489	-42.962	"
	N max.	+	3	-105.545	31.933	-42.962	"
		-					
	S max.	+					
		-	3	-26.881	23.027	-95.216	1.00
C1	M max.	+	3	130.956	-328.460	-31.933	"
		-					
	N max.	+					
		-	3	95.471	-411.185	-21.945	1.00
	S max.	+					
		-	3	130.956	-328.460	-31.933	1.00
C2	M max.	+	3	85.351	-252.036	31.933	"
		-					
	N max.	+					
		-	3	50.271	-343.836	20.072	1.00
	S max.	+	3	85.351	-252.036	31.933	"
		-					

These value is divided by "i".

i ; coefficient of increase
in basic stresses

2) due to longitudinal force



	M (tm)	N (ton)	H (ton)	
case-7				1.00
case-8	45.9	439.5	6.4	1.25
case-9	50.2	400.9	7.7	1.15
case-10	65.1	439.5	9.7	1.30
case-11				1.00

CASE 8

	N	H	y	M
WDL	193.9			
WLL (B)	222.1			
FB (B)		6.38	7.20	45.9
W	23.5			
TOTAL	439.5	6.38		45.9

M = 45.9 t·m

N = 439.5 ton

H = 6.4 ton

CASE 9

	N	H	y	M
WDL	193.9			
WLL, FB (A)	183.5	4.30	7.20	31.0
W	23.5			
WL (Super)		1.40	7.20	10.1
WL (1)		0.85	6.55	5.6
WL (2)		1.10	3.20	3.5
TOTAL	400.9	7.65		50.2

M = 50.2 t·m

N = 400.9 ton

H = 7.7 ton

CASE 10

	N	H	y	M
WDL	193.9			
WLL , FB(B)	222.1	6.38	7.20	45.9
W	23.5			
WL (Super)		1.40	7.20	10.1
WL (1)		0.85	6.55	5.6
WL (2)		1.10	3.20	3.5
TOTAL	439.5	9.73		65.1

M = 65.1 t·m

N = 439.5 ton

H = 9.7 ton

CASE

	N	H	y	M
TOTAL				

M = t·m

N = ton

H = ton

	at B4	at B5	at C1
	case 3	case 3	case 3
M (tm)	310.084	34.866	130.956
N (ton)	-9.501	-13.938	328.460
Q;shear force (ton)	180.985	51.657	31.933
b (cm)	80	80	80
d (cm)	145	150	110
d' (cm)	10	10	10
As (cm^2)	As=112.6 cm² (D32 10cm Pitch) ×2 As'=56.3 cm² (D32 10cm Pitch)	56.3 (D32 10cm Pitch)	56.3 (D32 10cm Pitch)
d'/d			0.091
f=(M/N)+u (cm)			89.9
f/d			0.82
n	15	15	15
nF=n•As/b•d	0.146	0.070	0.096
M'=M+N•u (tm)			295.2
M'/(b•d^2) (kg/cm²)	18.4	1.94	30.5
Q/b•d (kg/cm^2)	15.6	4.3	3.63
C	4.54	7.2	2.75
S	7.8	16.0	0.8
Z	1.14	1.15	0.80
σ_c (kg/cm^2)	84	14	84
σ_s (kg/cm^2)	2153	466	366
τ (kg/cm^2)	17.8 *	4.9	2.9
σ_{ca} (kg/cm^2)	85	85	85
σ_{sa} (kg/cm^2)	2340	2340	2340
τ_a (kg/cm^2)	10.3	10.3	10.3

* See page 53'

	case	case 10	case
M (tm)		65.1	
N (ton)		439.5	
Q;shear force (ton)		9.7	
b (cm)		120	
d (cm)		70	
d' (cm)		10	
As (cm^2)		39.3 D25 (15^{cm} Pitch)	
d'/d		0.14	
f=(M/N)+u (cm)		44.8	
f/d		0.64	
n	15	15	15
nP=n·As/b·d		0.070	
M'=M+N·u (tm)		197.0	
M'/(b·d^2) (kg/cm^2)		33.5	
Q/b·d (kg/cm^2)		1.15	
C		2.51	
S		――	
Z		0.21	
σc (kg/cm^2)		84.1	
σs (kg/cm^2)		――	
τ (kg/cm^2)		0.2	
σca (kg/cm^2)		111	
σsa (kg/cm^2)		3042	
τa (kg/cm^2)		10.7	

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Check for stirrups.

$$\tau = \frac{S_h}{b \cdot d} \times Z = \frac{180.985 \times 10^3}{80 \times 145} \times 1.14 = 17.79 \ kg/cm^2$$

$$> \tau_a = 8.20 \ kg/cm^2$$

$$Req.\ A_w = \frac{S_h \times a}{\sigma_{sa} \cdot d} \times Z$$

$$= \frac{180.985 \times 10^3 \times 12.5}{1780 \times 145} \times 1.14 = 9.99 \ cm^2$$

$\Phi 20$ ctc 125^{mm} nos. = 4

Used $A_w = 3.14 \times 4 = 12.56 \ cm^2 > Req\ A_w = 9.99 \ cm^2$

Vol. 3

M.J B-RAMP BR. P_3 Pier

(P -   )

§ 1 DESIGN CONDITIONS

1 Pier type

Rigid-frame pier

hight H = m

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footing foundation

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2.4?7 t/m^3

4 Allowable stresses of reinforced concrete

1.) concrete (grade 25 , BS 5400)

cube strength at 28 days ck = 255 kg/cm^2

bending stress ca = 85

direct stress ca = 64.3

shear stress a = 8.2

2.) reinforcement (hot rolled high yield bars, BS 4449)

specified characteristic strength

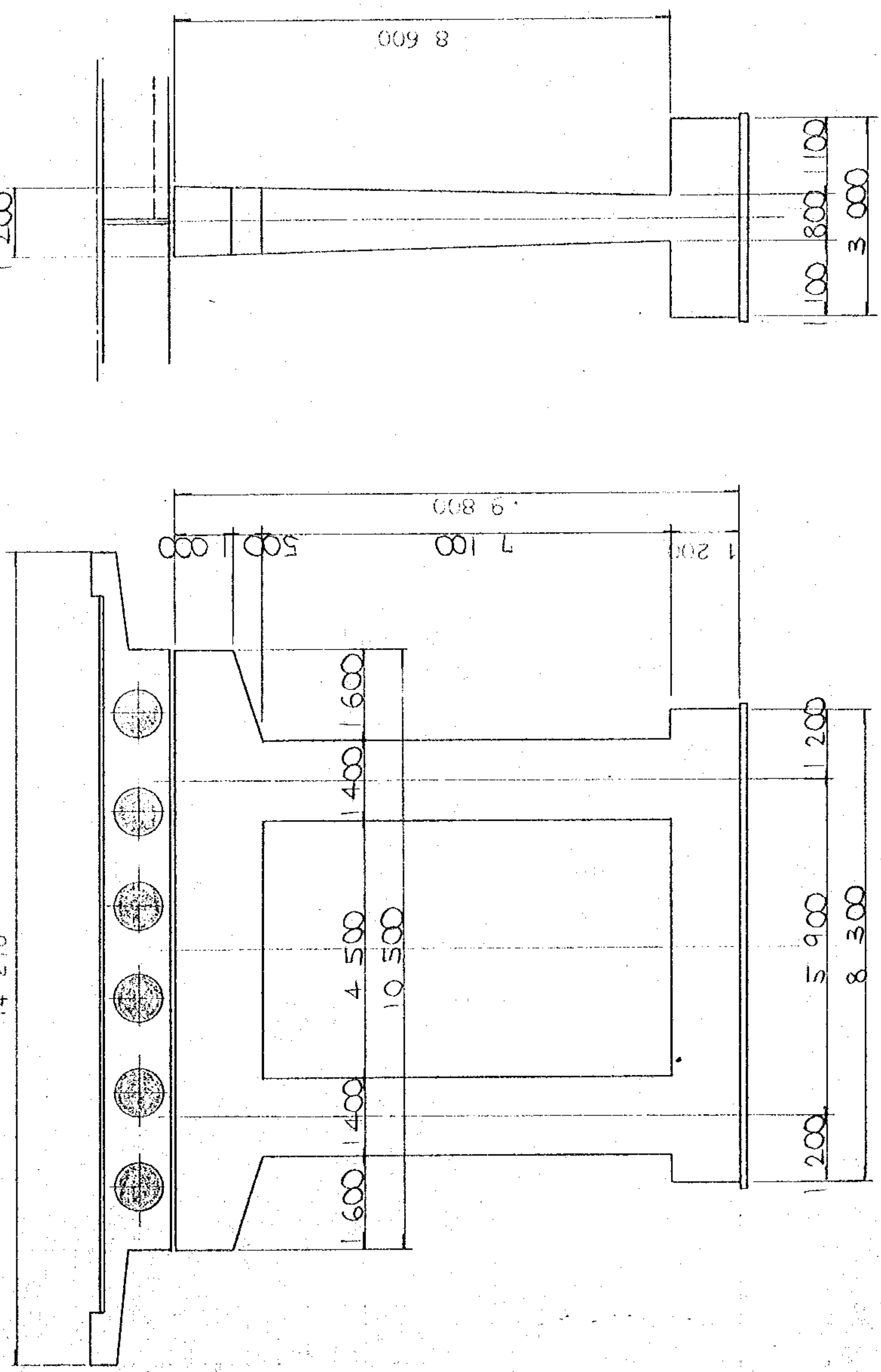
su = 4 180 kg/cm^2

permissible tensile stress

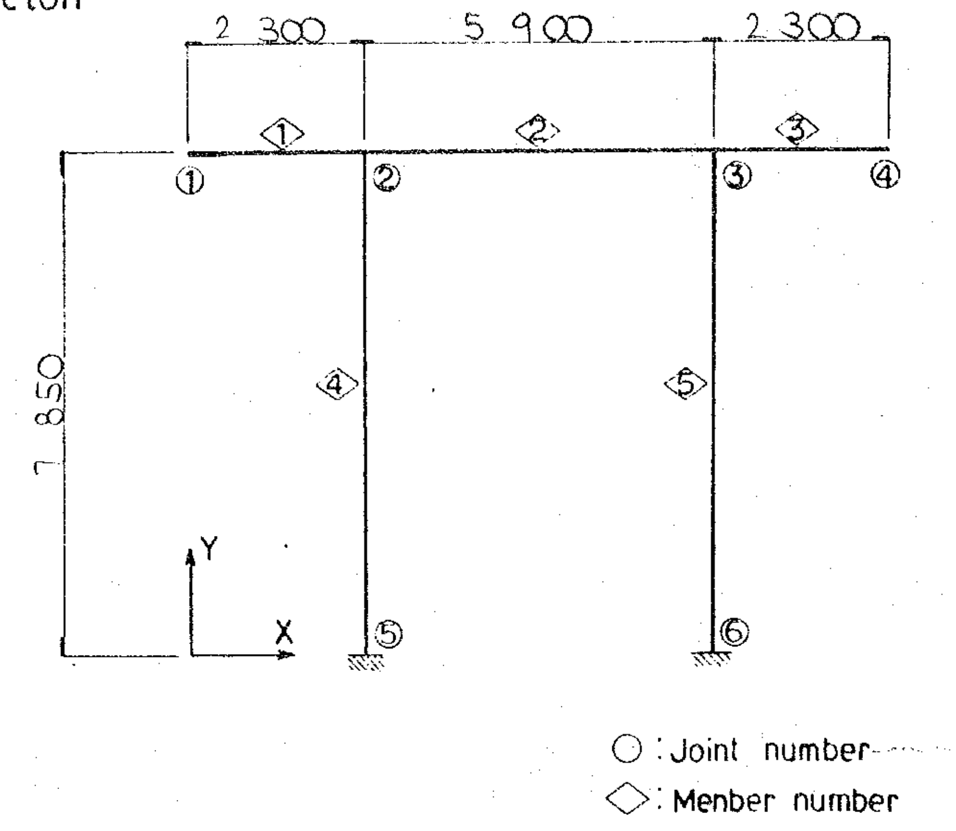
sa = 2 340 kg/cm^2

modular ratio n = 15

§ 2 GENERAL DIMENSION



Skeleton



Coordinates

(m)

	X	Y		X	Y
①	0.0	7.85	④	10.50	7.85
②	2.30	7.85	⑤	2.30	0.0
③	8.20	7.85	⑥	8.20	0.0

Modulus of elasticity of concrete

$E_c = 26\ kN/mm^2$

$= 2.65 \times 10^6\ t/m^2$

member	section B x H	area of section A (m²)	moment of inertia I (m⁴)
◇1	1.17 × 1.25	1.46	0.1904
◇2	1.17 × 1.50	1.76	0.3291
◇3	1.17 × 1.50	1.46	0.1904
◇4	0.97 × 1.40	1.36	0.2218
◇5	0.97 × 1.40	1.36	0.2218

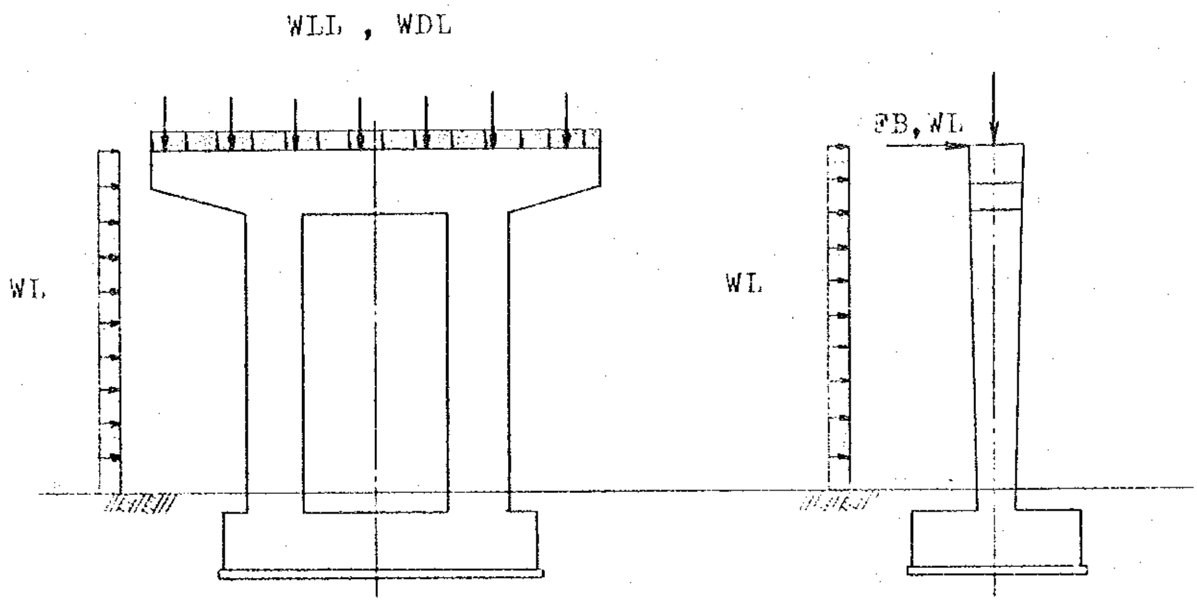
§ 3 CALCULATION OF LOADS

1.) Loading case and increase in basic stresses

No.	base load case	mark
1	dead load of deck	WDL
2	max reaction under HA	WLL(A)
3	max reaction under HB	WLL(B)
4	HA braking	FB(A)
5	HB braking	FB(B)
6	self weight	W
7	temperture change and drying schrinkage	FT & FS
8	wind	WL

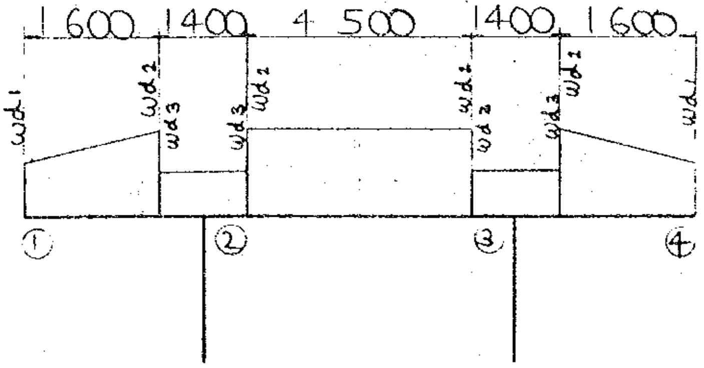
case	load combination	increase in basic stresses
1	1, 6, 7	1.00
2	1, 6, 7, 8	1.00
3	1, 2, 6, 7	1.00
4	1, 3, 6, 7	1.25
5	1, 2, 6, 7, 8	1.15
6	1, 3, 6, 7, 8	1.30
7	1, 2, 4, 6, 7	1.00
8	1, 3, 5, 6, 7	1.25
9	1, 2, 4, 6, 7, 8	1.15
10	1, 3, 5, 6, 7, 8	1.30
11	1, 6, 7, 8	1.00

2.) Loading diagram



3) Dead load

(a) beam



wd1 = 1.17 × 1.00 × 2.407 = 2.82 t/m

wd2 = 1.17 × 1.50 × 2.407 = 4.22 t/m

wd3 = 1.17 × 0.75 × 2.407 = 2.11 t/m

(b) column

pw = 0.97 × 1.40 × 2.407 = 3.27 t/m

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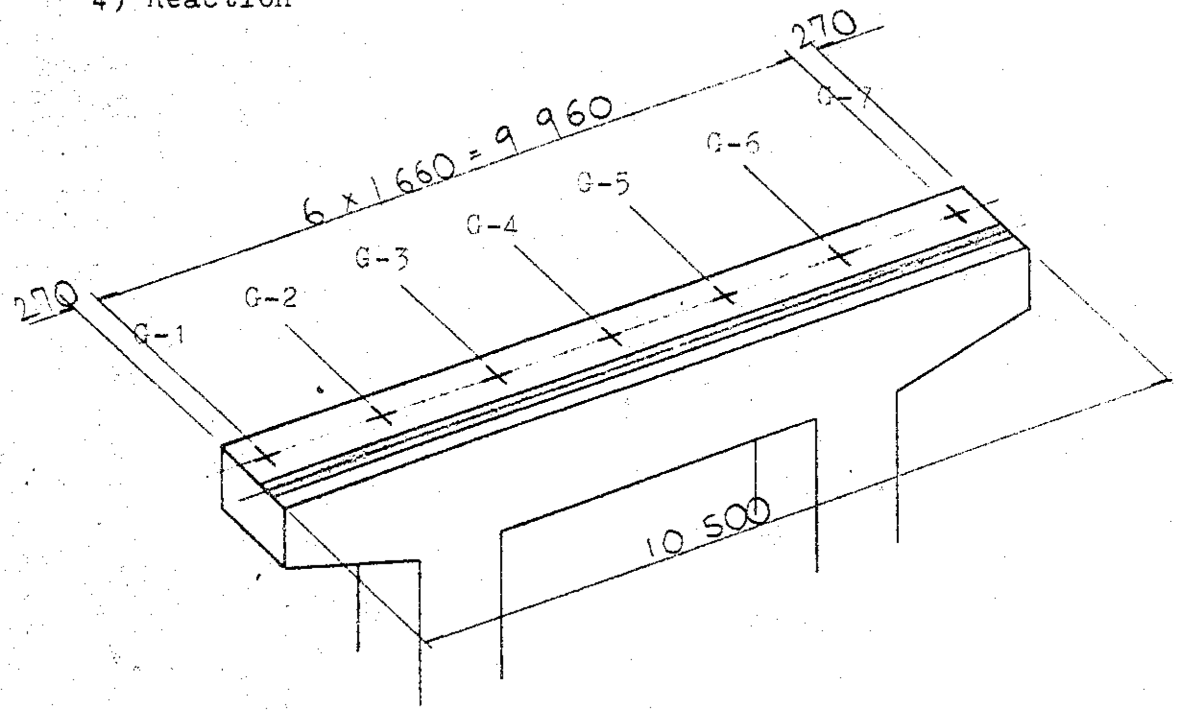
4) Reaction



		G-1	G-2	G-3	G-4	G-5	G-6	G-7		
Dead load		74.3	4.8	19.2	15.7	11.7	19.2	6.9		
		11.03 t/m								
HA load		95.8	43.3	20.5	22.3	21.7	22.9	23.9		
		3.99 t/m								
HB load		139.3	34.4	28.6	25.2	21.7	34.7	35.1		
		0.95 t/m								

5.) Temperture change and Drying schrinkage

temperture change -12 +20 deg.

drying schrinkage -20 deg.

6.) Wind Load (transverse)

(a) For superstructure

Vc = 38 x 1.0 x 1.0 x 1.56 = 59.3 m/sec. > 35 m/sec.

Unloaded

Pt = q·A·Cd

$q = 0.613 \times 59.3^2 \times 0.102 = 219.9$ kg/m²

$A = 1.38 \times 14.6 = 20.1$ m²

Cd= 1.20

$Pt = 219.9 \times 20.1 \times 1.20 = 5\,304$ kg

$= 5.3$ ton

Live loaded

Pt = q·A·Cd

$q = 0.613 \times 35^2 \times 0.102 = 76.6$ kg/m²

$A = 3.73 \times 14.6 = 54.5$ m²

Cd= 1.35

$Pt = 76.6 \times 54.5 \times 1.35 = 5\,636$ kg

$= 5.6$ ton

(b) For safety fences

Vc = 38 x 1.0 x 1.0 x 1.56 = 59.3 m/sec.

Pt = q·A·Cd

$q = 219.9$ kg/m²

$A = (0.150 \times 14.6 + 0.850 \times 0.05 \times \frac{14.6}{2}) \times 2 = 5.00$ m²

Cd= 1.1

$Pt = 219.9 \times 5.00 \times 1.1 = 1\,209$ kg

$= 1.2$ ton.

(c) For Pier

$V_c = 38 \times 1.0 \times 1.0 \times 1.56 = 59.3$ m/sec.

Unloaded

$q = 219.9\ kg/m^2$

$A1 = 1/2(1.20 + 0.82) \times 8.10 = 8.18\ m^2$

$A2 = 1/2(1.13 + 0.82) \times 6.60 = 6.44\ m^2$

$Cd = 1.7$

$Pt = 219.9 \times (8.18 + 6.44) \times 1.7 = 5465\ kg$

$= 5.5\ ton$

Live loaded

$q = 76.6\ kg/m^2$

$A = A1 + A2 = 14.62\ m^2$

$Cd = 1.7$

$Pt = 76.6 \times 14.62 \times 1.7 = 1904\ kg = 1.9\ ton$

(d) Table of Wind load (transverce)

(ton)

	unloaded	live loaded
super-structure	5.3	5.6
safety fences	1.2	——
Pier	5.5	1.9

7.) Longitudinal force

(a) due to breaking

HA ———— 25.8 ton

HB ———— 38.3 ton

(b) due to Wind

for superstructure

unloaded PLS = 0.25 Pt = 0.25×5.3

= 1.33 ton

live loaded PLL = 0.5 Pt

Pt = 76.6 × (2.5×14.6) × 1.35

= 3.8 ton

PLL = 0.5 × 3.8 = 1.9 ton

PLS = 0.25 Pt

Pt = 76.6 × (3.73 − 2.50) × 14.6 × 1.20

= 1.7 ton

PLS = 0.25 × 1.7 = 0.4 ton

for safety fences

vertical member

PL = 0.8 Pt

$Pt = 219.9 \times (0.85 \times 0.05 \times \frac{14.6}{2} \times 2) \times 1.1$

= 150 kg = 0.2 ton

PL = 0.8 × 0.2 = 0.2 ton

longitudinal member

PL = 0.4 Pt

Pt = 219.9 × (0.15 × 14.6 × 2) × 1.1

= 1059 kg = 1.1 ton

PL = 0.4 × 1.1 = 0.4 ton

for Pier

Vc = 59.3 m/sec.

unloaded

q = 219.9 kg/m²

A1= 1.50 × 10.50 − 1.60 × 0.50 = 15.0 m²

A2= 1.40 × 6.60 × 2 = 18.5 m²

Cd1= 2.1

Cd2= 2.2

Pt1= 219.9 × 15.0 × 2.1 = 6.9 ton

Pt2= 219.9 × 18.5 × 2.2 = 8.9 ton

live loaded

q = 76.6 kg/m²

A1= 15.0 m²

A2= 18.5 m²

Cd1= 2.1

Cd2= 2.2

Pt1= 76.6 × 15.0 × 2.1 = 2.4 ton

Pt2= 76.6 × 18.5 × 2.2 = 3.1 ton

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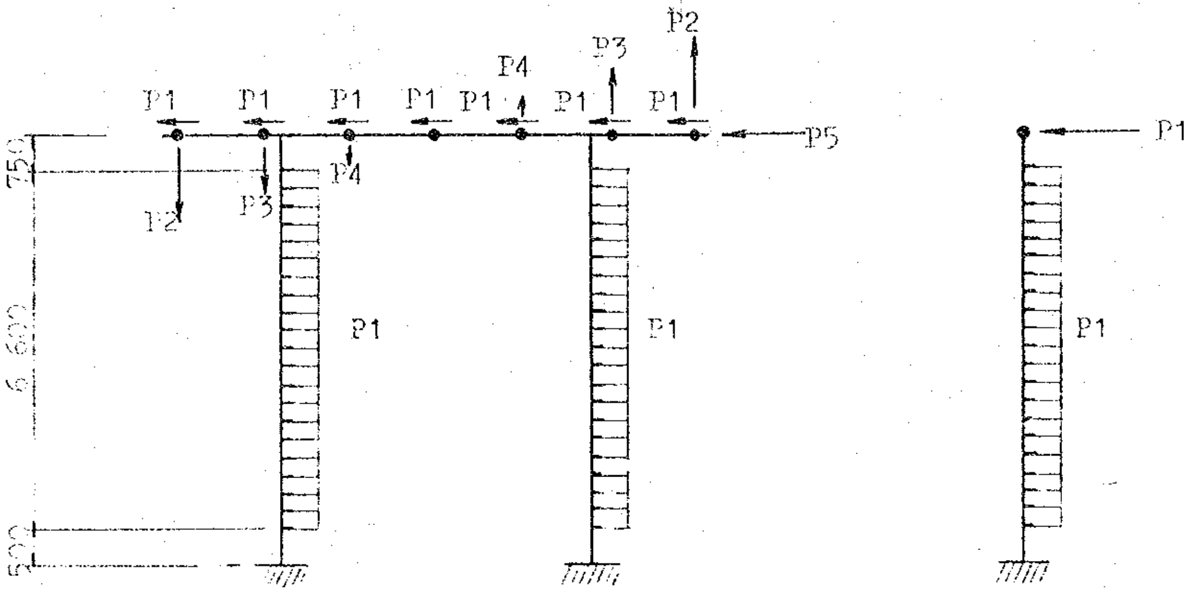
8) Wind loading diagram



		For Place	unloaded	live loaded
(T)	P1	superstructure safety fences	0.93 ton	0.80 ton
	P2	superstructure safety fences	0.49 ton	0.94 ton
	P3	superstructure safety fences	0.33 ton	0.63 ton
	P4	superstructure safety fences	0.16 ton	0.31 ton
	P5	Pier	0.69 ton	0.58 ton
	P1	Pier	0.40 t/m	0.10 t/m
(L)	P1	superstructure safety fences	4.42 ton	2.35 ton
	P1	Pier	0.67 t/m	0.23 t/m

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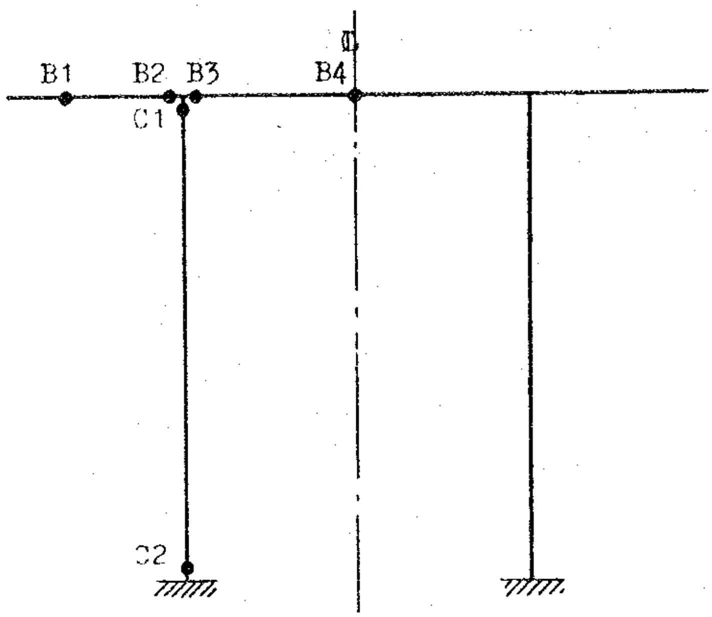
§ 4 ACTING FORCE TABLE

1.) due to transverse force



			case	M (tm)	N (ton)	S (ton)	
B1	M max.	+					
		-	3	-0.650	0	-174.924	1.00
	N max.	+	2	-0.508	0.930	-78.561	1.00
		-					
	S max.	+					
		-	3	-0.650	0	-174.924	1.00
B2	M max.	+					
		-	3	-249.550	0	-199.620	1.00
	N max.	+	2	-117.796	0.930	-98.070	1.00
		-					
	S max.	+					
		-	3	-249.550	0	-199.620	1.00

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			case	M (tm)	N (ton)	S (ton)	
B3	M max.	+					
		-	3	-352.047	4.621	164.775	1.00
	N max.	+	3	-263.102	29.141	111.493	1.00
		-	5	-186.276	-6.455	119.030	1.15
	S max.	+	3	-300.014	21.235	164.775	1.00
		-					
B4	M max.	+	3	95.717	10.679	37.411	1.00
		-	4	-83.314	13.631	46.078	1.25
	N max.	+	3	-28.584	29.141	33.083	1.00
		-	3	43.684	-5.935	37.411	1.00
	S max.	+	6	-17.132	22.023	48.906	1.30
		-					
C1	M max.	+	5	18.809	-217.420	-7.847	1.15
		-	3	-148.155	-371.141	29.141	1.00
	N max.	+					
		-	3	-111.242	-424.423	21.235	1.00
	S max.	+	3	-148.155	-371.142	29.141	1.00
		-					
C2	M max.	+	3	21.536	-173.271	5.935	1.00
		-	3	-114.420	-162.145	-29.141	1.00
	N max.	+					
		-	3	-60.689	-238.909	-13.897	1.00
	S max.	+					
		-	3	-114.420	-162.145	-29.141	1.00

These value is divided by "i".

i ; coefficient of increase in basic stresses

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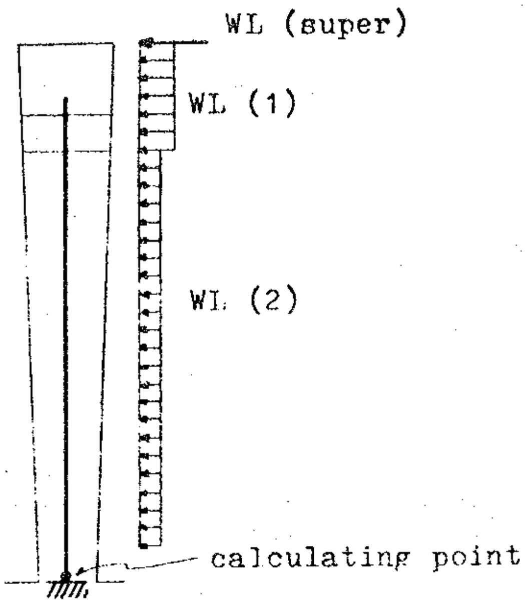
2) due to longitudinal force



	M (tm)	N (ton)	H (ton)	
case-7				1.00
case-8	82.6	340.5	9.6	1.25
case-9	81.7	323.8	10.5	1.15
case-10	108.4	340.5	13.6	1.30
case-11				1.00

CASE 8

	N	H	y	M
WDL	133.8			
WLL (B)	162.4			
FB (B)		9.6	8.60	82.6
W	44.3			
TOTAL	340.5	9.6		82.6

M = 82.6 t·m

N = 340.5 ton

H = 9.6 ton

CASE 9

	N	H	y	M
WDL	133.8			
WLL, FB (A)	145.7	6.5	8.60	55.9
W	44.3			
WL (super)		1.2	8.60	10.3
WL (1)		1.2	7.85	9.4
WL (2)		1.6	3.80	6.1
TOTAL	323.8	10.5		81.7

M = 81.7 t·m

N = 323.8 ton

H = 10.5 ton

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CASE 10

	N	H	y	M
WDL	133.8			
WLL, FB(B)	162.4	9.6	8.60	82.6
W	44.3			
WL (super)		1.2	8.60	10.3
WL (1)		1.2	7.85	9.4
WL (2)		1.6	3.80	6.1
TOTAL	340.5	13.6		108.4

M = 108.4 t·m

N = 340.5 ton

H = 13.6 ton

CASE

	N	H	y	M
TOTAL				

M = t·m

N = ton

H = ton

	at B3	at B4	at C1
	case 3	case 3	case 3
M (tm)	352.047	95.717	148.155
N (ton)	-4.621	-10.679	371.141
Q;shear force (ton)	164.775	37.411	29.141
b (cm)	113	113	113
d (cm)	135	135	130
d' (cm)	15	15	10
As (cm^2)	As = 144.7 cm^2 (D32 11.6 cm pitch × 2) As' = 72.4 cm^2 (D32 11.6 cm pitch)	72.4 (D32 11.6 cm pitch)	44.2 (D25 11.6 cm pitch) minimum As
d'/d	0.11		0.077
f=(M/N)+u (cm)			60.4
f/d			0.465
n	15	15	15
nP=n•As/b•d	0.142	0.0712	0.0451
M'=M+N•u (tm)			370.8
M'/(b•d^2) (kg/cm^2)	17.09	4.65	19.42
Q/b•d (kg/cm^2)	10.80	2.45	1.98
C	4.80	7.15	
S	8.0	15.7	
Z	1.14	1.12	
σ_c (kg/cm^2)	82	33	
σ_s (kg/cm^2)	2051	1095	
τ (kg/cm^2)	12.3 ※	2.7	
σ_{ca} (kg/cm^2)	85	85	85
σ_{sa} (kg/cm^2)	2340	2340	2340
τ_a (kg/cm^2)	8.2	8.2	8.2

※ See page 75'

	at C2 case 3	case 10	case
M (tm)	114.420	108.4	
N (ton)	162.145	340.5	
Q;shear force (ton)	29.141	13.6	
b (cm)	80	140	
d (cm)	130	70	
d' (cm)	10	10	
As (cm^2)	24.6 (D25 15 cm pitch)	54.0 (D25 12 cm pitch)	
d'/d	0.077	0.143	
f=(M/N)+u (cm)	130.6	61.8	
f/d	1.00	0.88	
n	15	15	15
nP=n·As/b·d	0.0355	0.083	
M'=M+N·u (tm)	211.7	210.6	
M'/(b·d^2) (kg/cm^2)	15.7	30.7	
Q/b·d (kg/cm^2)	2.8	1.39	
C	4.5	3.2	
S	5.0	1.6	
Z	0.88	0.84	
σc (kg/cm^2)	71	98	
σs (kg/cm^2)	1178	737	
τ (kg/cm^2)	2.5	1.2	
σca (kg/cm^2)	85	111	
σsa (kg/cm^2)	2340	3042	
τa (kg/cm^2)	8.2	10.7	

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check for stirrups

$$\tau = \frac{Sh}{b \cdot d} \times z = \frac{164\,775}{113 \times 135} \times 1.14 = 12.31 \ kg/cm^2$$

$$> \tau a = 8.2 \ kg/cm^2$$

$$Req \ Aw = \frac{Sh \times a}{\sigma sa \times d} \times z$$

$$= \frac{164\,775 \times 12.5}{1780 \times 135} \times 1.14 = 9.77 \ cm^2$$

Φ 20 ctc 125 nos. = 4

Used $Aw = 3.14 \times 4 = 12.56 \ cm^2$ > Req $Aw = 9.77$

§ 6 Caiculation of stability

Pier self weight

Cantilever beam	½×(1.00+1.50)×1.60×1.17×2.407×2	11.26
beam	7.30×1.50×1.17×2.407	30.84
column	1.40×7.10×0.97×2.407×2	46.42
Footing	3.00×8.30×1.20×2.407	71.92
Σ		158.71

Reaction due to superstructure

	P
Dead load	267.7
HA Live load	129.5
HB Live load	134.1
Crowd load	——
Total (HA)	397.2
Total (HB)	401.8

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Transverse direction

a) due to wind

· for superstructure

Unloaded $P_t = 5.3$ ton

Live loaded $P_t = 5.6$ ton

· for safety fences

$P_t = 1.2$ ton

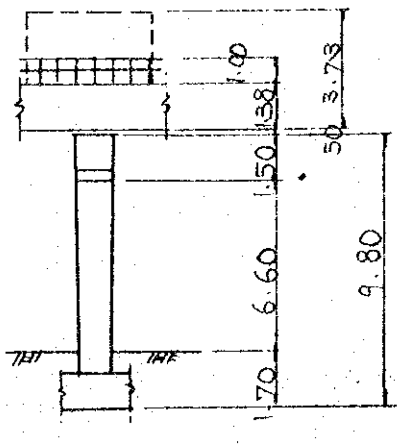
· for pier

Unloaded $P_{t-1} = 0.7$ ton

$P_{t-2} = 4.8$ ton

Live loaded $P_{t-1} = 0.2$ ton

$P_{t-2} = 1.7$ ton



Longitudinal direction

a) due to braking

Under HA ; FB = 25.8 × ½ = 12.9 ton

" HB ; FB = 38.3 × ½ = 19.2 ton

b) due to wind

· for superstructure

Unloaded P_{LS} = 1.3

Live loaded P_{LL} = 1.9

P_{LS} = 0.4

· for safety fences P_{L1} = 0.2

P_{L2} = 0.4

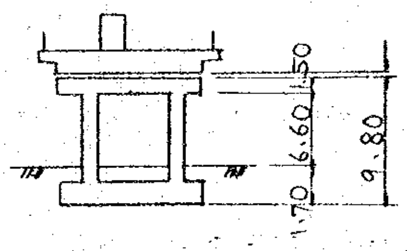
· for pier

Unloaded P_{L1} = 6.9

P_{L2} = 8.9

Live loaded P_{L-1} = 2.4

P_{L-2} = 3.1



		Vertical Force N (t)	distance x (m)	Moment N·x (t·m)	Horizontal Force H (t)	distance y (m)	Moment H·y (t·m)
	WDL	267.7					
	WLL (HA)	129.5			12.9	9.85	127.07
	WLL (HB)	134.1			19.2	9.85	189.12
	Self weight	158.7					
Transverse direction	WL (Unloaded)						
	for superstruct.				5.3	10.54	55.86
	for safety fence				1.2	11.73	14.08
	for pier (1)				0.7	9.05	6.34
	(2)				4.8	5.00	24.00
	WL (live loaded)						
	for superstruct (1)				5.6	11.72	65.63
	for pier (1)				0.2	9.05	1.81
	〃 (2)				1.7	5.00	8.50
Longitudinal direction	WL (Unloaded)						
	for superstruct.				1.3	9.85	12.81
	for safety fence				0.6	9.85	5.91
	for pier (1)				6.9	9.05	62.45
	(2)				8.9	5.00	44.50
	WL (Live loaded)						
	for superstruct. (1)				1.9	9.85	18.72
	〃 (2)				0.4	9.85	3.94
	for pier (1)				2.4	9.05	21.72
	(2)				3.1	5.00	15.50

Longitudinal direction

Case No	Loading combination	N (t)	H (t)	M (t)
1	Dead load only	426.4	0	0
2	Dead load + wind	426.4	17.7	125.67
3	HA Loading	555.9	12.9	127.07
4	HB Loading	560.5	19.2	189.12
5	HA Loading + wind	555.9	20.7	186.95
6	HB loading + wind	560.5	27.0	249.00

Calculation of Stability

- eccentric $e = M/N$ $\qquad B/6 = 0.50^m$
- Soil reaction i) $e < B/6$

$$q_{\substack{max \\ min}} = \frac{N}{B \times L} \left(1 \pm \frac{6 \times e}{B}\right)$$

ii) $e > B/6$ $\qquad x = (\frac{B}{2} - e) \times 3$

$$q_{max} = \frac{2 \cdot N}{B \times L}$$

- Sliding $F = \frac{N \times 0.6}{H}$

Case No.	B/6 (m)	eccentric e (m)	Siol reaction q max (t/m²)	q min (t/m²)	qa t/m²	Sliding F	Fa
1		0	17.1				
2	0.500	0.295	27.2	7.0	60.0	14	1.5
3	↓	0.229	32.6	12.1	60.0	26	↓
4		0.337	37.7	7.3	75.0	18	
5		0.336	37.3	7.3	69.0	16	
6		0.444	42.5	2.5	78.0	13	

Transverse direction

Case No	Loading combination	N (t)	H (t)	M (t)
1	~~Dead load only~~			
2	Dead load + wind	426.4	12.0	100.28
3	~~HA Loading~~			
4	~~HB Loading~~			
5	HA Loading + wind	555.9	7.5	75.94
6	HB Loading + wind	560.5	7.5	75.94

Calculation of Stability

- eccentric $e = M/N$ $\qquad B/6 = 8.10/6 = 1.35$
- Soil reaction i) $e < B/6$

$$q_{max,min} = \frac{N}{B \times L}\left(1 \pm \frac{6 \times e}{B}\right)$$

ii) $e > B/6$

$$q_{max} = \frac{2 \cdot N}{B \times L}$$

- Sliding $F = \dfrac{N \times 0.6}{H}$

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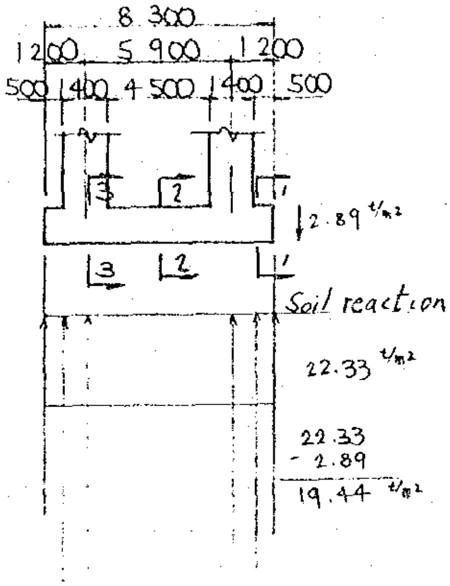
Case No.	B/6 (m)	eccentric e (m)	Soil reaction q_{max} (t/m²)	Soil reaction q_{min} (t/m²)	q_a t/m²	Sliding F	Sliding F_a
~~1~~							
2	1.350	0.235	20.6	14.5	60.0		
~~3~~							
~~4~~							
5	1.350	0.137	25.2	20.6	69.0		
6	1.350	0.135	25.4	20.8	78.0		

Calculation of footing section

1 Transverse direction



Sect 1.

$$M = 19.44 \times 0.5^2 \times \frac{1}{2} \times 3.0 = 7.29 \ \text{t·m}$$

$$M' = 7.29 \times \frac{1}{3} = 2.43 \ \text{t·m}$$

Sect 2.

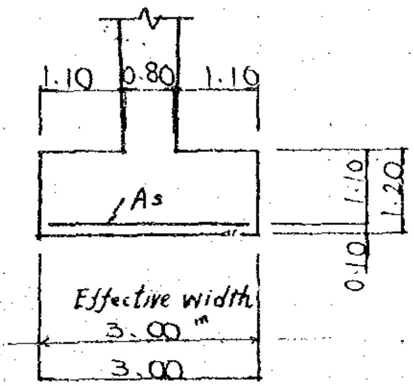
$$M = 19.44 \times 4.50^2 \times \frac{1}{8} \times 3.0 = 147.62 \ \text{t·m}$$

$$M' = 147.62 \times \frac{1}{3} = 49.21 \ \text{t·m}$$

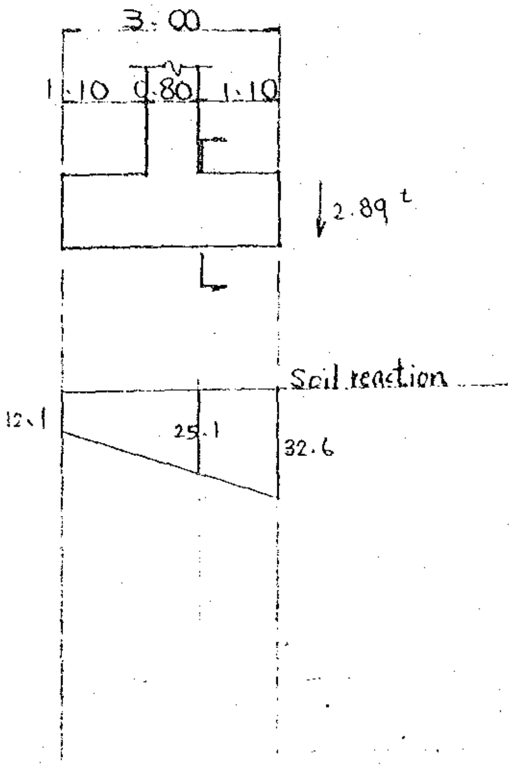
Sect 3.

$$M = 19.44 \times 5.90^2 \times \frac{1}{12} \times 3.0 = 169.18 \ \text{t·m}$$

$$M' = 169.18 \times \frac{1}{3} = 56.39 \ \text{t·m}$$



2 Longitudinal direction



$$S = 2.89 \times 1.10 \times 8.30 \quad (26.39)$$

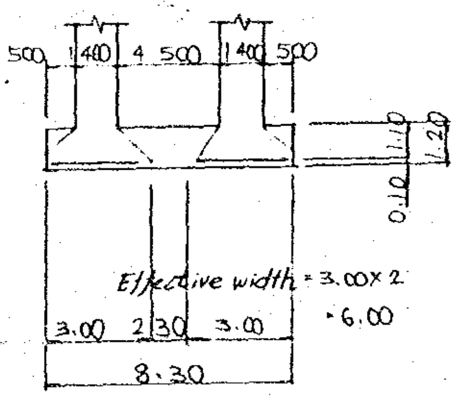
$$- \frac{1}{2} \times (32.6 + 25.1) \times 1.10 \times 8.30 \quad (263.40) \quad = -237.01$$

$$M = 26.39 \times \frac{1}{2} \times 1.10 \quad (14.51)$$

$$- 263.40 \times \frac{1}{3} \times \frac{2 \times 32.6 + 25.1}{32.6 + 25.1} \times 1.10 \quad (151.15) \quad = -136.64$$

$$S' = -237.01 \times \frac{1}{6.00} = 39.50 \text{ ton}$$

$$M' = -136.64 \times \frac{1}{6.00} = 22.77 \text{ t.m}$$



	Transverse direction		Longitudinal direction
	case bottom	case Top	case bottom
M (tm)	56.39	49.21	22.77
N (ton)			
Q;shear force (ton)			
b (cm)	100	100	100
d (cm)	110	110	110
d' (cm)	10	10	10
As (cm^2)	D20 − 125 = 25.12	D20 − 125 = 25.12	D16 − 125 = 16.08
d'/d			
f=(M/N)+u (cm)			
f/d			
n	15	15	15
nP=n•As/b•d	0.034	0.034	0.022
M'=M+N•u (tm)			
M'/(b•d^2) (kg/cm^2)	4.66	4.07	1.88
Q/b•d (kg/cm^2)			
C	9.46	9.46	11.3
S	32.0	32.0	48.5
Z			
σ_c (kg/cm^2)	44.1	38.5	21.2
σ_s (kg/cm^2)	2237	1954	1368
τ (kg/cm^2)			
σ_{ca} (kg/cm^2)			
σ_{sa} (kg/cm^2)			
τ_a (kg/cm^2)			

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Vol. 4

M.J G-RAMP BR. P_1 Pier

(P -)

§ 1 DESIGN CONDITIONS

1 Pier type

Rigid-frame pier

hight H = m

2 Foundation type

footing foundation

3 Unit weight of reinforced concrete

2.407 t/m^3

4 Allowable stresses of reinforced concrete

1.) concrete (grade 25 , BS 5400)

cube strength at 28 days σck = 255 kg/cm^2

bending stress σca = 85

direct stress σca = 64.3

shear stress τa = 8.2

2.) reinforcement (hot rolled high yield bars, BS 4449)

specified characteristic strength

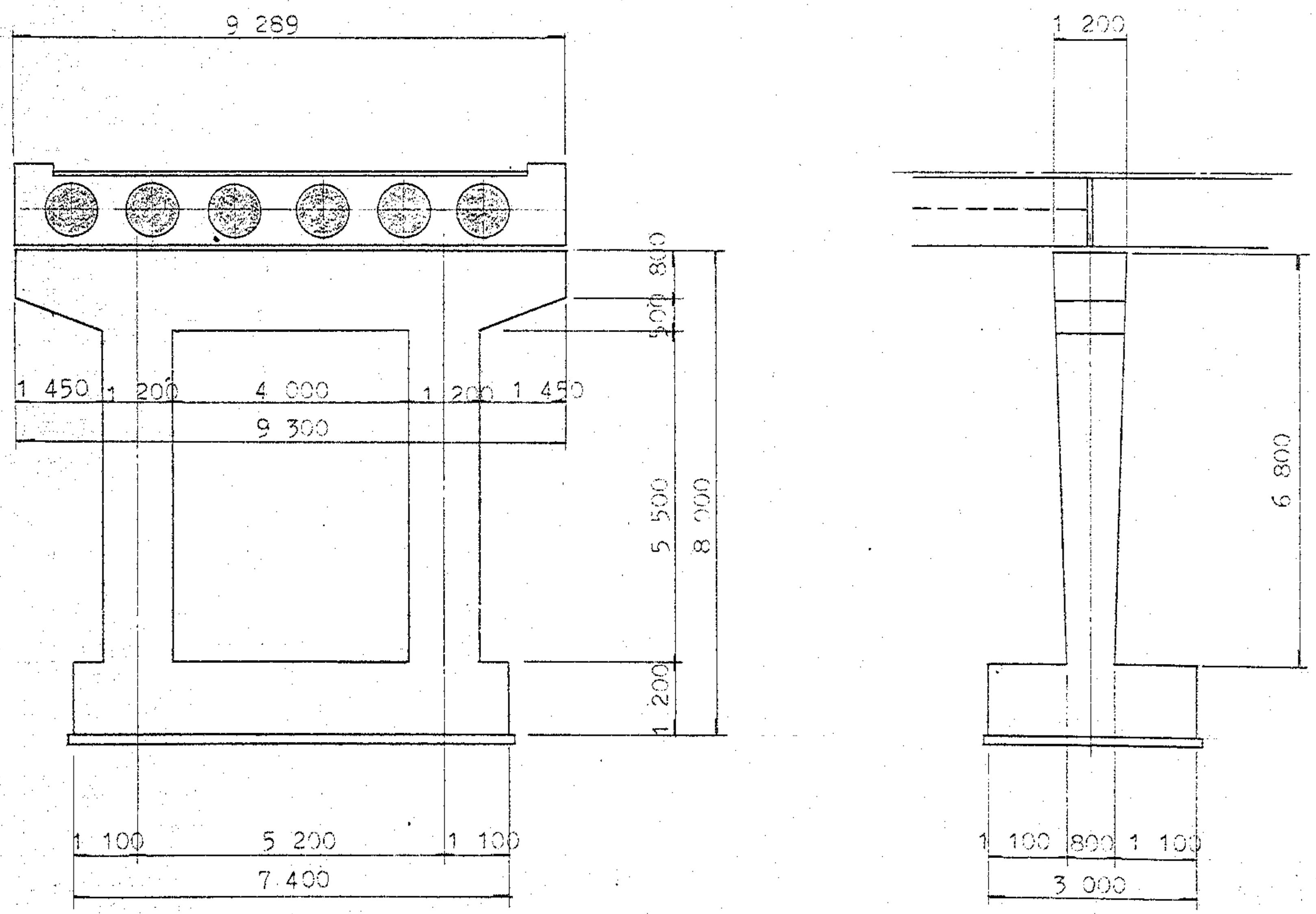
σsu = 4 180 kg/cm^2

permissible tensile stress

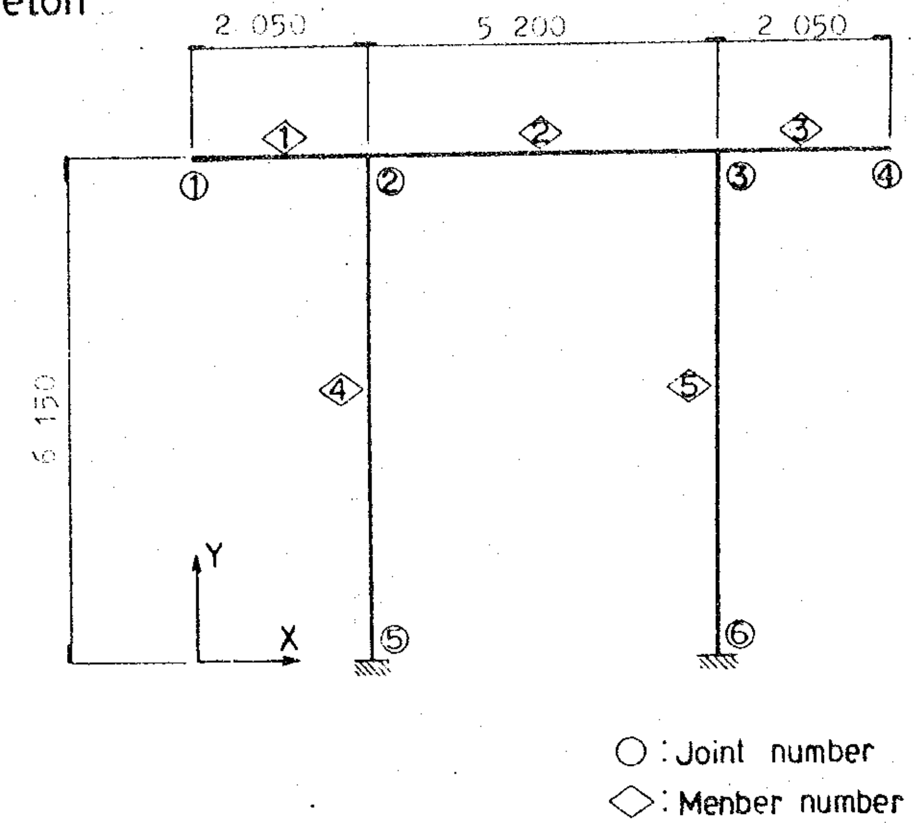
σsa = 2 340 kg/cm^2

modular ratio n = 15

§ 2 GENERAL DIMENSION



Skeleton



Coordinates

(m)

	X	Y		X	Y
①	0.0	6.15	④	9.30	6.15
②	2.05	6.15	⑤	2.05	0.0
③	7.25	6.15	⑥	7.25	0.0

Modulus of elasticity of concrete

$$E_c = 26\ kN/mm^2$$
$$= 2.65 \times 10^6\ t/m^2$$

member	section B x H	area of section A (m^2)	moment of inertia I (m^4)
①	1.16 x 1.05	1.22	0.1119
②	1.16 x 1.30	1.51	0.2124
③	1.16 x 1.05	1.22	0.1119
④	0.98 x 1.20	1.18	0.1411
⑤	0.98 x 1.20	1.18	0.1411

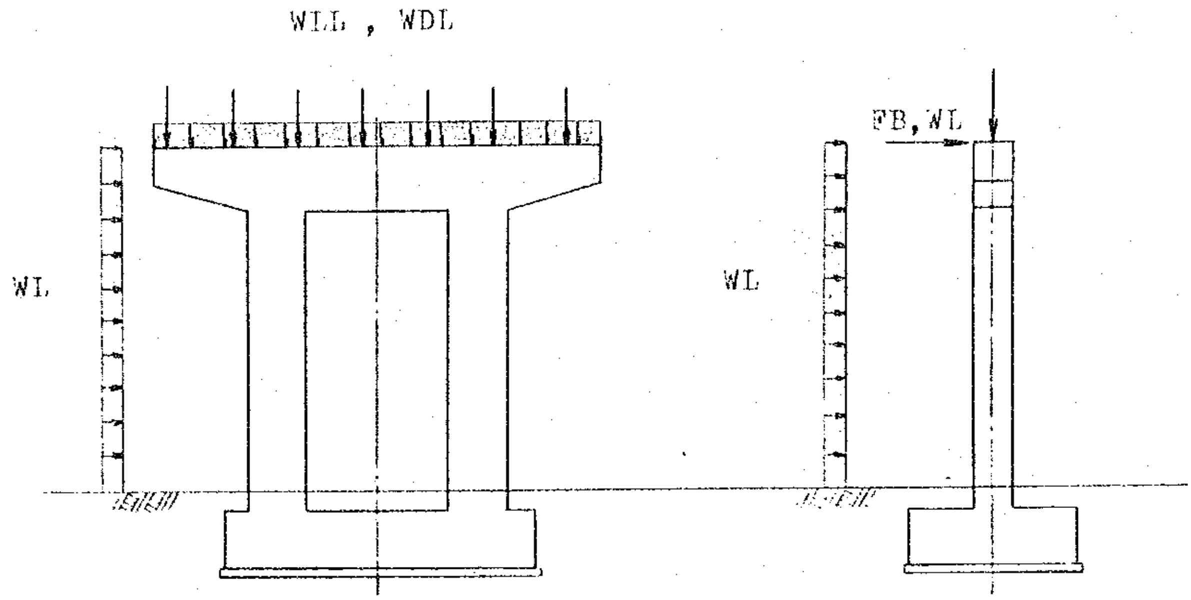
§ 3 CALCULATION OF LOADS

1.) Loading case and increase in basic stresses

No.	base load case	mark
1	dead load of deck	WDL
2	max reaction under HA	WLL(A)
3	max reaction under HB	WLL(B)
4	HA braking	FB(A)
5	HB braking	FB(B)
6	self weight	W
7	tenperture change and drying schrinkage	FT & FS
8	wind	WL

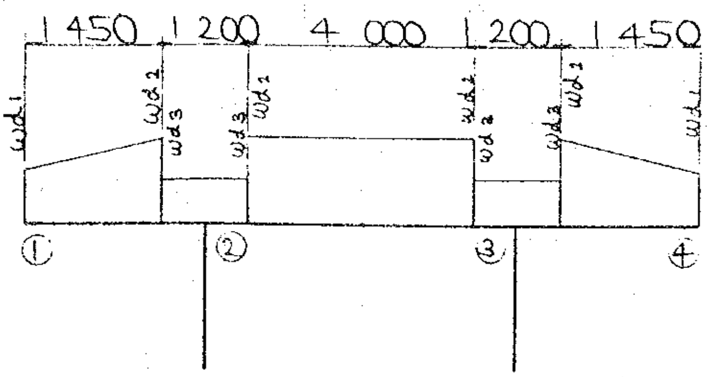
case	load combination	increase in basic stresses
1	1, 6, 7	1.00
2	1, 6, 7, 8	1.00
3	1, 2, 6, 7	1.00
4	1, 3, 6, 7	1.25
5	1, 2, 6, 7, 8	1.15
6	1, 3, 6, 7, 8	1.30
7	1, 2, 4, 6, 7	1.00
8	1, 3, 5, 6, 7	1.25
9	1, 2, 4, 6, 7, 8	1.15
10	1, 3, 5, 6, 7, 8	1.30
11	1, 6, 7, 8	1.00

2.) Loading diagram



3) Dead load

(a) beam



wd1 = 1.16 × 0.80 × 2.407 = 2.23 t/m

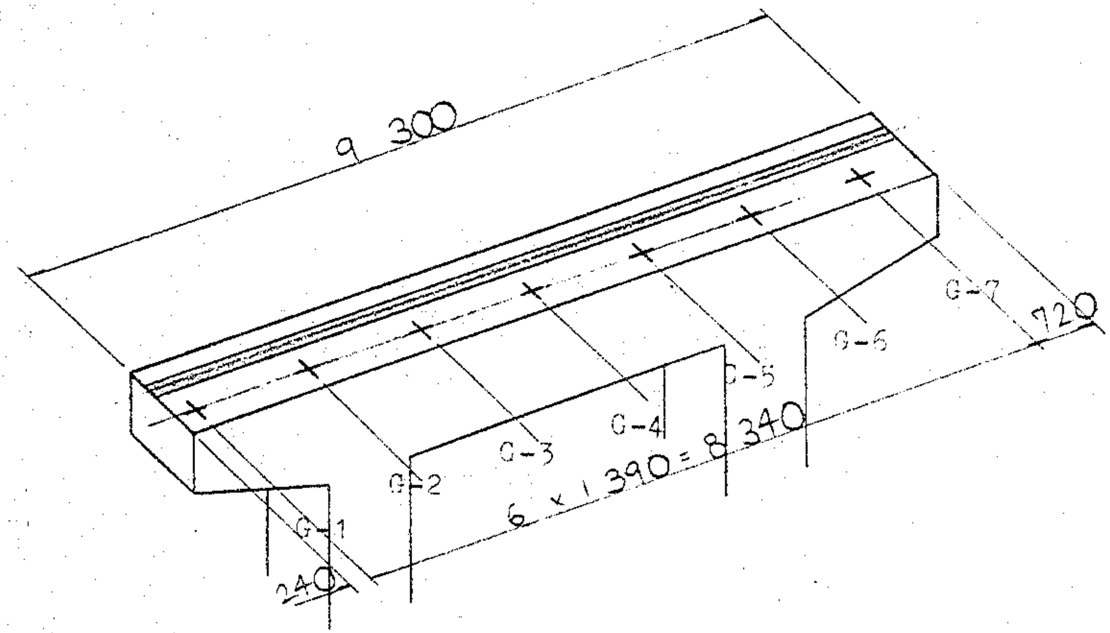
wd2 = 1.16 × 1.30 × 2.407 = 3.63 t/m

wd3 = 1.16 × 0.65 × 2.407 = 1.81 t/m

(b) column

pw = 0.98 × 1.20 × 2.407 = 2.83 t/m

4) Reaction



		G-1	G-2	G-3	G-4	G-5	G-6	G-7		
Dead load		43.7	16.1	22.5	21.9	18.1	24.3	2.8		
		4.76 t/m								
HA load		18.0	14.8	13.8	15.5	12.6	15.2	4.9		
		2.24 t/m								
HB load		40.5	25.6	29.4	32.3	28.2	31.1	14.1		
		0.32 t/m								

5.) Temperture change and Drying schrinkage

temperture change -12 +20 deg.

drying schrinkage -20 deg.

6.) Wind Load (transverse)

(a) For superstructure

Vc = 38 x 1.0 x 1.0 x 1.56 = 59.3 m/sec. 35 m/sec.

Unloaded

Pt = q・A・Cd

q = 0.613 × 59.3² × 0.102 = 219.9 kg/m²

A = 1.43 × 10.5 = 15.0 m²

Cd = 1.3

Pt = 219.9 × 15.0 × 1.3 = 4 288 kg

= 4.3 ton

Live loaded

Pt = q・A・Cd

q = 0.613 × 35² × 0.102 = 76.6 kg/m²

A = 3.78 × 10.5 = 39.7 m²

Cd = 1.45

Pt = 76.6 × 39.7 × 1.45 = 4 409 kg

= 4.4 ton

(b) For safety fences

Vc = 38 x 1.0 x 1.0 x 1.56 = 59.3 m/sec.

Pt = q・A・Cd

q = 219.9 kg/m²

$A = (0.150 \times 10.5 + 0.850 \times 0.05 \times \frac{10.5}{2}) \times 2 = 3.60$ m²

Cd = 1.1

Pt = 219.9 × 3.60 × 1.1 = 871 kg

= 0.9 ton

(c) For Pier

$Vc = 38 \times 1.0 \times 1.0 \times 1.56 = 59.3$ m/sec.

Unloaded

$q = 219.9$ kg/m²

$A1 = 0.98 \times 6.30 = 6.17$ m²

$A2 = 0.98 \times 5.00 = 4.90$ m²

$Cd = 2.0$

$Pt = 219.9 \times (6.17 + 4.90) \times 2.0 = 4\ 869$ kg

$= 4.9$ ton

Live loaded

$q = 76.6$ kg/m²

$A = A1 + A2 = 11.07$ m²

$Cd = 2.0$

$Pt = 76.6 \times 11.07 \times 2.0 = 1\ 696$ kg $= 1.7$ ton

(d) Table of Wind load (transverce)

(ton)

	unloaded	live loaded
super-structure	4.3	4.4
safety fences	0.9	—
Pier	4.9	1.7

٢

7.) Longitudinal force

(a) due to breaking

HA ———— 25.8 ton

HB ———— 38.3 ton

(b) due to Wind

for superstructure

unloaded PLS = 0.25 Pt = 0.25 × 4.3

= 1.1 ton

live loaded PLL = 0.5 Pt

Pt = 76.6 × (2.5 × 10.5) × 1.45

= 2.9 ton

PLL = 0.5 × 2.9 = 1.5 ton

PLS = 0.25 Pt

Pt = 76.6 × (3.78 − 2.5) × 10.5 × 1.3

= 1.3 ton

PLS = 0.25 × 1.3 = 0.3 ton

for safety fences

vertical member

PL = 0.8 Pt

$Pt = 219.9 \times (0.85 \times 0.05 \times \frac{10.5}{2} \times 2) \times 1.1$

= 108 kg = 0.1 ton

PL = 0.8 × 0.1 = 0.1 ton

longitudinal member

PL = 0.4 Pt

Pt = 219.9 × (0.15 × 10.5 × 2) × 1.1

= 762 kg = 0.8 ton

PL = 0.4 × 0.8 = 0.3 ton

/2

for Pier

Vc = 59.3 m/sec.

unloaded

q = 219.9 kg/m²

A1= 9.30×1.30−1.45×0.50 = 11.4 m²

A2= 5.00×1.20×2 = 12.0 m²

Cd1= 2.1

Cd2= 2.2

Pt1= 219.9×11.4×2.1 = 5.3 ton

Pt2= 219.9×12.0×2.2 = 5.8 ton

live loaded

q = 76.6 kg/m²

A1= 11.4 m²

A2= 12.0 m²

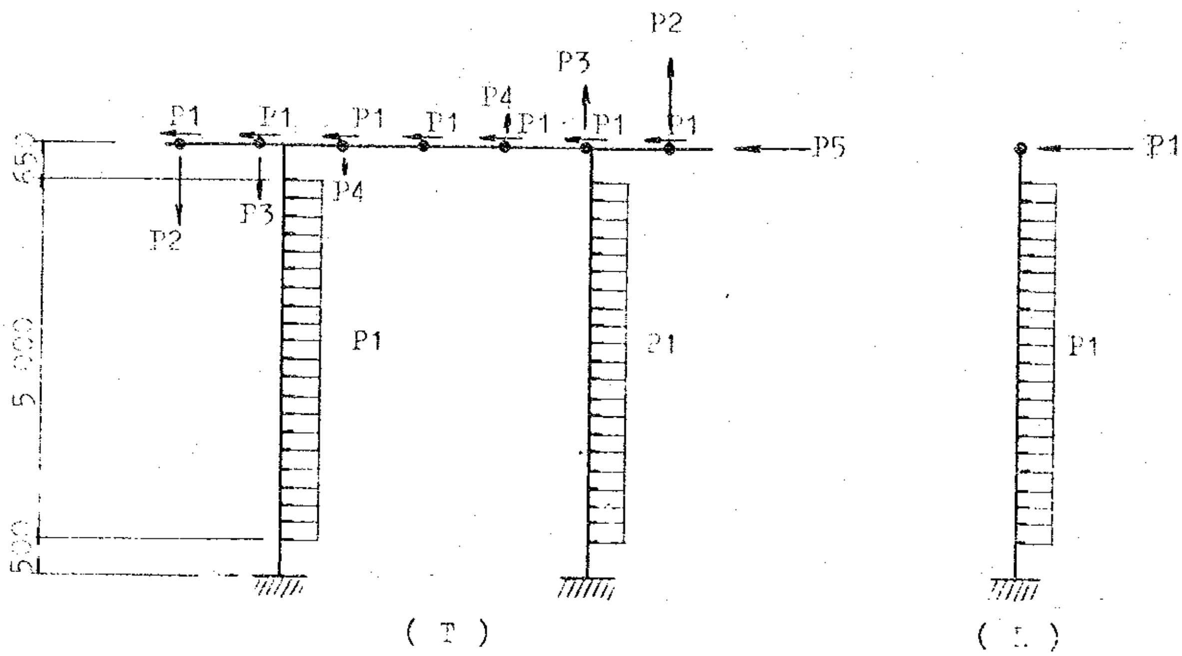
Cd1= 2.1

Cd2= 2.2

Pt1= 76.6×11.4×2.1 = 1.8 ton

Pt2= 76.6×12.0×2.2 = 2.0 ton

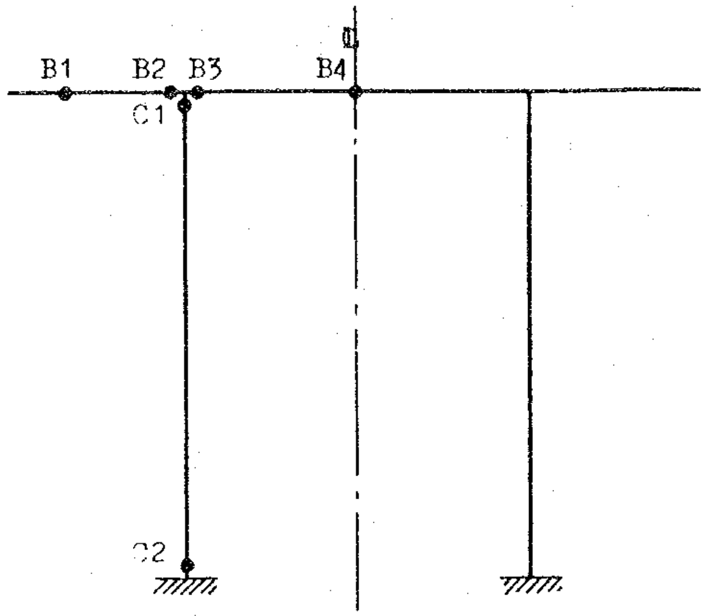
8) Wind loading diagram



		For Place	unloaded	live loaded
(T)	P1	superstructure safety fences	0.74 ton	0.63 ton
	P2	superstructure safety fences	0.45 ton	0.86 ton
	P3	superstructure safety fences	0.30 ton	0.57 ton
	P4	superstructure safety fences	0.15 ton	0.29 ton
	P5	Pier	0.60 ton	0.20 ton
	P1	Pier	0.43 t/m	0.15 t/m
(L)	P1	superstructure safety fences	3.40 ton	1.80 ton
	P1	Pier	0.58 t/m	0.20 t/m

§ 4 ACTING FORCE TABLE

1.) due to transverse force



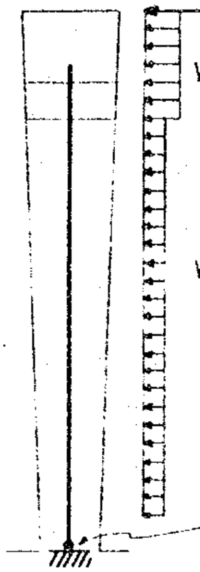
			case	M (tm)	N (ton)	S (ton)	
B1	M max.	+					
		-	3	-0.268	0	-63.943	1.00
	N max.	+	2	-0.204	0.740	-45.855	1.00
		-					
	S max.	+					
		-	4	-0.170	0	-68.786	1.25
B2	M max.	+					
		-	4	-88.046	0	-76.652	1.25
	N max.	+	2	-61.260	0.740	-55.300	1.00
		-					
	S max.	+					
		-	4	-88.046	0	-76.652	1.25

			case	M (tm)	N (ton)	S (ton)	
B3	M max.	+					
		-	6	-154.604	-6.095	106.608	1.30
	N max.	+	3	-91.428	16.138	75.660	1.00
		-	6	-110.919	-10.268	95.738	1.30
	S max.	+	4	-118.097	9.448	108.213	1.25
		-					
B4	M max.	+	4	79.670	5.107	-5.215	1.25
		-	4	-15.334	0.454	12.849	1.25
	N max.	+	3	37.510	16.138	10.538	1.00
		-	4	43.685	-9.882	-5.215	1.25
	S max.	+	6	33.326	12.551	23.586	1.30
		-					
C1	M max.	+	6	31.406	-154.447	-11.237	1.30
		-	4	-55.052	-178.265	15.443	1.25
	N max.	+					
		-	4	-30.943	-221.532	9.448	1.25
	S max.	+	3	-53.645	-187.944	16.138	1.00
		-					
C2	M max.	+	3	27.428	-132.479	9.627	1.00
		-	2	-64.940	-88.220	-17.701	1.00
	N max.	+					
		-	4	-30.581	-146.299	-6.102	1.25
	S max.	+					
		-	2	-64.940	-88.220	-17.701	1.00

These value is divided by "i".

i ; coefficient of increase in basic stresses

2) due to longitudinal force



	M (tm)	N (ton)	H (ton)	
case-7				1.00
case-8	65.3	230.3	9.6	1.25
case-9	58.8	186.0	9.3	1.15
case-10	79.9	230.3	12.4	1.30
case-11				1.00

CASE 8

	N	H	y	M
WDL	96.8			
WLL (B)	102.1			
FB (B)		9.6	6.80	65.3
W	31.4			
TOTAL	230.3	9.6		65.3

M = 65.3 t·m

N = 230.3 ton

H = 9.6 ton

CASE 9

	N	H	y	M
WDL	96.8			
WLL, FB (A)	57.8	6.5	6.80	44.2
W	31.4			
WL (super)		0.9	6.80	6.1
WL (1)		0.9	6.15	5.5
WL (2)		1.0	3.00	3.0
TOTAL	186.0	9.3		58.8

M = 58.8 t·m

N = 186.0 ton

H = 9.3 ton

CASE 10

	N	H	y	M
WDL	96.8			
WLL . FB(B)	102.1	9.6	6.80	65.3
W	31.4			
WL (super)		0.9	6.80	6.1
WL (1)		0.9	6.15	5.5
WL (2)		1.0	3.00	3.0
TOTAL	230.3	12.4		79.9

M = 79.9 t·m

N = 230.3 ton

H = 12.4 ton

CASE

	N	H	y	M
TOTAL				

M = t·m

N = ton

H = ton

	at B3 case 6	at B4 case 4	at C2 case 2
M (tm)	154.604	79.670	64.940
N (ton)	6.095	-5.107	88.220
Q: shear force (ton)	106.608	5.215	17.701
b (cm)	112	112	80
d (cm)	120	120	110
d' (cm)	10	10	10
As (cm^2)	72.36 (D32 11.5 cm Pitch)	44.19 (D25 11.5 cm Pitch)	24.6 (D25 15 cm Pitch)
d'/d			0.091
e=(M/N)+u (cm)			123.6
e/d			1.12
n	15	15	15
p=n·As/b·d	0.081	0.049	0.042
M'=M+N·u (tm)			109.1
M'/(b·d²) (kg/cm²)	9.59	4.94	11.3
Q/b·d (kg/cm²)	7.93	0.39	2.01
C	6.82	8.20	4.70
S	13.8	22.5	6.4
Z	1.12	1.09	0.97
σ_c (kg/cm²)	65	41	53
σ_s (kg/cm²)	1985	1667	1085
τ (kg/cm²)	8.9 *	0.4	1.9
σ_{ca} (kg/cm²)	85	85	85
σ_{sa} (kg/cm²)	2340	2340	2340
τ_a (kg/cm²)	8.2	8.2	8.2

* See page 106

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	case 10	case	case
M (tm)	79.9		
N (ton)	230.3		
Q;shear force (ton)	12.4		
b (cm)	120		
d (cm)	70		
d' (cm)	10		
As (cm^2)	44.2 (D25 12.5cm Pitch)		
d'/d	0.14		
f=[illegible] (cm)	64.7		
f/d	0.92		
n	15	15	15
np=n·As/b·d	0.079		
M'=M+N·f (tm)	149.0		
M'/(b·d^2) (kg/cm^2)	25.3		
Q/b·d (kg/cm^2)	1.48		
C	3.30		
S	1.8		
Z	0.84		
σ_c (kg/cm^2)	83		
σ_s (kg/cm^2)	683		
τ (kg/cm^2)	1.2		
σ_{ca} (kg/cm^2)	111		
σ_{sa} (kg/cm^2)	3042		
τ_a (kg/cm^2)	10.7		

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Check for stirrups

$$\tau = \frac{Sh}{b \cdot d} \times Z = \frac{106\,608}{112 \times 120} \times 1.12 = 8.88 \ cm^2$$

$$Req\ Aw = \frac{Sh \times a}{\sigma sa \times d} \times Z$$

$$= \frac{106\,608 \times 12.5}{1780 \times 120} \times 1.12 = 6.99 \ cm^2$$

Φ 16 etc 125 nos = 4

Used $Aw = 2.01 \times 4 = 8.04 \ cm^2 > Req\ Aw = 6.99 \ cm^2$

§ 6 Caiculation of stability

Pier self weight

Cantilever beam	½×(0.80+1.30)×1.45×1.162×2.407	4.26
beam	6.40×1.30×1.162×2.407	23.27
column	1.20×5.50×0.977×2.407×2	31.04
Footing	7.40×3.00×1.20×2.407	64.12
Σ		122.69

Reaction due to superstructure

	P_1
Dead load	193.7
HA Live load	87.4
HB Live load	103.2
Crowd load	——
Total (HA)	281.1
Total (HB)	296.9

Transverse direction

a) due to wind

· for superstructure

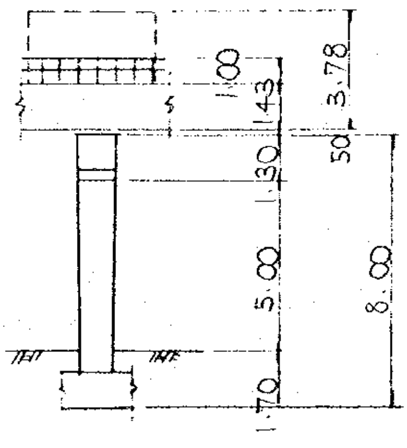
Unloaded	Pt = 4.3	ton
Live loaded	Pt = 4.4	ton

· for safety fences

	Pt = 0.9	ton

· for pier

Unloaded	Pt-1 = 0.7	ton
	Pt-2 = 4.2	ton
Live loaded	Pt-1 = 0.2	ton
	Pt-2 = 1.5	ton



Longitudinal direction

a) due to braking

Under HA ; $FB = 25.8 \times \frac{1}{2} = 12.9$ ton

" HB ; $FB = 38.3 \times \frac{1}{2} = 19.2$ ton

b) due to wind

- for superstructure

Unloaded $P_{LS} = 1.1$ ton

Live loaded $P_{LL} = 1.5$ ton

$P_{LS} = 0.3$ ton

- for safety fences $P_{L1} = 0.1$ ton

$P_{L2} = 0.3$ ton

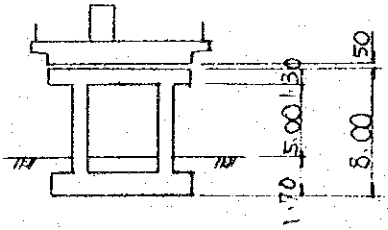
- for pier

Unloaded $P_{L1} = 5.3$ ton

$P_{L2} = 5.8$ ton

Live loaded $P_{L-1} = 1.8$ ton

$P_{L-2} = 2.0$ ton



		Vertical Force N (t)	distance x (m)	Moment N·x (t·m)	Horizontal Force H (t)	distance y (m)	Moment H·y (t·m)
	WDL	193.7					
	WLL (HA)	87.4			12.9	8.05	103.85
	WLL (HB)	103.2			19.2	8.05	154.56
	Self weight	122.7					
Transverse direction	WL (Unloaded)						
	for superstruct.				4.3	8.77	37.71
	for safety fence				0.9	9.98	8.98
	for pier (1)				0.7	7.35	5.15
	(2)				4.2	4.20	17.64
	WL (Live loaded)						
	for superstruct (1)				4.4	8.77	38.59
	for pier (1)				0.2	7.35	1.47
	" (2)				1.5	4.20	6.30
Longitudinal direction	WL (Unloaded)						
	for superstruct.				1.1	8.05	8.86
	for safety fence				0.4	8.05	3.22
	for pier (1)				5.3	7.35	38.96
	(2)				5.8	4.20	24.36
	WL (Live loaded)						
	for superstruct. (1)				1.5	8.05	12.08
	" (2)				0.3	8.05	2.42
	for pier (1)				1.8	7.35	13.23
	(2)				2.0	4.20	8.40

Longitudinal direction

Case No	Loading combination	N (t)	H (t)	M (t)
1	Dead load only	316.4	0	0
2	Dead load + wind	316.4	12.6	75.40
3	HA Loading	403.8	12.9	103.85
4	HB Loading	419.6	19.2	154.56
5	HA Loading + wind	403.8	18.5	139.98
6	HB Loading + wind	419.6	24.8	190.69

Calculation of Stability

- eccentric $e = M/N$ $B/6 = 0.5$
- Soil reaction i) $e < B/6$

$$q_{\substack{max \\ min}} = \frac{N}{B \times L}\left(1 \pm \frac{6 \times e}{B}\right)$$

ii) $e > B/6$ $X = \left(\frac{B}{2} - e\right) \times 3$

$$q_{max} = \frac{2 \cdot N}{X \cdot L}$$

- Sliding $F = \dfrac{N \times 0.6}{H}$

Case No.	B/6 (m)	eccentric	Soil reaction		q_a t/m²	Sliding	
		e (m)	q_{max} (t/m²)	q_{min} (t/m²)		F	Fa
1		0	14.3		60.0		
2	0.500	0.238	21.0	7.5	60.0	15	1.5
3	↓	0.257	27.5	8.8	60.0	19	↓
4	↓	0.368	32.8	5.0	75.0	13	↓
5	↓	0.347	30.8	5.6	69.0	13	↓
6	↓	0.454	36.1	1.7	78.0	10	↓

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Transverse direction

Case No	Loading combination	N (t)	H (t)	M (t)
1	~~Dead load only~~			
2	Dead load + wind	316.4	10.1	69.48
3	~~HA Loading~~			
4	~~HB Loading~~			
5	HA Loading + wind	403.8	6.1	46.36
6	HB Loading + wind	419.6	6.1	46.36

Calculation of Stability

- eccentric $e = M/N$ $\qquad B/6 = 7.40/6 = 1.23$
- Soil reaction i) $e < B/6$

$$q_{max/min} = \frac{N}{B \cdot L}\left(1 \pm \frac{6 \cdot e}{B}\right)$$

ii) $e > B/6$

$$q_{max} = \frac{2 \cdot N}{B \cdot L}$$

- Sliding $\quad F = \dfrac{N \times 0.6}{H}$

Case No.	B/6 (m)	eccentric e (m)	Soil reaction q_{max} (t/m²)	Soil reaction q_{min} (t/m²)	q_a t/m²	Sliding F	Sliding Fa
~~1~~							
2	1.23	0.220	16.8	11.7	60.0		
~~3~~							
~~4~~							
5	1.23	0.115	19.9	16.5	69.0		
6	1.23	0.110	20.6	17.2	78.0		

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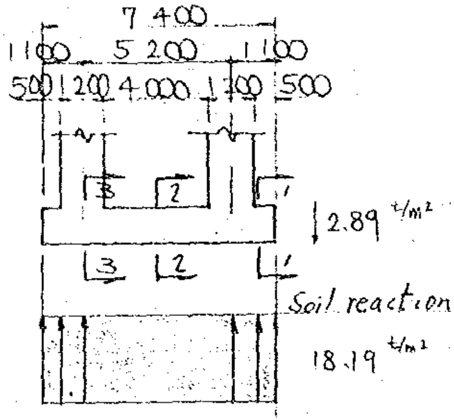
§ 7. Calculation of footing section

1 Transverse direction



18.19
- 2.89
15.30 t/m²

Sect 1.

$M = 15.30 \times 0.5^2 \times \frac{1}{2} \times 3.0 = 5.74$ t·m

$M' = 5.74 \times \frac{1}{3} = 1.91$ t·m

Sect 2.

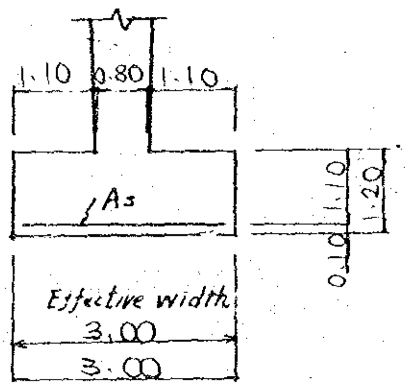
$M = 15.30 \times 4.0^2 \times \frac{1}{8} \times 3.0 = 91.80$ t·m

$M' = 91.80 \times \frac{1}{3} = 30.60$ t·m

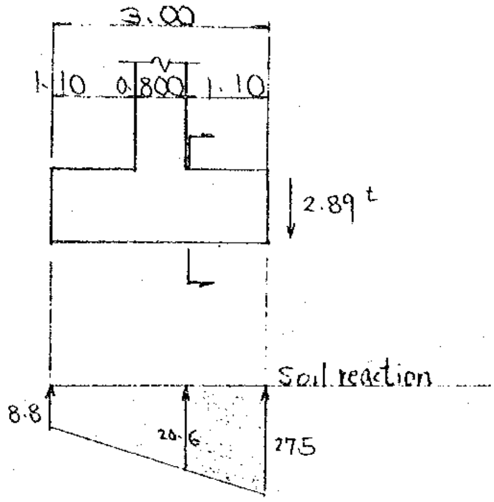
Sect 3

$M = 15.30 \times 5.20^2 \times \frac{1}{12} \times 3.0 = 103.43$ t·m

$M' = 103.43 \times \frac{1}{3} = 34.48$ t·m



2 Longitudinal direction



$$S = 2.89 \times 1.10 \times 7.40 \quad (23.52)$$

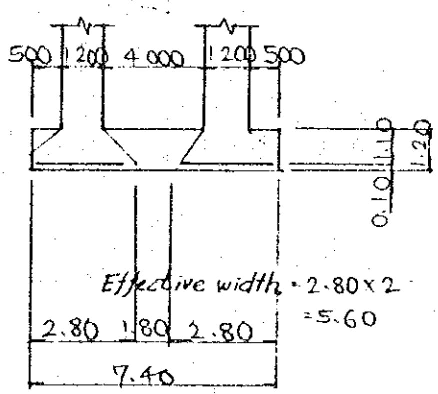
$$- \frac{1}{2} \times (27.5 + 20.6) \times 1.10 \times 7.40 \quad (195.77) = -172.25$$

$$M = 23.52 \times \frac{1}{2} \times 1.10 \quad (12.94)$$

$$- 195.77 \times \frac{1}{3} \times \frac{2 \times 27.5 + 20.6}{27.5 + 20.6} \times 1.10 \quad (112.82) = -99.88$$

$$S' = -172.25 \times \frac{1}{5.60} = 30.76 \text{ ton}$$

$$M' = -99.88 \times \frac{1}{5.60} = 17.84 \text{ tm}$$



	Transverse direction		Longitudinal direction
	case bottom	case Top	case bottom
M (tm)	34.48	30.60	17.84
N (ton)			
S: shear force (ton)			
b (cm)	100	100	100
d (cm)	110	110	110
d' (cm)	10	10	10
As (cm^2)	D16-125 = 16.08	D16-125 = 16.08	D16-125 = 16.08
d'/d			
e=(M/N)+u (cm)			
e/d			
n	15	15	15
np=n·As/b·d	0.022	0.022	0.022
M'=M+N·u (tm)			
M'/(b·d²) (t/m²)	2.85	2.53	1.47
S/b·d (kg/cm²)			
C	11.3	11.3	11.3
S	48.5	48.5	48.5
Z			
σ_c (kg/cm²)	32.2	28.6	16.6
σ_s (kg/cm²)	2073	1841	1069
τ (kg/cm²)			
σ_{ca} (kg/cm²)			
σ_{sa} (kg/cm²)			
τ_a (kg/cm²)			

Vol. 5

M.J G-RAMP BR. P_2 Pier

(P -)

§ 1 DESIGN CONDITIONS

1 Pier type

Rigid-frame pier

hight H = m

2 Foundation type

footing foundation

3 Unit weight of reinforced concrete

2.400 t/m^3

4 Allowable stresses of reinforced concrete

1.) concrete (grade 25 , BS 5400)

cube strength at 28 days	ck = 255 kg/cm^2	
bending stress	ca = 85	
direct stress	ca = 64.3	
shear stress	a = 8.2	

2.) reinforcement (hot rolled high yield bars, BS 4449)

specified characteristic strength

su = 4 180 kg/cm^2

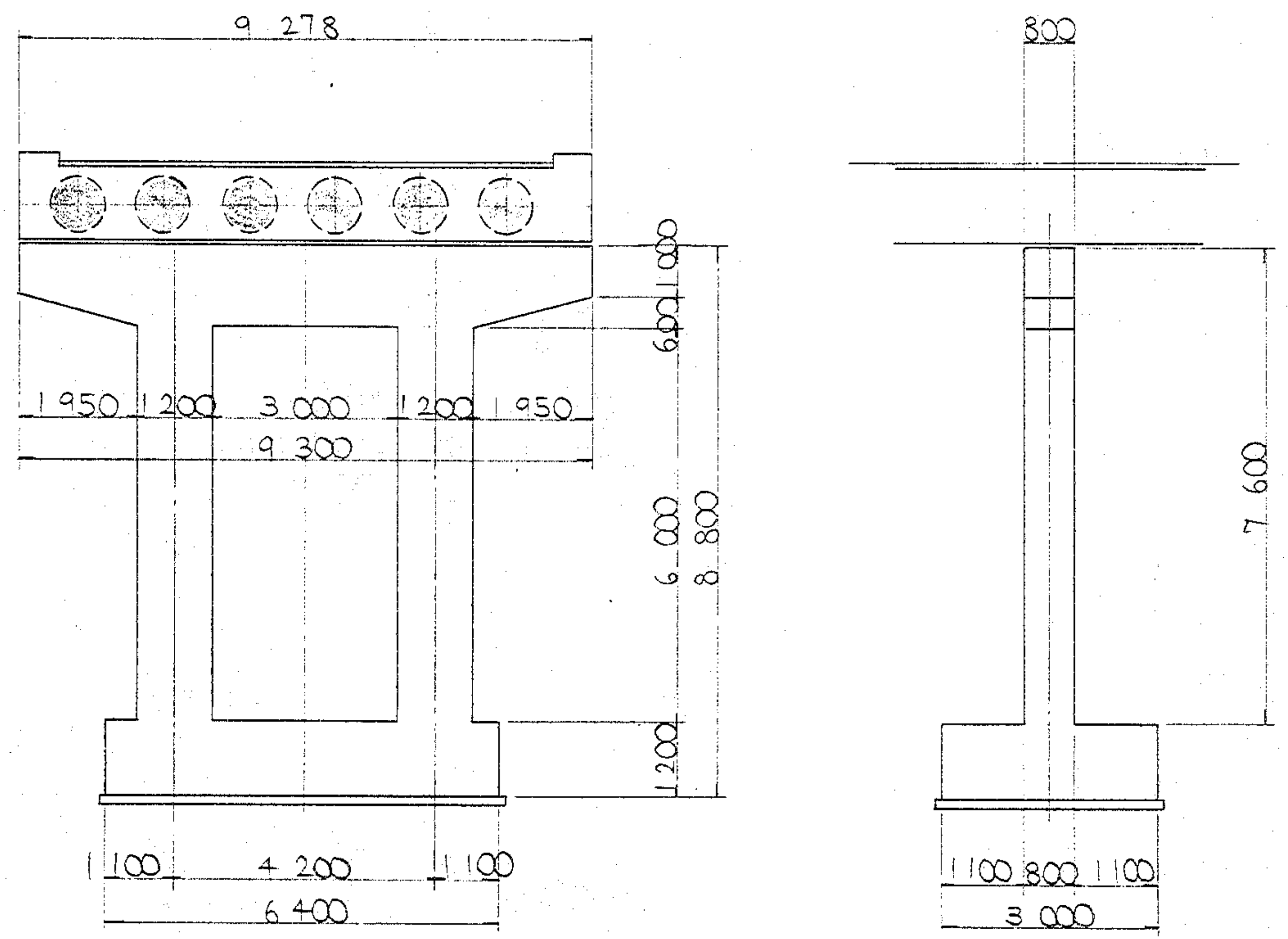
permissible tensile stress

sa = 2 340 kg/cm^2

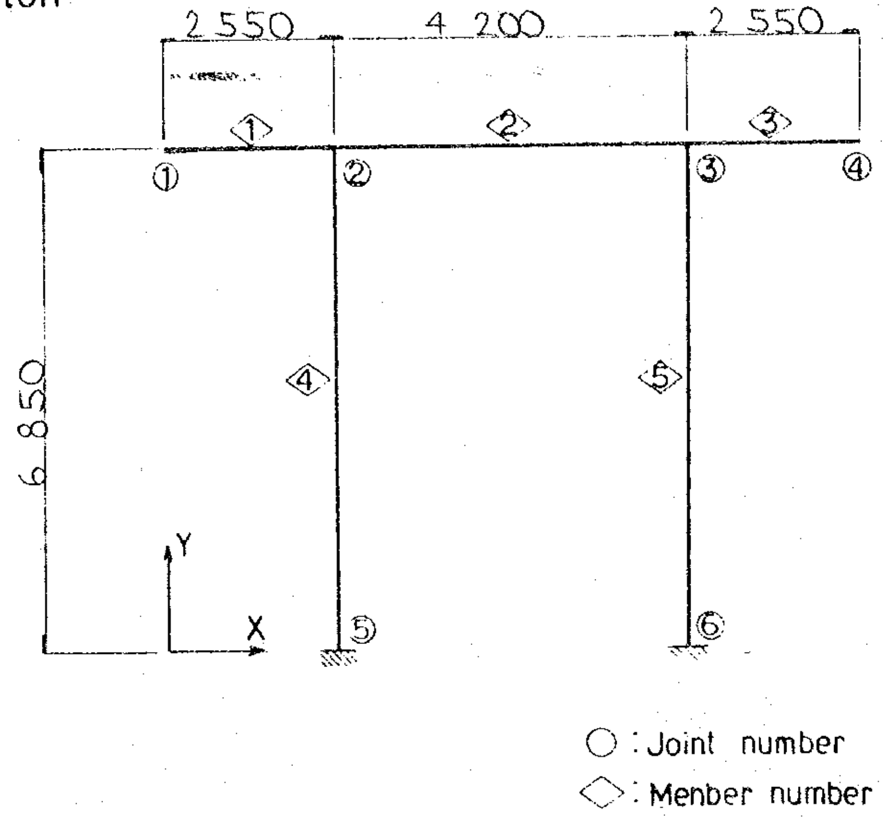
modular ratio n = 15

M-G
P2

§ 2 GENERAL DIMENSION



1) Skeleton



Coordinates

(m)

	X	Y		X	Y
①	0.0	6.85	④	9.30	6.85
②	2.55	6.85	⑤	2.55	0.0
③	6.75	6.85	⑥	6.75	0.0

Modulus of elasticity of concrete

$$E_c = 26 \ kN/mm^2$$
$$= 2.65 \times 10^6 \ t/m^2$$

member	section B x H	area of section A (m²)	moment of inertia I (m⁴)
⟨1⟩	0.80 x 1.25	1.00	0.1302
⟨2⟩	0.80 x 1.50	1.20	0.2250
⟨3⟩	0.80 x 1.25	1.00	0.1302
⟨4⟩	0.80 x 1.20	0.96	0.1152
⟨5⟩	0.80 x 1.20	0.96	0.1152

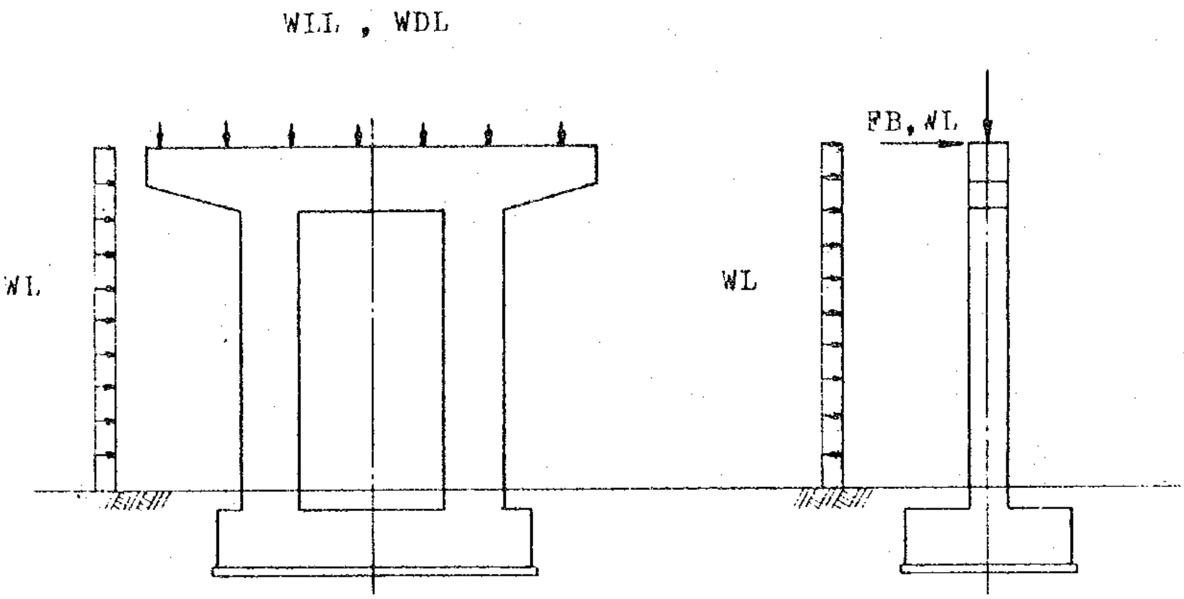
§ 3 CALCULATION OF LOADS

1.) Loading case and increase in basic stresses

No.	base load case	mark
1	dead load of deck	WDL
2	max reaction under HA	WLL(A)
3	max reaction under HB	WLL(B)
4	HA braking	FB(A)
5	HB braking	FB(B)
6	self weight	W
7	temperture change and drying schrinkage	FT & FS
8	wind	WL

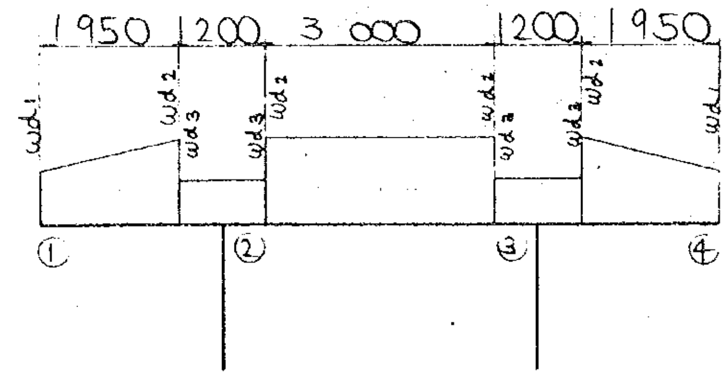
case	load combination	increase in basic stresses
1	1 6 7	1.00
2	1 6 7 8	1.00
3	1 2 6 7	1.00
4	1 3 6 7	1.25
5	1 2 6 7 8	1.15
6	1 3 6 7 8	1.30
7	1 2 4 6 7	1.00
8	1 3 5 6 7	1.25
9	1 2 4 6 7 8	1.15
10	1 3 5 6 7 8	1.30
11	1 6 7 8	1.00

2.) Loading diagram



3) Dead load

(a) beam



wd1 = 1.00 × 0.80 × 2.407 = 1.93 t/m

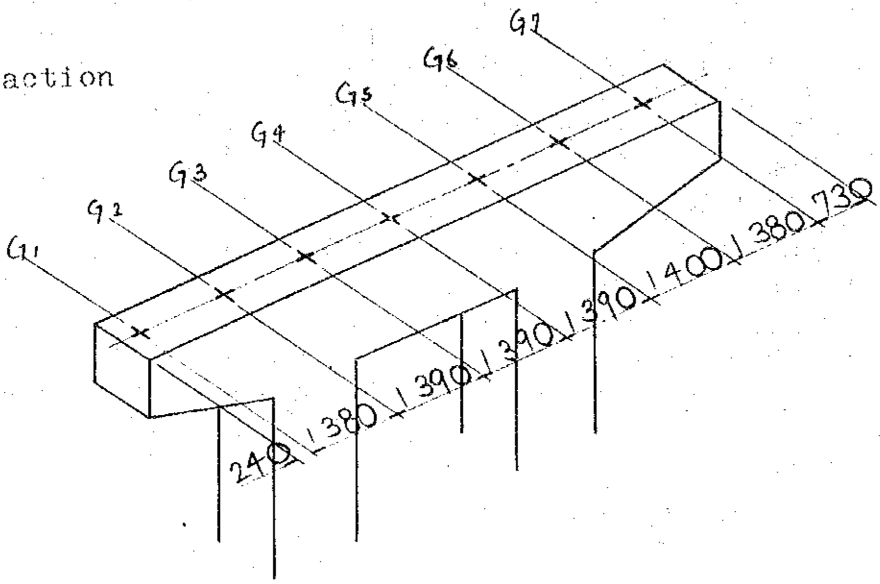
wd2 = 1.50 × 0.80 × 2.407 = 2.89 t/m

wd3 = 0.75 × 0.80 × 2.407 = 1.44 t/m

(b) column

pw = 1.20 × 0.80 × 2.407 = 2.31 t/m

4) Reaction



	G-1	G-2	G-3	G-4	G-5	G-6	G-7
Dead load	48.5	69.2	68.4	68.7	73.9	52.1	93.2
HA load	16.1	27.8	25.7	27.1	26.6	26.1	32.5
HB load	31.1	41.1	37.9	41.4	38.2	39.5	57.3

5.) Temperture change and Drying schrinkage

temperture change -12 ~ +20 deg.

drying schrinkage -20 deg.

6.) Wind Load (transverse)

(a) For superstructure

$Vc = 38 \times 1.0 \times 1.0 \times 1.56 = 59.3$ m/sec. > 35 m/sec.

Unloaded

$Pt = q \cdot A \cdot Cd$

$q = 0.613 \times 59.3^2 \times 0.102 = 219.9$ kg/m²

$A = 1.430 \times 15.8 = 22.6$ m²

$Cd = 1.3$

$Pt = 219.9 \times 22.6 \times 1.3 = 6461$ kg

$= 6.5$ ton

Live loaded

$Pt = q \cdot A \cdot Cd$

$q = 0.613 \times 35^2 \times 0.102 = 76.6$ kg/m²

$A = 3.78 \times 15.8 = 59.7$ m²

$Cd = 1.45$

$Pt = 76.6 \times 59.7 \times 1.45 = 6631$ kg

$= 6.6$ ton

(b) For safety fences

$Vc = 38 \times 1.0 \times 1.0 \times 1.56 = 59.3$ m/sec.

$Pt = q \cdot A \cdot Cd$

$q = 219.9$ kg/m²

$A = (0.150 \times 15.8 + 0.850 \times 0.05 \times \frac{15.8}{2}) \times 2 = 5.53$ m²

$Cd = 1.1$

$Pt = 219.9 \times 5.53 \times 1.1 = 1338$ kg

$= 1.3$ ton

(c) For Pier

$V_c = 38 \times 1.0 \times 1.0 \times 1.56 = 59.3$ m/sec.

Unloaded

$q = 0.613 \times 59.3^2 \times 0.102 = 219.9$ kg/m²

$A1 = 0.80 \times 7.10 = 5.68$ m²

$A2 = 0.80 \times 5.60 = 4.48$ m²

$Cd = 1.7$

$Pt = 219.9 \times (5.68 + 4.48) \times 1.7 = 3\,798$ kg

$= 3.8$ Ton

Live loaded

$q = 0.613 \times 35^2 \times 0.102 = 76.6$ kg/m²

$A = A1 + A2 = 10.16$ m²

$Cd = 1.7$

$Pt = 76.6 \times 10.16 \times 1.7 = 1323$ kg $= 1.3$ ton

(d) Table of Wind load (transverce)

(ton)

	unloaded	live loaded
super-structure	6.5	6.6
safety fences	1.3	—
Pier	3.8	1.3

7.) Longitudinal force

(a) due to breaking

HA ——— 25.8 ton

HB ——— 38.3 ton

(b) due to Wind

for superstructure

unloaded $FLS = 0.25\ Pt = 0.25 \times 6.5$

$= 1.6$ ton

live loaded $PLL = 0.5\ Pt$

$Pt = 76.6 \times (2.5 \times 15.8) \times 1.45$

$= 4.4$ ton

$PLL = 0.5 \times 4.4 = 2.2$ Ton

$PLS = 0.25\ Pt$

$Pt = 76.6 \times (3.78 - 2.5) \times 15.8 \times 1.3$

$= 2.0$ ton

$FLS = 0.25 \times 2.0 = 0.5$ ton

for safety fences

vertical member

$PL = 0.8\ Pt$

$Pt = 219.9 \times (0.85 \times 0.05 \times \frac{15.8}{2} \times 2) \times 1.1$

$= 162.4$ kg $= 0.16$ ton

$PL = 0.8 \times 0.16 = 0.13$ ton

longitudinal member

$PL = 0.4\ Pt$

$Pt = 219.9 \times (0.15 \times 15.8 \times 2) \times 1.1$

$= 1147$ kg $= 1.1$ ton

$PL = 0.4 \times 1.1 = 0.44$ ton

for Pier

Vc = 59.3 m/sec.

unloaded

q = 219.9 kg/m2

A1= 9.30 × 1.50 − 1.95 × 0.50 = 13.0 m2

A2= 5.60 × 1.20 × 2 = 13.4 m2

Cd1= 2.1

Cd2= 2.2

Pt1= 219.9 × 13.0 × 2.1 = 6.0 ton

Pt2= 219.9 × 13.4 × 2.2 = 6.5 ton

live loaded

q = 76.6 kg/m2

A1= 13.0 m2

A2= 13.4 m2

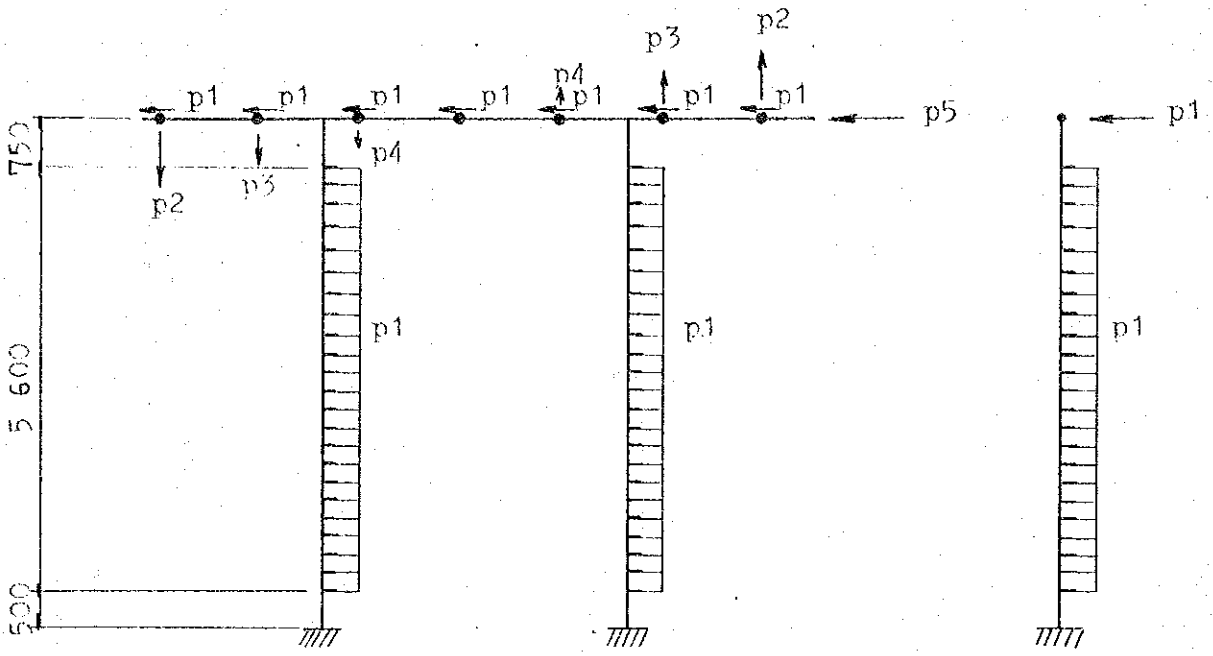
Cd1= 2.1

Cd2= 2.2

Pt1= 76.6 × 13.0 × 2.1 = 2.1 ton

Pt2= 76.6 × 13.4 × 2.2 = 2.3 ton

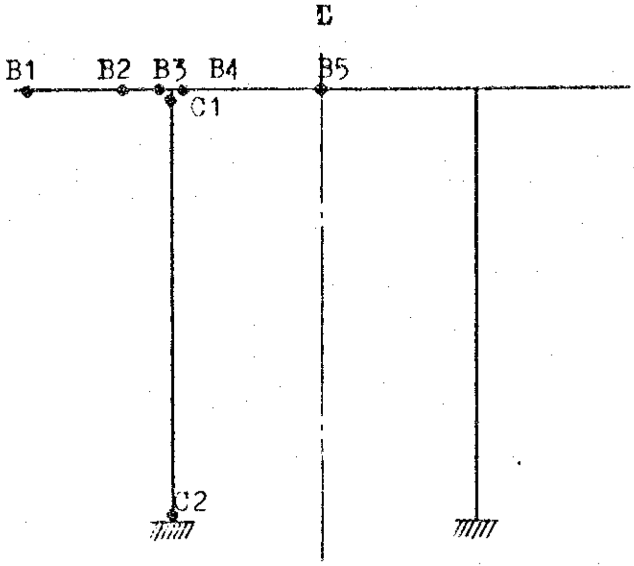
8) Wind loading diagram



		For Place	unloaded	live loaded
(T)	P1	superstructure safety fences	1.11 ton	0.94 ton
	P2	superstructure safety fences	0.82 ton	1.29 ton
	P3	superstructure safety fences	0.55 ton	0.86 ton
	P4	superstructure safety fences	0.27 ton	0.43 ton
	P5	pier	0.44 ton	0.18 ton
	P1	pier	0.30 t/m	0.10 t/m
(L)	P1	superstructure safety fences	4.09 ton	2.40 ton
	P1	pier	0.58 t/m	0.20 t/m

§ 4 ACTING FORCE TABLE

1.) due to transverse force



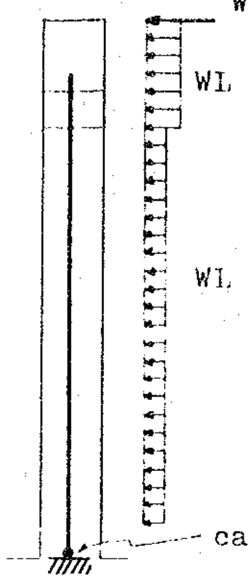
			case	M (tm)	N (ton)	S (ton)	
B1	M max	+					
		-	3	-0.546	0	127.242	
	N max	+	4	-0.437	0	121.634	
		-	2	-0.546	-0.440	93.922	
	S max	+	3	-0.546	0	127.242	
		-					
B2	M max	+					
		-	3	-92.029	0	-165.373	
	N max	+	2	-70.943	2.220	-122.843	
		-					
	S max	+	3	-92.029	0	-165.373	
		-					
B3	M max	+					
		-	3	-157.632	0	130.399	
	N max	+					
		-	2	-116.981	-1.550	97.079	
	S max	+	3	-157.632	0	130.399	
		-					

			case	M (tm)	N (ton)	S (ton)	
B4	M max.	+					
		-	3	-232.854	5.773	-153.652	
	N max.	+	3	-181.552	21.428	-104.927	
		-					
	S max.	+					
		-	3	-201.597	16.332	-153.652	
B5	M max.	+	4	31.667	9.738	-30.518	
		-	4	-84.132	11.991	-20.695	
	N max.	+	3	-50.257	21.428	-25.828	
		-					
	S max.	+	6	-23.457	15.137	11.094	
		-	4	-8.613	14.777	-58.061	
C1	M max.	+	6	91.802	-264.761	-22.290	
		-					
	N max.	+					
		-	3	68.941	-363.116	-16.332	
	S max.	+					
		-	6	91.802	-264.761	-22.290	
C2	M max.	+					
		-	2	-65.099	-260.768	-21.630	
	N max.	+					
		-	3	-42.932	-378.939	-16.332	
	S max.	+					
		-	6	-62.303	-276.933	-22.720	

These value is divided by "i".

i ; coefficient of increase
in basic stresses

2) due to longitudinal force



	M (tm)	N (ton)	H (ton)	
case-7	32.7	385.0	4.3	1.00
case-8	48.5	443.9	6.4	1.25
case-9	52.9	385.0	7.7	1.15
case-10	68.7	443.9	9.8	1.30
case-11	36.6	285.9	7.0	1.00

CASE 7

	N	H	y	M
WDL	260.6			
WLL (A)	99.1			
FB (A)		4.30	7.60	32.7
W	25.3			
TOTAL	385.0	4.30		32.7

M = 32.7 t·m

N = 385.0 ton

H = 4.3 ton

CASE 8

	N	H	y	M
WDL	260.6			
WLL (B)	158.0			
FB (B)		6.38	7.60	48.5
W	25.3			
TOTAL	443.9	6.38		48.5

M = 48.5 t·m

N = 443.9 ton

H = 6.4 ton

CASE 9

	N	H	y	M
WDL	260.6			
WLL , FB(A)	99.1	4.30	7.60	32.7
W	25.3			
WL (Super)		1.35	7.60	10.3
WL (1)		0.90	6.95	6.3
WL (2)		1.15	3.15	3.6
TOTAL	385.0	7.70		52.9

M = 52.9 t·m

N = 385.0 ton

H = 7.7 ton

CASE 10

	N	H	y	M
WDL	260.6			
WLL , FB (B)	158.0	6.38	7.60	48.5
W	25.3			
WL (Super)		1.35	7.60	10.3
WL (1)		0.90	6.95	6.3
WL (2)		1.15	3.15	3.6
TOTAL	443.9	9.78		68.7

M = 68.7 t·m

N = 443.9 ton

H = 9.8 ton

CASE II

	N	H	y	M
WDL	260.6			
W	25.3			
WL (super)		1.09	7.60	8.3
WL (1)		2.55	6.95	17.7
WL (2)		3.35	3.15	10.6
TOTAL	285.9	6.99		36.6

M = 36.6 t·m

N = 285.9 ton

H = 7.0 ton

CASE

	N	H	y	M
TOTAL				

M = t·m

N = ton

H = ton

	at B4 case 3	at B5 case 4	at C1 case 6
M (tm)	232.854	31.667	91.802
N (ton)	-5.773	-9.738	264.761
Q;shear force (ton)	153.652	30.518	22.290
b (cm)	80	80	80
d (cm)	145	150	110
d' (cm)	10	10	10
As (cm^2)	As=112.6 cm^2 (D32 10cm Pitch) ×2 As'=56.3 cm^2 (D32 10cm Pitch)	56.3 (D32 10cm Pitch)	56.3 (D32 10cm Pitch)
d'/d			0.091
f=(M/N)+u (cm)			34.7
f/d			0.32
n	15	15	15
nP=n·As/b·d	0.146	0.070	0.096
M'=M+N·u (tm)			224.2
M'/(b·d^2) (kg/cm^2)	13.8	1.8	23.2
Q/b·d (kg/cm^2)	13.2	2.5	2.5
C	4.54	7.2	2.58
S	7.8	16.0	——
Z	1.14	1.15	0.80
σ_c (kg/cm^2)	63	13	60
σ_s (kg/cm^2)	1 615	432	——
τ (kg/cm^2)	15.0 ※	2.9	2.0
σ_{ca} (kg/cm^2)	85	85	85
σ_{sa} (kg/cm^2)	2 340	2 340	2 340
τ_a (kg/cm^2)	8.2	8.2	8.2

See page 138'

2) Column section

	case	case 10	case
M (tm)		68.7	
N (ton)		443.9	
Q;shear force (ton)		9.8	
b (cm)		120	
d (cm)		70	
d' (cm)		10	
As (cm^2)		39.3 D25 (15cm pitch)	
d'/d		0.14	
f=(M/N)+u (cm)		45.5	
f/d		0.65	
n	15	15	15
nP=n·As/b·d		0.070	
M'=M+N·u (tm)		201.9	
M'/($b \cdot d^2$) (kg/cm²)		34.3	
Q/b·d (kg/cm²)		1.17	
C		2.51	
S		——	
Z		0.21	
σ_c (kg/cm²)		86.1	
σ_s (kg/cm²)		——	
τ (kg/cm²)		0.2	
σ_{ca} (kg/cm²)		111	
σ_{sa} (kg/cm²)		3042	
τ_a (kg/cm²)		10.7	

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Check for stirrups.

$$\tau = \frac{S}{b \cdot d} \times Z = \frac{153\,652}{80 \times 145} \times 1.14 = 15.1 \ kg/cm^2$$

$$> \tau a = 8.2 \ kg/cm^2$$

$$Req\ Aw = \frac{S \times a}{\sigma sa \times d} \times Z$$

$$= \frac{153\,652 \times 12.5}{1780 \times 145} \times 1.14 = 8.48\ cm^2$$

Φ 20 ctc 125 nos = 4

Used $Aw = 3.14 \times 4 = 12.56\ cm^2 > Req\ Aw = 8.48\ cm^2$

§ 6 Caiculation of stability

Pier self weight

Cantilever beam	$\frac{1}{2} \times (1.00+1.60) \times 1.950 \times 0.800 \times 2.407 \times 2$	9.76
beam	$1.60 \times 5.40 \times 0.80 \times 2.407$	16.64
column	$1.20 \times 6.00 \times 0.80 \times 2.407 \times 2$	27.73
Footing	$6.40 \times 3.00 \times 1.20 \times 2.407$	55.46
Σ		109.59

Reaction due to superstructure

	P_2
Dead load	521.3
HA Live load	142.1
HB Live load	159.1
Crowd load	——
Total (HA)	663.4
Total (HB)	680.4

Transverse direction

a) due to wind

· for superstructure

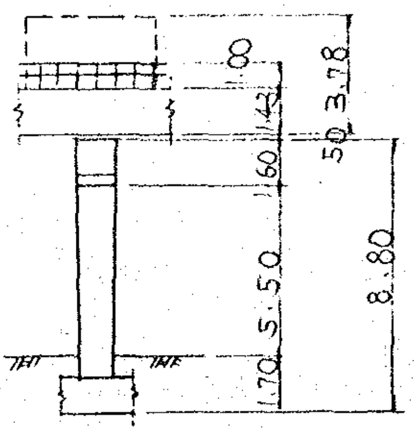
Unloaded	Pt = 6.5	ton
Live loaded	Pt = 6.6	ton

· for safety fences

Pt = 1.3 ton

· for pier

Unloaded	Pt-1 = 0.5	ton
	Pt-2 = 3.3	ton
Live loaded	Pt-1 = 0.2	ton
	Pt-2 = 1.1	ton



Longitudinal direction

a) due to braking

Under HA ; $F_B = 25.8 \times 1/3 = 8.6$ ton

" HB ; $F_B = 38.3 \times 1/3 = 12.8$ ton

b) due to wind

· for superstructure

Unloaded $P_{LS} = 1.6$ ton

Live loaded $P_{LL} = 2.2$ ton

$P_{LS} = 0.5$ ton

· for safety fences $P_{L1} = 0.1$ ton

$P_{L2} = 0.4$ ton

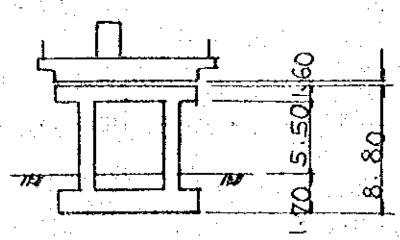
· for pier

Unloaded $P_{L1} = 6.0$ ton

$P_{L2} = 6.5$ ton

Live loaded $P_{L-1} = 2.1$ ton

$P_{L-2} = 2.3$ ton



		Vertical Force N (t)	distance x (m)	Moment N·x (t·m)	Horizontal Force H (t)	distance y (m)	Moment H·y (t·m)
	WDL	521.3					
	WLL (HA)	142.1			8.6	8.85	76.11
	WLL (HB)	159.1			12.8	8.85	113.28
	Self weight	109.6					
Transverse direction	WL (Unloaded)						
	for superstruct.				6.5	9.565	62.17
	for safety fence				1.3	10.780	14.01
	for pier (1)				0.5	8.000	4.00
	(2)				3.3	4.450	14.69
	WL (live loaded)						
	for superstruct (1)				6.6	10.740	70.88
	for pier (1)				0.2	8.000	1.60
	〃 (2)				1.1	4.450	4.90
Longitudinal direction	WL (Unloaded)						
	for superstruct.				1.6	8.85	14.16
	for safety fence				0.5	8.85	4.43
	for pier (1)				6.0	8.00	48.00
	(2)				6.5	4.45	28.93
	WL (Live loaded)						
	for superstruct. (1)				2.2	8.85	19.47
	〃 (2)				0.5	8.85	4.43
	for pier (1)				2.1	8.00	16.80
	(2)				2.3	4.45	10.24

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Longitudinal direction

Case No	Loading combination	N (t)	H (t)	M (t)
1	Dead load only	630.9	0	0
2	Dead load + wind	630.9	14.6	95.52
3	HA Loading	773.0	8.6	76.11
4	HB Loading	790.0	12.8	113.28
5	HA Loading + wind	773.0	15.7	127.05
6	HB Loading + wind	790.0	19.9	164.22

Calculation of Stability

- eccentric $e = M/N$ $\qquad B/6 = 0.50$
- Soil reaction i) $e < B/6$

$$q_{\substack{max \\ min}} = \frac{N}{B \times L}\left(1 \pm \frac{6 \times e}{B}\right)$$

ii) $e > B/6$ $\qquad x = \left(\frac{B}{2} - e\right) \times 3$

$$q_{max} = \frac{2 \cdot N}{x \times L}$$

- Sliding $F = \dfrac{N \times 0.6}{H}$

Case No.	B/6 (m)	eccentric e (m)	Siol reaction q max (t/m²)	q min (t/m²)	q_a t/m²	Sliding F	Fa
1		0	32.9				
2	0.500	0.150	42.7	23.0	60.0	26	1.5
3	↓	0.098	48.2	32.4	60.0	54	↓
4	↓	0.143	52.9	29.4	75.0	37	↓
5	↓	0.164	53.5	27.1	69.0	30	↓
6	↓	0.208	58.3	24.0	78.0	24	↓

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Transverse direction

Case No	Loading combination	N (t)	H (t)	M (t)
~~1~~	~~Dead load only~~			
2	Dead load + wind	630.9	11.6	94.87
~~3~~	~~HA Loading~~			
~~4~~	~~HB Loading~~			
5	HA Loading + wind	773.0	7.9	77.38
6	HB Loading + wind	790.0	7.9	77.38

Calculation of Stability

- eccentric $e = M/N$ $\qquad B/6 = 6.40/6 = 1.07$
- Soil reaction i) $e < B/6$

$$q_{\substack{max\\min}} = \frac{N}{B \times L}\left(1 \pm \frac{6 \times e}{B}\right)$$

ii) $e > B/6$

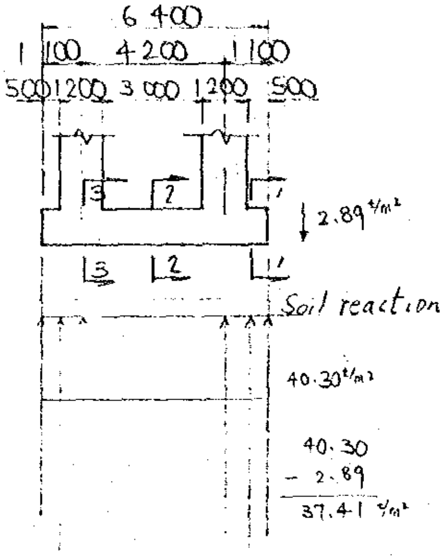
$$q_{max} = \frac{2 \cdot N}{B \times L}$$

- Sliding $F = \frac{N \times 0.6}{H}$

Case No.	B/6 (m)	eccentric e (m)	Soil reaction q_{max} (t/m²)	Soil reaction q_{min} (t/m²)	q_a t/m²	Sliding F	Sliding Fa
~~1~~							
2	1.070	0.150	37.5	28.2	60.0		
~~3~~							
~~4~~							
5	1.070	0.100	44.0	36.5	69.0		
6	1.070	0.098	44.9	37.4	78.0		

§7. Calculation of footing section

I Transverse direction



Sect 1.

$M = 37.41 \times 0.5^2 \times \frac{1}{2} \times 3.0 = 14.03$ t·m

$M' = 14.03 \times \frac{1}{3} = 4.68$ t·m

Sect 2.

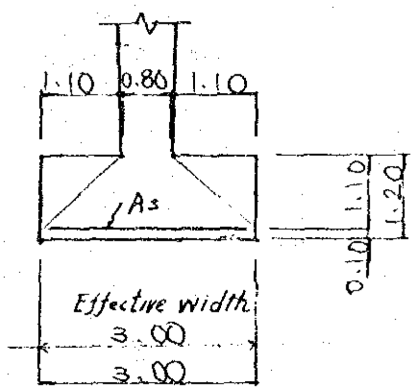
$M = 37.41 \times 3.00^2 \times \frac{1}{8} \times 3.0 = 126.26$ tm

$M' = 126.26 \times \frac{1}{3} = 42.09$ tm

Sect 3.

$M = 37.41 \times 4.20^2 \times \frac{1}{12} \times 3.0 = 164.98$ tm

$M' = 164.98 \times \frac{1}{3} = 54.99$ tm



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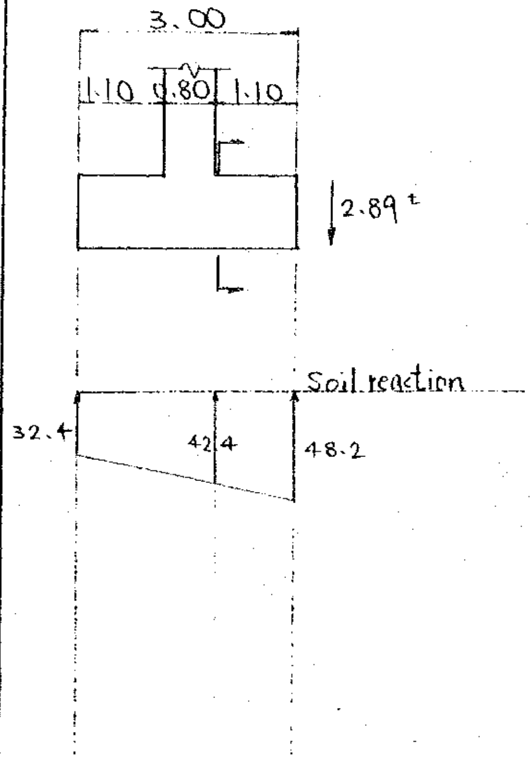
2 Longitudinal direction



$S = 2.89 \times 1.10 \times 6.40$ (20.35)

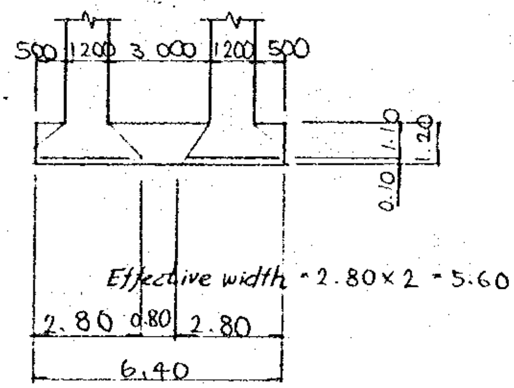
$- \frac{1}{2}(48.2 + 42.4) \times 1.10 \times 6.40$ (318.91) $= -298.56$

$M = 20.35 \times \frac{1}{2} \times 1.10$ (11.19)

$- 298.56 \times \frac{1}{3} \times \frac{2 \times 48.2 + 42.4}{48.2 + 42.4} \times 1.10 = -156.52$ (−167.71)

$S' = -298.56 \times \frac{1}{5.60} = 53.31$ ton

$M' = -156.52 \times \frac{1}{5.60} = 27.95$ t·m



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	Transverse direction		Longtudinal direction
	case bottom	case Top	case bottom
M (tm)	54.99	42.09	27.95
N (ton)			
Q;shear force (ton)			
b (cm)	100	100	100
d (cm)	110	110	110
d' (cm)	10	10	10
As (cm^2)	D20 - 125 = 25.12	D20 - 125 = 25.12	D16 - 125 = 16.08
d'/d			
e=(M/N)+u (cm)			
e/d			
n	15	15	15
np=n·As/b·d	0.034	0.034	0.022
M'=M+N·u (tm)			
M'/(b·d²) (kg/cm²)	4.54	3.48	2.31
Q/b·d (kg/cm²)			
C	9.46	9.46	11.3
S	32.0	32.0	48.5
Z			
σc (kg/cm²)	42.9	32.9	26.1
σs (kg/cm²)	2179	1670	1681
τ (kg/cm²)			
σca (kg/cm²)			
σsa (kg/cm²)			
τa (kg/cm²)			