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DIRECTORATE GENERAL OF LAND TRANSPORT
AND INLAND WATERWAYS

TENDER DOCUMENTS
FOR
NEW RAILWAY LINE FOR CENGKARENG AIRPORT CONSTRUCTION PROJECT

STRUCTURAL CALCULATION SHEETS

PACKAGE I CIVIL AND ARCHITECTURAL WORK

2 of 11

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STRUCTURAL CALCULATION SHEETS

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§§3. PIERS

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§1. Design criteria

1-1 Type of pier structure

Wall type pier made of R.C.

1-2 Track construction on superstructure

Ballast type track

1-3 Type of foundation

Pile foundation

Bearing stratum, Dcs formation of its N value $N > 30$.

1-4 Design Load

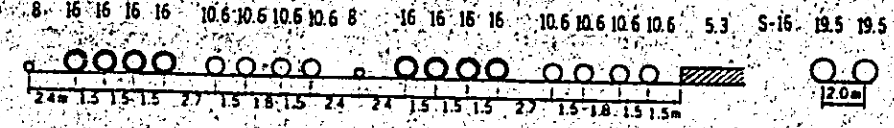
(1). Dead Load (Unit Weight)

Track assembly weight	0.45	t/m
Ballast	1.9	t/m³
Reinforced concrete	2.5	t/m³
Plain concrete	2.35	t/m³
Steel materials	7.85	t/m³

Material will be used actual unit weight of relevant.

(2). Train Load

Train Load will be equivalent to KS-16



(K-Loading) (S-Loading)

(3) Impact Load

The impact of train load shall be the train load mullipied by the following impact coefficient

Impact coefficient (KS-Loading)

Span l (m)	0	5	10	20
Impact coefficient(i)	0.60	0.48	0.43	0.37

(4). Centrifugal Load

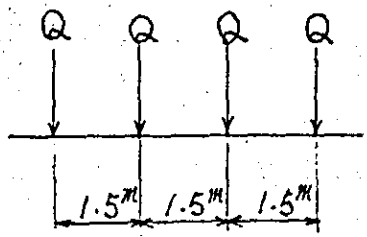
The magnitude of centrifugal load shall be the train load multiplied by the following coefficient as shown below. The working height of load is 1.8m above the rail level. The acting direction of load is horizontal and right angle to the track.

Curve Radius R (m)	Centritugal Coefficient α
R ≦ 700	0.12
700 < R ≦ 1000	0.10
1000 < R ≦ 1800	0.08
1800 < R	0

(5). Train Lateral Load

Train lateral load under KS loading scheme shall be Q loading diagram as shown on the figure which is 15% of a driving axle load per track under K-loading scheme working horizontal on the track at rail level in direction of right angle to the track.

In the case of structure supporting the line with two or more tracks. Train lateral laad is assumed as the laad of only one track.



(6). Brake Laad and Traction

Brake load and traction load per track shall be the value as indicated below, warking parallel to the track in the track center profile at 1.8m above rail level

Brake load	15% of the train load
Traction load	25% of the weight of the driving axle

(7). Earth Pressure

Coulomb and Rankine's coefficient of earth pressure will be used

(8). Seismic Effect

Seismic effect of eartquake is assumed as dead load and surcharge load multiplied by seismic coefficient plus seismic earth pressure

$K_h = 0.10$ ..... in horizontal direction.

$K_v = 0$ ..... in vertical direction.

(9). Transmitted load through superstructure

Shoe is consisted of rubber made support shoe and stopper of the type fitted to either fixed

end or movable end.

1). Vertical force

At movable end $R_m = \frac{R}{2}$

At fixed end $R_f = \frac{R}{2}$

R : Total reaction on girder

2). Horizontal force

$T_f = T - \frac{1}{2}\mu R_m \quad > \frac{T}{2}$

$T_m = \mu \cdot R_m \quad < \frac{T}{2}$

μ : Coefficient of friction of rubber shoe $\mu = 0.1$

T_f : Horizontal force acting at fixed end shoe.

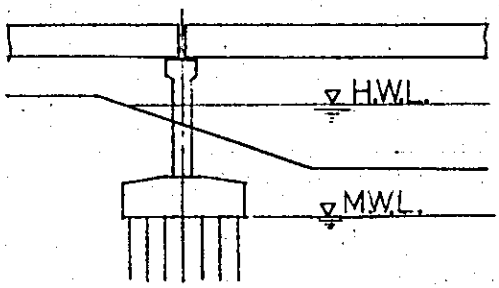
T_m : Horizontal force acting at movable end shoe.

T : Total horizontal force acting at Girder.

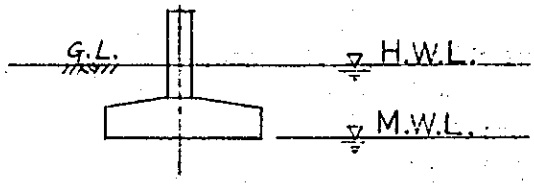
R_m : Girder reaction at movable side.

(10). Water level

1). Around river area



2). Around non-river area



1-5.. Concrete minimum Cover

Wall part 50mm (net thickness)

footing top or side face 50mm (net thickness)

bottom face 150" (from bar center to concrete face)

1-6 Material and allowble stress

(1) Material

1). Concrete $\sigma_{ck} = 210$ kg/m²

2). Reinforcing bar SD30

3). Max size of coarse aggregate 25 mm

(2). Allowable stress

1). Reinforced Concrete

			Design stress
Allowable compressive stress			80 kg/m²
Allowable shearing stress	Diagonal tension member	Bending shear τ_{a1}	3.7 "
		Punching shear τ_{ap}	5.1 "
		τ_{a2}	16 "
Allowable bonding stress		Deformed reinforcing bar	16 "

2). Reinforcing Bar

Type of reinforcing bar	SD30
Allowable tensile stress determined by yielding point	1800 kg/m²

Allowable stress for analysis, against cracking

Surrounding condition	Allowable valve corresponding to dead load	
	Slab	beam
Permanent wet condition	1400 kg/cm^2	1600 kg/cm^2
Alternate dry and wet condition	1000 kg/cm^2	1200 kg/cm^2

1-7. Allowable stress subjected combined load

Combination of loads	Given Extra
D + T + I	1.00
D + T + I + C	1.00
D + T + I + B	1.15
D + T + I + C + TL	1.25
D + S	1.5

D : Dead load

T : Train load

I : Impact load

C : Centrifugal load

TL : Train lateral load

B : Brake load

S : Seismic Force

1-8. Allowable Reaction of pile

$$Q = 30\,\bar{N} \cdot Ap$$

$\bar{N}$: Mean N value obtained from the N values measured within 4D vertical distance from pile bottom. $\bar{N} = 30$

Ap : Base area of pile. $Ap = \frac{1}{4} \cdot \pi \times 0.50^2 = 0.1963\ m^2$

Q : Ultimate reaclion of pile.

D : Diameter $D = 0.50\ m$

$$Q = 30 \times 30 \times 0.1963 = 176\ ^t$$

Under ordinary condition $Ra = \frac{Q}{F} = \frac{176}{3} = 58\ ^t/_{Pile}$

Under the condition of ordinary plus temporary

$$Ra = \frac{176}{2} = 88\ ^t/_{Pile}$$

Under the condition of earthquake

$$Ra = \frac{176}{1.5} = 117\ ^t/_{Pile}$$

Over-turning analysis

Under Ordinary condition

Ratio of minimum and maximum reaction of pile shall be 0.3 or more $\frac{R_{min}}{R_{max}} > 0.3$

1-9. Calculation for the pile elasticity,

horizontal direction

$$Kh = 0.4 \times \alpha' \times \alpha E_o Bh^{-\frac{3}{4}}$$

Where

Kh : Coefficient of elasticity, horizontal direction (kg/cm^3)

α' : Correction factor for the pile sides

$\alpha' = 1.2$ (circular section)

α : For the permanent load $\alpha = 2$

For the Temporary load $\alpha = 4$.

E_o : Deformation factor of the ground.

Assumed the average N value to be

$E_o = 2\ kg/cm^2$ as observed from the boring log.

Bh : Equivalent width of the pile

$$Bh = \sqrt{D \times \ell m}$$

D : Diameter of pile

ℓm : Depth of the first nonmove pint.

$$\beta = \sqrt[4]{\frac{Kh \cdot D}{4EI}}$$

D: Diameter of pile.

I: Moment of inertia of pile

E: Modulus of elasticity

$$Kh = 0.32\,(\alpha E_o)^{1.103} \times D^{-0.310} \times (EI)^{-0.103}$$

$$\ell m = \frac{\pi}{2\beta} \qquad D = 50^{cm}$$

$$E = 3.5 \times 10^5 \ kg/cm^2$$

$$E_o = 2 \ kg/cm^2$$

Under the condition	For the permanent load	For the Temporary load
$(\alpha.E)^{-0.103}$	9.91	21.29
I	255 300	255 300
$D^{-0.310}$	0.297	0.297
$(E.I)^{-0.103}$	0.074	0.074
Kh	0.070	0.150
β	1.77×10^{-3}	2.14×10^{-3}

1-10. P.C. Pile.

(1). Given conditions for preparing M.N Diagram.

Coefficient to be multiplied to basic allowable stress	Allowable compressive stress of concrete	Allowable tensile stress of Tendon used for P.C pile
1.0	150 kg/cm²	90 kg/mm²
1.1	165 "	100 "
1.2	180 "	110 "
1.5	225 "	135 "
1.65	250 "	150 "

Young's modulus of concrete.

$$E_c = 3.5 \times 10^5 \quad kg/cm^2$$

Young's modulus of Tendon

$$E_s = 2.0 \times 10^6 \quad kg/cm^2$$

$$n = \frac{E_s}{E_c} = 5.7$$

Design standard of concrete stress

$$\sigma_{ck} = 500 \ kg/cm^2$$

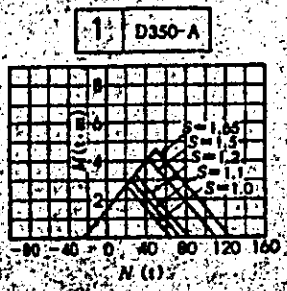
Prestressing Tendon

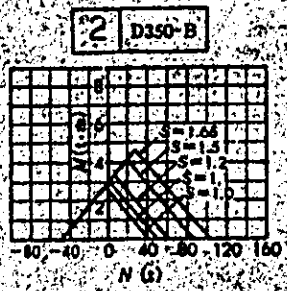
$$\sigma_{pa} = 0.6\,\sigma_{pu} \text{ or } 0.15\,\sigma_{py}$$

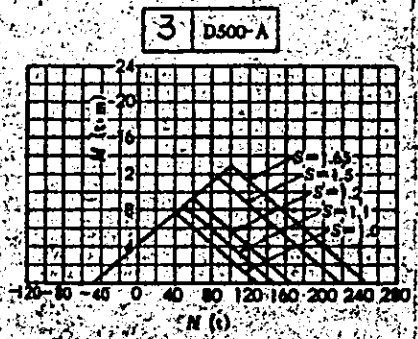
$$= 90 \ kg/mm^2 \ (\phi 7.0^{mm})$$

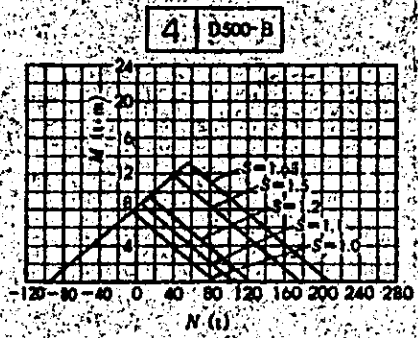
Where, concrete stress shall be $\sigma_c > 0$

Diameter of pile (mm)	Wall thickness of pile (mm)	Category of pile prestressing	Cross sectional area of Tendon used for P.C. pile (cm^2)	MN Diagram No.
350	65	A	3.1	1
		B	6.1	2
500	90	A	6.1	3
		B	12.2	4





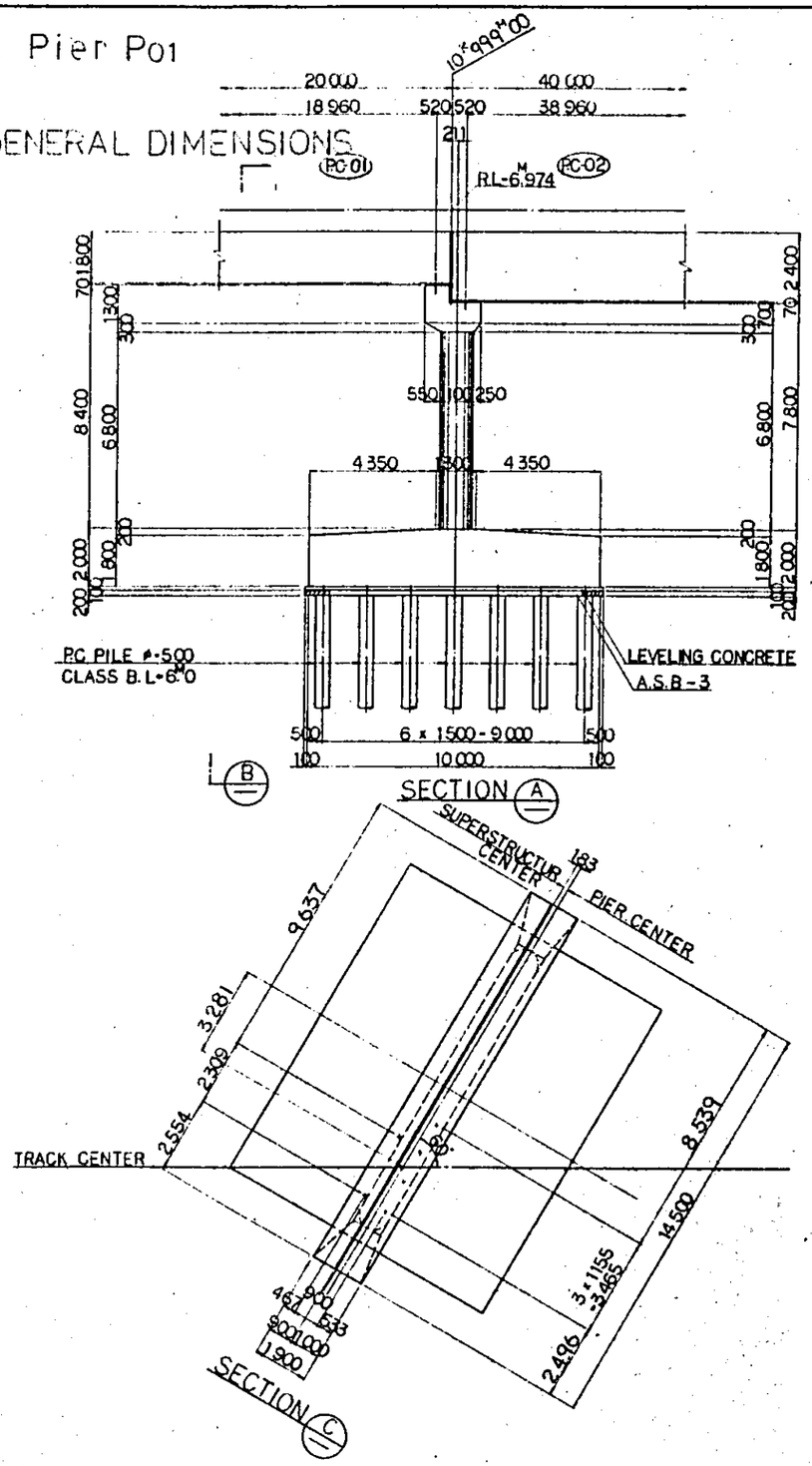


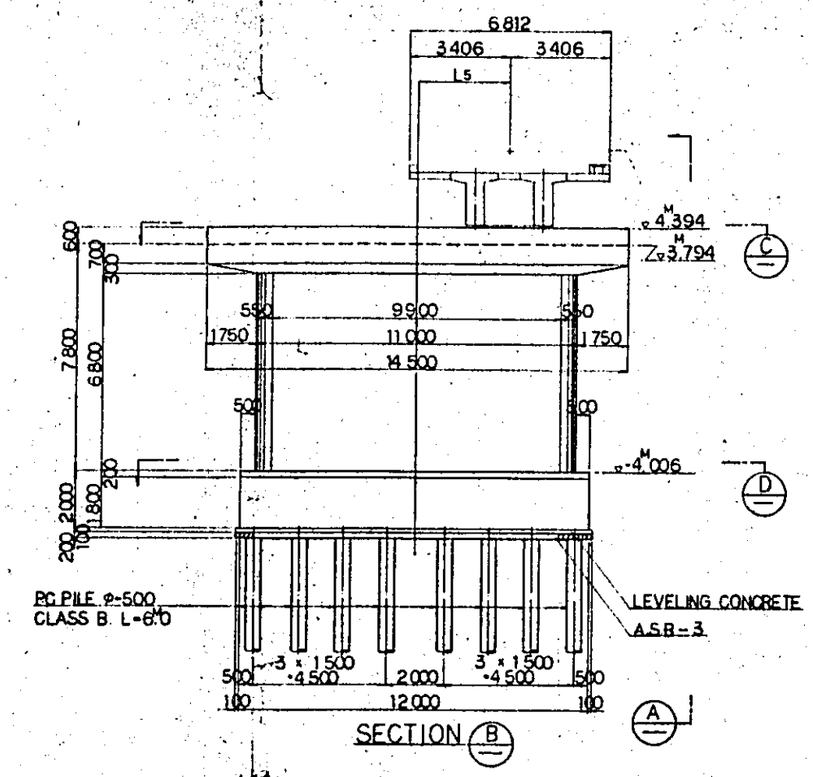


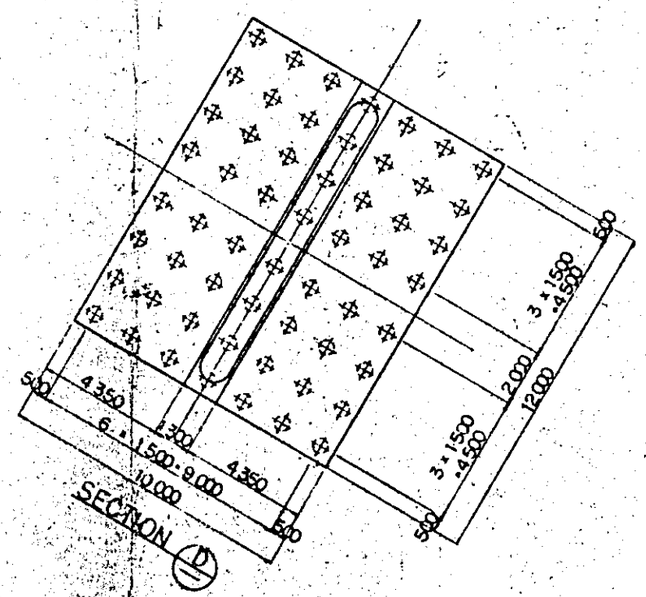
MN Diagram

§ 2. Pier P01

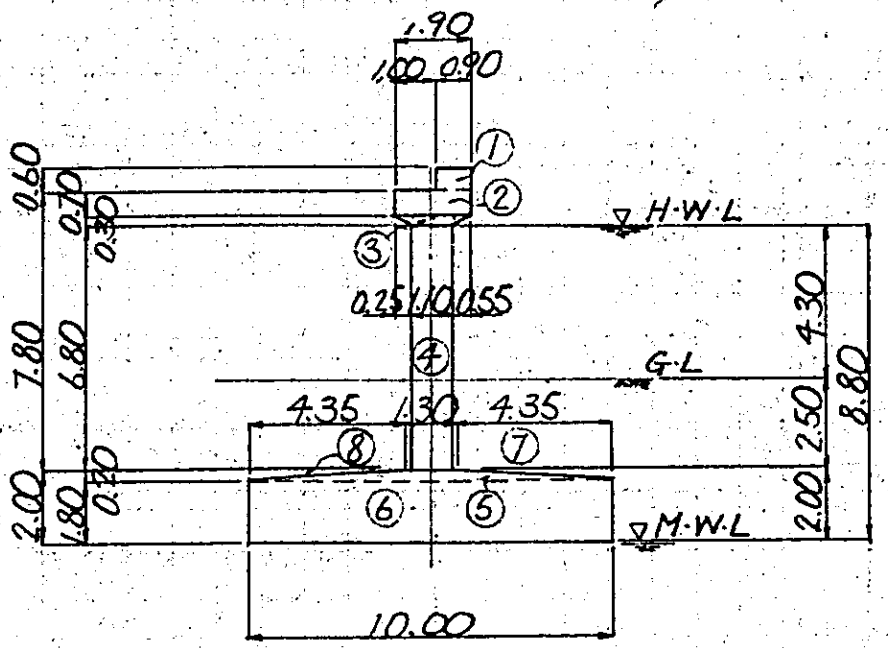
1 GENERAL DIMENSIONS

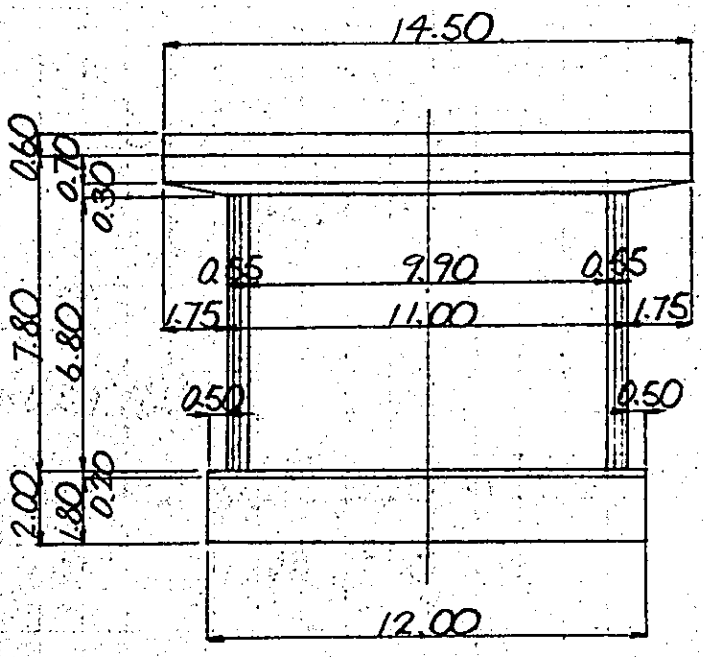






2 OWN WEIGHT OF SUBSTRUCTURE AND WEIGHT OF EARTH COVER.





1. OWN WEIGHT OF SUBSTRUCTURE AND WEIGHT OF EARTH COVER.

SUBSTRUCTURE

①	$2.5^{t/m^3} \times 0.90 \times 0.60 \times 14.50$	19.58^{t}
②	$2.5^{"} \times 1.90 \times 0.70 \times 14.50$	$48.21^{"}$
③	$2.5^{"} \times 0.30/6 \times \{14.50 \times 1.90 + 11.00 \times 1.10 + (14.50+11.00)(1.90+1.10)\}$	$14.52^{"}$
④	$2.5^{"} \times (1/4 \times \pi \times 1.10^2 + 1.10 \times 9.90) \sim^{11.840} \times 6.80$	$201.28^{"}$
⑤	$2.5^{"} \times 1/2 \times (1.30 + 10.00) \times 0.20 \times 12.00$	$33.90^{"}$
⑥	$2.5^{"} \times 1.80 \times 10.00 \times 12.00$	$540.00^{"}$
SUB-TOTAL		857.49^{t}

EARTH COVER

⑦	$1.8^{t/m^3} \times (10.00 \times 12.00 - 11.840) \times 2.50$	486.72^{t}
⑧	$1.8^{"} \times 1/2 \times 4.35 \times 0.20 \times 12.00 \times 2$	$18.79^{"}$
SUB-TOTAL		505.51^{t}

TOTAL

$$857.49 + 505.51 = 1363.00^{t}$$

2. BUOYANCY

$1.0^{t/m^3} \times 10.00 \times 12.00 \times 4.50 = 540.00^{t}$

$1.0^{"} \times 11.840 \times 4.30 = 50.91^{"}$

$\text{TOTAL} = 590.91^{t}$

3. HORIZONTAL FORCES DUE TO EARTHQUAKE LOAD

	N (t)	y (m)	N·y (t·m)
①	19.58	10.10	197.76
②	48.21	9.45	455.58
③	14.52	8.963	130.14
④	201.28	5.40	1086.91
⑤	33.90	1.874	63.53
⑥	540.00	0.90	486.00
Σ	857.49	———	2419.92

NOTE N: AXIAL FORCE

y: DISTANCE FROM THE BOTTOM OF FOOTING TO GRAVITY CENTER

4. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

$$ye = \frac{N \cdot y}{N} = \frac{2419.92}{857.49} = 2.822^{m}$$

$$P_E = 857.49 \times 0.1 = 85.75^{t}$$

$$M_o = 85.75 \times 2.822 = 241.99^{t\cdot m}$$

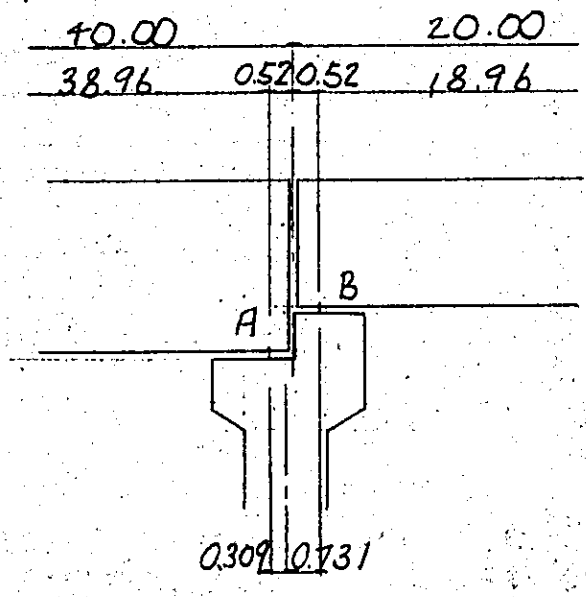
NOTE ye : DISTANCE FROM THE BOTTOM OF FOOTING TO THE CENTER OF SUBSTRUCTURE.

P_E : HORIZONTAL FORCE DUE TO EARTHQUAKE LOAD

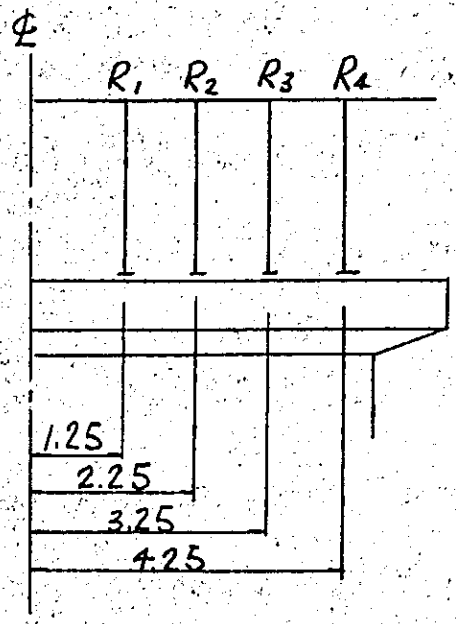
M_o : OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

3 REACTION FORCES TRANSMITTED FROM SUPERSTRUCTURE

1. REACTION FORCES DUE TO DEAD WEIGHT OF SUPERSTRUCTURE



1-1. REACTION FORCES ACTING AT BEARINGS - A.



R_1 = 104.24 t

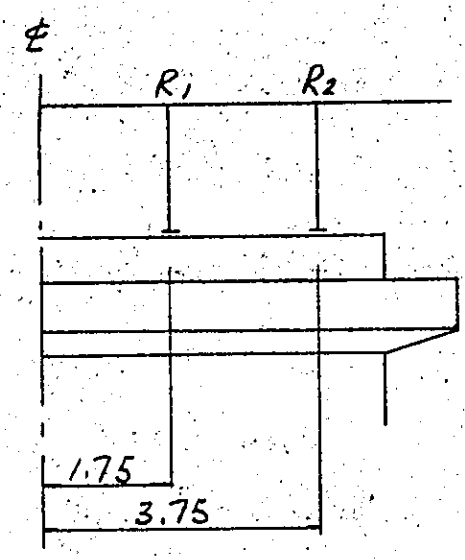
R_2 = 110.60 "

R_3 = 110.60 "

R_4 = 121.51 "

TOTAL = 446.95 t

1-2. REACTION FORCES ACTING AT BEARINGS-B



$R_1 = 66.23^{t}$

$R_2 = 70.84^{t}$

TOTAL $= 137.07^{t}$

1-3. SECTIONAL MOMENT AT THE CENTER OF PIER SHAFT DUE TO DEAD WEIGHT OF SUPERSTRUCTURE

SINGLE-TRACK LOADING FOR CALCULATION OF TRANSVERSAL STABILITY. DOUBLE-TRACK LOADING FOR CALCULATION OF LONGITUDINAL STABILITY

TRANSVERSAL DIRECTION $\frac{1}{\cos 30^{\circ}} = 1.1547$

$$M_1 = 1.1547 \times (1.25 \times 104.24 + 2.25 \times 110.60 + 3.25 \times 110.60 + 4.25 \times 121.51) + 1.1547 \times (1.75 \times 66.23 + 3.75 \times 70.84)$$

$$= 1889.75^{tm}$$

LONGITUDINAL DIRECTION

$$M_2 = (-446.95 \times 0.267 + 137.07 \times 0.633) \times 2$$

$$= -65.14^{tm}$$

1-4. HORIZONTAL FORCES DUE TO EARTHQUAKE ACTING ON DEAD WEIGHT OF SUPERSTRUCTURE

a) LONGITUDINAL DIRECTION

38.96^{m} - SPAN SIDE

$$P_{E_1} = 446.95 \times 2 \times 0.1 - 1/2 \times 0.1 \times 446.95 = 67.04^{t}$$

18.96^{m} - SPAN SIDE

$$P_{E_2} = 0.1 \times 137.07 = 13.71^{t}$$

$$\Sigma P_E = 67.04 + 13.71 = 80.75^{t}$$

OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

COMPONENT OF ΣP_E VERTICAL TO THE WALL

$$H_L = 80.75 \times \sin 60^{\circ} = 69.93^{t}$$

COMPONENT OF ΣP_E PARALLEL TO THE WALL

$$H_T = 80.75 \times \cos 60^{\circ} = 40.38^{t}$$

$$M_L = 69.93 \times 12.02 = 840.56^{t\cdot m}$$

$$M_T = 40.38 \times 12.02 = 485.37^{"}$$

b) TRANSVERSAL DIRECTION

38.96 m - SPAN SIDE

$P_{E_1} = 446.95 \times 0.1 = 44.70^{t}$

18.96 m - SPAN SIDE

$P_{E_2} = 137.01 \times 0.1 = 13.71^{t}$

$\Sigma P_E = 44.70 + 13.71 = 58.41^{t}$

OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

COMPONENT OF ΣP_E VERTICAL TO THE WALL.

$H_L = 58.41 \times \cos 60^{\circ} = 29.21^{t}$

COMPONENT OF ΣP_E PARALLEL TO THE WALL.

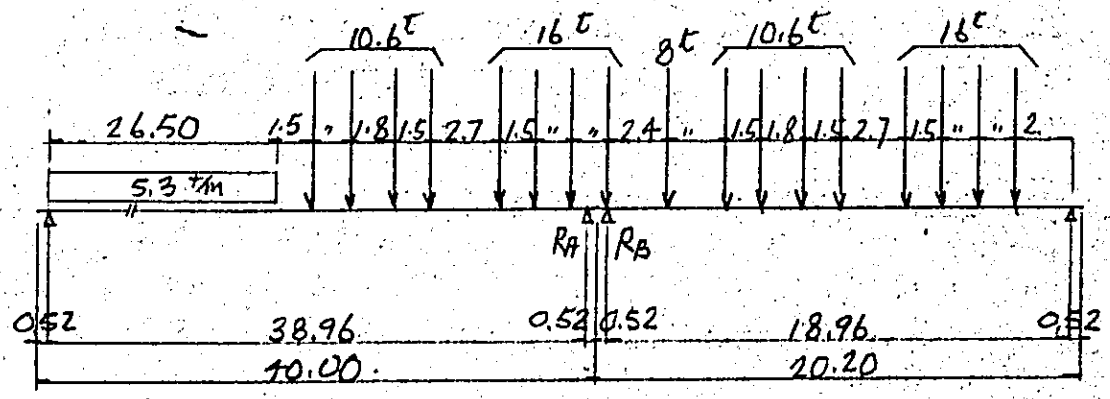
$H_T = 58.41 \times \sin 60^{\circ} = 50.58^{t}$

$M_L = 29.21 \times 12.02 = 351.10^{tm}$

$M_T = 50.58 \times 12.02 = 607.97^{"}$

2. REACTION FORCES DUE TO LIVE LOAD PLUS IMPACT

EQUIVALENT TO KS-16 LOADING.
CALCULATION IS CARRIED OUT UNDER THE LOADING CONDITION OF PRODUCING MAXIMUM REACTION FORCE ON PIER.



$$R_A = \frac{1}{38.96} \times (5.3 \times 26.50^2 \times 1/2 + 10.6 \times 4 \times 30.40 + 16 \times 3 \times 37.00)$$

$$= 126.44^t$$

$$R_B = \frac{1}{18.96} \times (16 \times 18.96 + 8 \times 16.56 + 10.6 \times 4 \times 11.76 + 16 \times 4 \times 4.41)$$

$$= 64.17^t$$

$$\text{TOTAL} = 190.61^t$$

IMPACT COEFFICIENT

38.96^m - SPAN SIDE --- $i = 0.322$

18.96^m - SPAN SIDE --- $i = 0.376$

LIVE LOAD PLUS IMPACT

$R_{(A+L)} = 126.44 \times 1.322 = 167.15^{t}$

$R_{(B+L)} = 64.17 \times 1.376 = 88.30^{t}$

TOTAL = 255.45^{t}

2-1. SECTIONAL MOMENT ACTING AT THE CENTER OF PIER SHAFT

SINGLE-TRACK LOADING FOR CALCULATION OF TRANSVERSAL STABILITY. DOUBLE-TRACK LOADING FOR CALCULATION OF LONGITUDINAL STABILITY.

TRANSVERSAL DIRECTION

$M_1 = 255.45 \times 3.281$

$= 838.13^{tm}$

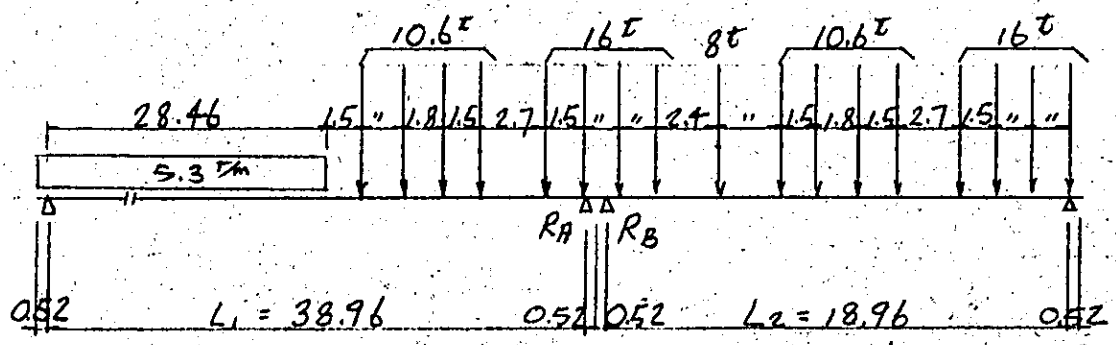
LONGITUDINAL DIRECTION

$M_2 = (-167.15 \times 0.267 + 88.30 \times 0.633) \times 2$

$= 22.53^{tm}$

3. BRAKE LOAD AND TRACTION LOAD

UNDER THE LOADING CONDITION AS SHOWN BELOW



3-1. BRAKE LOAD

15% OF KS LOADING.

L1 - SPAN SIDE

$$P_{B-1} = (5.3 \times 28.98 + 10.6 \times 4 + 16 \times 2) \times 0.16 \times 1/2$$

$$= 17.10\ t$$

L2 - SPAN SIDE

$$P_{B-2} = (16 \times 6 + 8 + 10.6 \times 4) \times 0.15 \times 1/2$$

$$= 10.98\ t$$

$$\Sigma P_B = 17.10 + 10.98 = 28.08\ t$$

3-2. TRACTION LOAD

25% OF MOVING WHEEL AXLE LOAD OF KS LOADING

L1 - SPAN SIDE

$P_{T-1} = 16 \times 2 \times 0.25 \times 1/2 = 4.00^{t}$

L2 - SPAN SIDE

$P_{T-2} = 16 \times 6 \times 0.25 \times 1/2 = 12.00^{t}$

$\therefore \Sigma P_T = 4.00 + 12.00 = 16.00^{t} < \Sigma P_B = 28.08^{t}$

3-3. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

COMPONENT OF ΣP_B VERTICAL TO THE WALL.

$H_L = 28.08 \times \sin 60^{\circ} = 24.32^{t}$

COMPONENT OF ΣP_B PARALLEL TO THE WALL.

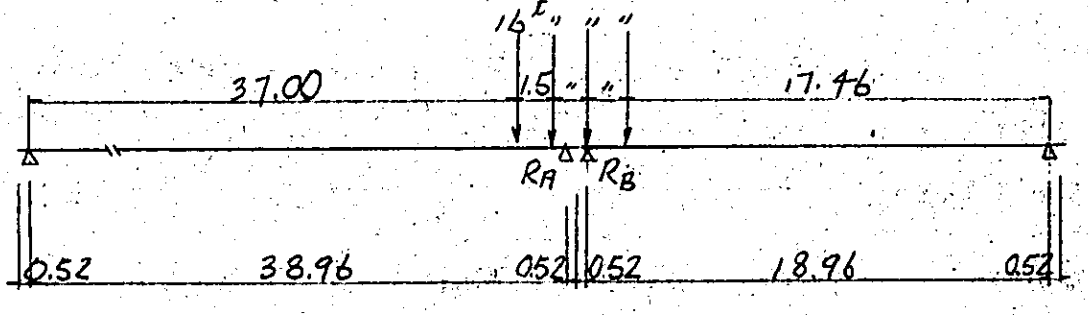
$H_T = 28.08 \times \cos 60^{\circ} = 14.04^{t}$

$\therefore M_L = 24.32 \times 14.78 = 359.45^{tm}$

$M_T = 14.04 \times 14.78 = 207.51^{"}$

4. TRAIN LATERAL LOAD

TRANSVERSAL FORCE DUE TO LIVE (TRAIN) LOAD IS ASSUMED TO BE EQUIVALENT TO THE SERIES OF CONCENTRATED LOADS CONSISTED OF 15% OF MOVING WHEEL AXLE LOAD ACTING TRANSVERSALLY AT THE TRACK LEVEL.
CALCULATION IS MADE UNDER THE SINGLE-TRACK LOADING



$$R_A + R_B = \frac{16}{38.96} \times (37.00 + 38.50) + \frac{16}{18.96} \times (17.46 + 18.96)$$
$$= 61.74^{t}$$

$$P_Q = 61.74 \times 0.15 = 9.26^{t}$$

4-1. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.

COMPONENT OF P_Q VERTICAL TO THE WALL

$$H_L = 9.26 \times \cos 60^{\circ} = 4.63^{t}$$

COMPONENT OF P_Q PARALLEL TO THE WALL

$$H_T = 9.26 \times \sin 60^{\circ} = 8.02^{t}$$

$$\therefore M_L = 4.63 \times 12.98 = 60.10^{t}$$

$$M_T = 8.02 \times 12.98 = 104.10^{"}$$

4 CALCULATION ON STABILITY

1. COMBINATION OF LOADS

1-1. TRANSVERSAL DIRECTION

No1. DEAD LOAD (M.W.L)

No2. DEAD LOAD + (TRAIN + IMPACT) LOAD (M.W.L)

No3. ——— " ——— (H.W.L)

No4. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ TRAIN LATERAL LOAD
± BRAKE LOAD OR TRACTION LOAD (M.W.L)

No5. ——— " ——— (H.W.L)

No6. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

No7. DEAD LOAD (M.W.L)

No8. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ CENTRIFUGAL LOAD (M.W.L)

No9. ——— " ——— (H.W.L)

No10. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ TRAIN LATERAL LOAD
+ BRAKE LOAD OR TRACTION LOAD (M.W.L)

No11 ——— " ——— (H.W.L)

No12 DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

THE ABOVE LOADING COMBINATIONS ARE APPLIED NO. 1 THRU NO. 6 FOR SINGLE-TRACK LOADING AND NO. 7 THRU NO. 12 FOR DOUBLE-TRACK LOADING.

1-2. LONGITUDINAL DIRECTION.

No.1. DEAD LOAD (M.W.L)

No.2. DEAD LOAD + (TRAIN + IMPACT) LOAD + CENTRIFUGAL LOAD (M.W.L)

No.3. ——"—— (H.W.L)

No.4. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ TRAIN LATERAL LOAD
+ BRAKE LOAD or TRACTION LOAD (M.W.L)

No.5. ——"——, (H.W.L)

No.6. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

ALL OF THE ABOVE LOADING COMBINATIONS ARE APPLIED FOR DOUBLE-TRACK LOADING.

2. TABLE OF FORCE AND MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.

2-1. TRANSVERSAL DIRECTION

SINGLE-TRACK LOADING

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No1	1363.00 + 446.95 + 137.07 = 1947.02	1889.75	———
No2	1947.02 + 255.45 = 2202.47	1889.75 + 838.13 = 2727.88	———
No3	2202.47 - 590.91 = 1611.56	2727.88	———
No4	2202.47	2727.88 + 207.51 + 104.10 = 3039.49	14.04 + 8.02 = 22.06
No5	1611.56	3039.49	22.06
No6	1947.02	241.99 + 485.37 + 607.97 + 1889.75 = 3225.08	85.75 + 40.38 + 50.58 = 176.71

DOUBLE-TRACK LOADING

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No7	1363.00 + 446.95×2 +137.07×2 = 2531.04	——	——
No8	2531.04 +255.45×2 = 3041.94	——	——
No9	3049.20 - 590.91 = 2451.03	——	——
No10	3041.94	207.51 +104.10 = 311.61	14.04+8.02 = 22.06
No11	2451.03	311.61	22.06
No12	2531.04	241.99 + 485.37×2 +607.97×2 = 2428.67	85.75 + 40.38×2 +50.58×2 = 267.67

2-2, LONGITUDINAL DIRECTION.

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No1	2531.04	65.14	———
No2	3041.94	65.14	———
No3	2451.03	65.14	———
No4	3041.94	65.14 + 359.45 + 60.10 = 484.69	24.32 + 4.63 = 28.95
No5	2451.03	484.69	28.95
No6	2531.04	241.99 + 65.14 + 840.56×2 + 351.10×2 = 2690.45	85.75 + 69.93×2 + 29.21×2 = 284.03

3. REACTION FORCE ACTING ON PILES

$$P = \frac{N}{n} \pm \frac{M}{I} \times x$$

WHERE: P REACTION FORCE

n NUMBER OF PILES

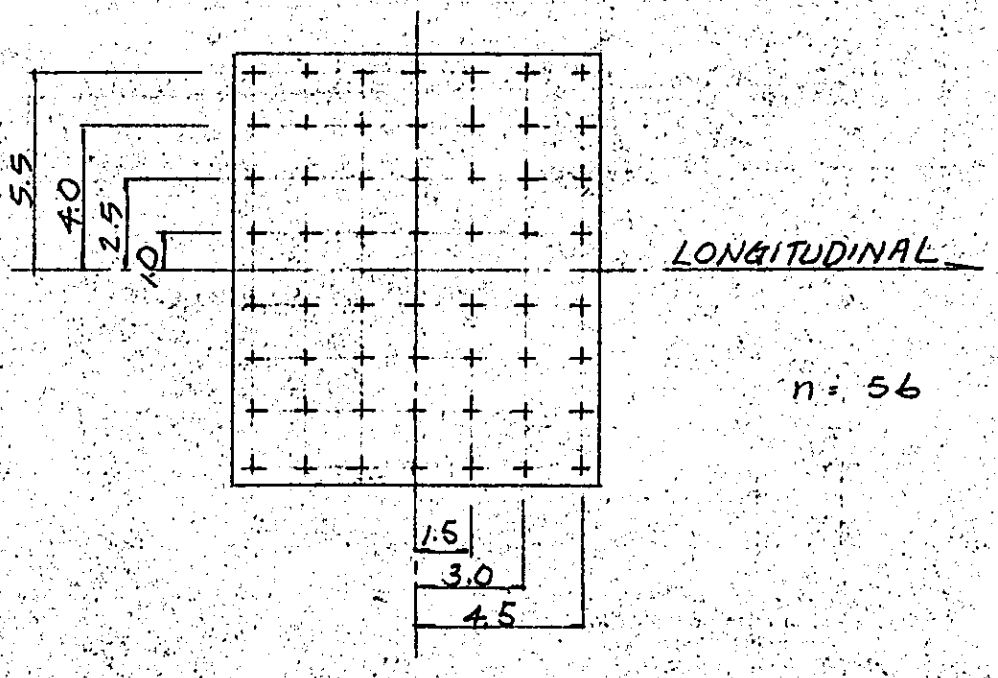
N AXIAL FORCE ACTING AT THE CENTER OF THE BOTTOM OF FOOTING

M MOMENT ACTING AT THE CENTER OF THE BOTTOM OF FOOTING

I MOMENT OF INERTIA OF THE GROUP OF PILES WITH RESPECT TO THE GEOMETRICAL CENTER

x DISTANCE FROM THE GEOMETRICAL CENTER OF THE GROUP OF PILES TO THE CENTER OF THE PILE TO BE CALCULATED

3-1. ARRANGEMENT OF PILES



3-2 REACTION FORCE ACTING ON PILES DUE TO TRANSVERSAL LOAD

	N (t)	M (t·m)	$\frac{N}{n}$ (t)	$\frac{M}{I}\left(\frac{t}{m}\right)$	P_{max} (t)	P_{min} (t)
No 1	1947.02	1889.75	34.77	2.52	48.63	20.91
No 2	2202.47	2727.88	39.33	3.64	59.35	19.31
No 3	1611.56	2727.88	28.78	3.64	48.80	8.76
No 4	2202.47	3039.49	39.33	4.06	61.66	17.00
No 5	1611.56	3039.49	28.78	4.06	51.11	6.45
No 6	1947.02	3225.08	34.77	4.31	58.48	11.07
No 7	2531.04	—	45.20	—	45.20	54.20
No 8	3041.94	—	54.32	—	54.32	54.32
No 9	2451.03	—	43.77	—	43.77	43.77
No 10	3041.94	311.61	54.32	0.42	56.63	52.01
No. 11	2451.03	311.61	43.77	0.42	46.08	41.46
No. 12	2531.04	2428.67	45.20	3.24	63.02	27.38

$$I = (1.00^2 + 2.50^2 + 4.00^2 + 5.50^2) \times 7 \times 2 = 749.00\ m^2$$

$$x = 5.50\ m$$

3-3. REACTION FORCE ACTING ON PILES DUE TO LONGITUDINAL LOAD.

	N (t)	M (t·m)	$\frac{N}{n}$ (t)	$\frac{M}{I}$ ($\frac{t}{m}$)	$x_{(m)}$	P_{max} (t)	P_{min} (t)
No1	2531.04	65.14	45.20	0.13	x_1	45.40	45.00
					x_2	45.59	44.81
					x_3	45.79	44.61
No2	3041.94	65.14	54.32	0.13	x_1	54.52	54.12
					x_2	54.71	54.93
					x_3	54.91	54.73
No3	2451.03	65.14	43.77	0.13	x_1	43.97	43.57
					x_2	44.16	43.38
					x_3	44.36	43.18
No4	3041.94	484.69	54.32	0.96	x_1	55.76	52.88
					x_2	57.20	51.44
					x_3	58.64	50.00
No5	2451.03	484.69	43.77	0.96	x_1	45.21	42.33
					x_2	46.65	40.89
					x_3	48.09	39.45
No6	2531.04	2690.45	45.20	5.34	x_1	53.21	37.19
					x_2	61.22	29.18
					x_3	69.23	21.17

$$I = (1.50^2 + 3.00^2 + 4.50^2) \times 8 \times 2 = 504.00\ m^2$$

$x_1 = 1.50^m$

$x_2 = 3.00^m$

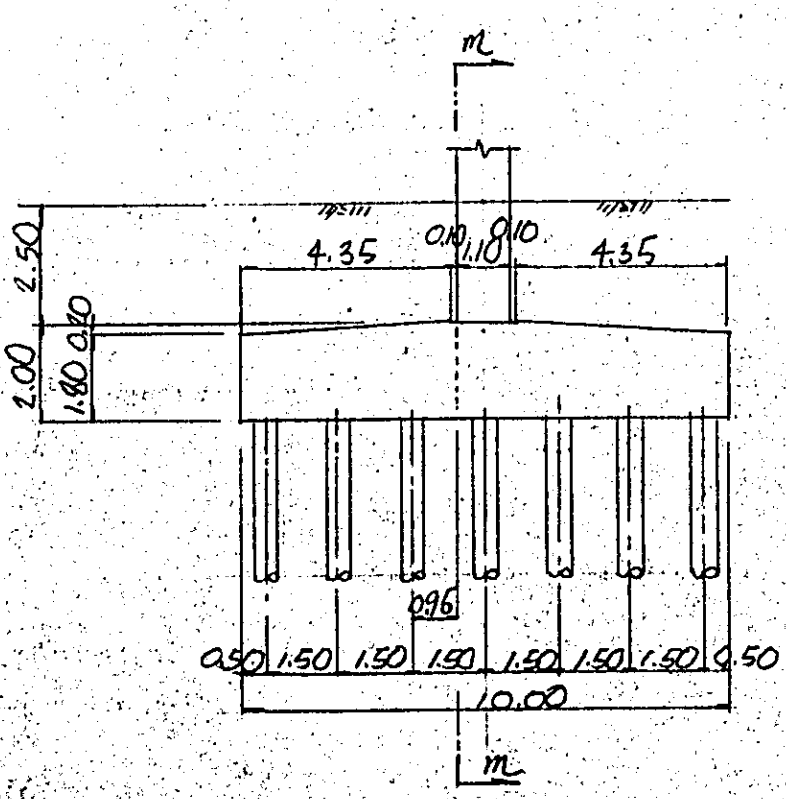
$x_3 = 4.50^m$

5 DESIGN OF FOOTING

CALCULATION IS MADE ONLY THE CASE OF LONGITUDINAL LOADING, BECAUSE NO STRESS OCCURS UNDER THE TRANSVERSAL LOADING DUE TO REACTION FORCES ON PILES WITHIN THE WALL SHAFT.

1. EXAMINATION OF SAFETY AGAINST BENDING MOMENT

1-1. BENDING MOMENT DUE TO OWN WEIGHT OF FOOTING AND WEIGHT OF EARTH COVER



WHERE: m SECTION WHERE MOMENT IS CALCULATED

M_m BENDING MOMENT AT SECTION m

BENDING MOMENT AT SECTION m

i) THE CASE NO BUOYANCY IS CONSIDERED

$M_m = (2.5^{t/m^3} \times 2.00 + 1.8^{t/m^3} \times 2.50) \times 4.45^2 \times 1/2$
$- 1/2 \times 4.35 \times 0.20 \times 3.00 \times (2.5 - 1.8)$ $= 93.15^{t\cdot m}$

ii) THE CASE BUOYANCY IS CONSIDERED

$M_m = 93.15 - 1.00^{t/m^3} \times 4.45^2 \times 1/2 \times 4.50$ $= 48.59^{t\cdot m}$

1-2, STRESS DUE TO REACTION FORCE ON PILES

BENDING MOMENT AT SECTION m

No.1 $M_m = (45.79 \times 4.05 + 45.59 \times 2.55 + 45.40 \times 1.05) \times \frac{8}{12.00} = 232.92^{t\cdot m}$

No.2 $M_m = (54.91 \times$ " $+ 54.71 \times$ " $+ 54.52 \times$ " $) \times$ " $= 279.43$"

No.3 $M_m = (44.36 \times$ " $+ 44.16 \times$ " $+ 43.97 \times$ " $) \times$ " $= 225.62$"

No.4 $M_m = (58.64 \times$ " $+ 57.20 \times$ " $+ 55.76 \times$ " $) \times$ " $= 294.46$"

No.5 $M_m = (48.09 \times$ " $+ 46.65 \times$ " $+ 45.21 \times$ " $) \times$ " $= 240.80$"

No.6 $M_m = (69.23 \times$ " $+ 61.22 \times$ " $+ 53.21 \times$ " $) \times$ " $= 328.24$"

1-3. SUMMARY OF BENDING MOMENT ON FOOTING

No1 : $M_m = (232.92 - 93.15) \times 1.8/1.4 = 179.70$ t·m/m

No2 : $M_m = (279.43 - 93.15) \times 1.00 = 186.28$ "

No3 : $M_m = (225.62 - 48.59) \times 1.00 = 177.03$ "

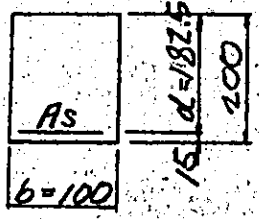
No4 : $M_m = (294.46 - 93.15) \times 1/1.15 = 175.05$ "

No5 : $M_m = (240.80 - 48.59) \times 1/1.15 = 167.14$ "

No6 : $M_m = (328.24 - 93.15) \times 1/1.50 = 156.73$ "

1-4. EXAMINATION OF SAFETY

$M_m = 186.28$ t·m/m



$As = \frac{6.67}{6.67} - 025 = 67.56$

$p = \frac{As}{b \cdot d} = \frac{67.56}{100 \times 182.5} = 0.00370$

$\frac{1}{Lc} = 7.82 \qquad \frac{1}{Ls} = 298$

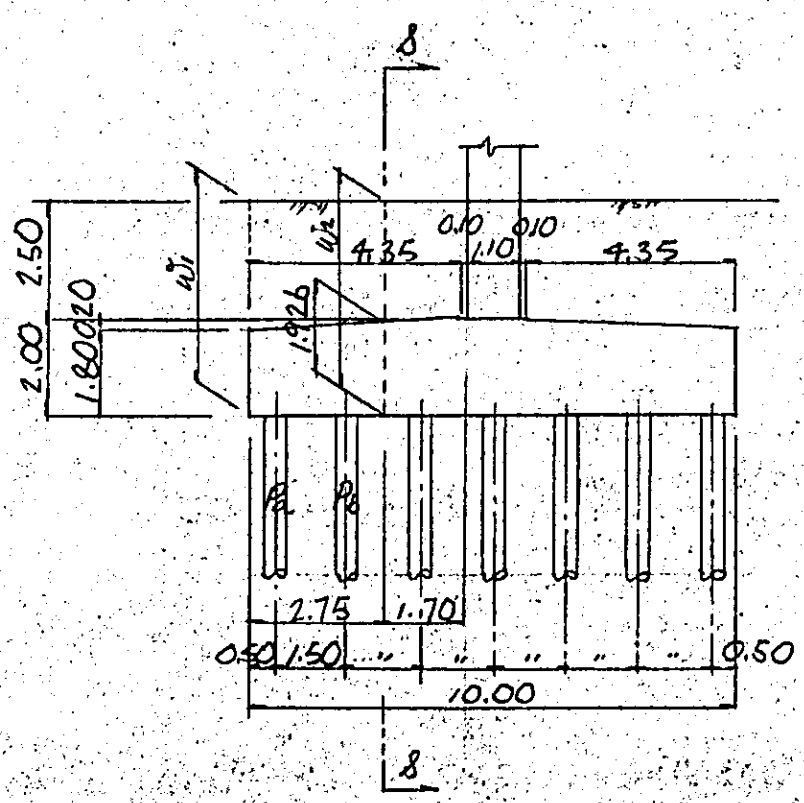
$\sigma_c = \frac{M}{b \cdot d^2} \times \frac{1}{Lc} = \frac{186.28 \times 10^5}{100 \times 182.5^2} \times 7.82 = 43.7$ Kg/cm² < 80 Kg/cm²

$\sigma_s = \frac{M}{b \cdot d^2} \times \frac{1}{Ls} =$ ——"—— $\times 298 = 1667$ Kg/cm² < 1800 "

1. EXAMINATION OF SAFETY AGAINST SHEARING FORCE

EXAMINATION ON THE COMBINATION No.6

2-1. SHEARING FORCE DUE TO OWN WEIGHT OF FOOTING AND WEIGHT OF EARTH COVER.



WHERE: δ SECTION WHERE SHEARING FORCE IS CALCULATED

S_δ SHEARING FORCE AT SECTION δ

SHEARING FORCE AT SECTION 8

$W_1 = 2.5^{t/m^3} \times 1.80 + 1.8^{t/m^3} \times 2.10 = 9.36^{t/m}$

$W_2 = (2.5'' \times 1.926 + 1.8'' \times 2.574) \times \frac{1.70}{2 \times (1.926 - 0.15)} = 4.52''$

$S_8 = 1/2 \times (9.36 + 4.52) \times 2.75 = 19.09^{t}$

2-2. STRESS DUE TO REACTION FORCE ON PILES

SHEARING FORCE AT SECTION 8

$P_a = 69.23 \times \frac{3.95}{2 \times (1.926 - 0.15)} = 76.99^{t} > \underline{69.23^{t}}$

$P_a = 61.22 \times \frac{2.45}{2 \times (1.926 - 0.15)} = 42.22''$

$\therefore S_8 = (69.23 + 42.22) \times \frac{8}{12.00} = 74.30^{t}$

2-3. SUMMARY OF SHEARING FORCES ON FOOTING

$\Sigma S_8 = 74.30 - 19.09 = 55.21^{t}$

2-4. EXAMINATION OF SAFETY,

$\tau = \frac{55.21 \times 10^3}{1.00 \times (192.6 - 15)} = 3.11^{Kg/cm^2} < 3.7^{Kg/cm^2}$

6 DESIGN OF SUBSTRUCTURE.

EXAMINATION IS MADE ONLY THE CASE OF LONGITUDINAL LOADING.

1. COMBINATION OF LOADS

No.6 DEAD LOAD + EARTHQUAKE LOAD

2. BENDING MOMENT AND AXIAL FORCES ACTING AT THE BOTTOM OF WALL.

THE FOLLOWING FIGURES ARE REFERRED TO THE CALCULATION OF THE REACTION FORCES TRANSMITTED FROM THE SUPERSTRUCTURE.

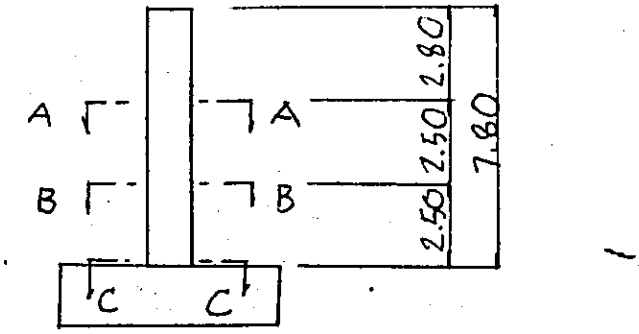
$$M = (19.58 \times 8.10 + 48.21 \times 7.45 + 14.52 \times 6.963 + 201.28 \times 3.40) \times 0.10 + 65.14 + (69.93 + 29.21) \times 2 \times 10.02 = 2182.23 \ t\cdot m$$

$$N = 19.58 + 48.21 + 14.52 + 201.28 + (446.95 + 137.07) \times 2 = 1451.63 \ t$$

3. EXAMINATION OF SAFETY

M (tm)	2182.23
N (t)	1451.63
S (t)	
b (cm)	990
h (cm)	110
d (cm)	
d' (cm)	8.5
As (cm²)	D32-81 = 643.30
p	0.00590
As' (cm²)	= As
p'	= p
e = M/N (cm)	150.3
e = M/N + u (cm)	
e = M/N − u (cm)	
e/h	1.366
d/e	
d'/h	0.077
d'/d	
Ne/bd² (kg/cm²)	13.329
k	0.362
c	0.114
j	
1/Lc	
1/Le	
β = σs/σc	
σc (kg/cm²)	11.67
σs (kg/cm²)	2704
τ (kg/cm²)	
σsa (kg/cm²)	120
σca (kg/cm²)	2700
τa (kg/cm²)	

4. DEDUCTION OF REINFORCING BARS



4-1 BENDING MOMENT AND AXIAL FORCE ACTING AT THE SECTION A AND B.

$M_A = 65.14 + (19.58 \times 3.10 + 48.21 \times 2.45 + 14.52 \times 1.963 + 2.5 \times 11.840 \times 1.80^2 \times 1/2) \times 0.1 + (69.93 + 29.21) \times 5.02 \times 2 = 1086.03$ t·m

$N_A = 19.58 + 48.21 + 14.52 + 2.5 \times 11.840 \times 1.80 + (446.95 + 137.07) \times 2 = 1303.63$ t

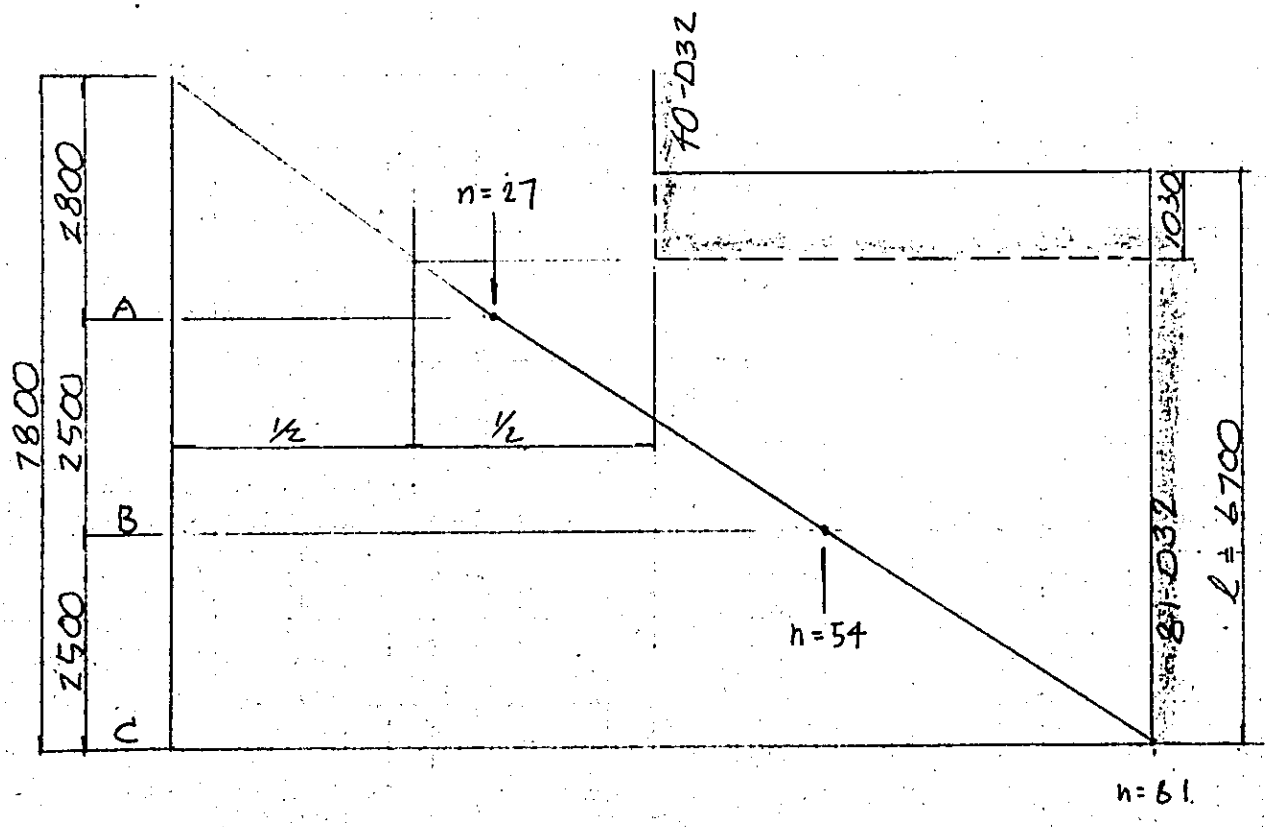
$M_B = 65.14 + (19.58 \times 5.60 + 48.21 \times 4.95 + 14.52 \times 4.463 + 2.5 \times 11.840 \times 4.30^2 \times 1/2) \times 0.1 + (69.93 + 29.21) \times 1.52 \times 2 = 1624.88$ t·m

$N_B = 1303.63 + 2.5 \times 11.840 \times 2.50 = 1377.63$ t

4-2. THE LEAST REINFORCING BARS REQUIRED AT THE SECTION A AND B

SECTION	A	B	C
M (tm)	1086.03	1624.88	2182.23
N (t)	1303.63	1377.63	1451.63
b (cm)	990	〃	〃
h (〃)	110	〃	〃
d' (〃)	8.5	〃	〃
As	032-27	032-54	032-81
σ_c (kg/cm²)	94.5	106.2	116.7
σ_s (〃)	2672	2674	2707

4-3. MOMENT DIAGRAM



7 DESIGN OF PILE

1. REACTION FORCES ACTING ON PILES

EXAMINATION IS MADE ONLY TO THE EARTHQUAKE LOADING.

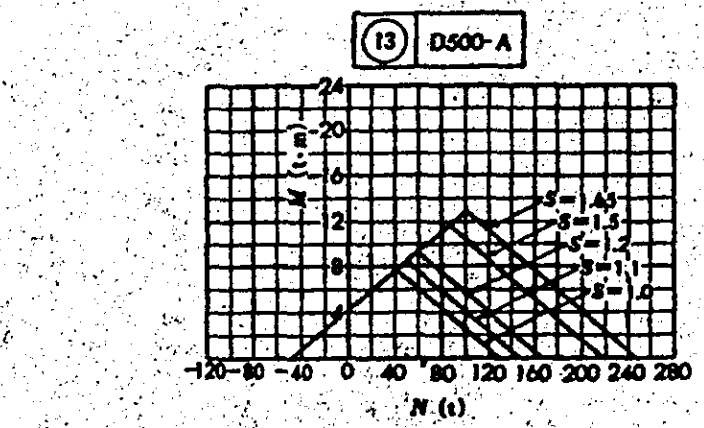
	LONGITUDINAL DIRECTION ①	TRANSVERSAL DIRECTION	
		② SINGLE TRACK	③ DOUBLE TRACK
WHOLE HORIZONTAL FORCE, ΣH (t)	284.03	176.71	267.67
HORIZONTAL FORCE PER PILE, H (t)	5.07	3.16	4.78
VALUE OF β (m^{-1})	0.214	〃	〃
MAXIMUM MOMENT PER PILE, Mmax (tm)	7.63	4.75	7.19
MAXIMUM AXIAL FORCE PER PILE, Pmax (t)	69.23	58.48	63.02
MINIMUM AXIAL FORCE PER PILE, Pmin (t)	21.17	11.07	27.38

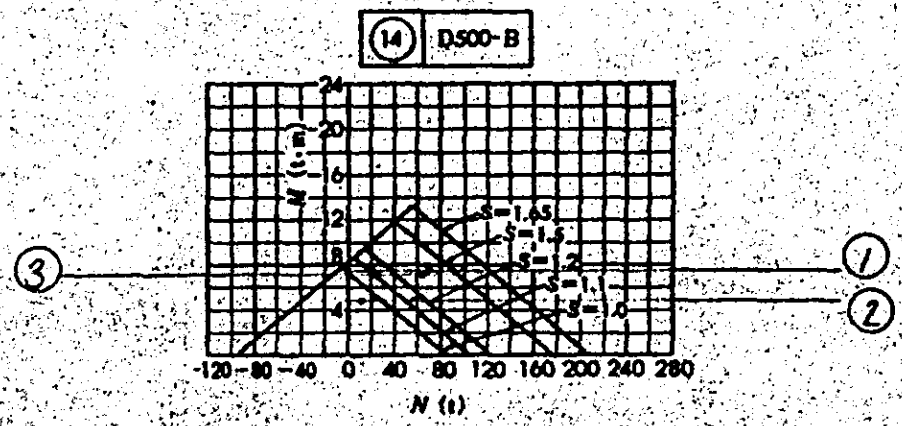
WHERE, $H = \Sigma H / n$, n ···· NUMBER OF PILE

$n = 56$

$$M_{max} = \frac{0.322 \cdot H}{\beta}$$

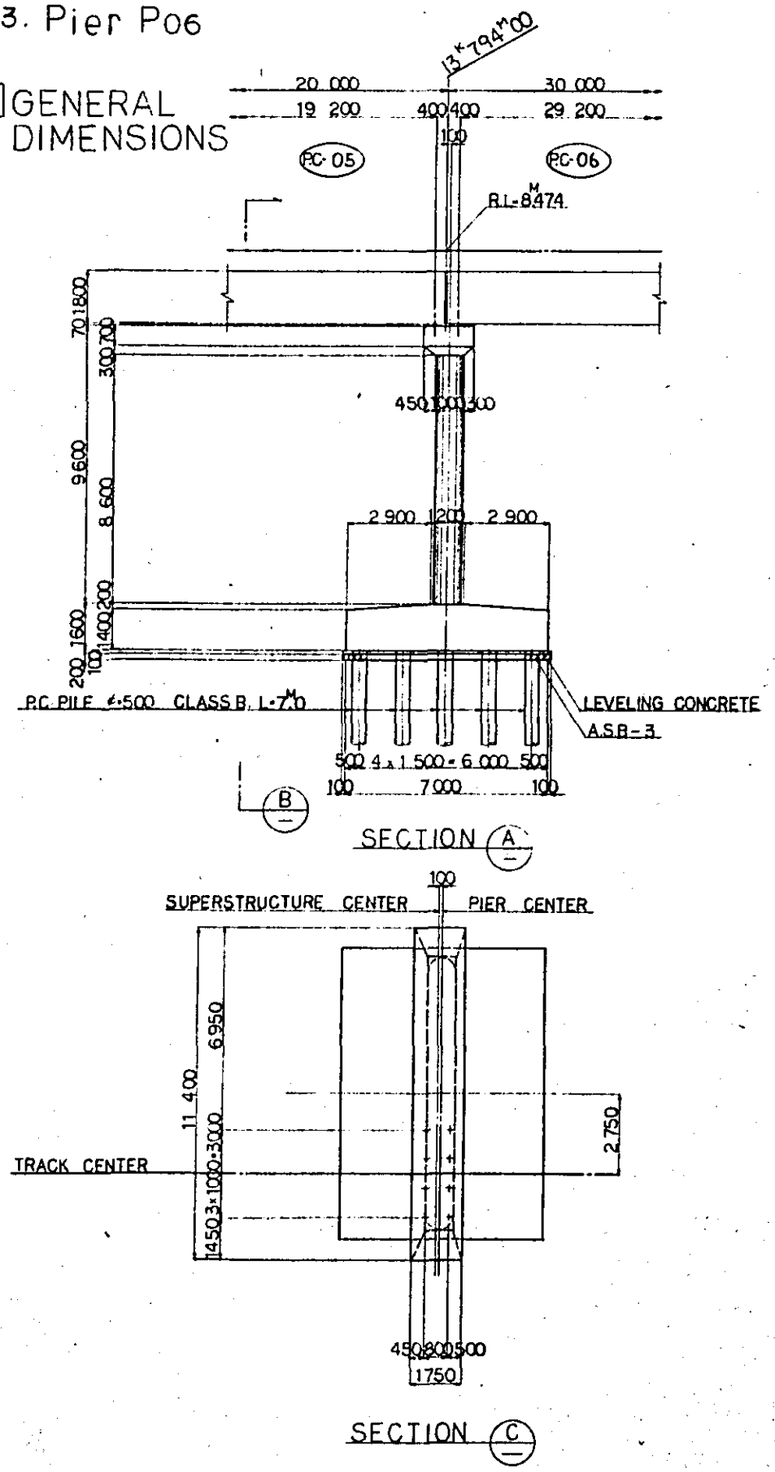
2. EXAMINATION OF SAFETY

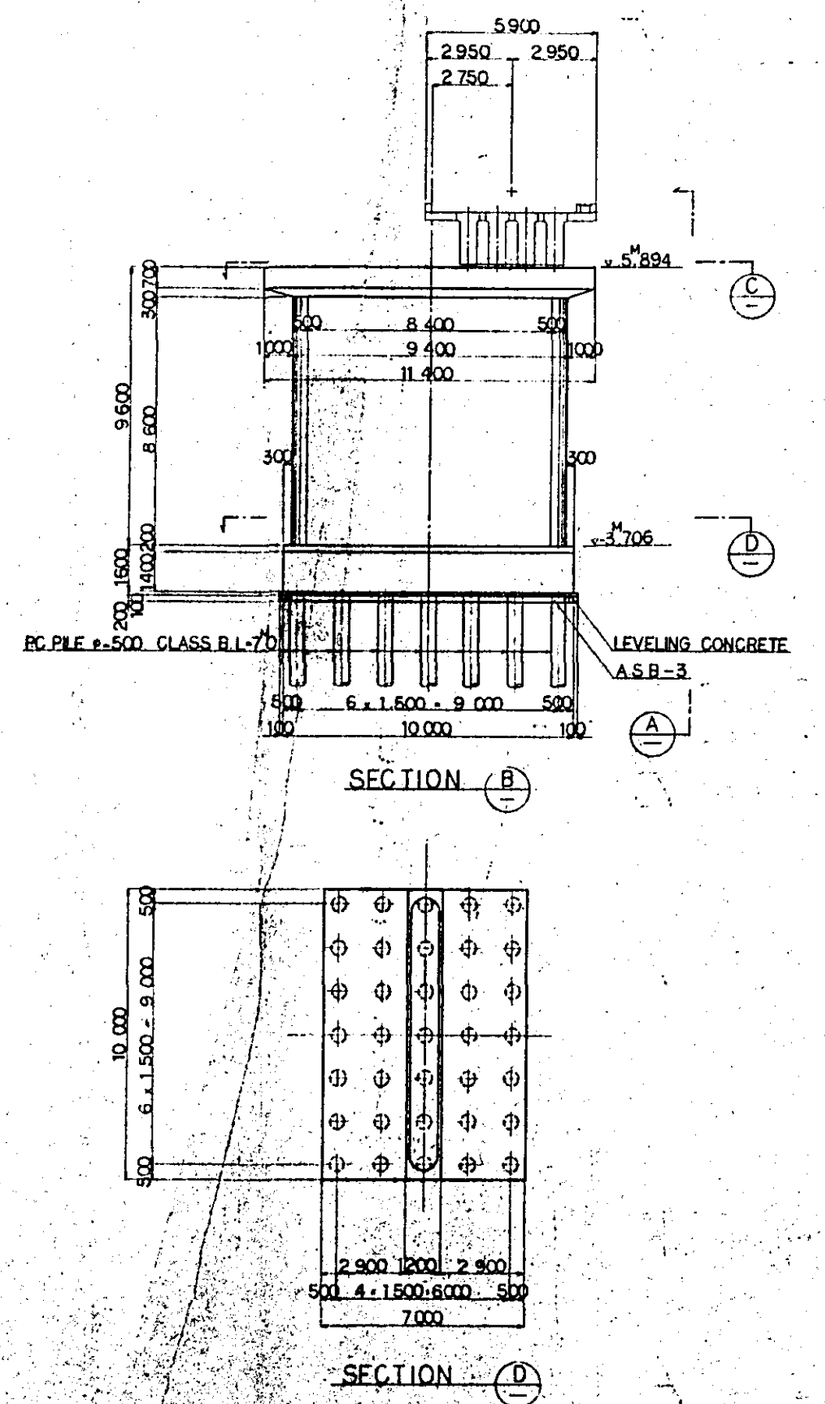




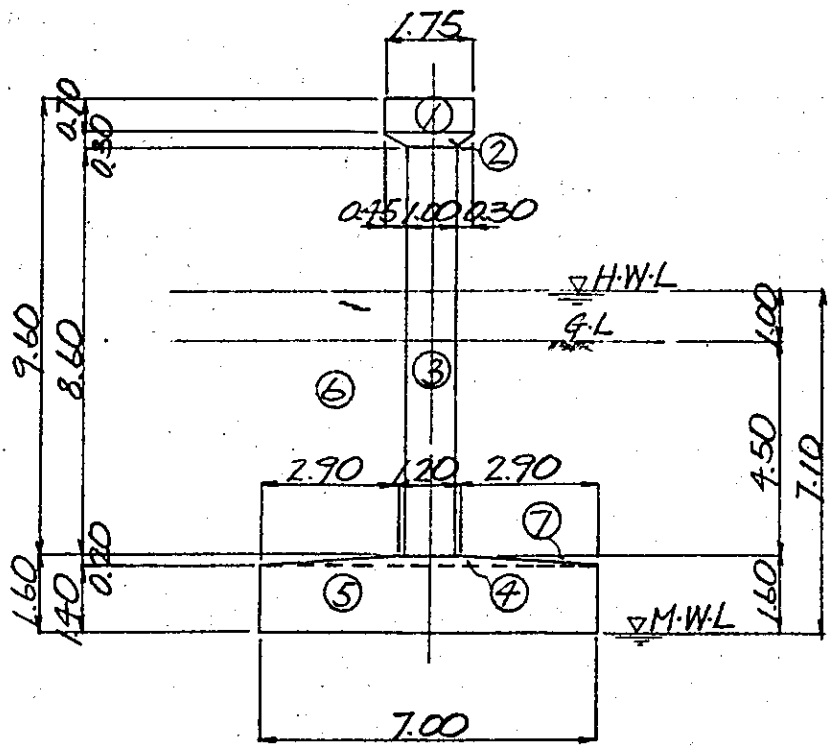
§3. Pier P06

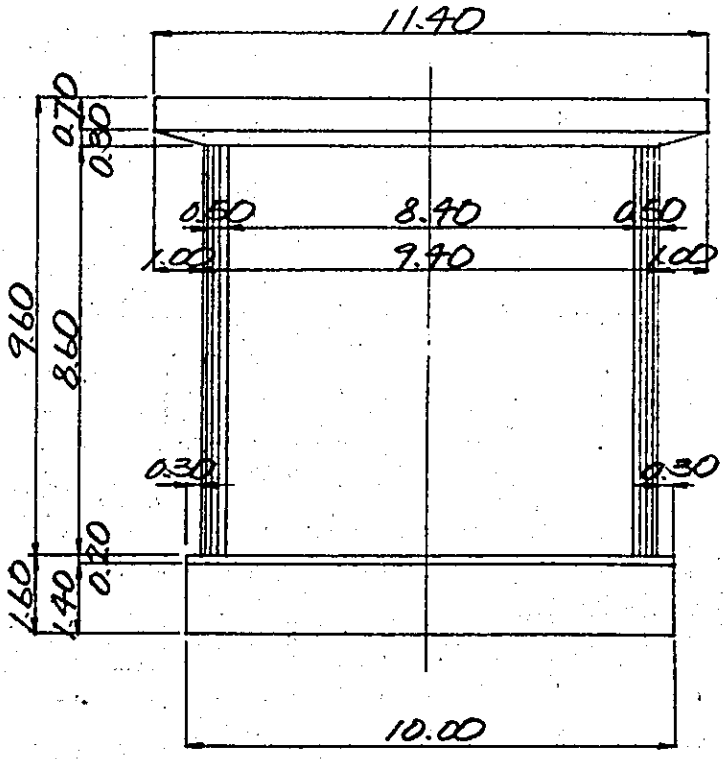
1 GENERAL DIMENSIONS





2 OWN WEIGHT OF SUBSTRUCTURE AND WEIGHT OF EARTH COVER





1. OWN WEIGHT OF SUBSTRUCTURE AND WEIGHT OF EARTH COVER

SUBSTRUCTURE

①	$2.5^{t/m^3} \times 1.75 \times 0.70 \times 11.40$	39.41^{t}
②	$2.5'' \times \frac{30}{6} \times \{1.75 \times 11.40 + 1.00 \times 9.40 + (1.75+1.00) \times (11.40+9.40)\}$	$10.82''$
③	$2.5'' \times (\frac{\pi}{4} \times 1.00^2 + 1.00 \times 8.40) \times 8.60$ (7.185)	$197.48''$
④	$2.5'' \times \frac{1}{2} \times (1.20+7.00) \times 0.20 \times 10.00$	$20.50''$
⑤	$2.5'' \times 7.00 \times 1.40 \times 10.00$	$245.00''$
	SUB-TOTAL	513.21^{t}

EARTH COVER

⑥	$1.8^{t/m^3} \times (7.00 \times 10.00 - 9.185) \times 4.50$	492.60^{t}
⑦	$1.8'' \times \frac{1}{2} \times 2.90 \times 0.20 \times 10.00 \times 2$	$10.44''$
	SUB-TOTAL	503.04^{t}

TOTAL

$$513.21 + 503.04 = 1016.25^{t}$$

2. BUOYANCY

$$1.0^{t/m^3} \times 9.185^{m^3} \times 1.00 = 9.19^{t}$$

$$1.0'' \times 7.00 \times 10.00 \times 6.10 = 427.00''$$

$$\text{TOTAL} = 436.19^{t}$$

3. HORIZONTAL FORCES DUE TO EARTHQUAKE LOAD

	N (t)	y (m)	N×y (t·m)
①	39.41	10.85	427.60
②	10.82	10.364	112.14
③	197.48	5.90	1165.13
④	20.50	1.476	30.26
⑤	245.00	0.70	171.50
Σ	513.21		1906.63

NOTE N: AXIAL FORCE

y: DISTANCE FROM THE BOTTOM OF FOOTING TO GRAVITY CENTER

4. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

$$ye = \frac{N \cdot y}{N} = \frac{1906.63}{513.21} = 3.715^{m}$$

$$P_E = 513.21 \times 0.1 = 51.32^{t}$$

$$M_o = 51.32 \times 3.715 = 190.65^{tm}$$

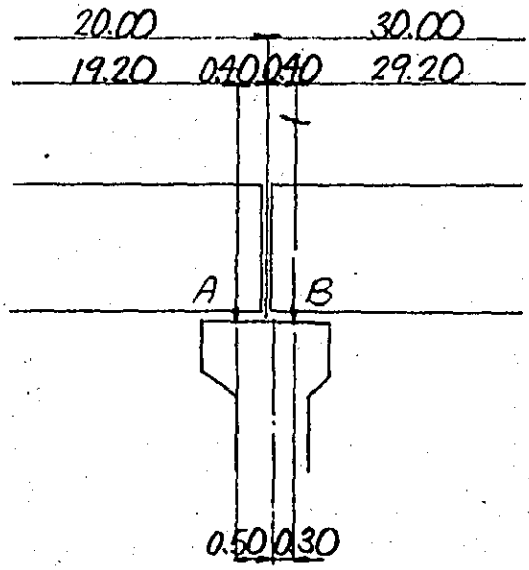
NOTE ye : DISTANCE FROM THE BOTTOM OF FOOTING TO THE CENTER OF SUBSTRUCTURE.

P_E : HORIZONTAL FORCE DUE TO EARTHQUAKE LOAD

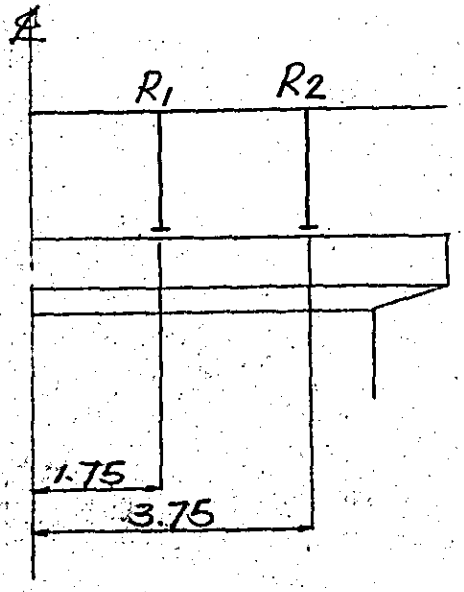
M_o : OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

3 REACTION FORCES TRANSMITTED FROM SUPERSTRUCTURE

1. REACTION FORCES DUE TO DEAD WEIGHT OF SUPERSTRUCTURE



1-1. REACTION FORCES ACTING AT BEARINGS - A

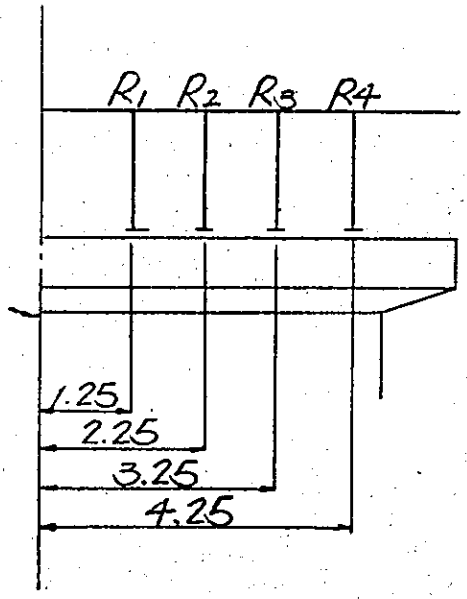


$R_1 = 64.98^{t}$

$R_2 = 72.24^{"}$

$TOTAL = 137.22^{t}$

1-2. REACTION FORCES ACTING AT BEARINGS-B



$R_1 = 70.17^t$

$R_2 = 70.17^{"}$

$R_3 = 70.17^{"}$

$R_4 = 73.36^{"}$

$TOTAL = 283.87^t$

1-3, SECTIONAL MOMENT AT THE CENTER OF PIER SHAFT DUE TO DEAD WEIGHT OF SUPERSTRUCTURE

SINGLE-TRACK LOADING FOR CALCULATION OF TRANSVERSAL STABILITY. DOUBLE-TRACK LOADING FOR CALCULATION OF LONGITUDINAL STABILITY

TRANSVERSAL DIRECTION

$$M_1 = 64.98 \times 1.75 + 72.24 \times 3.75 + 70.17 \times 2.25 \times 3 + 73.36 \times 4.25 = 1170.04^{t\cdot m}$$

LONGITUDINAL DIRECTION

$$M_2 = (137.22 \times -0.50 + 283.87 \times 0.30) \times 2 = 33.10^{t\cdot m}$$

1-4. HORIZONTAL FORCES DUE TO EARTHQUAKE ACTING ON DEAD WEIGHT OF SUPERSTRUCTURE

a) LONGITUDINAL DIRECTION

19.2^{m} - SPAN SIDE

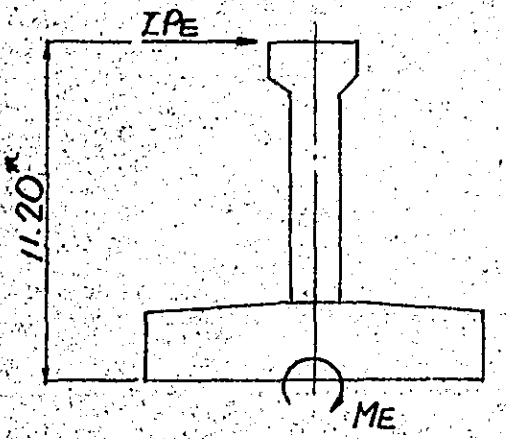
$$P_{E1} = 0.1 \times 137.22 = 13.72^{t}$$

29.2^{m} - SPAN SIDE

$$P_{E2} = 283.87 \times 2 \times 0.1 - \frac{1}{2} \times 0.1 \times 283.87 = 42.58^{t}$$

$$\Sigma P_E = P_{E1} + P_{E2} = 13.72 + 42.58 = 56.30^{t}$$

OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING



$$M_E = 56.30 \times 11.20 = 630.56^{tm}$$

b) TRANSVERSAL DIRECTION

19.2^{m} - SPAN SIDE

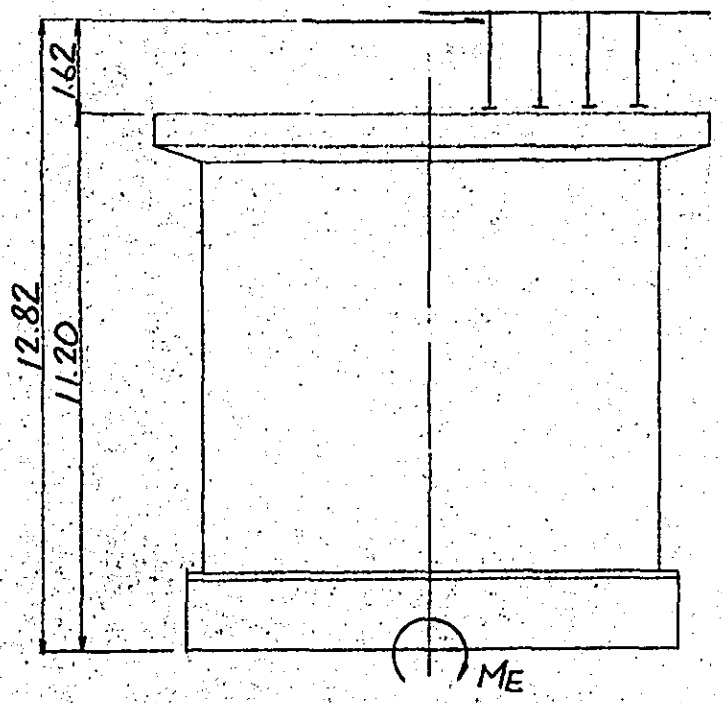
$P_{E1} = 137.22 \times 0.1 = 13.72^{t}$

29.2^{m} - SPAN SIDE

$P_{E2} = 283.87 \times 0.1 = 28.39^{t}$

$\Sigma P_E = P_{E1} + P_{E2} = 13.72 + 28.39 = 42.11^{t}$

OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

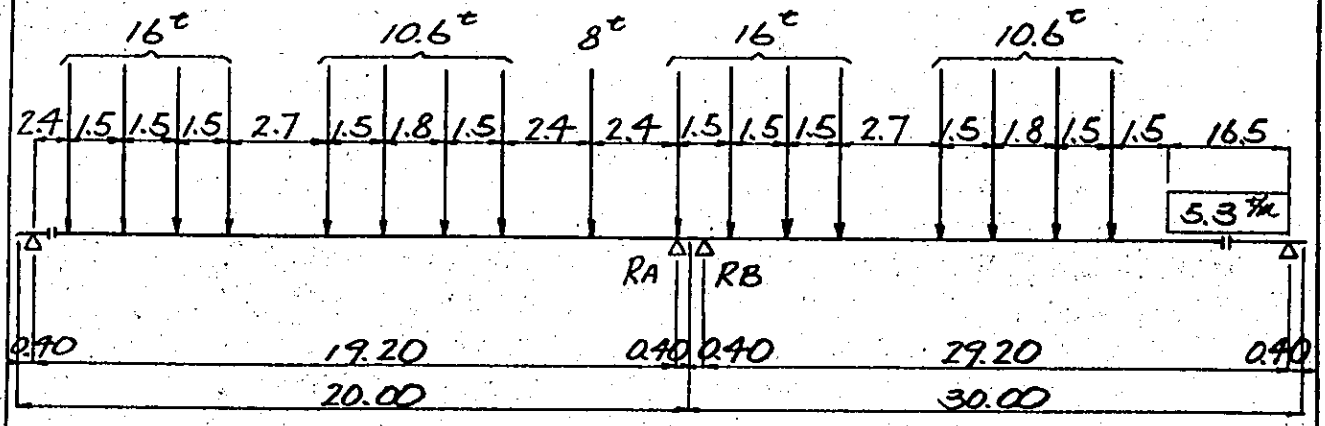


$M_E = 42.11 \times 12.82 = 539.85^{tm}$

2. REACTION FORCES DUE TO LIVE LOAD PLUS IMPACT LOAD

EQUIVALENT TO KS-16 LOADING

CALCULATION IS CARRIED OUT UNDER THE LOADING CONDITION OF PRODUCING MAXIMUM REACTION FORCE ON PIER



$$R_A = \frac{1}{19.20} \times (16 \times 4 \times 4.65 + 10.6 \times 4 \times 12.00 + 8 \times 16.8 + 16 \times 19.20) = 65.00^t$$

$$R_B = \frac{1}{29.20} \times (16 \times 3 \times 27.00 + 10.6 \times 4 \times 20.40 + 5.3 \times 16.50^2 \times \frac{1}{2}) = 98.71^t$$

IMPACT COEFFICIENT

19.2m - SPAN SIDE --- $i = 0.375$

29.2m - SPAN SIDE --- $i = 0.342$

. LIVE LOAD PLUS IMPACT

$R(A+L) = 65.00 \times 1.375 = 89.38^{t}$

$R(B+L) = 98.71 \times 1.342 = 132.47^{"}$

TOTAL $= 221.85^{t}$

2-1. SECTIONAL MOMENT ACTING AT THE CENTER OF PIER SHAFT

SINGLE-TRACK LOADING FOR CALCULATION OF TRANSVERSAL STABILITY, DOUBLE-TRACK LOADING FOR CALCULATION OF LONGITUDINAL STABILITY.

TRANSVERSAL DIRECTION

$$M_1 = 89.38 \times \frac{1}{2} \times (1.75 + 3.75) + 132.47 \times \frac{1}{4} \times (1.25 + 2.25 + 3.25 + 4.25)$$

$$= 610.09^{t\text{-m}}$$

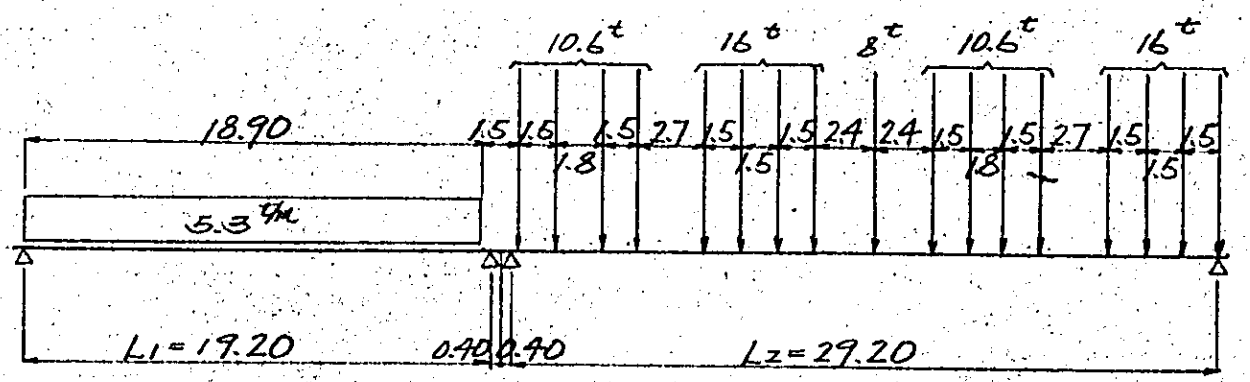
LONGITUDINAL DIRECTION

$$M_2 = (89.38 \times -0.50 + 132.47 \times 0.30) \times 2$$

$$= -9.90^{t\text{-m}}$$

3. BRAKE LOAD AND TRACTION LOAD

UNDER THE LOADING CONDITION AS SHOWN BELOW



3-1. BRAKE LOAD

15% OF KS LOADING.

L1 - SPAN SIDE

$$P_{B-1} = 5.3 \times 18.90 \times 0.15 \times \frac{1}{2}$$

$$= 7.51^{t}$$

L2 - SPAN SIDE

$$P_{B-2} = (16 \times 8 + 10.6 \times 8 + 8) \times 0.15 \times \frac{1}{2}$$

$$= 16.56^{t}$$

$$\Sigma P_B = P_{B-1} + P_{B-2} = 7.51 + 16.56 = 24.07^{t}$$

3-2. TRACTION LOAD

25% OF MOVING WHEEL AXLE LOAD OF KS LOADING

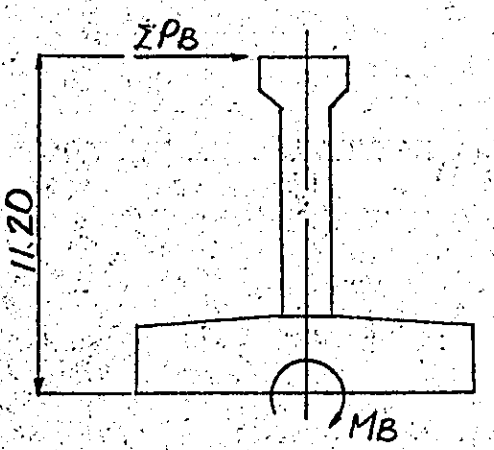
L1 - SPAN SIDE

$P_{T-1} = 0$

L2 - SPAN SIDE

$$P_{T-2} = 16 \times 8 \times 0.25 \times \frac{1}{2} = 16.00^{t} < \Sigma P_B = 24.07^{t}$$

3-3. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING



$$M_B = 24.07 \times 11.20 = 269.58^{t/m}$$

4. CENTRIFUGAL LOAD

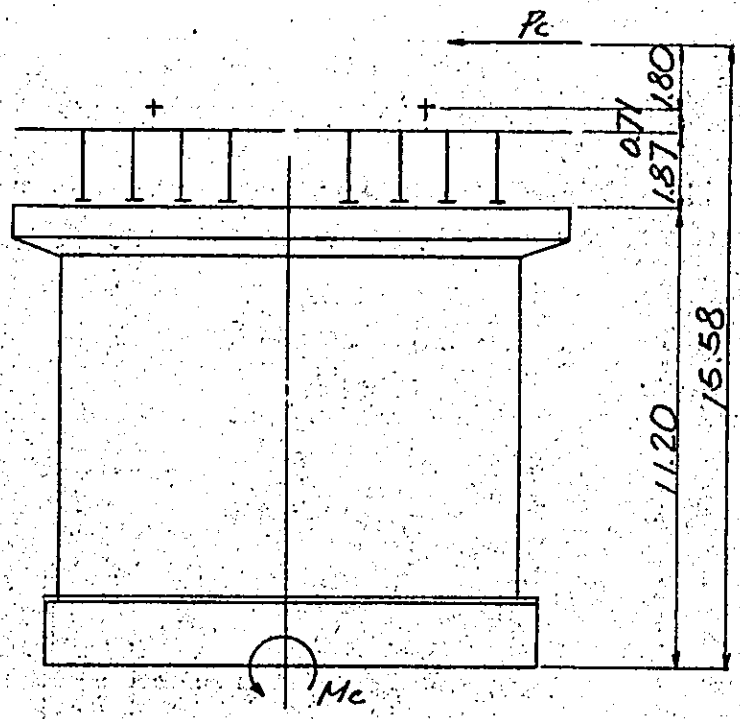
ASSUMED THAT THE LOAD IS EQUIVALENT TO THE LIVE (TRAIN) LOAD MULTIPLIED BY α AND IS ACTING TRANSVERSALLY ON 1.8 m ABOVE THE TRACK LEVEL.

REFERENCE IS MADE FOR THE LOADING CALCULATION OF LIVE (TRAIN) LOAD PLUS IMPACT

$$R = 500^{m} \quad ---- \quad \alpha = 0.12$$

$$P_c = (65.00 + 98.71) \times 0.12 = 19.65^{t}$$

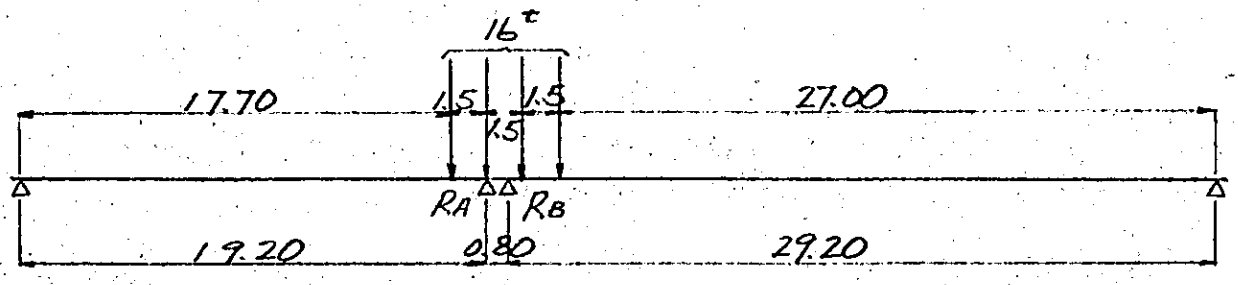
4-1. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.



$$M_c = 19.65 \times 15.58 = 306.15^{t}$$

5. TRAIN LATERAL LOAD

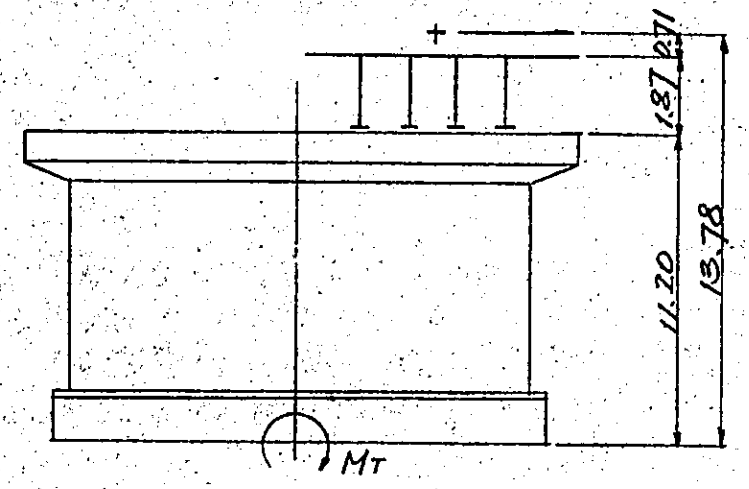
TRANSVERSAL FORCE DUE TO LIVE (TRAIN) LOAD. IS ASSUMED TO BE EQUIVALENT TO THE SERIES OF CONCENTRATED LOADS CONSISTED OF 15% OF MOVING WHEEL AXLE LOAD ACTING TRANSVERSALLY AT THE TRACK LEVEL.
CALCULATION IS MADE UNDER THE SINGLE-TRACK LOADING



$$R_A + R_B = \frac{16}{19.20} \times (17.70 + 19.20) + \frac{16}{29.20} \times (27.00 + 28.50) = 61.16^{t}$$

$$P_T = 61.16 \times 0.15 = 9.17^{t}$$

5-1. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.



$$M_T = 9.17 \times 13.78 = 126.36^{t/m}$$

4 CALCULATION ON STABILITY

1. COMBINATION OF LOADS

1-1 TRANSVERSAL DIRECTION

No1. DEAD LOAD (M.W.L)

No2. DEAD LOAD + (TRAIN + IMPACT) LOAD (M.W.L)

No3. ——————〃—————— (H.W.L)

No4. DEAD LOAD + (TRAIN + IMPACT) LOAD + TRAIN LATERAL LOAD (M.W.L)

No5. ——————〃—————— (H.W.L)

No6. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

No7. DEAD LOAD (M.W.L)

No8. DEAD LOAD + (TRAIN + IMPACT) LOAD + CENTRIFUGAL LOAD (M.W.L)

No9. ——————〃—————— (H.W.L)

No10. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

THE ABOVE LOADING COMBINATIONS ARE APPLIED NO.1 THRU NO.6 FOR SINGLE-TRACK LOADING AND NO.7 THRU NO.10 FOR DOUBLE-TRACK LOADING.

1-2. LONGITUDINAL DIRECTION.

No.1. DEAD LOAD (M.W.L)

No.2. DEAD LOAD + (TRAIN + IMPACT) LOAD (M.W.L)

No.3. ——————〃—————— (H.W.L)

No.4. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ BREAKING LOAD or TRACTION LOAD (M.W.L)

No.5. ——————〃—————— (H.W.L)

No.6. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

ALL OF THE ABOVE LOADING COMBINATIONS ARE APPLIED FOR DOUBLE-TRACK LOADING.

2. TABLE OF FORCE AND MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.

2-1. TRANSVERSAL DIRECTION

SINGLE-TRACK LOADING

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No1	1016.25 + 137.22 + 283.87 = 1437.34	1170.04	———
No2	1437.34 + 221.85 = 1659.19	1170.04 + 610.09 = 1780.13	———
No3	1659.19 - 436.19 = 1223.00	1780.13	———
No4	1659.19	1780.13 + 126.36 = 1906.49	9.17
No5	1223.00	1906.49	9.17
No6	1437.34	1170.04 + 190.66 + 539.85 = 1900.54	51.32 + 42.11 = 93.43

DOUBLE-TRACK LOADING

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No7	1437.34 + 137.22 + 283.87 = 1858.43	———	———
No8	1858.43 + 221.85 × 2 = 2302.13	306.15 × 2 = 612.30	19.65 × 2 = 39.30
No9	2302.13 - 436.19 = 1865.94	612.30	39.30
No10	1858.43	190.65 + 539.85 × 2 = 1270.35	51.32 + 42.11 × 2 = 135.54

2-2, LONGITUDINAL DIRECTION

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No1	1858.43	33.10	———
No2	2302.13	33.10	———
No3	1865.94	33.10	———
No4	2302.13	33.10+269.58 = 302.68	24.07
No5	1865.94	302.68	24.07
No6	1858.43	190.65+630.56×2 +33.10=1484.87	61.32+56.30×2 =163.92

3. REACTION FORCE ACTING ON PILES

$$P = \frac{N}{n} \pm \frac{M}{I} \times x$$

WHERE: P REACTION FORCE

n NUMBER OF PILES

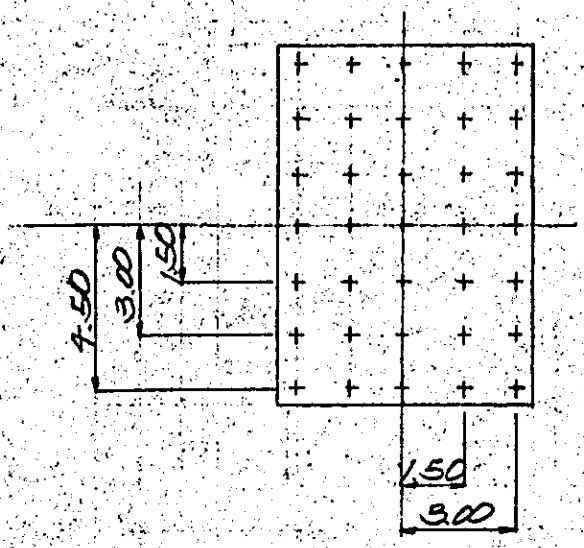
N AXIAL FORCE ACTING AT THE CENTER OF THE BOTTOM OF FOOTING

M MOMENT ACTING AT THE CENTER OF THE BOTTOM OF FOOTING

I MOMENT OF INERTIA OF THE GROUP OF PILES WITH RESPECT TO THE GEOMETRICAL CENTER

x DISTANCE FROM THE GEOMETRICAL CENTER OF THE GROUP OF PILES TO THE CENTER OF THE PILE TO BE CALCULATED

3-1. ARRANGEMENT OF PILES



LONGTUDINAL

$n = 35$

3-2 REACTION FORCE ACTING ON PILES - DUE TO TRANSVERSAL LOAD

	N (t)	M (t·m)	$\frac{N}{n}$ (t)	$\frac{M}{I}$ ($\frac{t}{m}$)	P_{max} (t)	P_{min} (t)
No 1	1437.34	1170.04	41.07	3.71	57.77	24.38
No 2	1659.19	1780.13	47.41	5.65	72.84	21.99
No 3	1223.00	1780.13	34.94	5.65	60.37	9.52
No 4	1659.19	1906.49	47.41	6.05	74.64	20.19
No 5	1223.00	1906.49	34.94	6.05	62.17	7.72
No 6	1437.34	1900.54	41.07	6.03	68.21	13.94
No 7	1858.43	———	53.10	———	53.10	53.10
No 8	2302.13	612.30	65.78	1.94	74.51	57.05
No 9	1865.94	612.30	53.31	1.94	62.04	44.58
No 10	1858.43	1270.35	53.10	4.03	71.24	34.97

$$I = (1.50^2 + 3.00^2 + 4.50^2) \times 2 \times 5 = 315.00\ m^4$$

$$x = 4.50\ m$$

3-3. REACTION FORCE ACTING ON PILES DUE TO LONGITUDINAL LOAD

	N (t)	M (t·m)	$\frac{N}{n}$ (t)	$\frac{M}{I}$ ($\frac{t}{m}$)	$x_{(m)}$	P_{max} (t)	P_{min} (t)
No1	1858.43	33.10	53.10	0.21	x_1	53.42	52.78
					x_2	53.73	52.47
					x_3	———	———
No2	2302.13	33.10	65.78	0.21	x_1	66.10	65.46
					x_2	66.41	65.15
					x_3	———	———
No3	1865.94	33.10	53.31	0.21	x_1	53.63	52.99
					x_2	53.94	52.68
					x_3	———	———
No4	2302.13	302.68	65.78	1.92	x_1	68.66	62.90
					x_2	71.54	60.02
					x_3	———	———
No5	1865.94	302.68	53.31	1.92	x_1	56.19	50.43
					x_2	59.07	47.55
					x_3	———	———
No6	1858.43	1484.87	53.10	9.43	x_1	67.25	38.95
					x_2	81.39	24.81
					x_3	———	———

$$I = (1.50^2 + 3.00^2) \times 2 \times 7 = 157.50\ m^4$$

$$x_1 = 1.50\ m$$

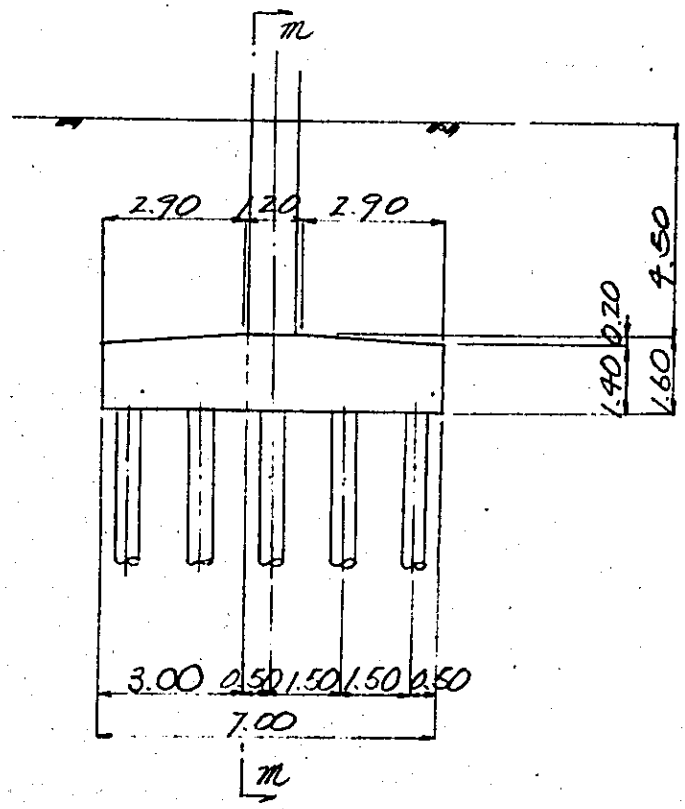
$$x_2 = 3.00\ m$$

5 DESIGN OF FOOTING

CALCULATION IS MADE ONLY THE CASE OF LONGITUDINAL LOADING, BECAUSE NO STRESS OCCURS UNDER THE TRANSVERSAL LOADING DUE TO REACTION FORCES ON PILES WITHIN THE WALL SHAFT

1. EXAMINATION OF SAFETY AGAINST BENDING MOMENT

1-1. BENDING MOMENT DUE TO OWN WEIGHT OF FOOTING AND WEIGHT OF EARTH COVER



WHERE m SECTION WHERE MOMENT IS CALCULATED

M_m BENDING MOMENT AT SECTION m

BENDING MOMENT AT SECTION m

i) THE CASE NO BUOYANCY IS CONSIDERED

$$Mm = (2.5^{t/m^3} \times 1.60 + 1.8^{t/m^3} \times 4.50) \times \frac{1}{2} \times 3.00^2$$
$$- (2.5-1.8) \times 1/2 \times 2.90 \times 0.20 \times 2.033 \quad = 54.04^{tm}$$

ii) THE CASE BUOYANCY IS CONSIDERED

$$Mm = 54.04 - \frac{1}{2} \times 3.00^2 \times 6.10 \times 1.0^{t/m^3} = 26.59^{tm}$$

1-2, STRESS DUE TO REACTION FORCE ON PILES

BENDING MOMENT AT SECTION m

NO 1 $Mm = (53.42 \times 1.10 + 53.73 \times 2.60) \times \frac{7}{10.00} = 138.92^{tm}$

NO 2 $Mm = (66.10 \times \text{〃} + 66.41 \times \text{〃}) \times \text{〃} = 171.76$ 〃

NO 3 $Mm = (53.63 \times \text{〃} + 53.94 \times \text{〃}) \times \text{〃} = 139.47$ 〃

NO 4 $Mm = (68.66 \times \text{〃} + 71.54 \times \text{〃}) \times \text{〃} = 183.07$ 〃

NO 5 $Mm = (56.19 \times \text{〃} + 59.07 \times \text{〃}) \times \text{〃} = 150.77$ 〃

NO 6 $Mm = (67.25 \times \text{〃} + 81.39 \times \text{〃}) \times \text{〃} = 199.91$ 〃

1-3. SUMMARY OF BENDING MOMENT ON FOOTING

No1 : $M_m = (138.92 - 54.04) \times \frac{1.8}{1.4} = 109.13$ t/m

No2 : $M_m = (171.76 - 54.04) \times \frac{1}{1.0} = 117.72$ "

No3 : $M_m = (139.47 - 26.59) \times \frac{1}{1.0} = 112.88$ "

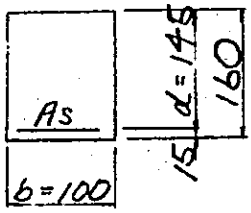
No4 : $M_m = (183.07 - 54.04) \times \frac{1}{1.15} = 112.20$ "

No5 : $M_m = (150.77 - 26.59) \times \frac{1}{1.15} = 107.98$ "

No6 : $M_m = (199.91 - 54.04) \times \frac{1}{1.5} = 97.25$ "

1-4. EXAMINATION OF SAFETY

$M_m = 117.72$ t/m



$As = 032 - 6.67 = 52.97$ cm²

$p = \frac{As}{b \cdot d} = \frac{52.97}{100 \times 145} = 0.00365$

$\frac{1}{Lc} = 7.86 \qquad \frac{1}{Ls} = 302$

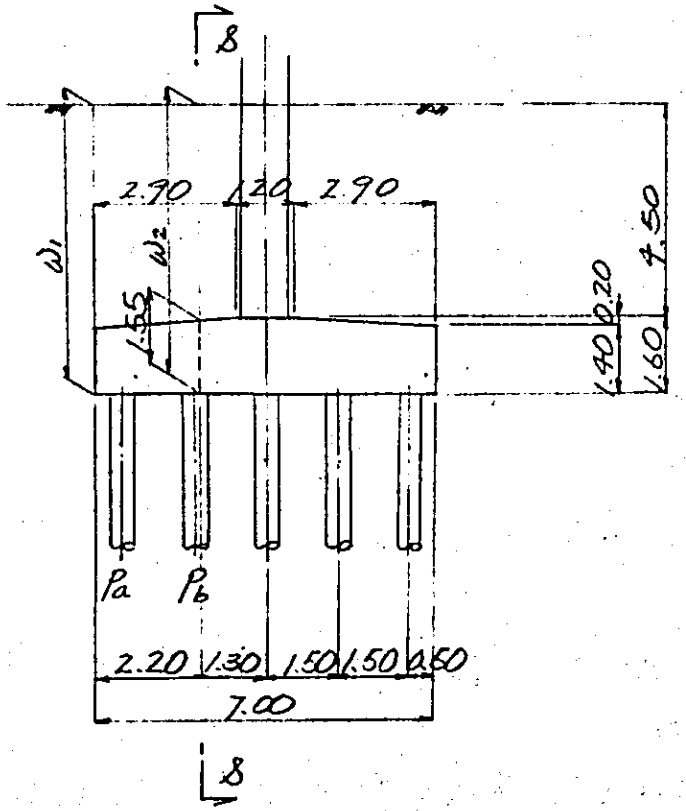
$\sigma_c = \frac{M}{b \cdot d^2} \times \frac{1}{Lc} = \frac{117.72 \times 10^5}{100 \times 145^2} \times 7.86 = 44.0$ kg/cm² < 80 kg/cm²

$\sigma_s = \frac{M}{b \cdot d^2} \times \frac{1}{Ls} =$ ——— 〃 ——— $\times 302 = 1691$ " < 1800 "

2. EXAMINATION OF SAFETY AGAINST SHEARING FORCE

EXAMINATION ON THE COMBINATION No.6

2-1. SHEARING FORCE DUE TO OWN WEIGHT OF FOOTING AND WEIGHT OF EARTH COVER



WHERE: δ SECTION WHERE SHEARING FORCE IS CALCULATED

S_δ SHEARING FORCE AT SECTION δ

SHEARING FORCE AT SECTION 8

$$\omega_1 = 2.5^{t/m^3} \times 1.40 + 1.8^{t/m^3} \times 4.70 = 11.96^{t/m}$$

$$\omega_2 = (2.5^{t/m^3} \times 1.55 + 1.8^{t/m^3} \times 4.55) \times \frac{0.80}{2 \times (1.55 - 0.15)} = 3.45^{"}$$

$$S_8 = 1/2 \times (11.96 + 3.45) \times 2.20 = 16.95^{t}$$

2-2. STRESS DUE TO REACTION FORCE ON PILES

SHEARING FORCE AT SECTION 8

$$P_a = 81.39 \times \frac{2.50}{2 \times (1.55 - 0.15)} = 72.67^{t}$$

$$P_b = 67.25 \times \frac{1.00}{2 \times (1.55 - 0.15)} = 24.02^{"}$$

$$S_8 = (72.67 + 24.02) \times \frac{7}{10.00} = 67.68^{t}$$

2-3. SUMMARY OF SHEARING FORCES ON FOOTING

$$S_8 = 67.68 - 16.95 = 50.73^{t}$$

2-4. EXAMINATION OF SAFETY.

$$\tau = \frac{50.73 \times 10^3}{100 \times 140} = 3.62^{kg/cm^2} < 3.7^{kg/cm^2}$$

6 DESIGN OF SUBSTRUCTURE.

EXAMINATION IS MADE ONLY THE CASE OF LONGITUDINAL LOADING

1. COMBINATION OF LOADS

No.6 DEAD LOAD + EARTHQUAKE LOAD

2. BENDING MOMENT AND AXIAL FORCE ACTING AT THE BOTTOM OF WALL

THE FOLLOWING FIGURES OF THE REACTIONFORCES TRANSMITTED FROM SUPERSTRUCTURE.

$$M = 39.41 \times 0.1 \times 9.25 + 10.82 \times 0.1 \times 8.764 + 197.48 \times 0.1 \times 4.30 + 56.30 \times 9.60 \times 2 + 33.10$$

$$= 1244.91^{tm}$$

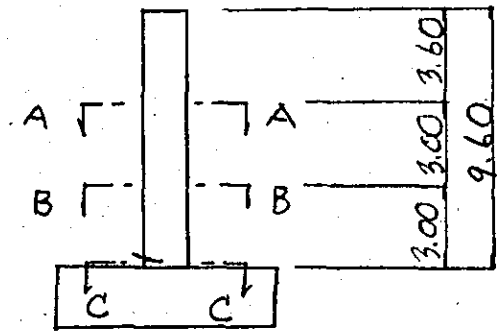
$$N = 39.41 + 10.82 + 197.48 + (137.22 + 283.87) \times 2$$

$$= 1089.89^{t}$$

3. EXAMINATION OF SAFETY

	-	
M (tm)	1244.91	
N (t)	1089.89	
S (t)		
b (cm)	890	
h (cm)	100	
d (cm)		
d' (cm)	8.5	
As (cm²)	D32-57 =452.69	
p	0.00538	
As' (cm²)	=As	
p'	=p	
e=M/N (cm)	114.2	
e=M/N+u (cm)		
e=M/N−u (cm)		
e/h	1.142	
d/e		
d'/h	0.085	
d'/d		
Ne/bd² (kg/cm²)	12.974	
k	0.368	
c	0.126	
j		
1/Lc		
1/Ls		
β=σs/σc		
σc (kg/cm²)	102.1	
σs (kg/cm²)	2269	
τ (kg/cm²)		
σsa (kg/cm²)	120	
σca (kg/cm²)	2700	
τa (kg/cm²)		

4. DEDUCTION OF REINFCRCING BARS



4-1 BENDING MOMENT AND AXIAL FORCE ACTING AT THE SECTION A AND B.

M_A = 33.10 + (39.41 × 3.25 + 10.82 × 2.764
+ 2.5 × 9.185 × 2.60² × ½) × 0.1
+ 56.30 × 3.60 × 2 = 462.02 t·m

N_A = 39.41 + 10.82 + 2.5 × 9.185 × 2.60
+ (137.22 + 283.87) × 2 = 952.11 t

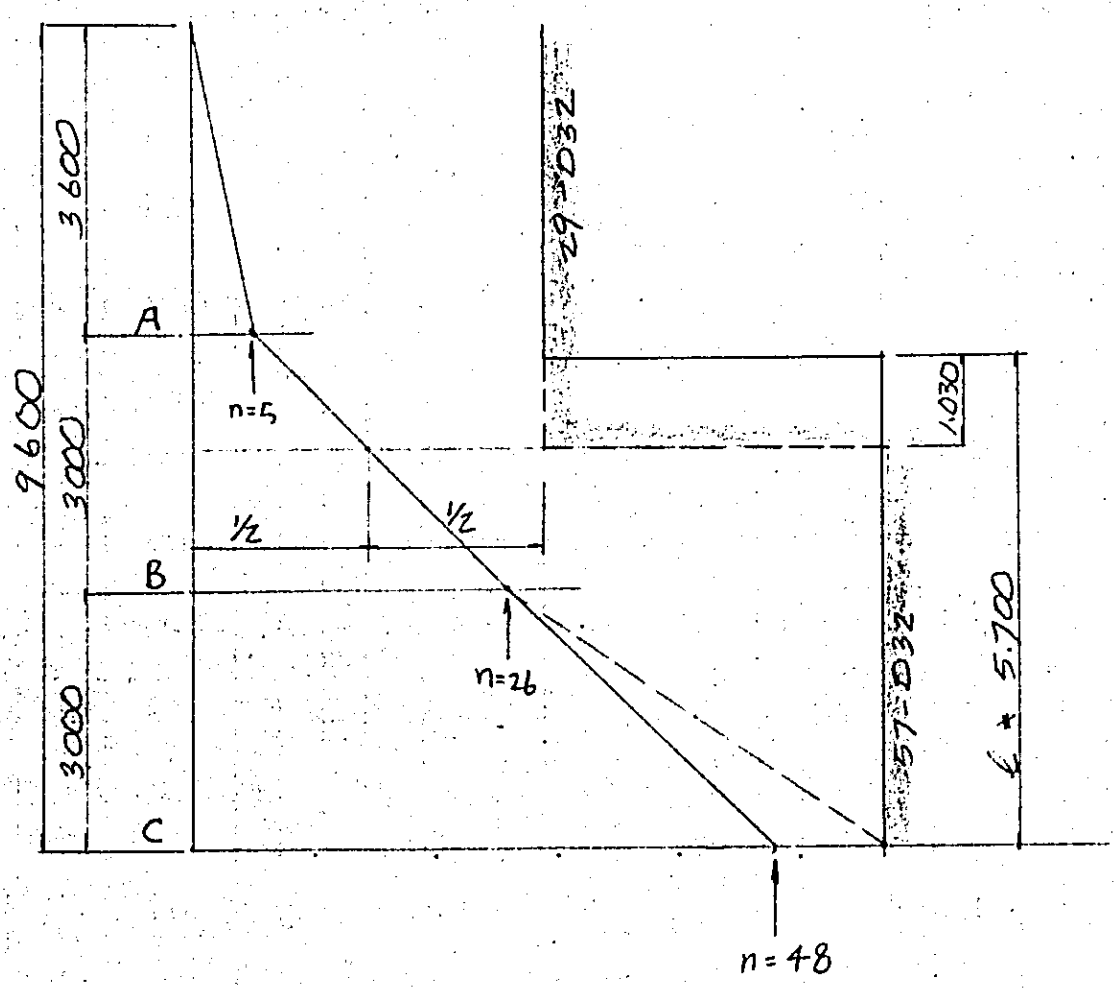
M_B = 33.10 + (39.41 × 6.25 + 10.82 × 5.764
+ 2.5 × 9.185 × 5.60² × ½) × 0.1
+ 56.30 × 6.60 × 2 = 843.13 t·m

N_B = 952.11 + 2.5 × 9.185 × 3.00 = 1021.00 t

4-2. THE LEAST REINFORCING BARS REQUIRED AT THE SECTION A AND B

SECTION	A	B	C
M (tm)	462.02	843.13	1244.91
N (t)	952.11	1021.00	1089.89
b (cm)	840	"	"
h (")	100	"	"
d' (")	85	"	"
As	D32-5	D32-26	D32-48
σ_c (kg/cm^2)	80.7	97.6	110.5
σ_s (")	2488	2634	2669

4-3. MOMENT DIAGRAM



7 DESIGN OF PILE

1. REACTION FORCES ACTING ON PILES

EXAMINATION IS MADE ONLY TO THE EARTHQUAKE LOADING.

	LONGITUDINAL DIRECTION ①	TRANSVERSAL DIRECTION	
		② SINGLE TRACK	③ DOUBLE TRACK
WHOLE HORIZONTAL FORCE, ΣH (t)	163.92	93.43	135.54
HORIZONTAL FORCE PER PILE, H (t)	4.68	2.67	3.87
VALUE OF β (m^{-1})	0.214	〃	〃
MAXIMUM MOMENT PER PILE, Mmax (tm)	7.04	4.02	5.82
MAXIMUM AXIAL FORCE PER PILE, Pmax (t)	81.39	68.21	71.24
MINIMUM AXIAL FORCE PER PILE, Pmin (t)	24.81	13.94	34.97

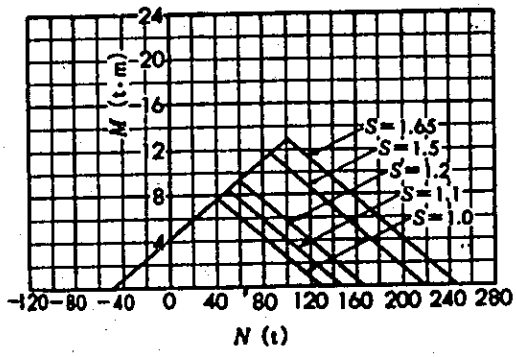
WHERE $H = \Sigma H / n$, n ··· NUMBER OF PILE

$n = 35$

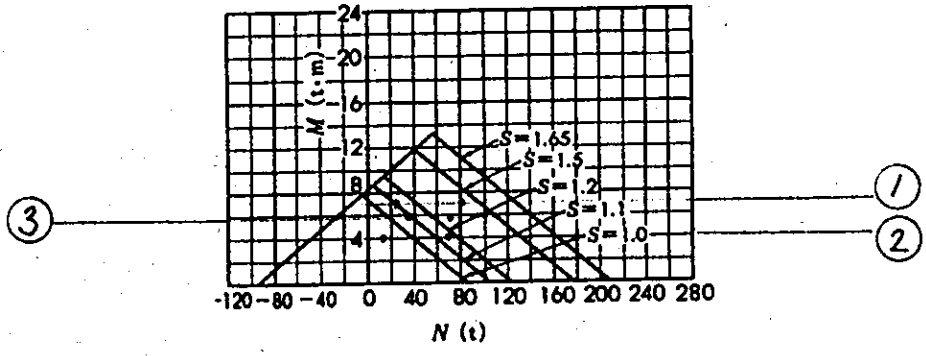
$$M_{max} = \frac{0.322 \cdot H}{\beta}$$

2. EXAMINATION OF SAFETY

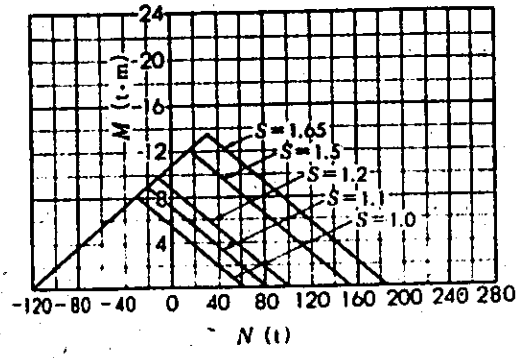
(13) D500-A



(14) D500-B

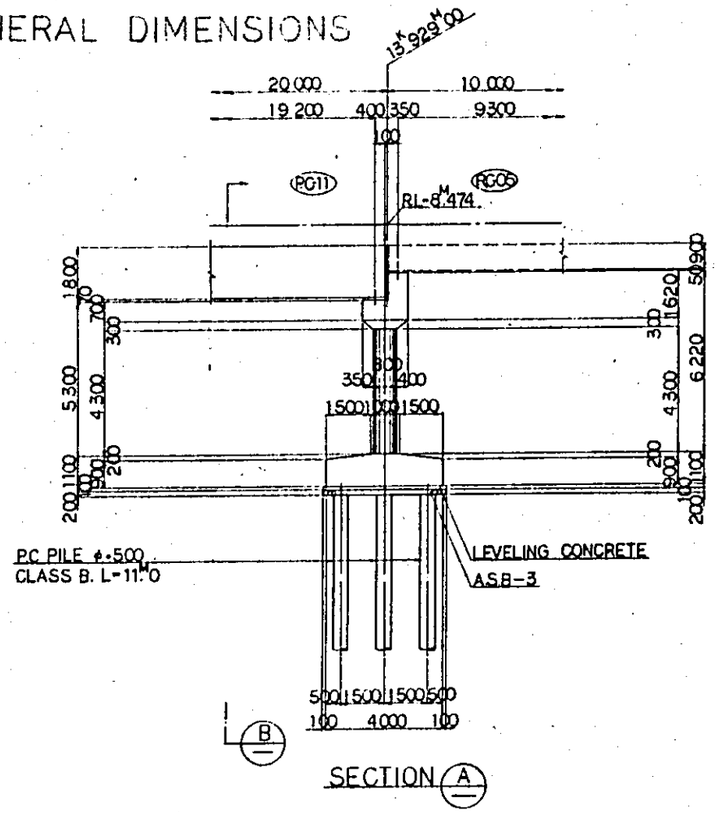


(15) D500-C

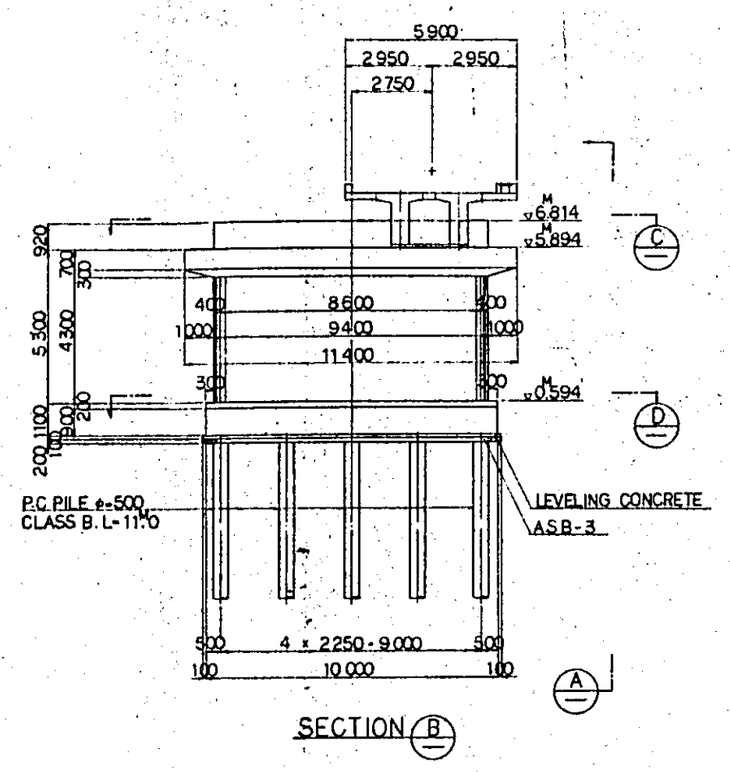


§4. Pier P12

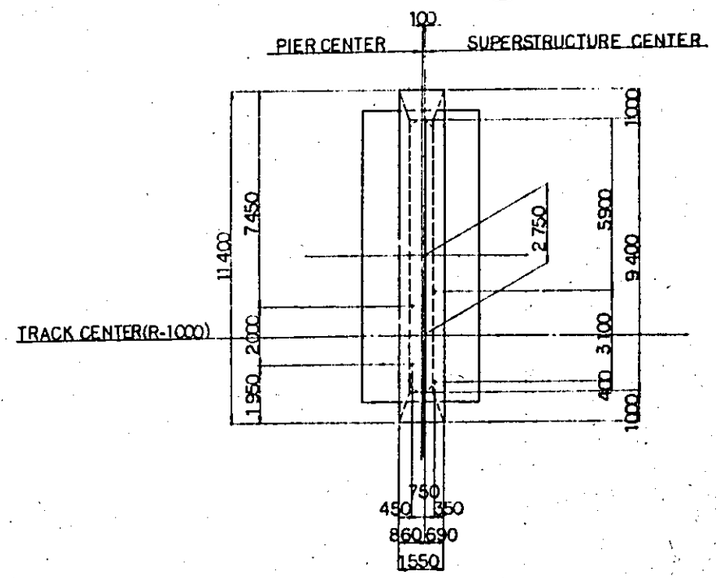
1 GENERAL DIMENSIONS



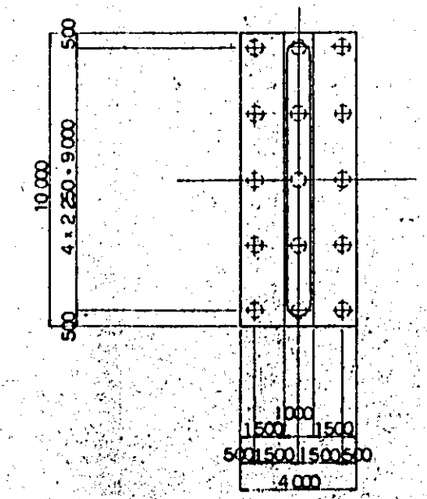
SECTION (A)



SECTION (B)

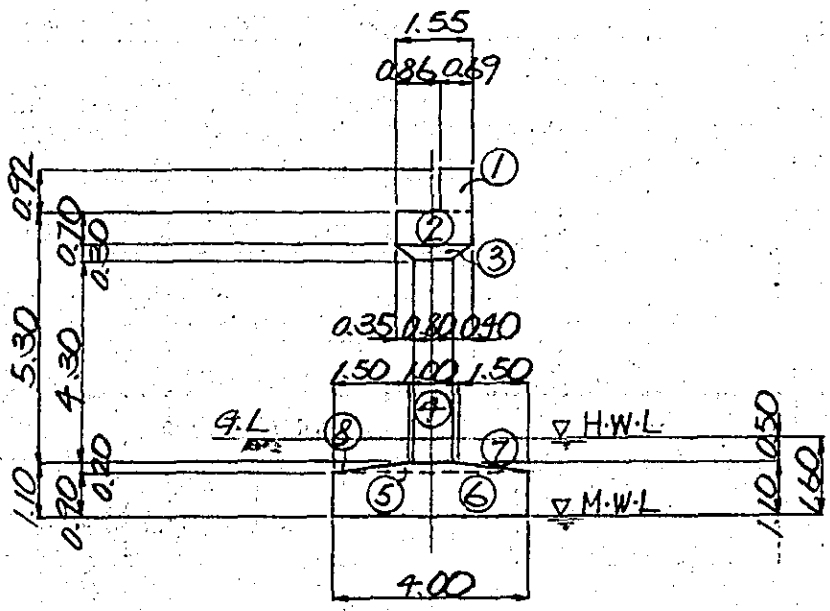


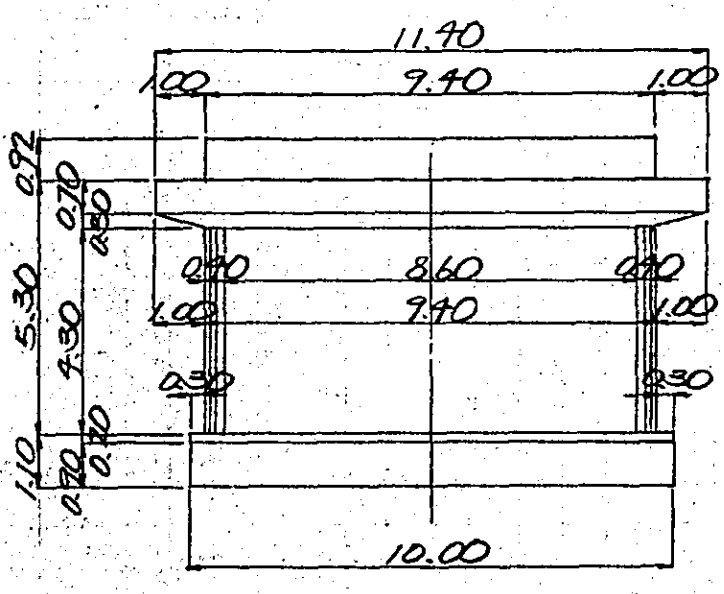
SECTION (C)



SECTION (D)

[2] OWN WEIGHT OF SUBSTRUCTURE AND WEIGHT OF EARTH COVER





1. OWN WEIGHT OF SUBSTRUCTURE AND WEIGHT OF EARTH COVER

SUBSTRUCTURE

①	$2.5^{t/m^3} \times 0.69 \times 0.92 \times 9.40$	14.92 t
②	$2.5" \times 1.55 \times 0.70 \times 11.40$	30.92 "
③	$2.5" \times 0.30/6 \times \{1.55 \times 11.40 + 0.80 \times 9.40 + (1.55+0.80)(11.40+9.40)\}$	9.26 "
④	$2.5" \times (1/4 \times \pi \times 0.80^2 + 0.80 \times 8.60) \sim 7.383 \times 4.30$	79.37 "
⑤	$2.5" \times 1/2 \times (1.00 + 4.00) \times 0.20 \times 10.00$	12.50 "
⑥	$2.5" \times 4.00 \times 0.90 \times 10.00$	90.00 "
	SUB-TOTAL	236.97 t

EARTH COVER

⑦	$1.8^{t/m^3} \times (4.00 \times 10.00 - 7.383) \times 0.50$	29.36 t
⑧	$1.8" \times 1/2 \times 1.50 \times 0.20 \times 10.00 \times 2$	5.40 "
	SUB-TOTAL	34.76 t

TOTAL

$$236.97 + 34.76 = 271.73\ t$$

2. BUOYANCY

$$1.0^{t/m^3} \times 4.00 \times 1.60 \times 10.00 = 64.00\ t$$

3. HORIZONTAL FORCES DUE TO EARTHQUAKE LOAD

	N (t)	y (m)	N·y (t·m)
①	14.92	6.86	102.35
②	30.92	6.05	187.07
③	9.26	5.566	51.54
④	79.37	3.25	257.95
⑤	12.50	0.98	12.25
⑥	90.00	0.45	40.50
Σ	236.97	———	651.66

NOTE N: AXIAL FORCE

y: DISTANCE FROM THE BOTTOM OF FOOTING TO GRAVITY CENTER

4. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

$$ye = \frac{N \cdot y}{N} = \frac{651.66}{236.97} = 2.75 \ ^{m}$$

$$Pe = 236.97 \times 0.10 = 23.70 \ ^{t}$$

$$Mo = 23.70 \times 2.75 = 65.18 \ ^{t\cdot m}$$

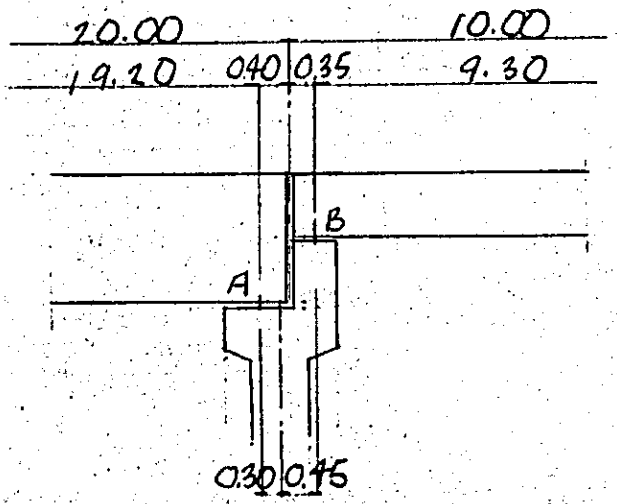
NOTE ye : DISTANCE FROM THE BOTTOM OF FOOTING TO THE CENTER OF SUBSTRUCTURE.

Pe : HORIZONTAL FORCE DUE TO EARTHQUAKE LOAD

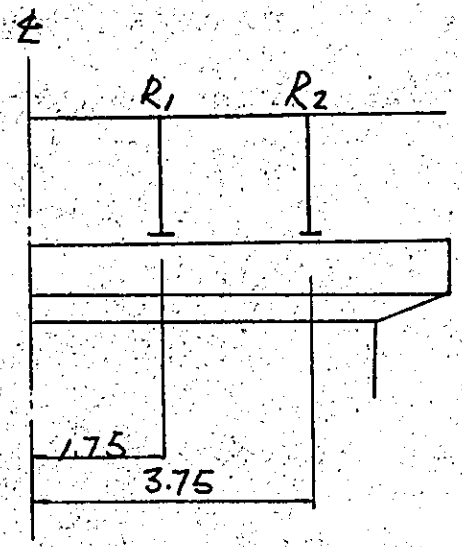
Mo : OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

3 REACTION FORCES TRANSMITTED FROM SUPERSTRUCTURE

1. REACTION FORCES DUE TO DEAD WEIGHT OF SUPERSTRUCTURE



1-1. REACTION FORCES ACTING AT BEARINGS-A.

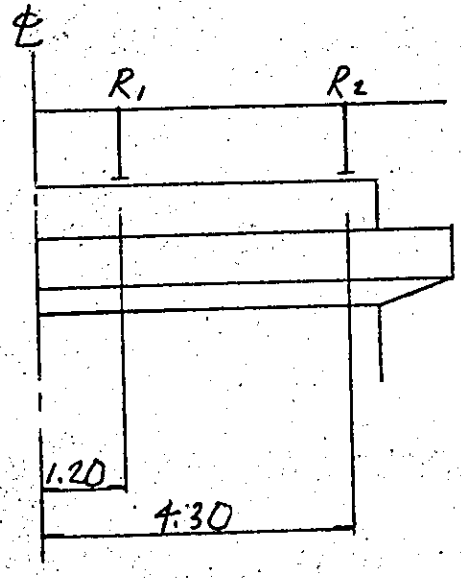


$R_1 = 64.98^{t}$

$R_2 = 72.24^{"}$

$\text{TOTAL} = 137.22^{t}$

1-2. REACTION FORCES ACTING AT BEARINGS-B



$R_1 = 34.00^t$

$R_2 = 34.00^{"}$

TOTAL = 68.00^t

1-3. SECTIONAL MOMENT AT THE CENTER OF PIER SHAFT DUE TO DEAD WEIGHT OF SUPERSTRUCTURE

SINGLE-TRACK LOADING FOR CALCULATION OF TRANSVERSAL STABILITY. DOUBLE-TRACK LOADING FOR CALCULATION OF LONGITUDINAL STABILITY

TRANSVERSAL DIRECTION

$M_1 = 64.98 \times 1.75 + 72.24 \times 3.75 + 34.00 \times (1.20 + 4.30) = 571.62^{tm}$

LONGITUDINAL DIRECTION

$M_2 = (137.22 \times -0.30 + 68.00 \times 0.45) \times 2 = -21.13^{tm}$

1-4. HORIZONTAL FORCES DUE TO EARTHQUAKE ACTING ON DEAD WEIGHT OF SUPERSTRUCTURE

a) LONGITUDINAL DIRECTION

19.20m - SPAN SIDE

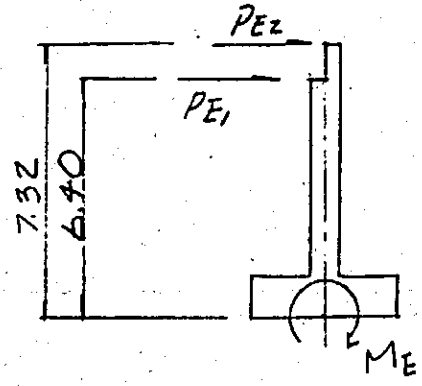
$$P_{E1} = 137.22 \times 2 \times 0.10 - \tfrac{1}{2} \times 137.22 \times 0.10$$
$$= 20.58^{t}$$

9.30m - SPAN SIDE

$$P_{E2} = 68.00 \times 2 \times 0.10 \times 0.55 = 7.48^{t}$$

$$\therefore \Sigma P_E = 20.58 + 7.48 = 28.06^{t}$$

OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING



$$M_E = 20.58 \times 6.40 + 7.48 \times 7.32 = 186.47^{tm}$$

b) TRANSVERSAL DIRECTION

19.20^{m} - SPAN SIDE

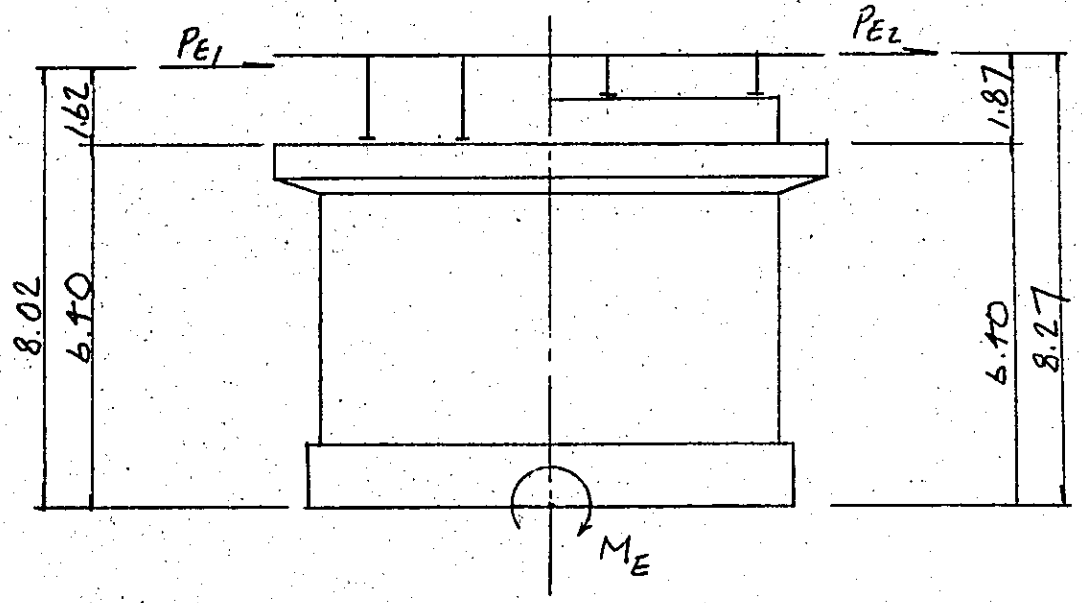
$$P_{E1} = 137.22 \times 0.10 = 13.72^{t}$$

9.30^{m} - SPAN SIDE

$$P_{E2} = 68.00 \times 0.10 = 6.80^{t}$$

$$\therefore \Sigma P_E = 13.72 + 6.80 = 20.52^{t}$$

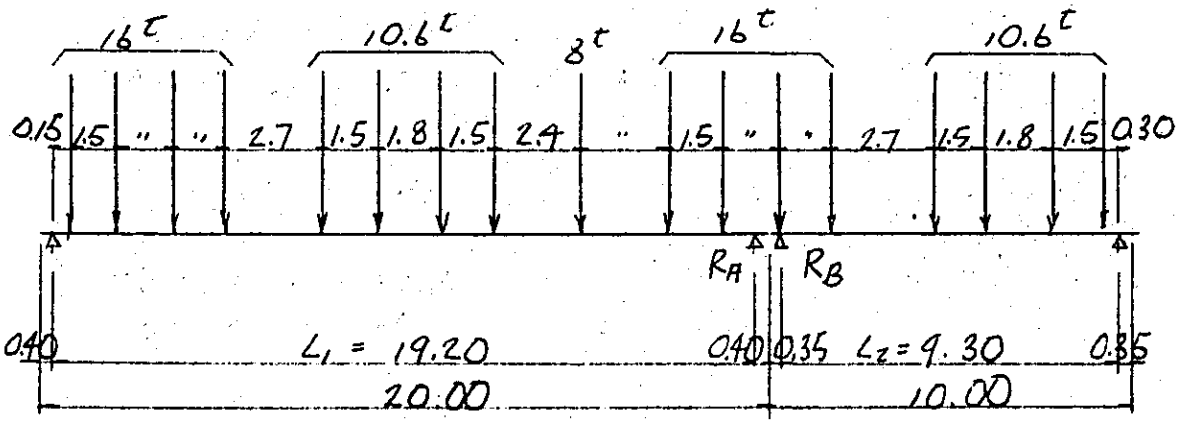
OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING



$$M_E = 13.72 \times 8.02 + 6.80 \times 8.27 = 166.27^{tm}$$

2. REACTION FORCES DUE TO LIVE LOAD PLUS IMPACT

EQUIVALENT TO KS-16 LOADING.
CALCULATION IS CARRIED OUT UNDE THE LOADING CONDITION OF PRODUCING MAXIMUM REACTION FORCE ON PIER.



$$R_A = \frac{1}{19.20} \times (16 \times 4 \times 2.40 + 10.6 \times 4 \times 9.75 + 8 \times 14.55 + 16 \times 2 \times 17.70) = 65.09^t$$

$$R_B = \frac{1}{9.30} \times (16 \times 2 \times 8.55 + 10.6 \times 4 \times 2.70) = 41.73^t$$

$$106.82^t$$

IMPACT COEFFICIENT

19.20^m - SPAN SIDE --- $i = 0.375$

9.30^m - SPAN SIDE --- $i = 0.437$

LIVE LOAD PLUS IMPACT

$R_{(A+L)} = 65.09 \times 1.375 = 89.50^{t}$

$R_{(B+L)} = 41.73 \times 1.437 = 59.97^{"}$

TOTAL $= 149.47^{t}$

2-1. SECTIONAL MOMENT ACTING AT THE CENTER OF PIER SHAFT

SINGLE-TRACK LOADING FOR CALCULATION OF TRANSVERSAL STABILITY. DOUBLE-TRACK LOADING FOR CALCULATION OF LONGITUDINAL STABILITY.

TRANSVERSAL DIRECTION

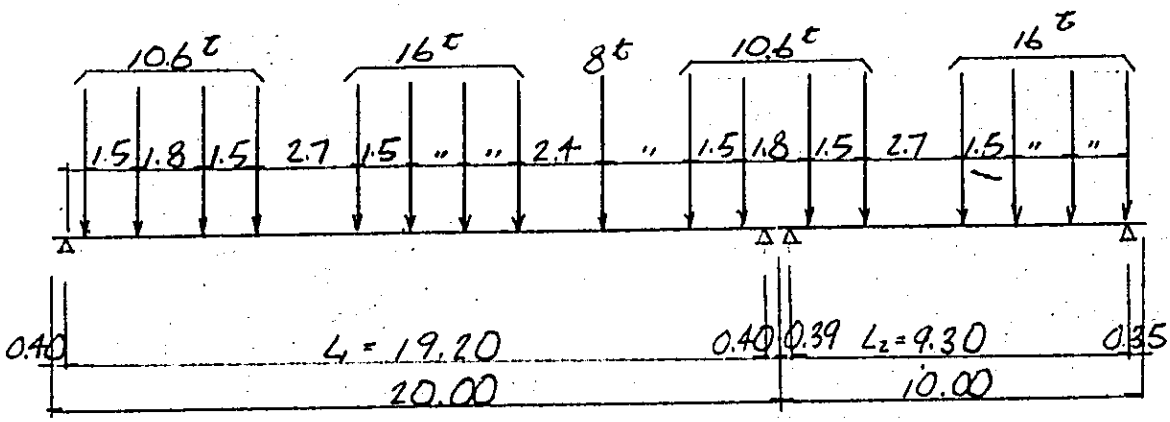
$M_1 = 89.50 \times 1/2 \times (1.75 + 3.75)$
$+ 59.97 \times 1/2 \times (1.20 + 4.30) = 411.04^{tm}$

LONGITUDINAL DIRECTION

$M_2 = \{ 89.50 \times (-0.30) + 59.97 \times 0.45 \} \times 2 = 0.27^{tm}$

3. BRAKE LOAD AND TRACTION LOAD

UNDER THE LOADING CONDITION AS SHOWN BELOW



3-1. BRAKE LOAD

15% OF KS LOADING

L1 - SPAN SIDE

$$P_{B-1} = (16 \times 4 + 10.6 \times 6 + 8) \times 0.15 \times 1/2$$

$$= 10.17^{t}$$

L2 - SPAN SIDE

$$P_{B-2} = (16 \times 4 + 10.6 \times 2) \times 0.15 \times 0.55$$

$$= 7.03^{t}$$

$$\therefore \Sigma P_B = 10.17 + 7.03 = 17.20^{t}$$

3-2. TRACTION LOAD

25% OF MOVING WHEEL AXLE LOAD OF KS LOADING

L1 - SPAN SIDE

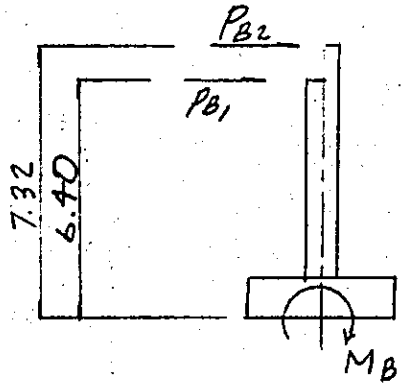
$P_{T-1} = 16 \times 4 \times 0.25 \times 1/2 = 8.00^{t}$

L2 - SPAN SIDE

$P_{T-2} = 16 \times 4 \times 0.25 \times 0.55 = 8.80^{t}$

$\therefore \Sigma P_T = 8.00 + 8.80 = 16.80^{t} < \Sigma P_B = 17.20^{t}$

3-3. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING



$M_B = 7.03 \times 7.32 + 10.17 \times 6.40 = 116.55^{tm}$

4. CENTRIFUGAL LOAD

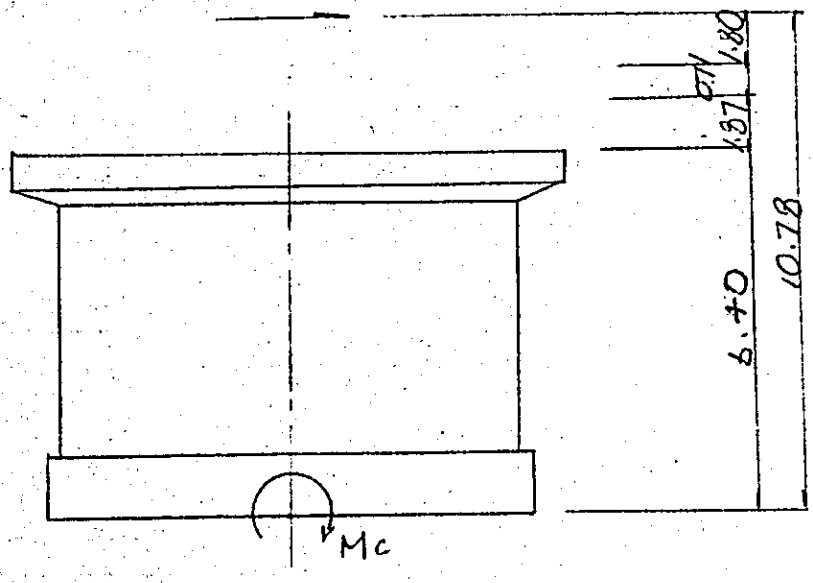
ASSUMED THAT THE LOAD IS EQUIVALENT TO THE LIVE (TRAIN) LOAD MULTIPLIED BY α AND IS ACTING TRANSVERSALLY ON 1.8 m ABOVE THE TRACK LEVEL.

REFERENCE IS MADE TO THE LOADING CALCULATION OF LIVE (TRAIN) LOAD PLUS IMPACT.

$R = 1000^{m}$ ---- $\alpha = 0.10$

$P_c = 106.82 \times 0.10 = 10.68^{t}$

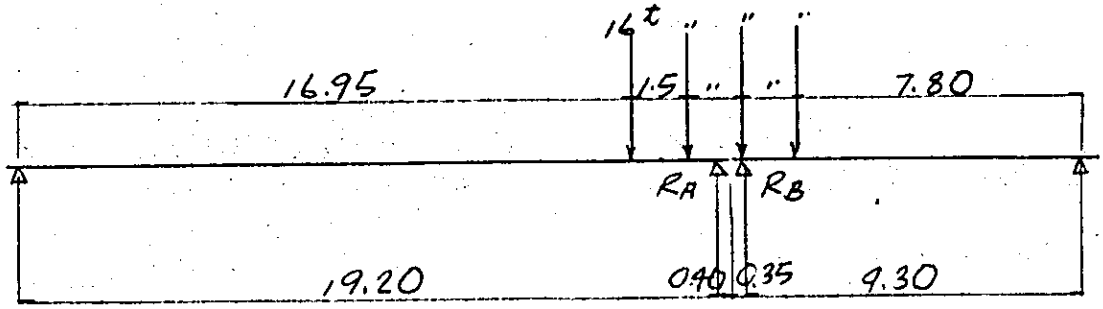
4-1. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.



$M_c = 10.68 \times 10.78 = 115.13^{tm}$

5. TRAIN LATERAL LOAD

TRANSVERSAL FORCE DUE TO LIVE (TRAIN) LOAD. IS ASSUMED TO BE EQUIVALENT TO THE SERIES OF CONCENTRATED LOADS CONSISTED OF 15% OF MOVING WHEEL AXLE LOAD ACTING TRANSVERSALLY AT THE TRACK LEVEL.
CALCULATION IS MADE UNDER THE SINGLE-TRACK LOADING

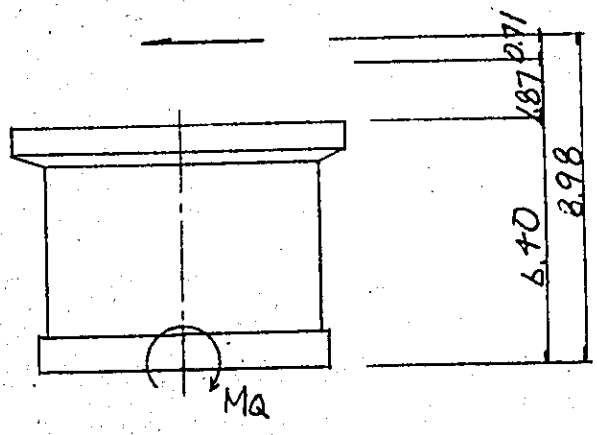


$$R_A + R_B = \frac{16}{19.20} \times (16.95 + 18.45) + \frac{16}{9.30} \times (7.80 + 9.30)$$

$$= 58.92\ ^t$$

$$P_Q = 58.92 \times 0.15 = 8.84\ ^t$$

5-1. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.



$$M_Q = 8.84 \times 8.98 = 79.38\ ^{tm}$$

4 CALCULATION ON STABILITY

1. COMBINATION OF LOADS

1-1 TRANSVERSAL DIRECTION

No1. DEAD LOAD (M.W.L)

No2. DEAD LOAD + (TRAIN + IMPACT) LOAD (M.W.L)

No3. ——————〃—————— (H.W.L)

No4. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ TRAIN LATERAL LOAD (M.W.L)

No5. ——————〃—————— (H.W.L)

No6. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

No7. DEAD LOAD (M.W.L)

No8. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ CENTRIFUGAL LOAD (M.W.L)

No9. ——————〃—————— (H.W.L)

No10. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

THE ABOVE LOADING COMBINATIONS ARE APPLIED No.1 THRU No.6 FOR SINGLE-TRACK LOADING AND NO.7 THRU NO.10 FOR DOUBLE-TRACK LOADING.

1-2. LONGITUDINAL DIRECTION.

No.1. DEAD LOAD (M.W.L)

No.2. DEAD LOAD + (TRAIN + IMPACT) LOAD (M.W.L)

No.3. ——————〃—————— (H.W.L)

No.4. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ BREAKING LOAD or TRACTION LOAD (M.W.L)

No.5. ——————〃—————— (H.W.L)

No.6. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

ALL OF THE ABOVE LOADING COMBINATIONS ARE APPLIED FOR DOUBLE-TRACK LOADING.

2. TABLE OF FORCE AND MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

2-1. TRANSVERSAL DIRECTION

SINGLE-TRACK LOADING

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No1	271.73 + 137.22 + 68.00 = 476.95	571.62	———
No2	476.95 + 149.47 = 626.42	571.62 + 411.04 = 982.66	———
No3	626.42 - 64.00 = 562.42	982.66	———
No4	626.42	982.66 + 79.38 = 1062.04	8.84
No5	562.42	1062.04	8.84
No6	476.95	65.18 + 571.62 + 166.27 = 803.07	23.70 + 20.52 = 44.22

DOUBLE-TRACK LOADING

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No7	271.73 + 137.22×2 + 68.00×2 = 682.17	———	———
No8	682.17 + 149.47×2 = 981.11	115.13 × 2 = 230.26	10.68 × 2 = 21.36
No9	981.11 - 64.00 = 917.11	230.26	21.36
No10	682.17	65.18 + 166.27 × 2 = 397.72	23.70 + 20.52 × 2 = 64.74

2-2, LONGITUDINAL DIRECTION

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No 1	682.17	21.13	—
No 2	981.11	21.13	
No 3	917.11	21.13	
No 4	981.11	21.13 + 116.55 = 137.68	17.20
No 5	917.11	137.68	17.20
No 6	682.17	65.18 + 21.13 + 186.47×2 = 459.26	23.70 + 28.06×2 = 79.82

3. REACTION FORCE ACTING ON PILES

$$P = \frac{N}{n} \pm \frac{M}{I} \times x$$

WHERE: P REACTION FORCE

n NUMBER OF PILE

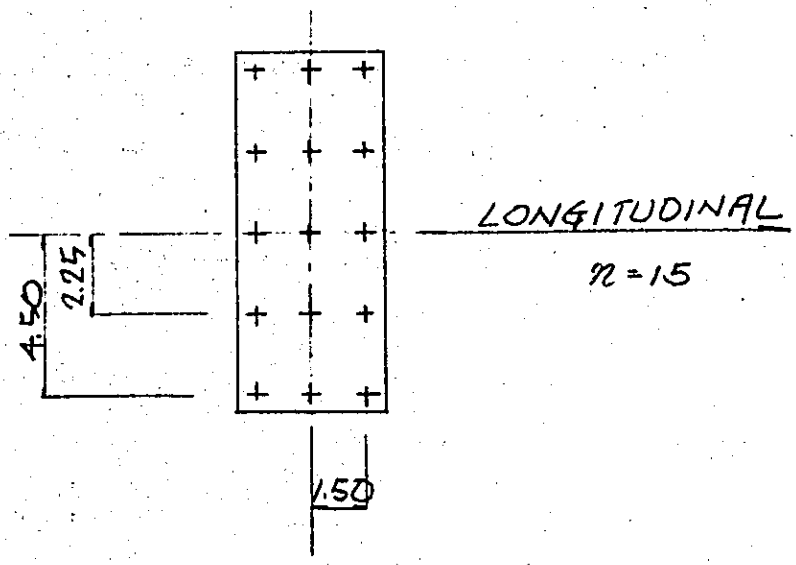
N AXIAL FORCE ACTING AT THE CENTER OF THE BOTTOM OF FOOTING

M MOMENT ACTING AT THE CENTER OF THE BOTTOM OF FOOTING

I MOMENT OF INERTIA OF THE GROUP OF PILES WITH RESPECT TO THE GEOMETRICAL CENTER

x DISTANCE FROM THE GEOMETRICAL CENTER OF THE GROUP OF PILES TO THE CENTER OF THE PILE TO BE CALCULATED

3-1. ARRANGEMENT OF PILES



3-2 REACTION FORCE ACTING ON PILES DUE TO TRANSVERSAL LOAD

	N (t)	M (t·m)	$\frac{N}{n}$ (t)	$\frac{M}{I}$ ($\frac{t}{m}$)	P_{max} (t)	P_{min} (t)
No1	476.95	571.62	31.80	3.76	48.72	14.88
No2	626.42	982.66	41.76	6.47	70.88	12.65
No3	562.42	982.66	37.49	6.47	66.61	8.38
No4	626.42	1062.04	41.76	6.99	73.22	10.31
No5	562.42	1062.04	37.49	6.99	68.95	6.04
No6	476.95	803.07	31.80	5.29	55.61	8.00
No7	682.17	—	45.48	—	45.48	45.48
No8	981.11	230.26	65.41	1.52	72.25	58.57
No9	917.11	230.26	61.14	1.52	67.98	54.30
No10	682.17	397.72	45.48	2.62	57.27	33.69

$$I = (4.50^2 + 2.25^2) \times 3 \times 2 = 151.875 \ m^2$$

$$x = 4.50 \ m$$

3-3. REACTION FORCE ACTING ON PILES DUE TO LONGITUDINAL LOAD

	N (t)	M (t·m)	$\frac{N}{n}$ (t)	$\frac{M}{I}$ ($\frac{t}{m}$)	$x_{(m)}$	P_{max} (t)	P_{min} (t)
No1	682.17	21.13	45.48	0.94	x_1	46.89	44.07
					x_2	—	—
					x_3	—	—
No2	981.11	21.13	65.41	0.94	x_1	66.82	64.00
					x_2	—	—
					x_3	—	—
No3	917.11	21.13	61.14	0.94	x_1	62.55	59.73
					x_2	—	—
					x_3	—	—
No4	981.11	137.68	65.41	6.12	x_1	74.59	56.23
					x_2	—	—
					x_3	—	—
No5	917.11	137.68	61.14	6.12	x_1	70.32	51.96
					x_2	—	—
					x_3	—	—
No6	682.17	459.25	45.48	20.41	x_1	76.10	14.87
					x_2	—	—
					x_3	—	—

$$I = 1.50^2 \times 5 \times 2 = 22.50 \ m^2$$

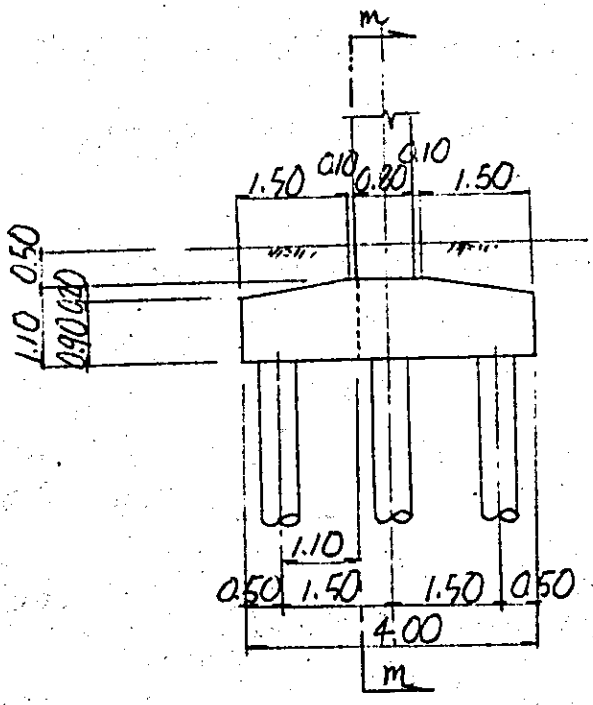
$$x = 1.50 \ m$$

5 DESIGN OF FOOTING

CALCULATION IS MADE ONLY THE CASE OF LONGITUDINAL LOADING, BECAUSE NO STRESS OCCURS UNDER THE TRANSVERSAL LOADING DUE TO REACTION FORCES ON PILES WITHIN THE WALL SHAFT.

1. EXAMINATION OF SAFETY AGAINST BENDING MOMENT

1-1. BENDING MOMENT DUE TO OWN WEIGHT OF FOOTING AND WEIGHT OF EARTH COVER



WHERE: m SECTION WHERE MOMENT IS CALCULATED

M_m BENDING MOMENT AT SECTION m

BENDING MOMENT AT SECTION m

i) THE CASE NO BUOYANCY IS CONSIDERED

$$M_m = (2.5^{t/m^3} \times 1.10 + 1.8^{t/m^3} \times 0.50) \times 1.60^2 \times 1/2 - 1/2 \times 1.50 \times 0.20 \times 1.10 \times (2.5-1.8)^{t/m^3} = 4.56^{t\cdot m/m}$$

ii) THE CASE BUOYANCY IS CONSIDERED

$$M_m = 4.56 - 1/2 \times 1.60^2 \times 1.60 \times 1.00^{t/m^3} = 2.51^{t\cdot m/m}$$

1-2, STRESS DUE TO REACTION FORCE ON PILES

BENDING MOMENT AT SECTION m

No.1 $M_m = 46.89 \times 1.20 \times 5 \times \frac{1}{10.00} = 28.13^{t\cdot m/m}$

No.2 $M_m = 66.82 \times \text{〃} \times \text{〃} \times \text{〃} = 40.09$ 〃

No.3 $M_m = 62.55 \times \text{〃} \times \text{〃} \times \text{〃} = 37.53$ 〃

No.4 $M_m = 74.59 \times \text{〃} \times \text{〃} \times \text{〃} = 44.75$ 〃

No.5 $M_m = 70.32 \times \text{〃} \times \text{〃} \times \text{〃} = 42.19$ 〃

No.6 $M_m = 76.10 \times \text{〃} \times \text{〃} \times \text{〃} = 45.66$ 〃

1-3. SUMMARY OF BENDING MOMENT ON FOOTING

No1 : $M_m = (28.13 - 4.56) \times 1.8/1.4 = 30.30$ t-m/m

No2 : $M_m = (40.09 - 4.56) \times 1.00 = 35.53$ "

No3 : $M_m = (37.53 - 2.51) \times 1.00 = 35.02$ "

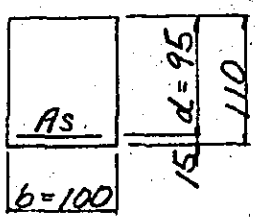
No4 : $M_m = (44.75 - 4.56) \times 1/1.15 = 34.95$ "

No5 : $M_m = (42.19 - 2.51) \times 1/1.15 = 34.50$ "

No6 : $M_m = (45.66 - 4.56) \times 1/1.50 = 27.40$ "

1-4. EXAMINATION OF SAFETY

$M_m = 35.53$ t-m



$As = 6.67 - 0.22 = 25.81$ cm²

$p = \frac{As}{b \cdot d} = \frac{25.81}{100 \times 95} = 0.00272$

$\frac{1}{Lc} = 8.80 \qquad \frac{1}{Ls} = 400$

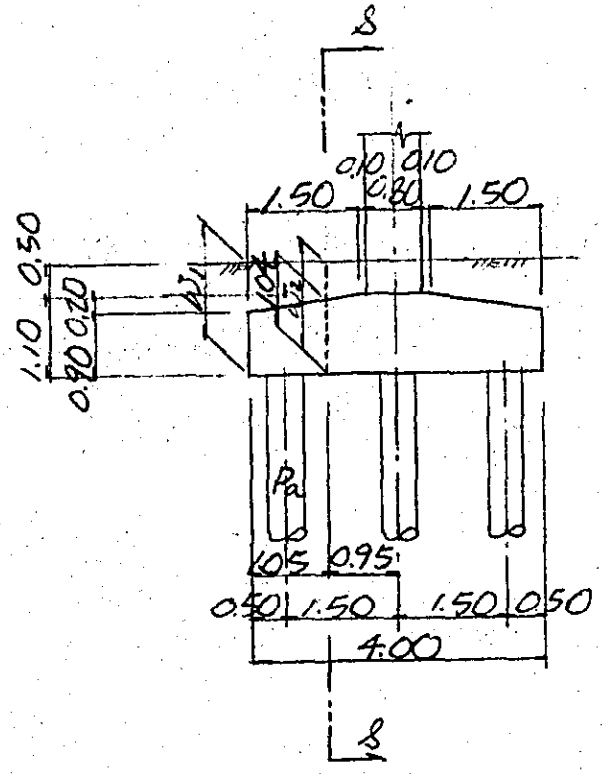
$\sigma c = \frac{M}{b \cdot d^2} \times \frac{1}{Lc} = \frac{35.53 \times 10^5}{100 \times 95^2} \times 8.80 = 34.6$ kg/cm² < 80 kg/cm²

$\sigma s = \frac{M}{b \cdot d^2} \times \frac{1}{Ls} =$ ——〃—— $\times 400 = 1575$ " < 1800"

2. EXAMINATION OF SAFETY AGAINST SHEARING FORCE

EXAMINATION ON THE COMBINATION No.6

2-1. SHEARING FORCE DUE TO OWN WEIGHT OF FOOTING AND WEIGHT OF EARTH COVER



WHERE: S SECTION WHERE SHEARING FORCE IS CALCULATED

S_S SHEARING FORCE AT SECTION S

SHEARING FORCE AT SECTION 8

$$W_1 = 2.5^{T/m^3} \times 0.90 + 1.8^{T/m^3} \times 0.70 = 3.51^{T}$$

$$W_2 = (2.5'' \times 1.04 + 1.8'' \times 0.56) \times \frac{0.55}{2 \times (1.04 - 0.15)} = 1.11''$$

$$\therefore S_8 = 1/2 \times (3.51 + 1.11) \times 1.05 = 2.43^{t}$$

2-2. STRESS DUE TO REACTION FORCE ON PILES

SHEARING FORCE AT SECTION 8

$$P_a = 76.10 \times \frac{1.10}{2 \times (1.04 - 0.15)} = 47.03^{t}$$

$$\therefore S_8 = 47.03 \times \frac{5}{10.00} = 23.52^{t}$$

2-3. SUMMARY OF SHEARING FORCES ON FOOTING

$$\Sigma S_8 = 23.52 - 2.43 = 21.09^{t}$$

2-4. EXAMINATION OF SAFETY.

$$\therefore \tau = \frac{21.09 \times 10^3}{100 \times (104 - 15)} = 2.37^{Kg/cm^2} < 3.7^{Kg/cm^2}$$

6 DESIGN OF SUBSTRUCTURE.

EXAMINATION IS MADE ONLY THE CASE OF LONGITUDINAL LOADING

1. COMBINATION OF LOADS

No.6 DEAD LOAD + EARTHQUAKE LOAD

2. BENDING MOMENT AND AXIAL FORCE ACTING AT THE BOTTOM OF WALL

THE FOLLOWING FIGURES ARE REFERRED TO THE CALCULATION OF THE REACTION FORCES TRANSMITTED FROM THE SUPERSTRUCTURE.

$$M = (14.92 \times 5.76 + 30.92 \times 4.95 + 9.26 \times 4.466 + 79.37 \times 2.15) \times 0.10 + 21.13 + (20.58 \times 5.30 + 7.48 \times 6.22) \times 2 = 377.43 \text{ tm}$$

$$N = 14.92 + 30.92 + 9.26 + 79.37 + (137.22 + 68.00) \times 2 = 544.91 \text{ t}$$

3. EXAMINATION OF SAFETY

M (tm)	377.43
N (t)	544.91
S (t)	
b (cm)	860
h (cm)	80
d (cm)	
d' (cm)	7.5
As (cm²)	D19-45 (ctc200) -128.92
p	0.00187
As' (cm²)	= As
p'	= p
e = M/N (cm)	69.2
e = M/N + u (cm)	
e = M/N − u (cm)	
e/h	0.865
d/e	
d'/h	0.100
d'/d	
Ne/bd²(kg/cm²)	7.920
k	0.290
c	0.104
j	
1/Lc	
1/Ls	
β = σs/σc	
σc (kg/cm²)	75.7
σs (kg/cm²)	2412
τ (kg/cm²)	
σsa (kg/cm²)	2700
σca (kg/cm²)	120
τa (kg/cm²)	

7 DESIGN OF PILE

1. REACTION FORCES ACTING ON PILES

EXAMINATION IS MADE ONLY TO THE EARTHQUAKE LOADING.

	LONGITUDINAL DIRECTION ①	TRANSVERSAL DIRECTION	
		② SINGLE TRACK	③ DOUBLE TRACK
WHOLE HORIZONTAL FORCE, ΣH (t)	79.82	44.22	64.74
HORIZONTAL FORCE PER PILE, H (t)	5.32	2.95	4.32
VALUE OF β (m^{-1})	0.214	〃	〃
MAXIMUM MOMENT PER PILE, Mmax (tm)	8.00	4.44	6.50
MAXIMUM AXIAL FORCE PER PILE, Pmax (t)	76.10	55.61	57.27
MINIMUM AXIAL FORCE PER PILE, Pmin (t)	14.87	8.00	33.69

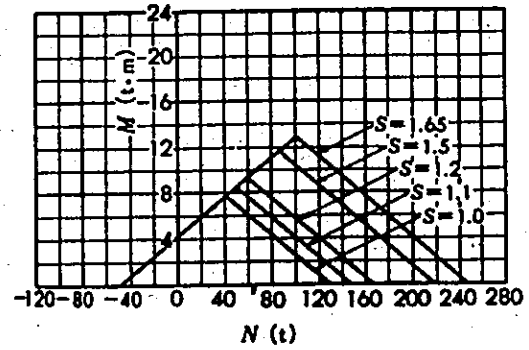
WHERE $H = \Sigma H / n$, n ···· NUMBER OF PILE

$n = 15$

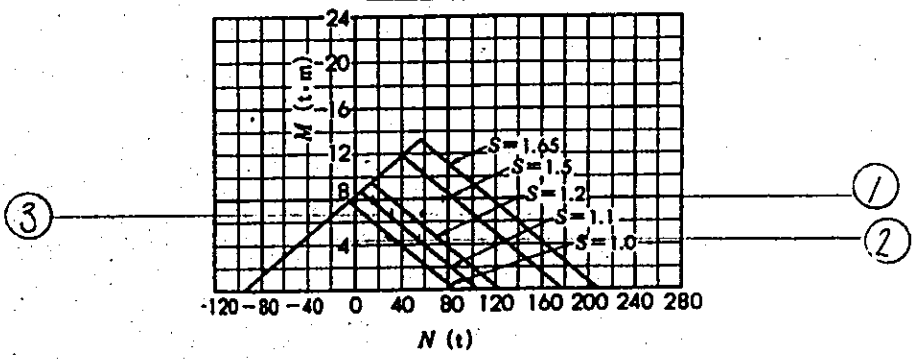
$$M_{max} = \frac{0.322 \cdot H}{\beta}$$

2. EXAMINATION OF SAFETY

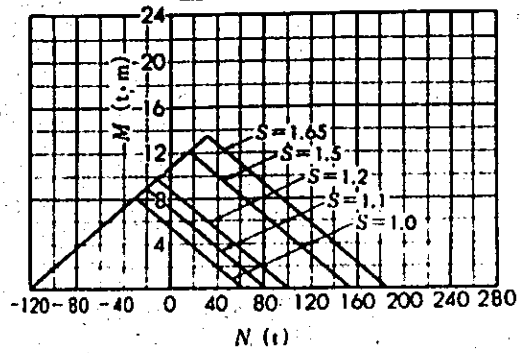
(13) D500-A



(14) D500-B

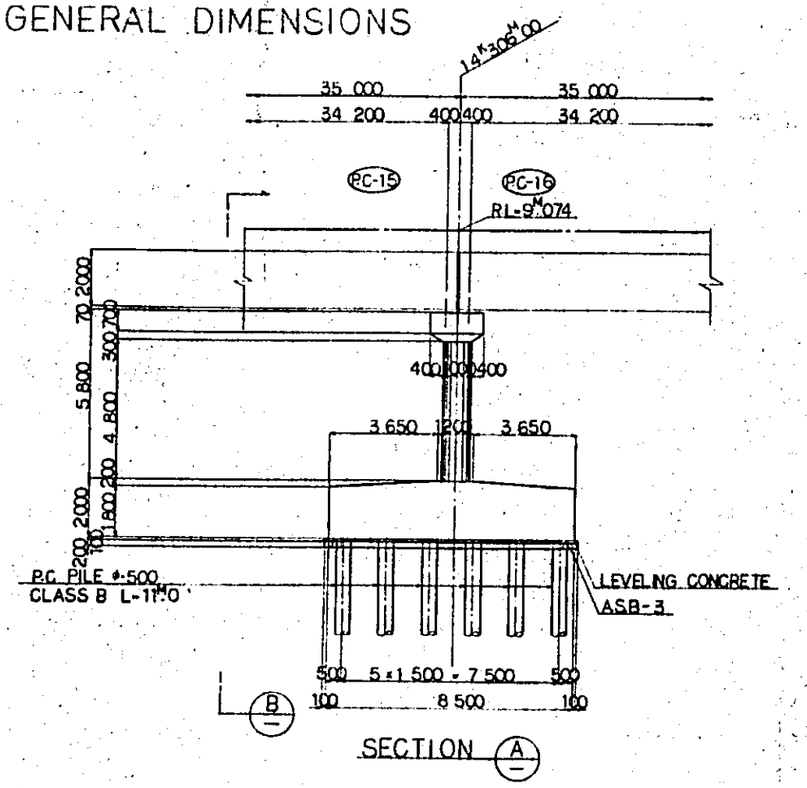


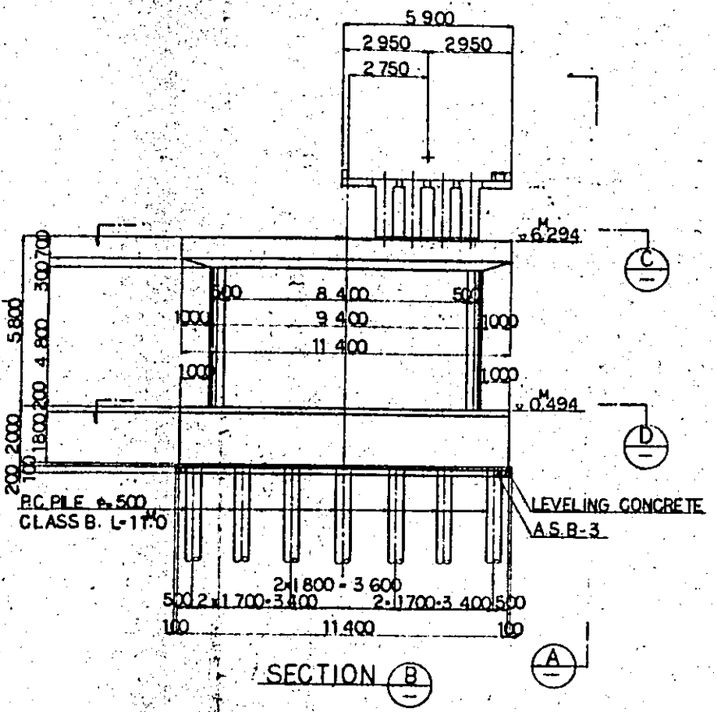
(15) D500-C

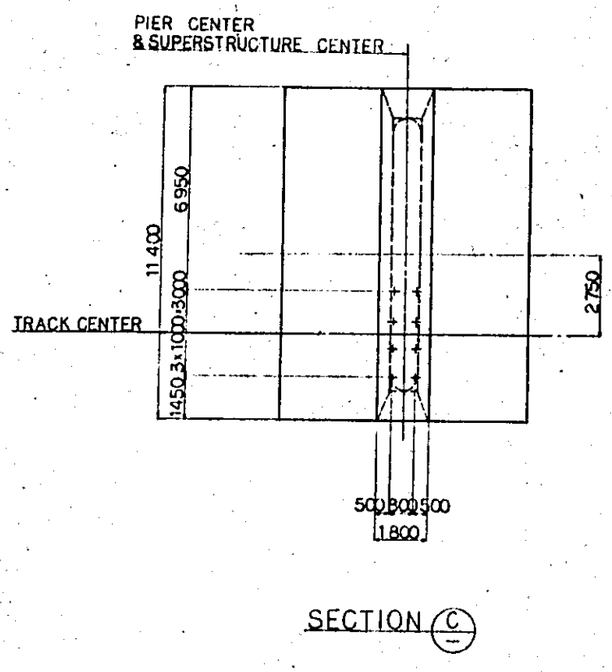


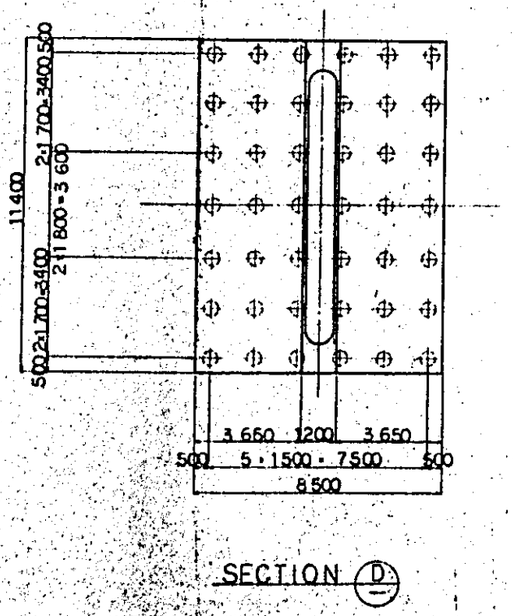
§5. Pier P18

[1] GENERAL DIMENSIONS

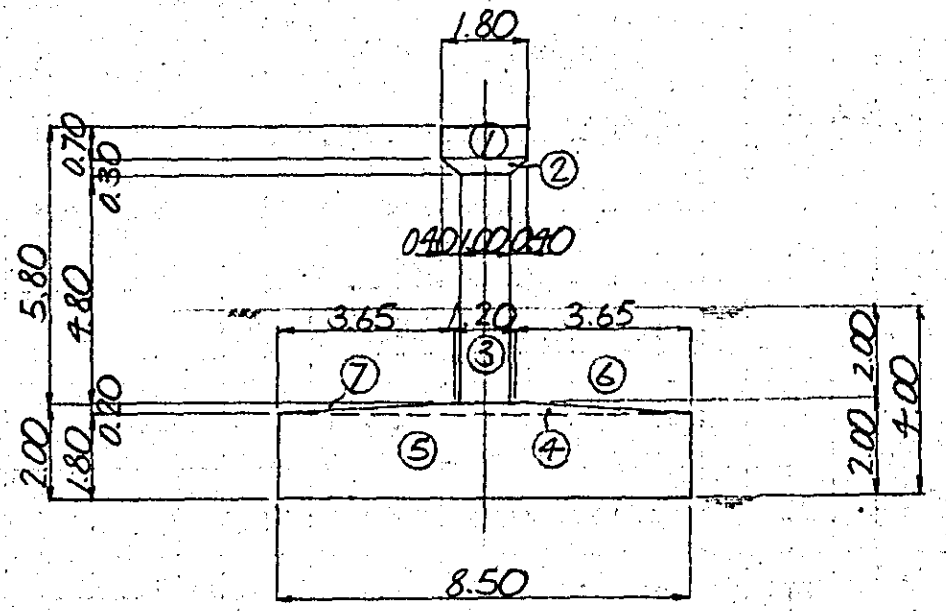


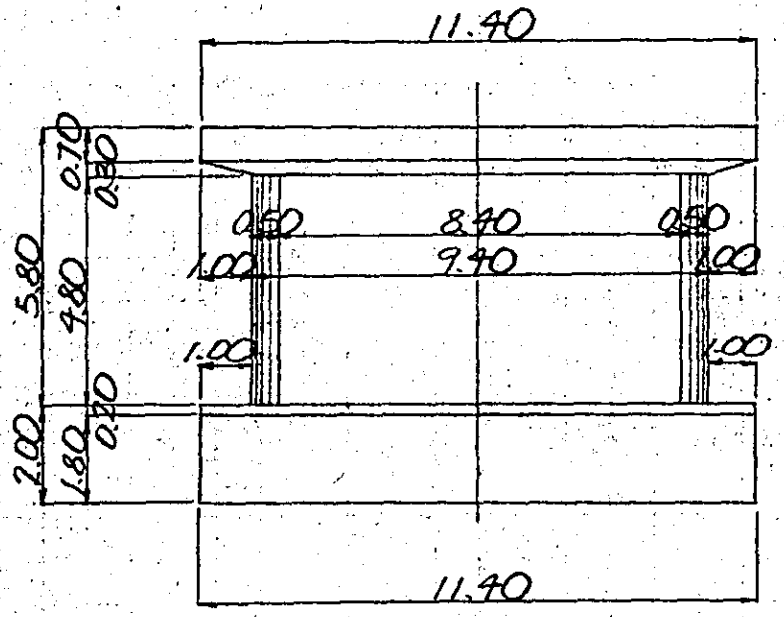






2 OWN WEIGHT OF SUBSTRUCTURE AND WEIGHT OF EARTH COVER





1. OWN WEIGHT OF SUBSTRUCTURE AND WEIGHT OF EARTH COVER

SUBSTRUCTURE

①	$2.5^{t/m^3} \times 1.80 \times 0.70 \times 11.40$	35.91^{t}
②	$2.5'' \times \frac{0.30}{2} \times \{1.80 \times 11.40 + 1.00 \times 9.40 + (1.80+1.00) \times (11.40+9.40)\}$	$11.02''$
③	$2.5'' \times (\frac{\pi}{4} \times 1.00^2 + 1.00 \times 8.40) \times 9.80$ (9.185)	$110.22''$
④	$2.5'' \times \frac{1}{2} \times (1.20+8.50) \times 0.20 \times 11.40$	$27.65''$
⑤	$2.5'' \times 8.50 \times 1.80 \times 11.40$	$436.05''$
	SUB-TOTAL	620.85^{t}

EARTH COVER

⑥	$1.8^{t/m^3} \times (8.50 \times 11.40 - 9.185) \times 2.00$	315.77^{t}
⑦	$1.8'' \times \frac{1}{2} \times 3.65 \times 0.20 \times 11.40 \times 2$	$14.98''$
	SUB-TOTAL	330.75^{t}

TOTAL

$$620.85 + 330.75 = 951.60^{t}$$

2. BUOYANCY

$$1.0^{t/m^3} \times 8.50 \times 11.40 \times 4.00 = 387.60^{t}$$

3. HORIZONTAL FORCES DUE TO EARTHQUAKE LOAD

	N (t)	y (m)	N×y (t·m)
①	35.91	7.45	267.53
②	11.02	6.964	76.74
③	110.22	4.40	484.97
④	27.65	1.875	51.84
⑤	436.05	0.90	392.45
Σ	620.85		1273.53

NOTE N: AXIAL FORCE

y: DISTANCE FROM THE BOTTOM OF FOOTING TO GRAVITY CENTER

4. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

$$y_e = \frac{N \cdot y}{N} = \frac{1273.53}{620.85} = 2.051^{m}$$

$$P_E = 620.85 \times 0.1 = 62.09^{t}$$

$$M_o = 62.09 \times 2.051 = 127.35^{tm}$$

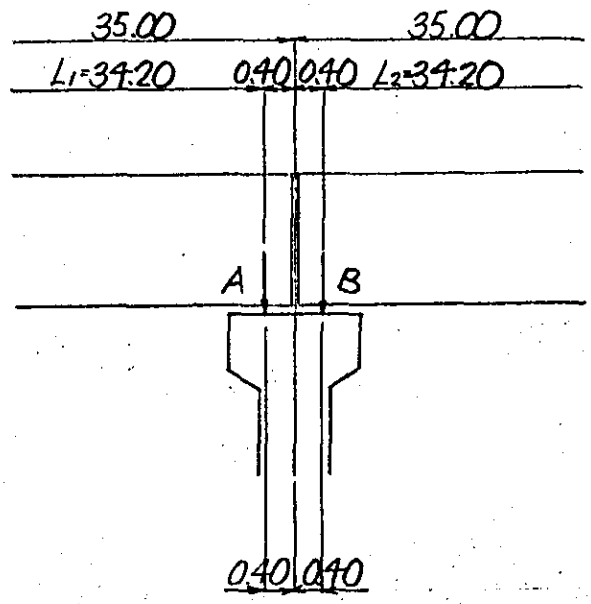
NOTE y_e : DISTANCE FROM THE BOTTOM OF FOOTING TO THE CENTER OF SUBSTRUCTURE.

P_E : HORIZONTAL FORCE DUE TO EARTHQUAKE LOAD

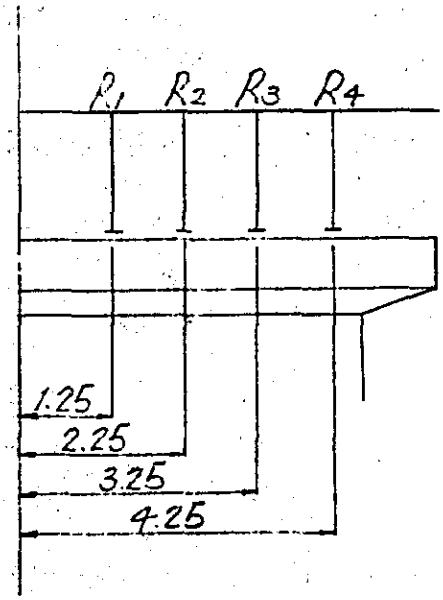
M_o : OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

3 REACTION FORCES TRANSMITTED FROM SUPERSTRUCTURE

1. REACTION FORCES DUE TO DEAD WEIGHT OF SUPERSTRUCTURE



1-1. REACTION FORCES ACTING AT BEARINGS - A



$R_1 = 87.11^{t}$

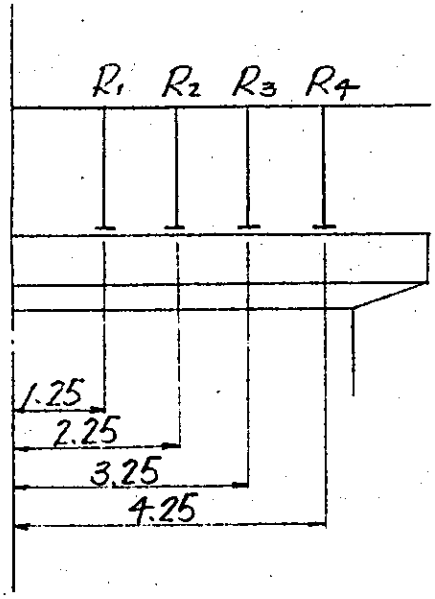
$R_2 = 87.11^{"}$

$R_3 = 87.11^{"}$

$R_4 = 90.30^{"}$

$TOTAL = 351.63^{t}$

1-2. REACTION FORCES ACTING AT BEARINGS-B



$R_1 = 87.11^{t}$

$R_2 = 87.11^{"}$

$R_3 = 87.11^{"}$

$R_4 = 90.30^{"}$

$TOTAL = 351.63^{t}$

1-3. SECTIONAL MOMENT AT THE CENTER OF PIER SHAFT DUE TO DEAD WEIGHT OF SUPERSTRUCTURE

SINGLE-TRACK LOADING FOR CALCULATION OF TRANSVERSAL STABILITY. DOUBLE-TRACK LOADING FOR CALCULATION OF LONGITUDINAL STABILITY

TRANSVERSAL DIRECTION

$$M_1 = \{87.11 \times (1.25 + 2.25 + 3.25) + 90.30 \times 4.25\}$$

$$\times 2 = 1943.54^{tm}$$

LONGITUDINAL DIRECTION

$M_2 = 0$

1-4. HORIZONTAL FORCES DUE TO EARTHQUAKE ACTING ON DEAD WEIGHT OF SUPERSTRUCTURE

a) LONGITUDINAL DIRECTION

L_1 - SPAN SIDE

$P_{E1} = 351.63 \times 2 \times 0.1$

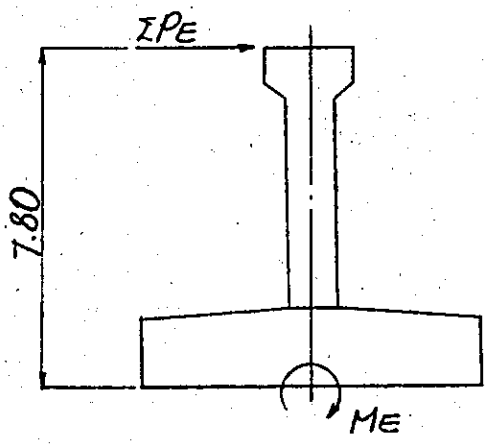
$- \frac{1}{2} \times 0.1 \times 351.63 = 52.74^{t}$

L_2 - SPAN SIDE

$P_{E2} = 0.1 \times 351.63 = 35.16^{t}$

$\Sigma P_E = P_{E1} + P_{E2} = 52.74 + 35.16 = 87.90^{t}$

OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING



$M_E = 87.90 \times 7.80 = 685.62^{tm}$

b) TRANSVERSAL DIRECTION

L_1 - SPAN SIDE

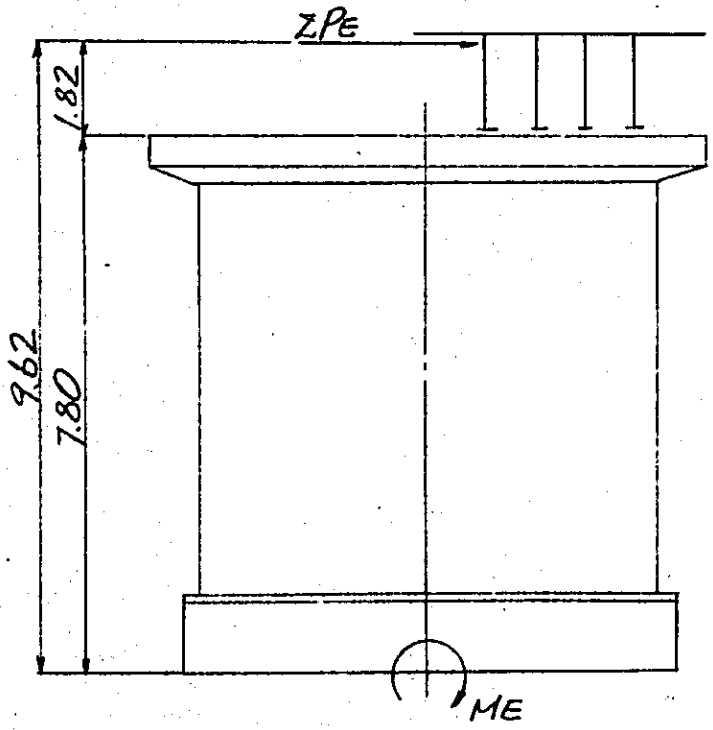
$P_{E1} = 351.63 \times 0.1 = 35.16^{t}$

L_2 - SPAN SIDE

$P_{E2} = 351.63 \times 0.1 = 35.16^{t}$

$\Sigma P_E = P_{E1} + P_{E2} = 35.16 + 35.16 = 70.32^{t}$

OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING

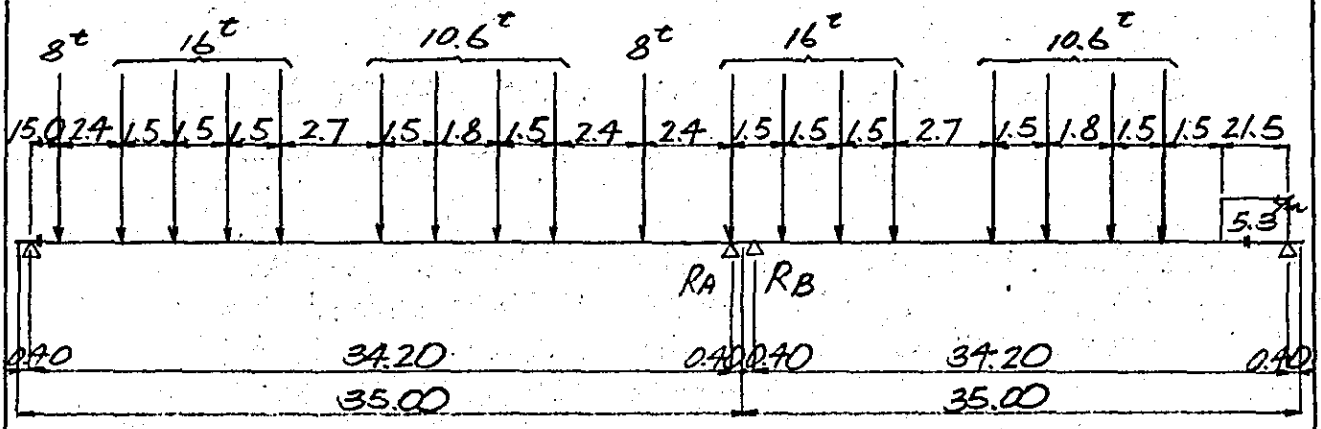


$M_E = 70.32 \times 9.62 = 676.48^{tm}$

2. REACTION FORCES DUE TO LIVE LOAD PLUS IMPACT LOAD

EQUIVALENT TO KS-16 LOADING

CALCULATION IS CARRIED OUT UNDER THE LOADING CONDITION OF PRODUCING MAXIMUM REACTION FORCE ON PIER



$$R_A = \frac{1}{34.20} \times (8 \times 15.00 + 16 \times 4 \times 19.65 + 10.6 \times 4 \times 27.00 + 8 \times 31.8 + 16 \times 34.20) = 97.19^{t}$$

$$R_B = \frac{1}{34.20} \times (5.3 \times 21.50 \times 10.75 + 10.6 \times 4 \times 25.4 + 16 \times 3 \times 32.00) = 112.22^{t}$$

IMPACT COEFFICIENT

34.20^{m} - SPAN ------- $i = 0.332$

LIVE LOAD PLUS IMPACT

$R(A+L) = 97.19 \times 1.332 = 129.46^{t}$

$R(B+L) = 112.22 \times 1.332 = 149.48^{"}$

TOTAL - 278.94^{t}

2-1. SECTIONAL MOMENT ACTING AT THE CENTER OF PIER SHAFT

SINGLE-TRACK LOADING FOR CALCULATION OF TRANSVERSAL STABILITY. DOUBLE-TRACK LOADING FOR CALCULATION OF LONGITUDINAL STABILITY.

TRANSVERSAL DIRECTION

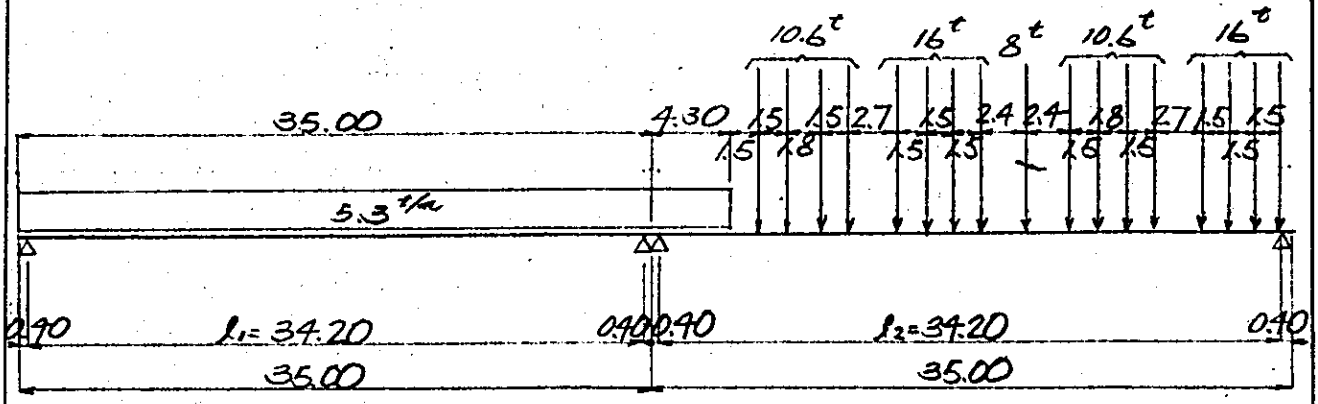
$M_1 = 278.94 \times \frac{1}{4} \times (1.25 + 2.25 + 3.25 + 4.25) = 767.09^{tm}$

LONGITUDINAL DIRECTION

$M_2 = (149.48 - 129.46) \times 0.40 \times 2 = 16.02^{tm}$

3. BRAKE LOAD AND TRACTION LOAD

UNDER THE LOADING CONDITION AS SHOWN BELOW



3-1. BRAKE LOAD

15% OF KS LOADING

L1 - SPAN SIDE

$$P_{B-1} = (5.3^{t/m} \times 4.30 + 10.6 \times 8 + 16 \times 8 + 8) \times 0.15 \times \frac{1}{2} = 18.27^{t}$$

L2 - SPAN SIDE

$$P_{B-2} = 5.3^{t/m} \times 35.00 \times 0.15 \times \frac{1}{2} = 13.91^{t}$$

$$\Sigma P_B = P_{B-1} + P_{B-2} = 18.27 + 13.91 = 32.18^{t}$$

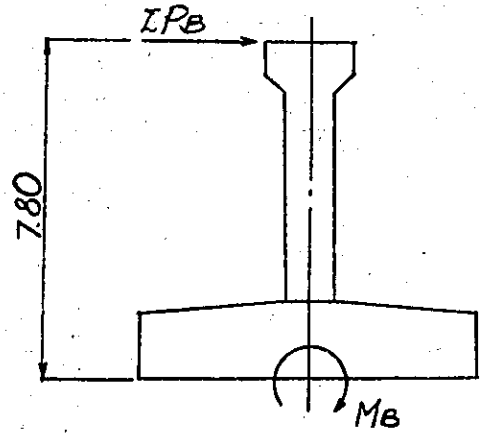
3-2. TRACTION LOAD

25% OF MOVING WHEEL AXLE LOAD OF KS LOADING

L_2 - SPAN SIDE

$$P_T = 16 \times 8 \times 0.25 \times \frac{1}{2} = 16.00^{t}$$

3-3. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING



$$M_B = 32.18 \times 7.80 = 251.00^{tm}$$

4. CENTRIFUGAL LOAD

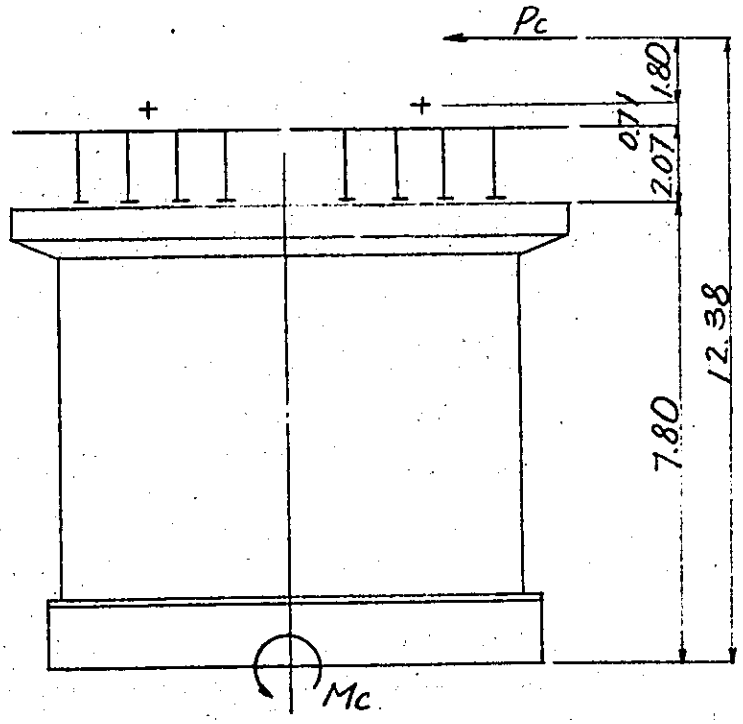
ASSUMED THAT THE LOAD IS EQUIVALENT TO THE LIVE(TRAIN) LOAD MULTIPLIED BY α AND IS ACTING TRANSVERSALLY ON 1.8 m ABOVE THE TRACK LEVEL.

REFERENCE IS MADE TO THE LOADING CALCULATION OF LIVE(TRAIN)LOAD PLUS IMPACT

$$R = 500^{m} \text{ ---- } \alpha = 0.12$$

$$P_c = (97.19 + 112.22) \times 0.12 = 25.13^{t}$$

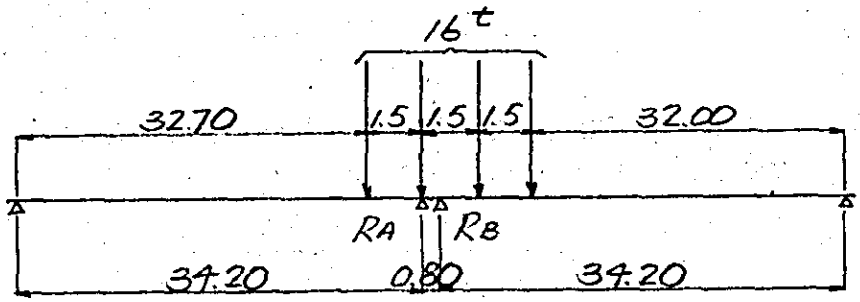
4-1. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.



$$M_c = 25.13 \times 12.38 = 311.11^{t\cdot m}$$

5. TRAIN LATERAL LOAD

TRANSVERSAL FORCE DUE TO LIVE (TRAIN) LOAD. IS ASSUMED TO BE EQUIVALENT TO THE SERIES OF CONCENTRATED LOADS CONSISTED OF 15% OF MOVING WHEEL AXLE LOAD ACTING TRANSVERSALLY AT THE TRACK LEVEL.
CALCULATION IS MADE UNDER THE SINGLE-TRACK LOADING

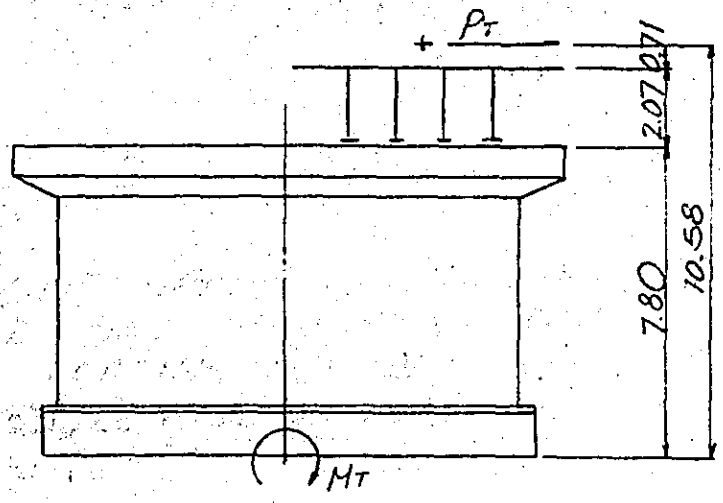


$$R_A + R_B = \frac{16}{34.20} \times (32.70 + 34.20 + 32.00 + 33.50)$$

$$= 61.94^{t}$$

$$P_T = 61.94 \times 0.15 = 9.29^{t}$$

5-1. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.



$$M_T = 9.29 \times 10.58 = 98.29^{tm}$$

4 CALCULATION ON STABILITY

1. COMBINATION OF LOADS

1-1 TRANSVERSAL DIRECTION

No1. DEAD LOAD (M.W.L)

No2. DEAD LOAD + (TRAIN + IMPACT) LOAD (M.W.L)

No3. ——————〃—————— (H.W.L)

No4. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ TRAIN LATERAL LOAD (M.W.L)

No5. ——————〃—————— (H.W.L)

No6. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

No7. DEAD LOAD (M.W.L)

No8. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ CENTRIFUGAL LOAD (M.W.L)

No9. ——————〃—————— (H.W.L)

No10. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

THE ABOVE LOADING COMBINATIONS ARE APPLIED No.1 THRU No.6 FOR SINGLE-TRACK LOADING AND No.7 THRU No.10 FOR DOUBLE-TRACK LOADING.

1-2. LONGITUDINAL DIRECTION.

No.1. DEAD LOAD (M.W.L)

No.2. DEAD LOAD + (TRAIN + IMPACT) LOAD (M.W.L)

No.3. ——————〃—————— (H.W.L)

No.4. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ BREAKING LOAD or TRACTION LOAD (M.W.L)

No.5. ——————〃—————— (H.W.L)

No.6. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

ALL OF THE ABOVE LOADING COMBINATIONS ARE APPLIED FOR DOUBLE-TRACK LOADING.

2. TABLE OF FORCE AND MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.

2-1. TRANSVERSAL DIRECTION

SINGLE-TRACK LOADING

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No1	951.60+351.63 ×2 = 1664.86	1943.54	———
No2	1664.86+278.94 = 1933.80	1943.54+767.09 = 2710.63	———
No3	1933.80-387.60 = 1546.20	2710.63	———
No4	1933.80	2710.63+98.29 = 2808.92	9.29
No5	1546.20	2808.92	9.29
No6	1664.86	127.35+1943.54 +676.48 = 2747.37	62.09+70.32 = 132.41

DOUBLE-TRACK LOADING

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No7	1654.86 + 351.63 × 2 = 2358.12	———	———
No8	2358.12 + 278.94 × 2 = 2916.00	311.11 × 2 = 622.22	25.13 × 2 = 50.26
No9	2916.00 - 387.60 = 2528.40	622.22	50.26
No10	2358.12	127.35 + 676.48 × 2 = 1480.31	62.09 + 70.32 × 2 = 202.73

2-2, LONGITUDINAL DIRECTION

	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
No1	2358.12	———	———
No2	2916.00	16.02	———
No3	2528.40	16.02	———
No4	2916.00	16.02 + 251.00 = 267.02	32.18
No5	2528.40	267.02	32.18
No6	2358.12	127.35 + 685.62 × 2 = 1498.59	62.09 + 87.90 × 2 = 237.89

3-2 REACTION FORCE ACTING ON PILES DUE TO TRANSVERSAL LOAD

	N (t)	M (t·m)	$\frac{N}{n}$ (t)	$\frac{M}{I}$ ($\frac{t}{m}$)	P_{max} (t)	P_{min} (t)
No 1	1654.86	1943.54	39.40	3.81	59.21	19.59
No 2	1933.80	2710.63	46.04	5.31	73.65	18.43
No 3	1546.20	2710.63	36.81	5.31	64.42	9.20
No 4	1933.80	2808.92	46.04	5.50	74.64	17.44
No 5	1546.20	2808.92	36.81	5.50	65.41	8.21
No 6	1654.86	2747.37	39.40	5.38	67.38	11.42
No 7	2358.12	———	56.15	———	56.15	56.15
No 8	2916.00	622.22	69.43	1.22	75.77	63.09
No 9	2628.40	622.22	60.20	1.22	66.54	53.86
No 10	2358.12	1480.31	56.15	2.90	71.23	41.07

$$I = (1.80^2 + 3.50^2 + 5.20^2) \times 2 \times 6 = 510.36\ m^2$$

$x = 5.20\ m$ $\qquad$ $n = 42$

3. REACTION FORCE ACTING ON PILES

$$P = \frac{N}{n} \pm \frac{M}{I} \times x$$

WHERE: P REACTION FORCE

n NUMBER OF PILES

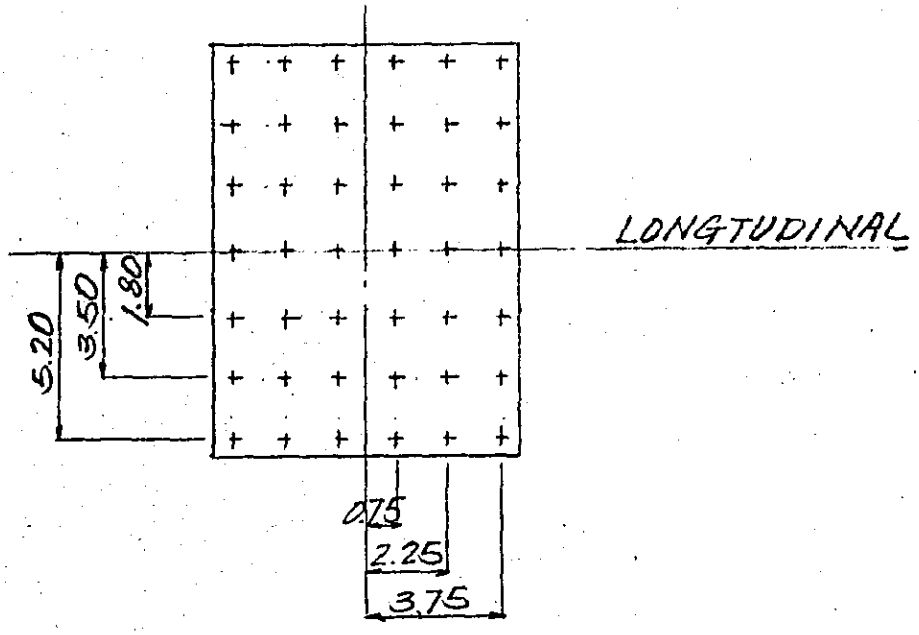
N AXIAL FORCE ACTING AT THE CENTER OF THE BOTTOM OF FOOTING

M MOMENT ACTING AT THE CENTER OF THE BOTTOM OF FOOTING

I MOMENT OF INERTIA OF THE GROUP OF PILES WITH RESPECT TO THE GEOMETRICAL CENTER

x DISTANCE FROM THE GEOMETRICAL CENTER OF THE GROUP OF PILES TO THE CENTER OF THE PILE TO BE CALCULATED

3-1. ARRANGEMENT OF PILES



3-3. REACTION FORCE ACTING ON PILES DUE TO LONGITUDINAL LOAD

	N (t)	M (t·m)	$\frac{N}{n}$ (t)	$\frac{M}{I}$ ($\frac{t}{m}$)	$x_{(m)}$	P_{max} (t)	P_{min} (t)
No1	2358.12	———	56.15	———	x_1	56.15	56.15
					x_2	"	"
					x_3	"	"
No2	2916.00	16.02	69.43	0.06	x_1	69.48	69.39
					x_2	69.57	69.30
					x_3	69.66	69.21
No3	2528.40	16.02	60.20	0.06	x_1	60.25	60.16
					x_2	60.34	60.07
					x_3	60.43	59.98
No4	2916.00	267.02	69.43	0.97	x_1	70.16	68.70
					x_2	71.67	67.25
					x_3	73.07	65.79
No5	2528.40	267.02	60.20	0.97	x_1	60.93	59.47
					x_2	62.38	58.12
					x_3	63.84	56.66
No6	2358.12	1498.59	56.15	5.44	x_1	60.23	52.07
					x_2	68.39	43.91
					x_3	76.55	35.75

$$I = (0.75^2 + 2.25^2 + 3.75^2) \times 2 \times 7 = 275.63^{m^2}$$

$x_1 = 0.75^m$

$x_2 = 2.25^{"}$

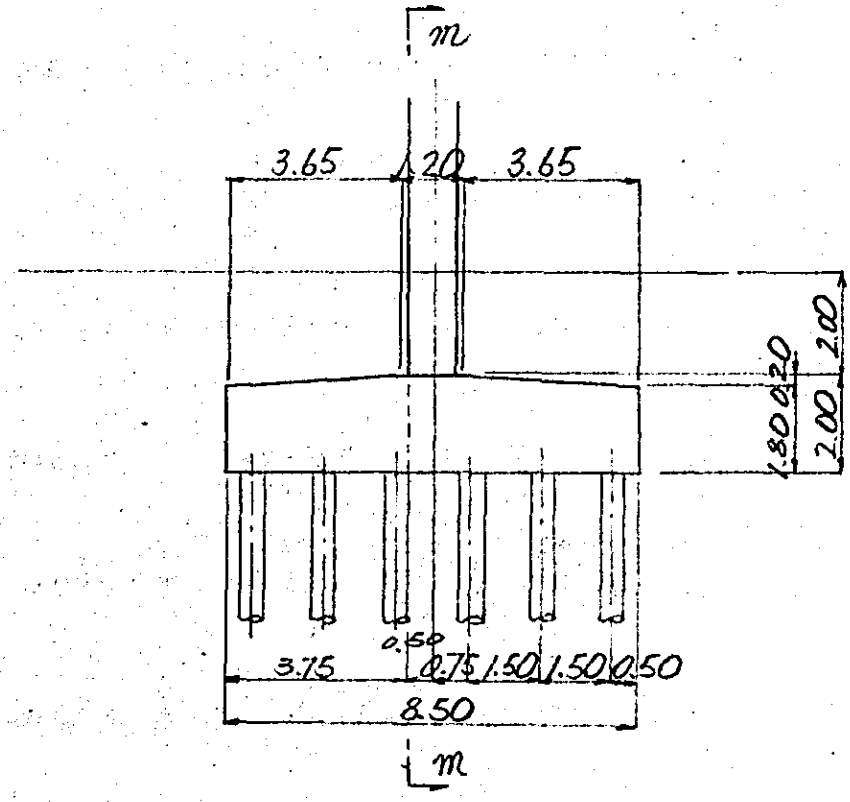
$x_3 = 3.75^{"}$

5 DESIGN OF FOOTING

1. DESIGN OF FOOTING AGAINST LONGITUDINAL LOADING

1-1. EXAMINATION OF SAFETY AGAINST BENDING MOMENT

a). BENDING MOMENT DUE TO OWN WEIGHT OF FOOTING AND WEIGHT OF EARTH COVER



WHERE: m SECTION WHERE MOMENT IS TO BE CALCULATED

M_m BENDING MOMENT AT SECTION m

BENDING MOMENT AT SECTION m

i) THE CASE NO BUOYANCY IS CONSIDERED

$$M_m = (2.5^{t/m^3} \times 2.00 + 1.8^{t/m^3} \times 2.00) \times \frac{1}{2} \times 3.75^2$$

$$-(2.5-1.8) \times 1/2 \times 3.65 \times 0.20 \times 2.533 = 59.82^{t\cdot m}$$

ii) THE CASE BUOYANCY IS CONSIDERED

$$M_m = 59.82 - \frac{1}{2} \times 3.75^2 \times 4.00 \times 1.0^{t/m^3} = 31.70^{t\cdot m}$$

b). STRESS DUE TO REACTION FORCE ON PILES

BENDING MOMENT AT SECTION m

No1 $M_m = (56.16 \times 0.35 + 56.15 \times 1.85 + 56.16 \times 3.35) \times \frac{7}{11.40} = 191.35^{t\cdot m}$

No2 $M_m = (69.48 \times 〃 + 69.57 \times 〃 + 69.66 \times 〃) \times 〃 = 237.26^{〃}$

No3 $M_m = (60.25 \times 〃 + 60.34 \times 〃 + 60.43 \times 〃) \times 〃 = 205.80^{〃}$

No4 $M_m = (70.16 \times 〃 + 71.61 \times 〃 + 73.07 \times 〃) \times 〃 = 246.73^{〃}$

No5 $M_m = (60.93 \times 〃 + 62.38 \times 〃 + 63.84 \times 〃) \times 〃 = 215.28^{〃}$

No6 $M_m = (60.23 \times 〃 + 68.39 \times 〃 + 76.55 \times 〃) \times 〃 = 248.10^{〃}$

C). SUMMARY OF BENDING MOMENT ON FOOTING

No1 : $M_m = (191.35 - 59.82) \times \frac{1.8}{1.4} = 169.11$ t/m

No2 : $M_m = (237.26 - 59.81) \times \frac{1}{1.0} = 177.44$ "

No3 : $M_m = (205.80 - 31.70) \times \frac{1}{1.0} = 174.10$ "

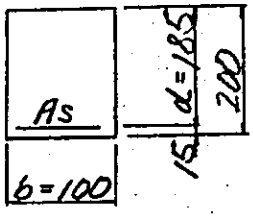
No4 : $M_m = (246.73 - 59.82) \times \frac{1}{1.15} = 162.63$ "

No5 : $M_m = (215.28 - 31.70) \times \frac{1}{1.15} = 169.63$ "

No6 : $M_m = (248.10 - 59.82) \times \frac{1}{1.5} = 125.62$ "

d). EXAMINATION OF SAFETY

$M_m = 177.44^{t/m}$



$As = 8 - D32 = 63.54^{cm^2}$

$p = \frac{As}{b \cdot d} = \frac{63.54}{100 \times 185} = 0.00343$

$\frac{1}{Lc} = 8.05 \qquad \frac{1}{Ls} = 320$

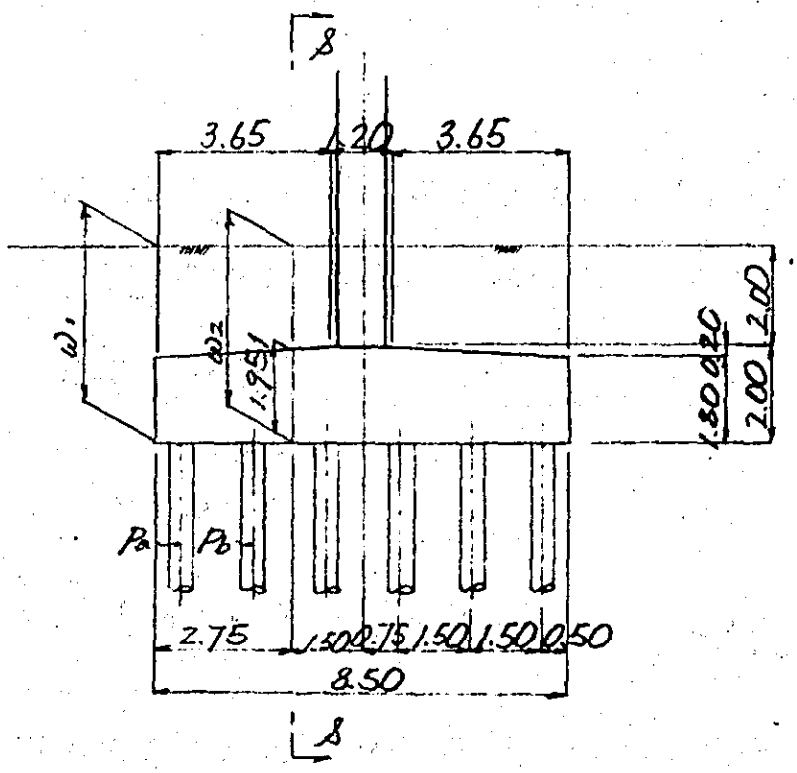
$\sigma c = \frac{M}{b \cdot d^2} \times \frac{1}{Lc} = \frac{177.44 \times 10^5}{100 \times 185^2} \times 8.05 = 41.7^{kg/cm^2} < 80^{kg/cm^2}$

$\sigma s = \frac{M}{b \cdot d^2} \times \frac{1}{Ls} =$ ——//—— $\times 320 = 1659$ " < 1800"

1-1. EXAMINATION OF SAFETY AGAINST SHEARING FORCE

EXAMINATION ON THE COMBINATION No.6

a). SHEARING FORCE DUE TO OWN WEIGHT OF FOOTING AND WEIGHT OF EARTH COVER



WHERE: δ SECTION WHERE SHEARING FORCE IS CALCULATED

S_δ SHEARING FORCE AT SECTION δ

SHEARING FORCE AT SECTION 8

$\omega_1 = 2.5\ t/m^3 \times 1.80 + 1.8\ t/m^3 \times 2.20 = 8.46\ t/m$

$\omega_2 = (2.5\ t/m^3 \times 1.95 + 1.8\ t/m^3 \times 2.049) \times \frac{1.00}{2 \times (1.95 + 0.15)} = 2.38\ t/m$

$S_8 = 1/2 \times (8.46 + 2.38 \times 2.75 = 14.91\ t$

b). STRESS DUE TO REACTION FORCE ON PILES

SHEARING FORCE AT SECTION 8

$P_a = 76.65 \times \frac{3.25}{2 \times (1.95 + 0.15)} = 69.07\ t$

$P_b = 68.39 \times \frac{1.75}{2 \times (1.95 + 0.15)} = 33.23\ t$

$S_8 = (69.07 + 33.23) \times \frac{7}{11.40} = 62.82\ t$

c). SUMMARY OF SHEARING FORCES ON FOOTING

$S_8 = 62.82 - 14.91 = 47.91\ t$

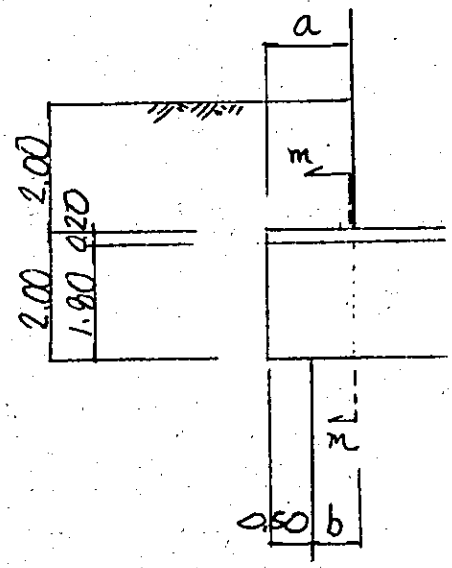
d). EXAMINATION OF SAFETY.

$\tau = \frac{47.91 \times 10^3}{100 \times 180} = 2.66\ kg/cm^2 < 3.7\ kg/cm^2$

2. DESIGN OF FOOTING AGAINST TRANSVERSAL LOADING

2-1. EXAMINATION OF SAFETY AGAINST BENDING MOMENT

a) BENDING MOMENT DUE TO OWN WEIGHT OF FOOTING AND WEIGHT OF EARTH COVER



$$a = 1.50 - \frac{1}{2} \times \sqrt{\frac{\pi \cdot 1.00^2}{4}} = 1.057 \text{ m}$$

$$b = 1.057 - (0.50 - 0.10) = 0.657 \text{ m}$$

BENDING MOMENT AT SECTION m

$$W = 2.5 \times \{ \tfrac{1}{2} \times (1.20 + 8.50) \times 0.20 + 1.80 \times 8.50 \}^{40.65} + 1.8 \times (\tfrac{1}{2} \times 0.20 \times 3.65 \times 2 + 2.00 \times 8.50)^{31.91} = 72.59 \text{ t/m}$$

$$\therefore Mm = 72.59 \times 1.057^2 \times \tfrac{1}{2} = 40.55 \text{ t·m}$$

b) STRESS DUE TO REACTION FORCE ON PILES

BENDING MOMENT AT SECTION m

CASE No.8

$M_m = 75.77 \times 6 \times 0.657 = 298.69^{t\cdot m}$

c) SUMMARY OF BENDING MOMENT ON FOOTING

$\Sigma M_m = 298.69 - 40.55$

$= 258.14^{t\cdot m}$

d) EXAMINATION OF SAFETY

$Be = 100 + 182.5 \times 2 = 465^{cm}$

$h = 200^{cm}$ $d = 182.5^{cm}$

$As = 31 - D19 = 88.82^{cm^2}$

$p = 88.82 / 465 \times 182.5 = 0.00105$

$\therefore \sigma_c = \frac{258.14 \times 10^5}{465 \times 182.5^2} \times 13.1 = 21.8^{kg/cm^2} < 80^{kg/cm^2}$

$\sigma_s = \quad " \quad \times 1009 = 1682" < 1800"$

6 DESIGN OF SUBSTRUCTURE.

EXAMINATION IS MADE ONLY THE CASE OF LONGITUDINAL LOADING.

1. COMBINATION OF LOADS

No.6 DEAD LOAD + EARTHQUAKE LOAD

2. BENDING MOMENT AND AXIAL FORCE ACTING AT THE BOTTOM OF WALL

THE FOLLOWING FIGURES ARE REFERRED TO THE CALCULATION OF THE REACTION FORCES TRANSMITTED FROM THE SUPERSTRUCTURE.

$$M = 35.91 \times 0.1 \times 5.45 + 11.02 \times 0.1 \times 4.964 + 110.22 \times 0.1 \times 2.40 + 87.90 \times 5.80 \times 2$$

$$= 1071.13 \ ^{t\cdot m}$$

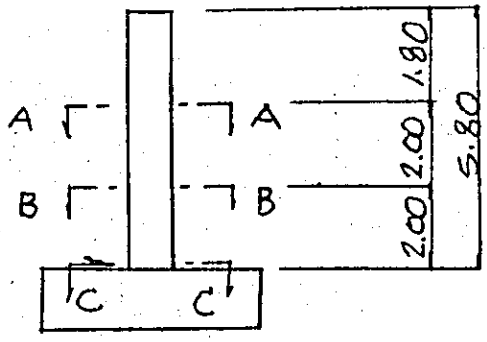
$$N = 35.91 + 11.02 + 110.22 + 351.63 \times 4$$

$$= 1563.67 \ ^{t}$$

3 EXAMINATION OF SAFETY

M (tm)	1071.13	
N (t)	1563.67	
S (t)		
b (cm)	840	
h (cm)	100	
d (cm)		
d' (cm)	8	
As (cm²)	D25-57 288.82	
p	0.00340	
As' (cm²)		
p'		
e = M/N (cm)	68.501	
e = M/N + u (cm)		
e = M/N − u (cm)		
e/h	0.685	
d/e		
d'/h	0.08	
d'/d		
Ne/bd² (kg/cm²)		
k	0.398	
c	0.173	
j		
1/Lc		
1/Ls		
β = σs/σc		
σc (kg/cm²)	106.5	
σs (kg/cm²)	2098	
τ (kg/cm²)		
σsa (kg/cm²)	2700	
σca (kg/cm²)	120	
τa (kg/cm²)		

4. DEDUCTION OF REINFORCING BARS



4-1 BENDING MOMENT AND AXIAL FORCE ACTING AT THE SECTION A AND B.

M_A = (35.91×1.45 + 11.02×0.964 + 2.5×9.185×0.80²×½)×C.1
+ 87.90×1.80×2 = 323.44 t·m

N_A = 35.91 + 11.02 + 2.5×9.185×0.80
+ 351.63×4 = 1471.82 t

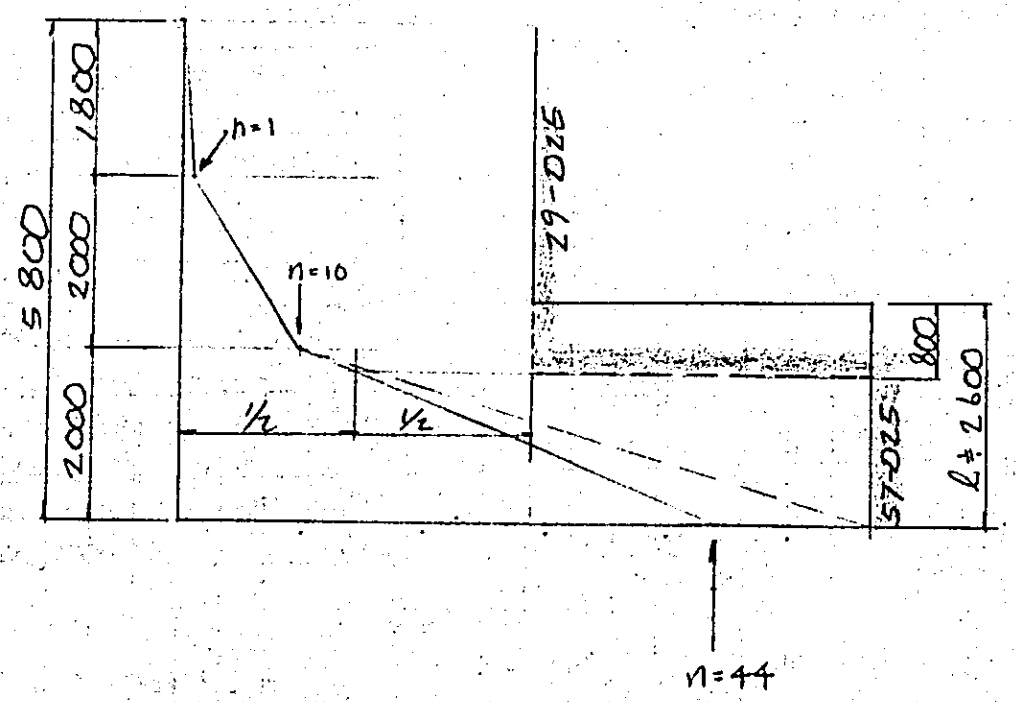
M_B = (35.91×3.45 + 11.02×2.964 + 2.5×9.185×2.80²×½)×C.1
+ 87.90×3.80×2 = 692.70 t·m

N_B = 1471.82 + 2.5×9.185×2.00 = 1517.75 t

4-2. THE LEAST REINFORCING BARS REQUIRED AT THE SECTION A AND B

SECTION	A	B	C
M (tm)	323.44	692.70	1071.13
N (t)	1471.82	1517.75	1563.67
b (cm)	840	〃	〃
h (〃)	100	〃	〃
d' (〃)	8	〃	〃
As	D25-1	D25-10	D25-44
σ_c (kg/cm²)	41.5	108.3	118.4
σ_s (〃)	57.	2656.	2639

7-3. MOMENT DIAGRAM



7 DESIGN OF PILE

1. REACTION FORCES ACTING ON PILES

EXAMINATION IS MADE ONLY TO THE EARTHQUAKE LOADING.

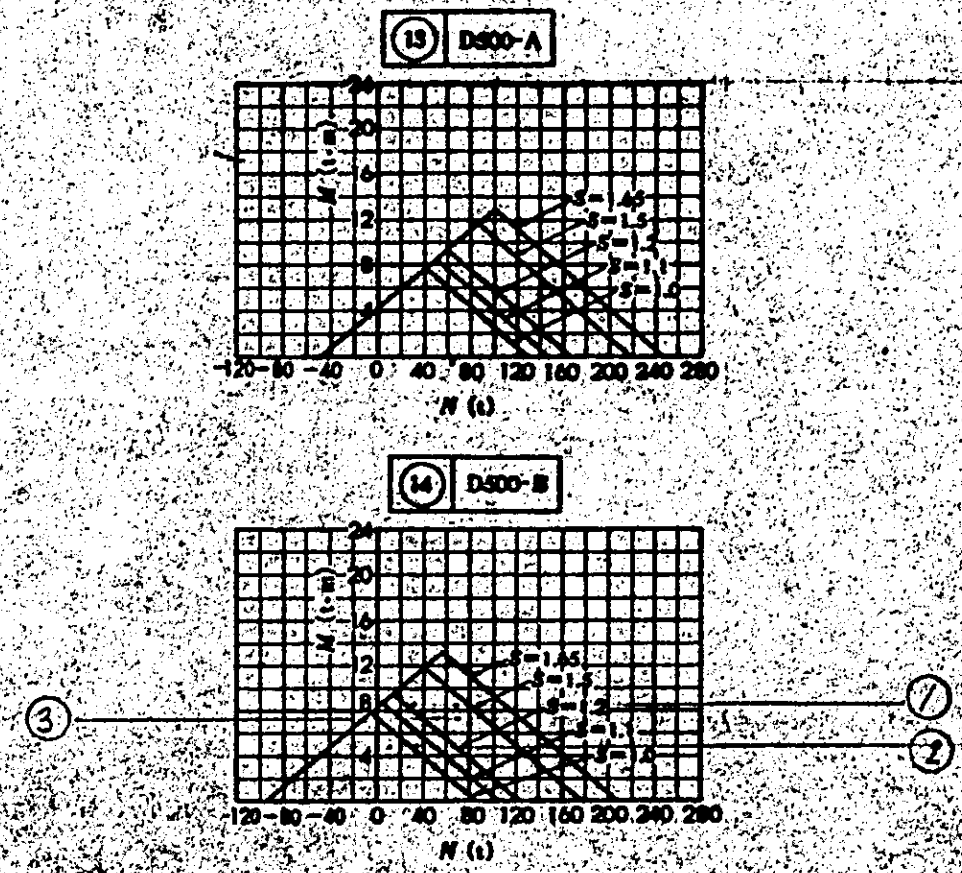
	LONGITUDINAL DIRECTION ①	TRANSVERSAL DIRECTION	
		② SINGLE TRACK	③ DOUBLE TRACK
WHOLE HORIZONTAL FORCE, ΣH (t)	237.89	132.41	202.73
HORIZONTAL FORCE PER PILE, H (t)	5.66	3.15	4.83
VALUE OF β (m^{-1})	0.214	〃	〃
MAXIMUM MOMENT PER PILE, Mmax (tm)	8.52	4.74	7.27
MAXIMUM AXIAL FORCE PER PILE, Pmax (t)	76.55	67.38	71.23
MINIMUM AXIAL FORCE PER PILE, Pmin (t)	35.75	11.42	41.07

WHERE $H = \Sigma H / n$, n ··· NUMBER OF PILE

$n = 42$

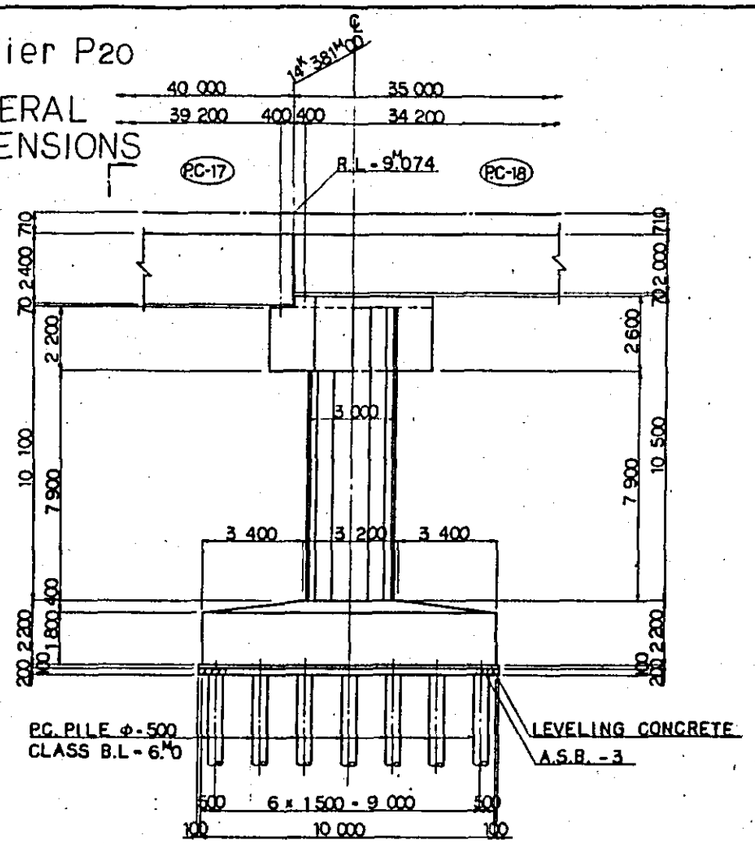
$$M_{max} = \frac{0.322 \cdot H}{\beta}$$

2. EXAMINATION OF SAFETY

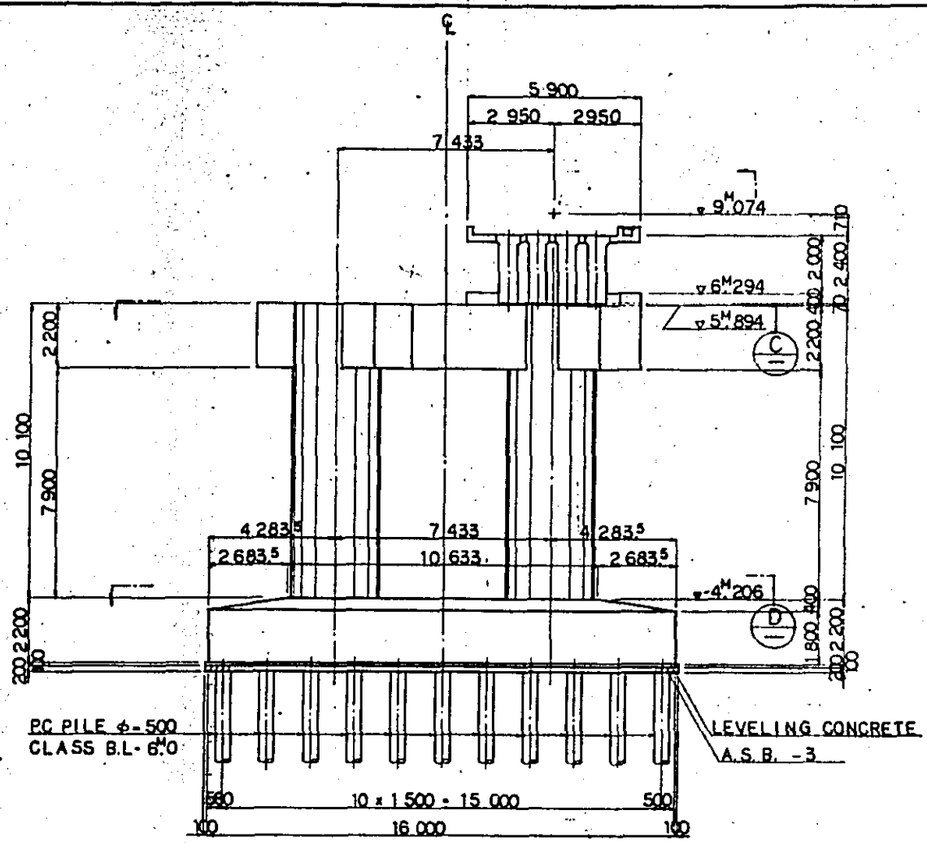


§6. Pier P20

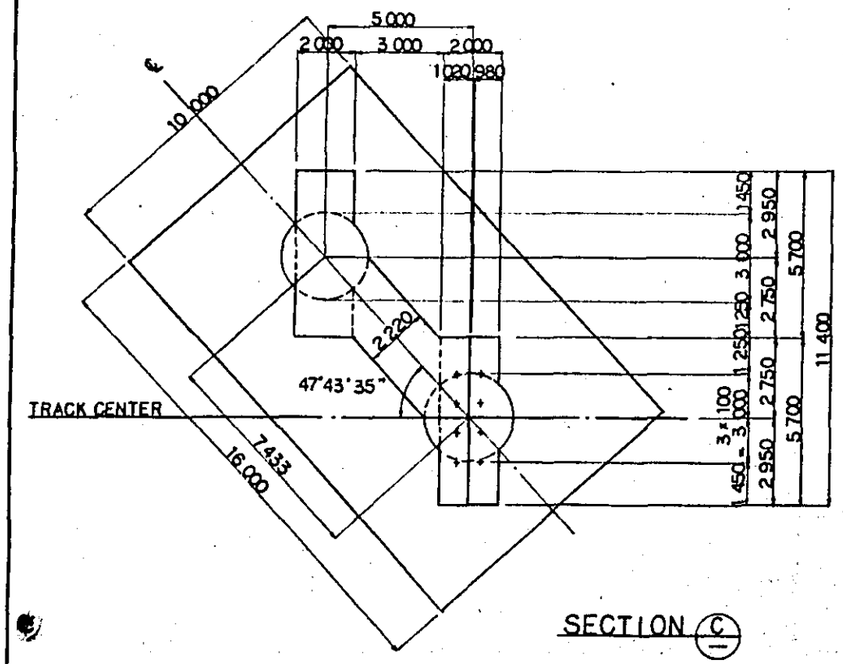
1 GENERAL DIMENSIONS



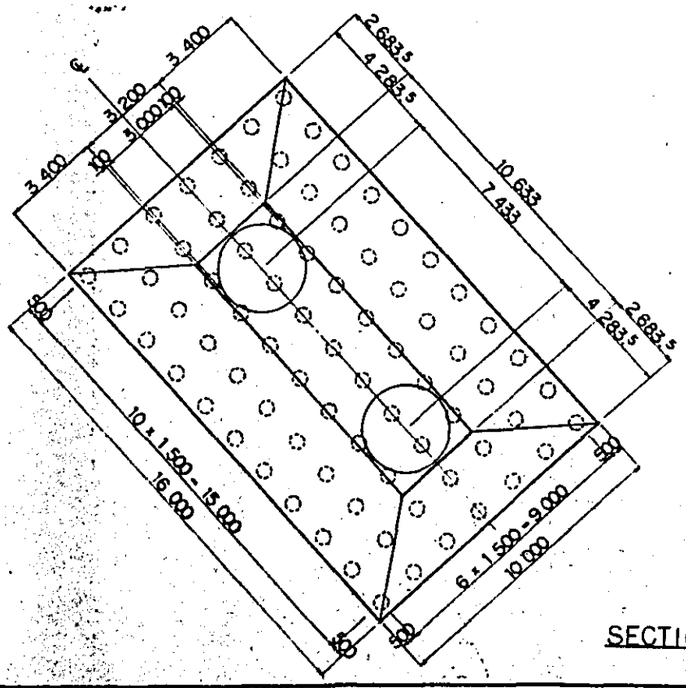
SECTION (B)–(A)



SECTION (B)–(A)

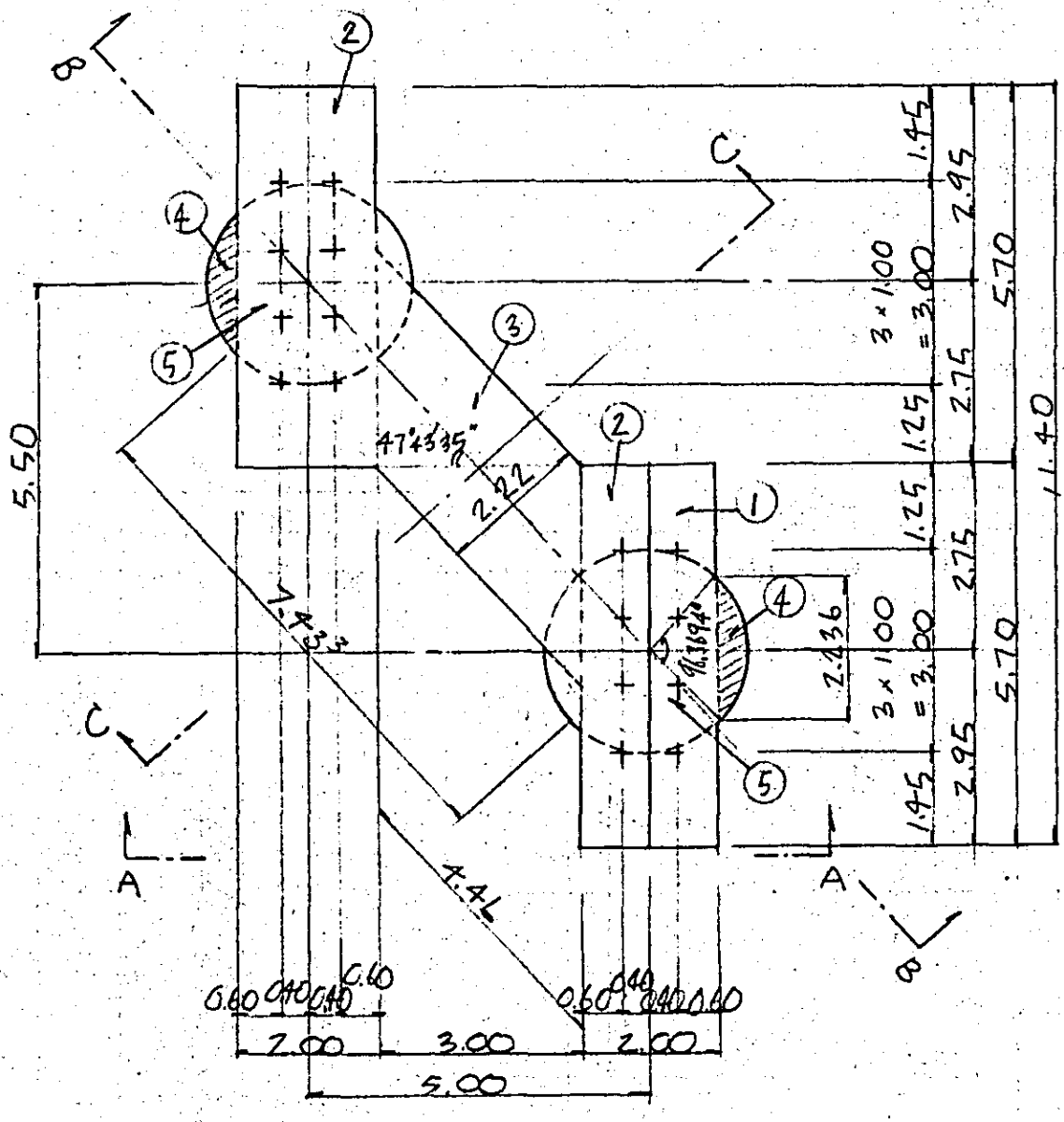


SECTION (C)–(C)

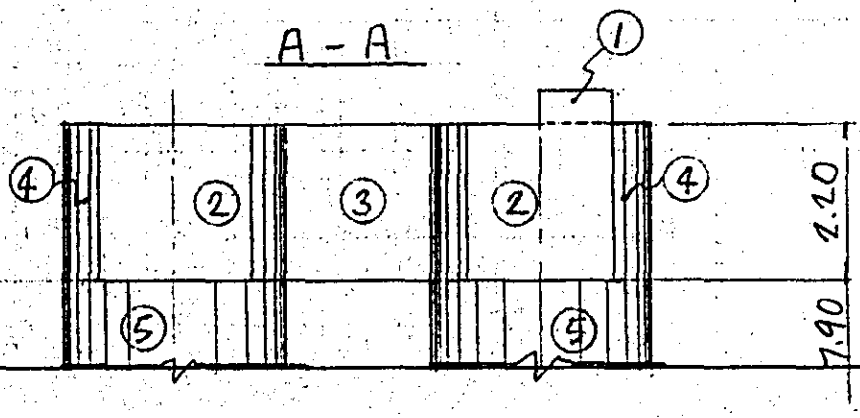


SECTION (D)–(D)

2 OWN WEIGHT OF SUBSTRUCTURE AND WEIGHT OF EARTH COVER

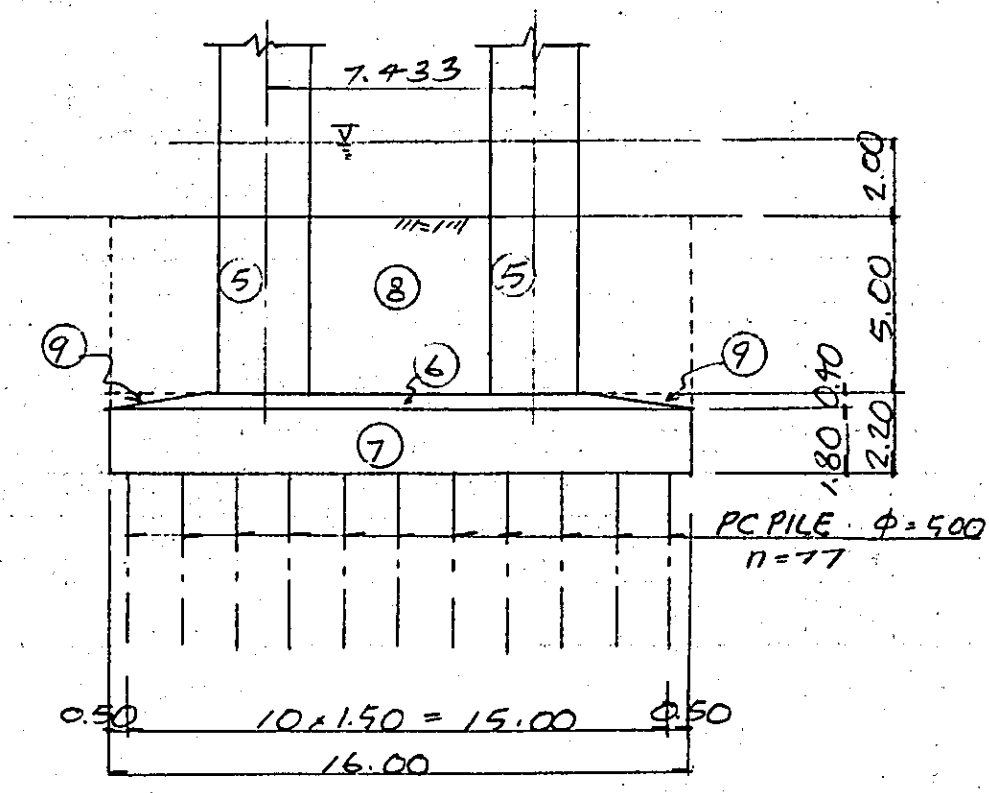


A - A

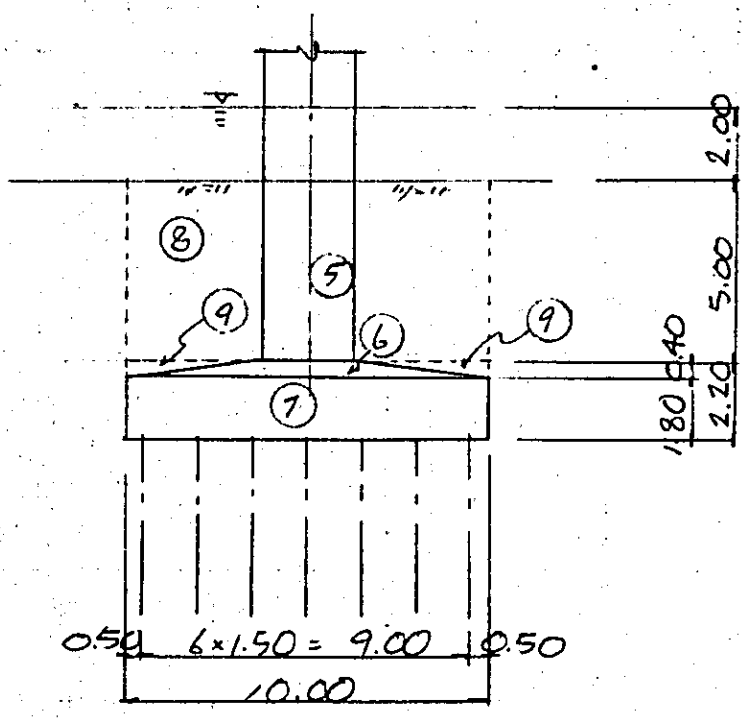


JICA

B - B


7.433
2.00
5.00
0.40
2.20
1.80
PC PILE φ=500
n=77
0.50
10×1.50 = 15.00
0.50
16.00

C - C


2.00
5.00
0.40
2.20
1.80
0.50
6×1.50 = 9.00
0.50
10.00

1. OWN WEIGHT OF SUBSTRUCTURE AND WEIGHT OF EARTH COVER

SUBSTRUCTURE

①	$2.5^{t/m^3} \times 1.00 \times 0.40 \times 5.70$	5.70^{t}
②	$2.5'' \times 2.00 \times 2.20 \times 5.70 \times 2$	$125.40''$
③	$2.5'' \times 2.22 \times 2.20 \times 4.46$	$54.46''$
④	$2.5'' \times (\pi \times 1.50^2 \times \frac{96.3694^\circ}{360^\circ} - \frac{1}{2} \times 2.236 \times 1.00) \times 2.20 \times 2$	$8.52''$
⑤	$2.5'' \times \pi \times 1.50^2 \times 7.90 \times 2$	$279.21''$
⑥	$2.5'' \times \frac{0.40}{6} \times (3.20 \times 10.633 + 10.00 \times 16.00 + 13.20 \times 26.633)$; 26.372	$90.93''$
⑦	$2.5'' \times 10.00 \times 16.00 \times 1.80$	$720.00''$
	SUB-TOTAL	$1284.22''$

EARTH COVER

⑧	$1.8^{t/m^3} \times (10.00 \times 16.00 - \pi \times 1.50^2 \times 2) \times 5.00$	1312.77^{t}
⑨	$1.8'' \times (10.00 \times 16.00 \times 0.40 - 36.37^2)$	$49.73''$
	SUB-TOTAL	$1362.50''$

TOTAL WEIGHT

$$1284.22 + 1362.50 = 2646.72^{t}$$

2. BUOYANCY

$$1.0^{t/m^3} \times 10.00 \times 16.00 \times 7.20 = 1152.00^{t}$$

$$1.0'' \times \pi \times 1.50^2 \times 2 \times 2.00 = 28.27''$$

$$\text{TOTAL} = 1180.27^{t}$$

3. HORIZONTAL FORCES DUE TO EARTHQUAKE LOAD

	N (t)	y (m)	N·y·(t·m)
①	5.70	12.50	71.25
②	125.40	11.20	1404.48
③	54.46	11.20	609.95
④	8.52	11.20	95.42
⑤	279.21	6.15	1717.19
⑥	90.93	1.94	176.40
⑦	720.00	0.90	648.00
Σ	1284.22	—	4722.64

NOTE N: AXIAL FORCE.

y: DISTANCE FROM THE BOTTOM OF FOOTING TO GRAVITY CENTER.

4. OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.

$$ye = \frac{N \cdot y}{N} = \frac{4722.64}{1284.22} = 3.677^{m}$$

$$P_E = 1284.22 \times 0.1 = 128.42^{t}$$

$$M_o = 128.42 \times 3.677 = 472.20^{t\cdot m}$$

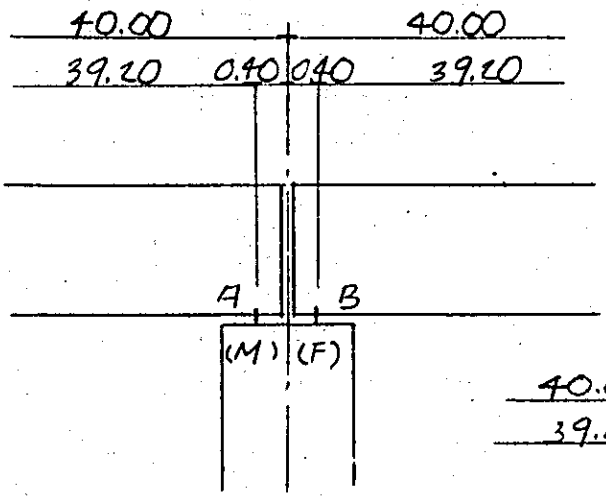
NOTE ye : DISTANCE FROM THE BOTTOM OF FOOTING TO THE CENTER OF SUBSTRUCTURE.

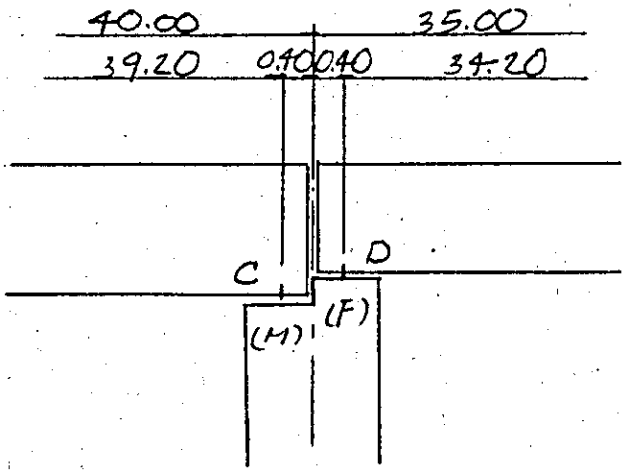
P_E : HORIZONTAL FORCE DUE TO EARTHQUAKE LOAD.

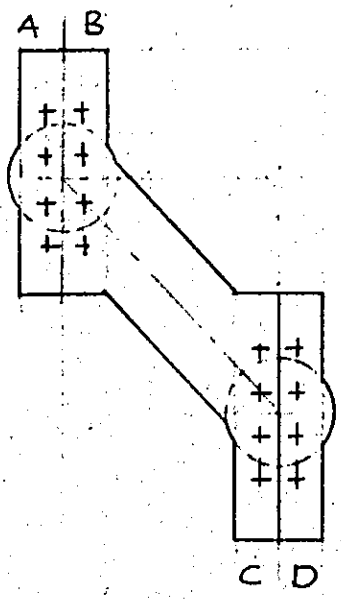
M_o : OVERTURNING MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING.

3 REACTION FORCES TRANSMITTED FROM SUPERSTRUCTURE

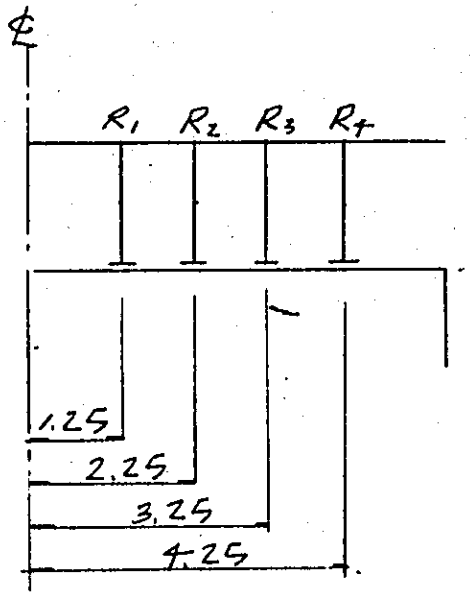
1. REACTION FORCES DUE TO DEAD WEIGHT OF SUPERSTRUCTURE







1-1. REACTION FORCES ACTING AT BEARINGS-A, B, C,



$L = 40.00^{m}$

$R_1 = 110.94^{t}$

$R_2 = 110.94^{"}$

$R_3 = 110.94^{"}$

$R_4 = 114.13^{"}$

TOTAL = 446.95^{t}

1-2. REACTION FORCES ACTING AT BEARING - D

$L = 35.00^{m}$

$R_1 = 87.11^{t}$

$R_2 = 87.11^{"}$

$R_3 = 87.11^{"}$

$R_4 = 90.30^{"}$

TOTAL = 351.63^{t}

1-3. HORIZONTAL FORCES DUE TO EARTHQUAKE ACTING ON DEAD WEIGHT OF SUPERSTRUCTURE

a) LONGITUDINAL DIRECTION

- $\ell = 39.20^{m}$, FIXED BEARING SIDE

$$P_{EB} = 446.95 \times 2 \times 0.1 - \tfrac{1}{2} \times 0.1 \times 446.95$$

$$= 67.04^{t}$$

- $\ell = 39.20^{m}$, MOVABLE BEARING SIDE

$$P_{EA} = P_{EC} = 0.1 \times 446.95$$

$$= 44.70^{t}$$

- $\ell = 34.20^{m}$, FIXED BEARING SIDE

$$P_{ED} = 351.63 \times 2 \times 0.1 - \tfrac{1}{2} \times 0.1 \times 351.63$$

$$= 52.74^{t}$$

∴ FOR SINGLE-TRACK LOADING

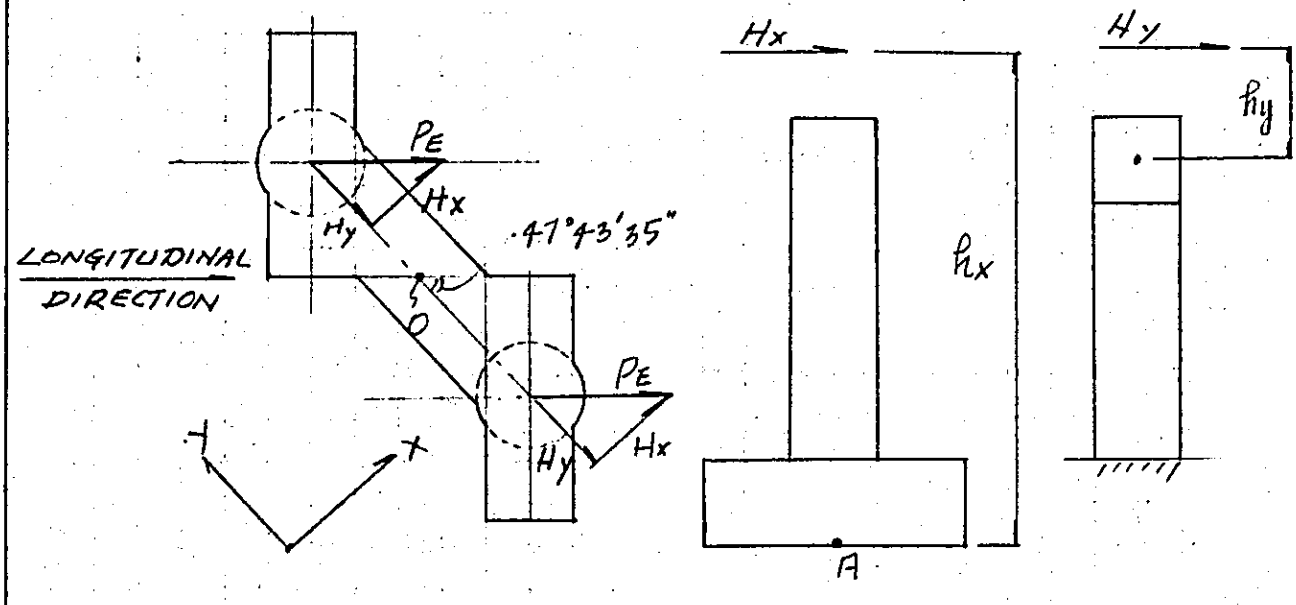
$$\Sigma P_E = P_{EC} + P_{ED}$$

$$= 44.70 + 52.74 \quad = 97.44^{t}$$

FOR DOUBLE-TRACK LOADING

$$\Sigma P_E = P_{EA} + P_{EB} + P_{EC} + P_{ED}$$

$$= 44.70 \times 2 + 67.04 + 52.74 = 209.18^{t}$$



COMPONENTS OF ΣPE

X-COMPONENT OF DOUBLE-TRACK LOADING

$H_x = 209.18 \times \sin 47°43'35'' = 154.78^{t}$

$h_x = 2.47 - 0.25 + 10.10 + 2.20 = 14.52^{m}$

$\therefore M_x = 154.78 \times 14.52 = 2247.41^{tm}$

Y-COMPONENT OF SINGLE-TRACK LOADING

$H_y = 97.44 \times \cos 47°43'35'' = 65.55^{t}$

$h_y = 2.47 - 0.25 + \frac{1}{2} \times 2.20 = 3.32^{m}$

$\therefore M_y = 65.55 \times 3.32 = 217.63^{tm}$

y-COMPONENT OF DOUBLE-TRACK LOADING.

$H_y = 209.18 \times \cos 47°43'35'' = 140.71^t$

$h_y = 3.32^m$

$\therefore M_y = 140.71 \times 3.32 = 467.16^{tm}$

b) TRANSUERSAL DIRECTION

· $\ell = 39.20^m$

$P_{EA} = P_{EB} = P_{EC}$

$= 446.95 \times 0.1 = 44.70^t$

· $\ell = 34.20^m$

$P_{ED} = 351.63 \times 0.1 = 35.16^t$

: FOR SINGLE-TRACK LOADING

$\Sigma P_E = P_{EC} + P_{ED}$

$= 44.70 + 35.16 = 79.86^t$

FOR DOUBLE-TRACK LOADING

$\Sigma P_E = P_{EA} + P_{EB} + P_{EC} + P_{ED}$

$= 44.70 \times 3 + 35.16 = 169.26^t$

COMPONENTS OF ΣP_E

- X-COMPONENT OF DOUBLE-TRACK LOADING

$H_x = 169.26 \times \cos 47°43'35'' = 113.86^t$

$h_x = 14.52^m$

$M_x = 113.86 \times 14.52 = 1653.25^{tm}$

- Y-COMPONENT OF SINGLE-TRACK LOADING

$H_y = 79.86 \times \sin 47°43'35'' = 59.09^t$

$h_y = 3.32^m$

$M_y = 59.09 \times 3.32 = 196.18^{tm}$

- Y-COMPONENT OF DOUBLE-TRACK LOADING

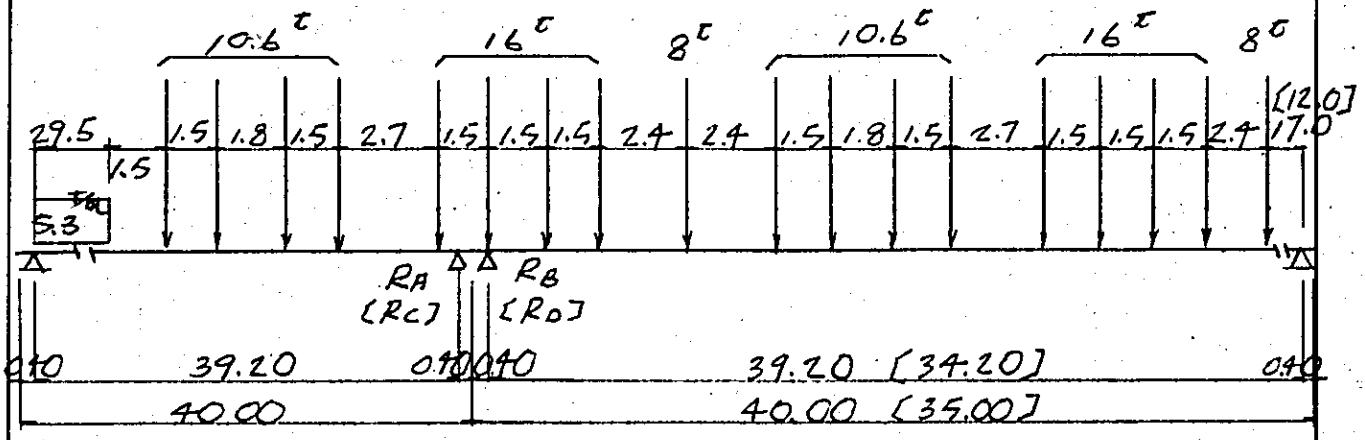
$H_y = 169.26 \times \sin 47°43'35'' = 125.24^t$

$h_y = 3.32^m$

$M_y = 125.24 \times 3.32 = 415.80^{tm}$

2. REACTION FORCES DUE TO LIVE LOAD PLUS IMPACT

EQUIVALENT TO KS-16 LOADING.
CALCULATION IS CARRIED OUT UNDER THE LOADING CONDITION OF PRODUCING MAXIMUM REACTION FORCE ON PIER.



$$R_A = \frac{1}{39.20} \times (5.3 \times 29.5 \times 14.75 + 10.6 \times 4 \times 33.40 + 16.0 \times 38.50) = 110.67^{t}$$

$$R_B = \frac{1}{39.20} \times (8 \times 2 \times 25.4 + 10.6 \times 4 \times 29.00 + 16 \times 4 \times 21.65 + 16 \times 3 \times 37.70) = 123.24^{"}$$

$$R_C = R_A = 110.67^{"}$$

$$R_D = \frac{1}{34.20} \times (8 \times 2 \times 20.4 + 10.6 \times 4 \times 24.00 + 16 \times 4 \times 16.65 + 16 \times 3 \times 32.70) = 116.35^{"}$$

IMPACT COEFFICIENT

$l = 34.20^{m}$ ------- $i = 0.332$

$l = 39.20^{m}$ ------- $i = 0.322$

LIVE LOAD PLUS IMPACT

$R_{(A+i)} = 110.67 \times (1 + 0.332) = 147.41$ t

$R_{(B+i)} = 123.24 \times (1 + 0.332) = 164.16$ "

TOTAL = 311.57 t

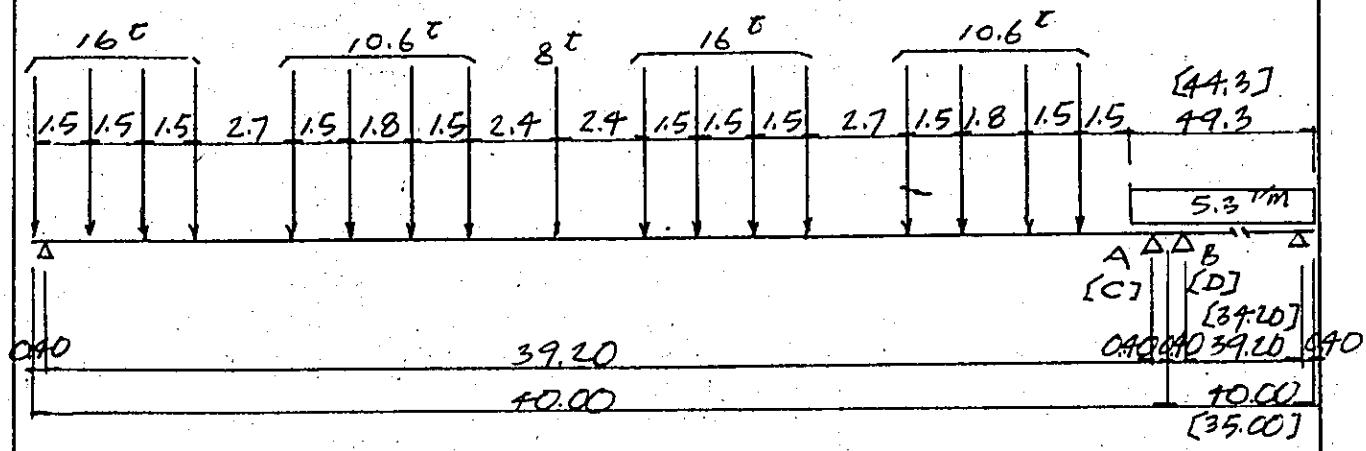
$R_{(C+i)} = 110.67 \times (1 + 0.332) = 147.41$ "

$R_{(D+i)} = 116.35 \times (1 + 0.322) = 153.81$ "

TOTAL = 301.22 t

3. BRAKE LOAD AND TRACTION LOAD

UNDER THE LOADING CONDITION AS SHOWN BELOW



3-1. BRAKE LOAD

15% OF KS LOADING

- $\Sigma L_1 = 40.00 + 40.00 = 80.00^m$

$P_{BA} = (16 \times 8 + 10.6 \times 8 + 8 + 5.3 \times 9.70) \times 0.15 \times 1/2 = 20.42^t$

$P_{B_B} = 5.3^{t/m} \times 40.0 \times 0.15 \times 1/2 = 15.90^t$

$P_{B(A+B)} = 36.32^t$

- $\Sigma L_2 = 40.00 + 35.00 = 75.00^m$

$P_{B_C} = P_{BA} = 20.42^t$

$P_{B_D} = 5.3^{t/m} \times 35.0 \times 0.15 \times 1/2 = 13.91^t$

$P_{B(C+D)} = 34.33^t$

3-2. TRACTION LOAD

25% OF MOVING WHEEL AXLE LOAD OF KS LOADING

$\Sigma L_1 = 80.00^{m}$

$P_{TA} = 16 \times 8 \times 0.25 \times 1/2 = 16.00^{t}$

$P_{TB} = 0$

$\Sigma L_2 = 75.00^{m}$

$P_{TC} = P_{TA} = 16.00^{t}$

$P_{TD} = 0$

3-3 COMPONENTS OF ΣP_B

. x-COMPONENT OF DOUBLE-TRACK LOADING

$H_x = 36.32 \times \sin 47°43'35'' = 26.87^{t}$

$h_x = 1.80 + 0.71 + 2.47 + 12.30 = 17.28^{m}$

$\therefore M_x = 26.87 \times 17.28 = 464.31^{t\cdot m}$

. y-COMPONENT OF SINGLE-TRACK LOADING

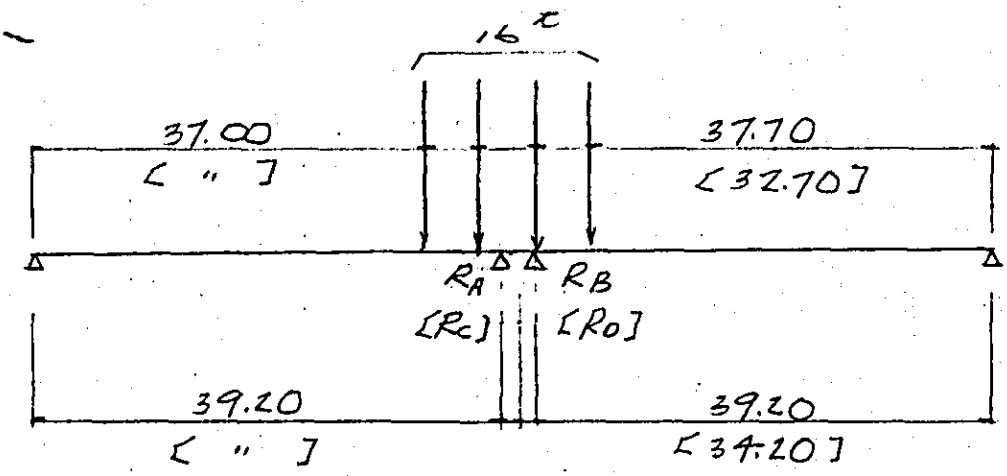
$H_{y_2} = 34.33^{t} \times \cos 47°43'35'' = 23.09^{t}$
[H_{y_1}] [36.32] [24.43 "]

$h_y = 1.80 + 0.71 + 2.47 + 1.10 = 6.08^{m}$

$M_{y_2} = 23.09 \times 6.08 = 140.39^{t\cdot m}$
[M_{y_1}] [24.43] [148.53"]

4. TRAIN LATERAL LOAD

TRANSVERSAL FORCE DUE TO LIVE (TRAIN) LOAD IS ASSUMED TO BE EQUIVALENT TO THE SERIES OF CONCENTRATED LOADS CONSISTED OF 15% OF MOVING WHEEL AXLE LOAD ACTING TRASVERALLY AT THE TRACK LEVEL. CALCULATION IS MADE UNDER THE SINGLE-TRACK LOADING.



$$R_A + R_B = \frac{1}{39.20} \times (38.45 + 37.75) \times 16 \times 2 = 62.20^{t}$$

$$R_C + R_D = \left(\frac{1}{39.20} \times 37.75 + \frac{1}{34.20} \times 33.45\right) \times 16 \times 2 = 62.12^{t}$$

$$\leq R_A + R_B$$

$$\therefore \Sigma P_T = 62.20 \times 0.15 = 9.33^{t}$$

X-COMPONENT OF ΣP_T

$$H_X = 9.33 \times \cos 47°43'35'' = 6.27^{t}$$

$$h_X = 0.71 + 2.47 + 12.30 = 15.48^{m}$$

$$M_X = 6.27 \times 15.48 = 97.06^{t\cdot m}$$

Y - COMPONENT OF IP_1

$H_y = 9.33 \times \sin 47°43'35" = 6.90^t$

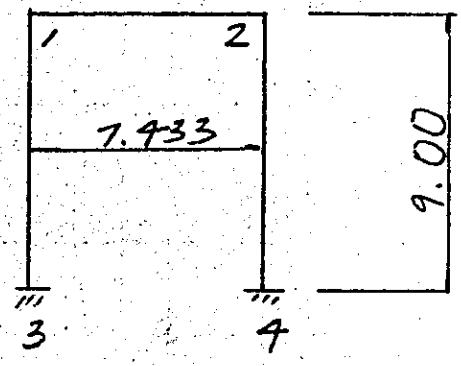
$h_y = 0.71 + 2.47 + 1.10 = 4.28^m$

$M_y = 690 \times 4.28 = 29.53^t$

4 ANALYSIS OF STATICALLY INDETERMINATE FRAME IN TRANSVERSAL DIRECTION.

1. FUNDAMENTAL CALCULATION

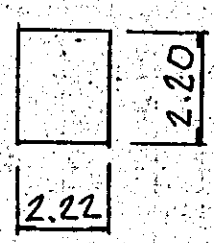
1-1 FRAME



$E_c = 2.55 \times 10^6$ tf/m²

1-2 AREA AND MOMENT OF INERTIA

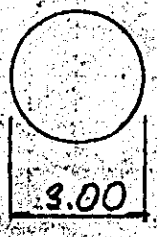
· MEMBER 1~2



$A = 2.22 \times 2.20 = 4.884$ m²

$I = 1/12 \times 2.22 \times 2.20^3 = 1.96988$ m⁴

· MEMBER 1~3, 2~4



$A = \pi/4 \times 3.00^2 = 7.069$ m²

$I = \pi/64 \times 3.00^4 = 3.97608$ m⁴

2. CALCULATION OF LOADS

2-1. DEAD LOAD

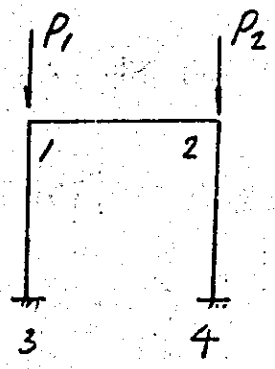
1) WEIGHT OF BEAM

$W_1 = 2.5\ ^{t/m^3} \times 2.22 \times 2.20 = 12.21\ ^{t/m}$

2) WEIGHT OF COLUMN

$W_2 = 2.5\ ^{t/m^3} \times \pi/4 \times 3.00^2 = 17.67\ ^{t/m}$

3) REACTION FORCES FROM SUPERSTRUCTURE



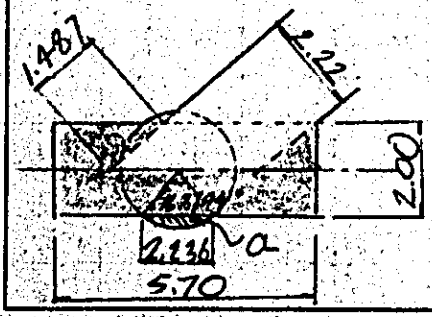
$P_1 = 446.95 \times 2 = 893.90^{t}$

$P_2 = 446.95 + 351.63 = 798.58^{"}$

4) CONCENTRATED LOAD ACTING AT THE JOINTS.

JOINT 1.

BEARING BEAM



$2.5\ ^{t/m^3} \times \{(2.00 \times 5.70 - 1.487 \times 2.22)$

$+ (\pi \times 1.50^2 \times \frac{96.3794^\circ}{360^\circ} - 1/2 \times 2.236 \times 1.00)\} \times 2.20$

$= 48.80^{t}$

a.

REACTION FORCE FROM SUPERSTRUCTURE P_1

$= 893.90^{t}$

DEDUCTION AT THE TOP OF COLUMN

$-2.5^{t/m^3} \times \pi \times 1.50^2 \times 1.10 = -19.44$ "

SINGLE TRACK ... $N_1 = 29.36^{t}$

DOUBLE TRACK ... $N_1' = 923.26$ "

JOINT 2.

BEARING BEAM

$48.80 + 2.5^{t/m^3} \times 1.00 \times 0.40 \times 5.70 = 54.50^{t}$

REACTION FORCE FROM SUPERSTRUCTURE P_2

$= 198.58$ "

DEDUCTION AT THE TOP OF COLUMN $= -19.44$ "

$N_2 = 833.64^{t}$

2-2. LIVE LOAD AND IMPACT

RERER TO [3] RECTION FORCES TRANS -MITTED FROM SUPERSTRUCTURE.

$P_{LL1} = 311.57^{t}$

$P_{LL2} = 301.22^{"}$

2-3. BRAKE LOAD

$H_{y2} = 23.09^{t}$ $\quad H_{y1} = 24.43^{t}$

$M_{y2} = 140.39^{tm}$ $\quad M_{y1} = 148.53^{tm}$

2-4 TRAIN LATERAL LOAD

$H_{y1} = H_{y2} = 6.90^{t}$

$M_{y1} = M_{y2} = 29.53^{tm}$

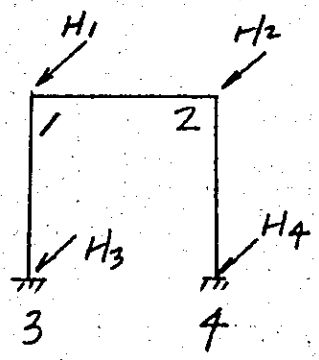
2-5. TEMPERATURE CHANGE AND DRYING SHRINKAGE

$t_1 = +10$ deg.

$t_2 = -10 - 15 = -25$ deg.

2-6 EARTHQUAKE LOAD

1) HORIZONTAL FORCES DUE TO DEAD WEIGHT OF SUBSTRUCTURE.



$$\Sigma N_{1+2} = 48.80 + 54.50 - 19.44 \times 2 + 12.21 \times 7.433 + 17.67 \times 9.00 \times \tfrac{1}{2} \times 2$$

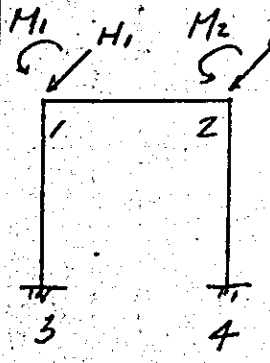
$$= 314.21^{t}$$

$$N_3 = N_4 = 17.67 \times 9.00 \times \tfrac{1}{2} = 79.52^{t}$$

$$\therefore H_1 = H_2 = 314.21 \times 0.1 \times \tfrac{1}{2} = 15.71^{t}$$

$$H_3 = H_4 = 79.52 \times 0.1 = 7.95^{t}$$

2) HORIZONTAL FORCES DUE TO DEAD WEIGHT OF SUPERSTRUCTURE.



$$H_1 = (44.70 + 67.04) \times \cos 47°43'35'' = 75.16^{t}$$

$$+ (44.70 + 44.70) \times \sin \;\; = 66.15^{t}$$

$$H_1 = 141.31^{t}$$

$$h_y = 3.32^{m}$$

$$\therefore M_1 = 141.31 \times 3.32 = 469.15^{t\cdot m}$$

$H_2 = (44.70 + 52.74) \times \cos 47°43'35'' = 65.55^{t}$

$+ (44.70 + 35.16) \times \sin\ \ '' \quad = 59.09\ ''$

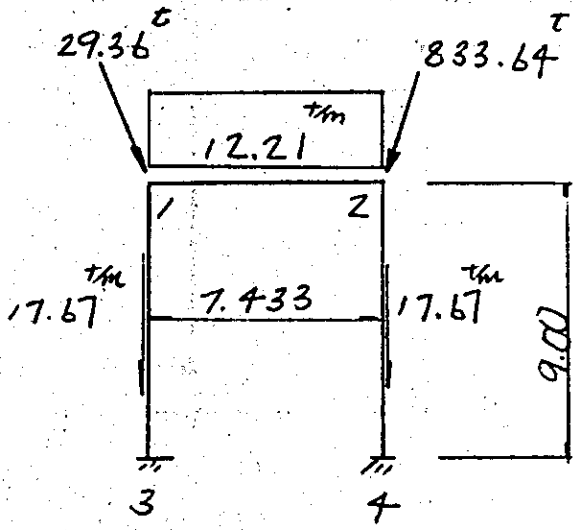
$H_2 = 124.64^{t}$

$h_y = 3.32^{m}$

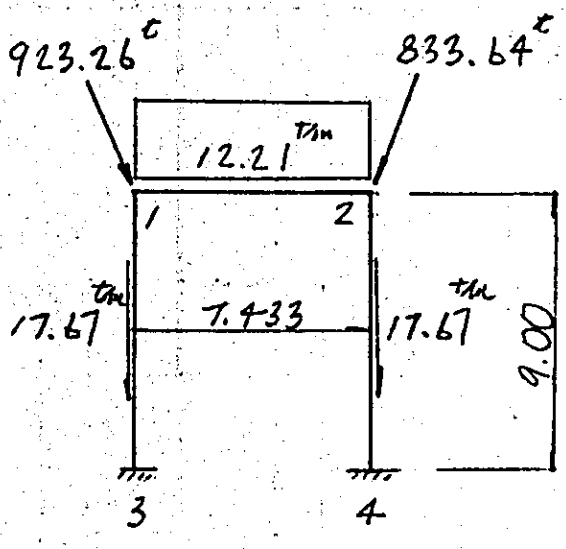
$M_2 = 124.64 \times 3.32 = 413.80^{tm}$

3. DIAGRAM OF LOADING

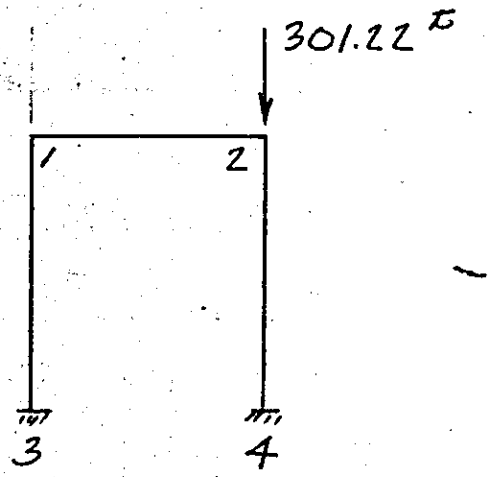
CASE 1. DEAD LOAD (FOR SINGLE-TRACK LOADING.)



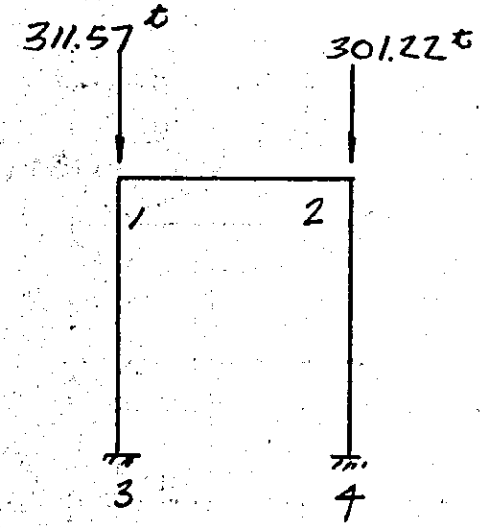
CASE 2. DEAD LOAD (FOR DOUBLE-TRACK LOADING.)



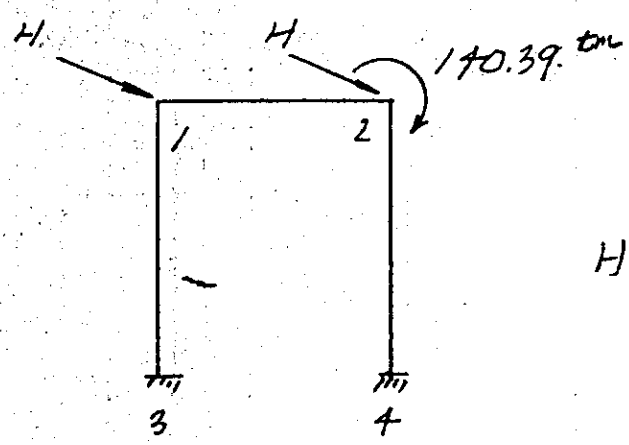
CASE 3 (TRAIN + IMPACT) LOAD (FOR SINGLE -TRACK LOADING.)



CASE 4. (TRAIN + IMPACT) LOAD (FOR DOUBLE -TRACK LOADING.)

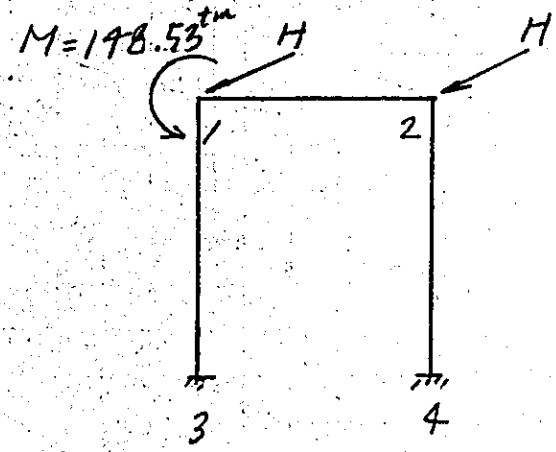


CASE 5 BRAKE LOAD (1)



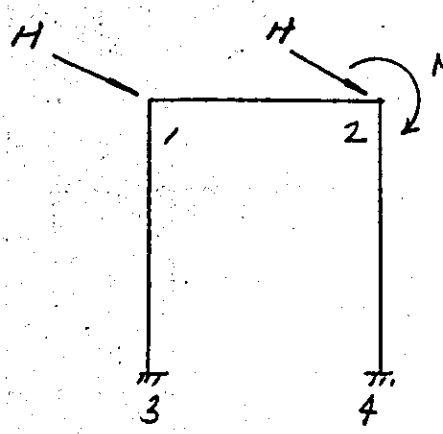
$H = 23.09 \times 1/2 - 11.55$ t

CASE 6 BRAKE LOAD (2)



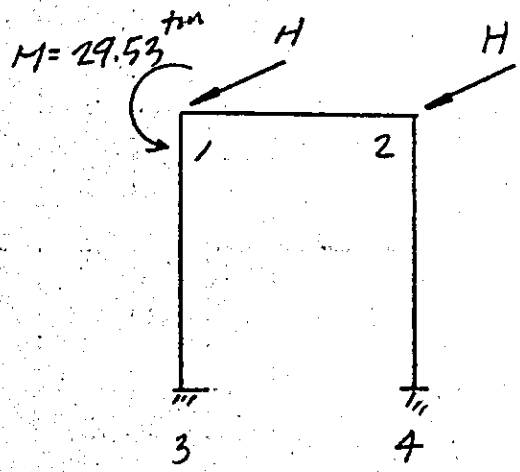
$H = 24.43 \times 1/2 = 12.22$ t

CASE 7 TRAIN LATERAL LOAD (1)



$H = 6.90 \times 1/2 = 3.45^{t}$

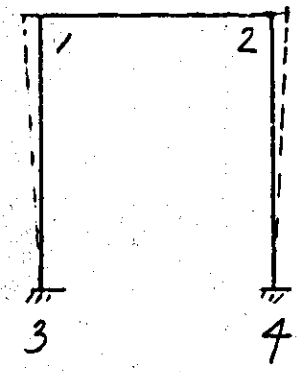
CASE 8 TRAIN LATERAL LOAD (2)



$H = 3.45^{t}$

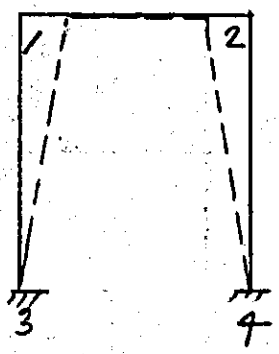
CASE 9 TEMPERATURE LOAD (1)

$t = +10$ deg.

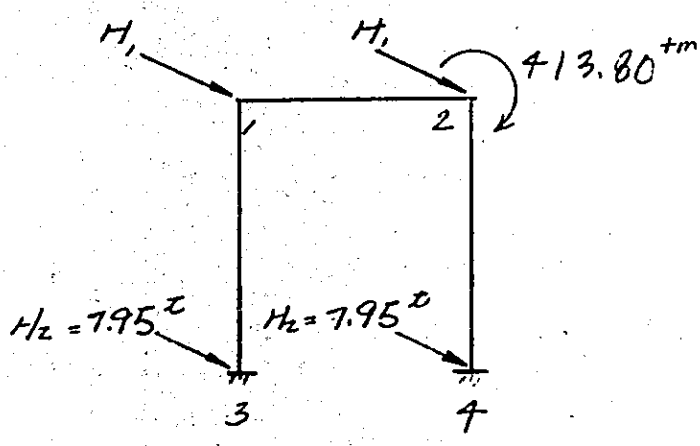


CASE 10 TEMPERATURE LOAD (2)

$t = -25$ deg.

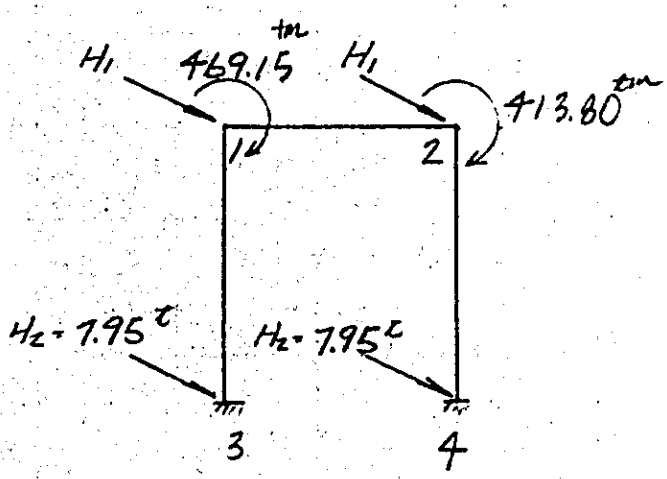


CASE 11 EARTHQUAKE LOAD (FOR SINGLE -TRACK LOADING)



$$H_1 = 15.71 + 124.64 \times 1/2 = 78.03^{t}$$

CASE 12 EARTHQUAKE LOAD (FOR DOUBLE -TRACK LOADING.)



$$H_1 = 15.71 + (124.64 + 141.31) \times 1/2 = 148.69^{t}$$

4. COMBINATION OF LOADS

i) FOR SINGLE-TRACK LOADING

COMB. CASE No.	CASE	α
13	1+3	1.00
14	1+3+5+7	1.15
15	1+3+9	〃
16	1+3+10	〃
17	1+3+5+7+9	1.25
18	1+3+5+7+10	〃
19	1+11	1.50

ii) FOR DOUBLE-TRACK LOADING

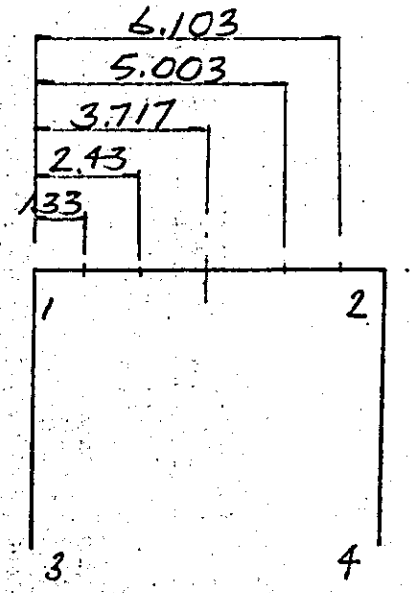
20	2+4	1.00
21	2+4+5+7	1.15
22	2+4+6+8	〃
23	2+4+9	〃
24	2+4+10	〃
25	2+4+5+7+9	1.25
26	2+4+5+7+10	〃
27	2+4+6+8+9	〃
28	2+4+6+8+10	〃

	CASE	α
29	2 + 12	1.50
30	2 - 12	"

iii) PICK-UP

Case 13 ~ Case 30

iv) POINTS OF CALCULATION



** CONTROL DATA **

SETTEN SU		4
BUZAI SU		3
SHITEN SU		2
KIHON KAJYU CASE SU		12
KUMIAWASE CASE SU		18
PICK UP CASE SU		1
BUNPU BANE TYPE SU		0
SUPPORT TYPE SU		1

** JOINT DATA **

PT.	X(M)	Y(M)
1	0.000	9.000
2	7.433	9.000
3	0.000	0.000
4	7.433	0.000

** MEMBER DATA **

K	ITAN	JTAN	IP	JP	L (M)	A(M2)	I(M4)	E(T/M2)	EPS
1	1	2	0	0	7.4330	4.884000	1.969880	.2550E+07	.1000E-04
2	1	3	0	0	9.0000	7.069000	3.976080	.2550E+07	.1000E-04
3	2	4	0	0	9.0000	7.069000	3.976080	.2550E+07	.1000E-04

** SUPPORT TYPE **

<TYPE NO. 1>

SUPPORT	KX (T/M)	KY (T/M)	KZ (T-M/RAD)
3	0.	0.	0.
4	0.	0.	0.

** CHAKUMOKU TEN DATA & LENGTH **

MEMBER	I-DISTANCE						
1	0.000	1.330	2.430	3.717	5.003	6.103	7.433
2	0.000	9.000					
3	0.000	9.000					

KIHON KAJYU CASE 1
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE1 DEAD LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
1	1	0	0.000	-29.360	0.000	0.000
1	2	0	0.000	-833.640	0.000	0.000
3	1	2	-12.210	0.000	0.000	0.000
3	2	2	-17.670	0.000	0.000	0.000
3	3	2	-17.670	0.000	0.000	0.000

KIHON KAJYU CASE 2
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE2 DEAD LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
1	1	0	0.000	-923.260	0.000	0.000
1	2	0	0.000	-833.640	0.000	0.000
3	1	2	-12.210	0.000	0.000	0.000
3	2	2	-17.670	0.000	0.000	0.000
3	3	2	-17.670	0.000	0.000	0.000

KIHON KAJYU CASE 3
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE3 (TRAIN+IMPACT) LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
1	2	0	0.000	-301.220	0.000	0.000

KIHON KAJYU CASE 4
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE4 (TRAIN+IMPACT) LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
1	1	0	0.000	-311.570	0.000	0.000
1	2	0	0.000	-301.220	0.000	0.000

KIHON KAJYU CASE 5
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE5 BRAKE LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
1	1	0	11.550	0.000	0.000	0.000
1	2	0	11.550	0.000	-140.390	0.000

KIHON KAJYU CASE 6
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE6 BRAKE LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
1	1	0	-12.220	0.000	148.530	0.000
1	2	0	-12.220	0.000	0.000	0.000

KIHON KAJYU CASE 7
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE7 TRAIN LATERAL LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
1	1	0	3.450	0.000	0.000	0.000
1	2	0	3.450	0.000	-29.530	0.000

KIHON KAJYU CASE 8
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE8 TRAIN LATERAL LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
1	1	0	-3.450	0.000	29.530	0.000
1	2	0	-3.450	0.000	0.000	0.000

KIHON KAJYU CASE 9
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE9 TEMPERTURE LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
5	1	1	10.000	0.000	0.000	0.000

KIHON KAJYU CASE 10
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE10 TEHPERATURE LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
5	1	1	-25.000	0.000	0.000	0.000

KIHON KAJYU CASE 11
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE11 EARTHQUAKE LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
1	1	0	78.030	0.000	0.000	0.000
1	2	0	78.030	0.000	-413.800	0.000
1	3	0	7.950	0.000	0.000	0.000
1	4	0	7.950	0.000	0.000	0.000

KIHON KAJYU CASE 12
BUNPU BANE TYPE NO. 1
SUPPORT TYPE NO. 1
LOAD TITLE CASE12 EARTHQUAKE LOAD

[SW]	[NN]	[LL]	[A]	[B]	[C]	[D]
1	1	0	148.690	0.000	-469.150	0.000
1	2	0	148.690	0.000	-413.800	0.000
1	3	0	7.950	0.000	0.000	0.000
1	4	0	7.950	0.000	0.000	0.000

** KUMIAWASE DATA **

CASE		1	2	3	4	5	6	7	8	9	10	11	12
13	1.0000	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	.8696	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
15	.8696	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
16	.8696	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
17	.8000	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0
18	.8000	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0
19	.6667	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
20	1.0000	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	.8696	0.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
22	.8696	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
23	.8696	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
24	.8696	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
25	.8000	0.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0
26	.8000	0.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0
27	.8000	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0
28	.8000	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0
29	.6667	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
30	.6667	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.0

** PICK UP DATA **

PICK UP NO. 1
PICK UP CASE 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

R E A C T I O N

CASE 1 CASE1 DEAD LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	7.059	246.188	-25.508
4	-7.059	1025.629	-66.807

CASE 2 CASE2 DEAD LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	7.059	1126.285	25.792
4	-7.059	1039.432	-15.506

CASE 3 CASE3 (TRAIN+IMPACT) LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	.000	4.651	-17.287
4	.000	296.569	-17.287

CASE 4 CASE4 (TRAIN+IMPACT) LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	-.000	311.410	.594
4	-.000	301.380	.594

CASE 5 CASE5 BRAKE LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	-20.364	-24.931	-107.274
4	-2.736	24.931	-55.707

CASE 6 CASE6 BRAKE LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	2.895	26.376	58.939
4	21.545	-26.376	113.496

CASE 7 CASE7 TRAIN LATERAL LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	-5.304	-6.181	-28.266
4	-1.596	6.181	-17.419

CASE 8 CASE8 TRAIN LATERAL LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	1.596	6.181	17.419
4	5.304	-6.181	28.266

CASE 9 CASE9 TEMPERTURE LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	25.699	.000	168.219
4	-25.699	-.000	-168.219

CASE 10 CASE10 TEMPERATURE LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	-64.248	-.000	-420.547
4	64.248	.000	420.547

CASE 11 CASE11 EARTHQUAKE LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	-111.959	-113.875	-561.951
4	-60.000	113.875	-409.955

CASE 12 CASE12 EARTHQUAKE LOAD

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	-153.165	-226.630	-927.249
4	-160.115	226.630	-947.580

CASE 13

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	7.059	250.839	-42.795
4	-7.059	1322.197	-84.093

CASE 14

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	-16.183	191.075	-155.081
4	-9.905	1176.838	-136.718

CASE 15

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	28.486	218.130	109.068
4	-28.486	1149.783	-219.411

CASE 16

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	-49.732	218.130	-402.922
4	49.732	1149.783	292.580

CASE 17

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	5.672	175.782	-8.094
4	-29.672	1082.647	-260.351

CASE 18

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	-66.286	175.782	-479.106
4	42.286	1082.647	210.661

CASE 19

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	-69.937	88.213	-391.659
4	-44.708	759.707	-317.857

CASE 20

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	7.059	1437.695	26.386
4	-7.059	1340.812	-14.912

CASE 21

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	-16.183	1223.165	-94.920
4	-9.905	1193.025	-76.558

CASE 22

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	10.044	1278.531	89.347
4	17.210	1137.658	110.309

CASE 23

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	28.486	1250.219	169.229
4	-28.486	1165.970	-159.250

CASE 24

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	-49.732	1250.219	-342.762
4	49.732	1165.970	352.740

CASE 25

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	5.672	1125.266	47.252
4	-29.672	1097.539	-205.005

CASE 26

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	-66.286	1125.266	-423.761
4	42.286	1097.539	266.007

CASE 27

SUPPORT	X (TON)	Y (TON)	Z (TON.M)
3	29.799	1176.202	216.771
4	-4.727	1046.604	-33.095

CASE 28

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	-42.159	1176.202	-254.242
4	67.231	1046.604	437.918

CASE 29

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	-97.409	599.800	-601.001
4	-111.455	844.084	-642.089

CASE 30

SUPPORT	X (TON)	Y (TON)	Z (TON,M)
3	106.821	901.988	635.393
4	102.043	541.896	621.414

D E F L E C T I O N

CASE 1 CASE1 DEAD LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.186	-.083	-.051
2	.182	-.472	-.031
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 2 CASE2 DEAD LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-.018	-.523	-.005
2	-.023	-.479	.014
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 3 CASE3 (TRAIN+IMPACT) LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.069	-.002	-.015
2	.069	-.148	-.015
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 4 CASE4 (TRAIN+IMPACT) LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-.002	-.155	.001
2	-.002	-.150	.001
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 5 CASE5 BRAKE LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.184	.012	-.014
2	.190	-.012	-.039
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 6 CASE6 BRAKE LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-.201	-.013	.041
2	-.195	.013	.015
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 7 CASE7 TRAIN LATERAL LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.049	.003	-.004
2	.050	-.003	-.009
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 8 CASE8 TRAIN LATERAL LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-.050	-.003	.009
2	-.049	.003	.004
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 9 CASE9 TEMPERTURE LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-.364	-.000	.047
2	.364	.000	-.047
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 10 CASE10 TEMPERATURE LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.910	.000	-.117
2	-.910	-.000	.117
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 16

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	1.014	-.074	-.159
2	-.573	-.540	.061
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 17

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.100	-.056	-.030
2	.684	-.509	-.113
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 18

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	1.119	-.056	-.161
2	-.335	-.509	.018
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 19

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.790	-.018	-.089
2	.797	-.353	-.125
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 20

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-.021	-.678	-.005
2	-.025	-.630	.015
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 11 CASE11 EARTHQUAKE LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.998	.057	-.083
2	1.014	-.057	-.156
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 12 CASE12 EARTHQUAKE LOAD

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	1.964	.113	-.243
2	1.962	-.113	-.233
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 13

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.256	-.086	-.066
2	.251	-.620	-.046
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 14

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.426	-.061	-.073
2	.427	-.553	-.082
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 15

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-.094	-.074	-.017
2	.535	-.540	-.081
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 21

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.185	-.576	-.020
2	.187	-.561	-.028
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 22

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-.237	-.604	.039
2	-.234	-.533	.029
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 23

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-.335	-.590	.036
2	.295	-.548	-.028
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 24

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.773	-.590	-.106
2	-.813	-.548	.114
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 25

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-.121	-.530	.019
2	.463	-.516	-.063
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 26

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.898	-.530	-.111
2	-.556	-.516	.067
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 27

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-.509	-.555	.073
2	.076	-.491	-.010
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 28

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	.510	-.555	-.057
2	-.944	-.491	.120
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 29

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	1.297	-.273	-.166
2	1.293	-.395	-.146
3	0.000	0.000	0.000
4	0.000	0.000	0.000

CASE 30

JOINT	X (MM)	Y (MM)	Z (M.RAD)
1	-1.321	-.424	.158
2	-1.323	-.244	.165
3	0.000	0.000	0.000
4	0.000	0.000	0.000

M E M B E R F O R C E

CASE 1 CASE1 DEAD LOAD

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-89.038	57.798	-7.059
	1.330	-22.966	41.559	-7.059
	2.430	15.362	28.128	-7.059
	3.717	41.450	12.414	-7.059
	5.003	47.318	-3.289	-7.059
	6.103	36.313	-16.720	-7.059
2	7.433	3.277	-32.959	-7.059
* * MEMBER 2 (1 - 3) * *				
1	0.000	89.038	-7.059	-87.158
3	9.000	25.508	-7.059	-246.188
* * MEMBER 3 (2 - 4) * *				
2	0.000	3.277	7.059	-866.599
4	9.000	66.807	7.059	-1025.629

CASE 2 CASE2 DEAD LOAD

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-37.737	43.995	-7.059
	1.330	9.977	27.755	-7.059
	2.430	33.120	14.324	-7.059
	3.717	41.443	-1.390	-7.059
	5.003	29.560	-17.092	-7.059
	6.103	3.371	-30.523	-7.059
2	7.433	-48.024	-46.762	-7.059
* * MEMBER 2 (1 - 3) * *				
1	0.000	37.737	-7.059	-967.255
3	9.000	-25.792	-7.059	-1126.285
* * MEMBER 3 (2 - 4) * *				
2	0.000	-48.024	7.059	-880.402
4	9.000	15.506	7.059	-1039.432

CASE 3 CASE3 (TRAIN+IMPACT) LOAD

I	L(M)	B.M(T.M)	S.F(T)	A.F(T)
* * MEMBER 1 (1 - 2) * *				
1	0.000	-17.287	4.651	0.000
	1.330	-11.101	4.651	0.000
	2.430	-5.984	4.651	0.000
	3.717	.002	4.651	0.000
	5.003	5.984	4.651	0.000
	6.103	11.101	4.651	0.000
2	7.433	17.287	4.651	0.000
* * MEMBER 2 (1 - 3) * *				
1	0.000	17.287	-.000	-4.651
3	9.000	17.287	-.000	-4.651
* * MEMBER 3 (2 - 4) * *				
2	0.000	17.287	-.000	-296.569
4	9.000	17.287	-.000	-296.569

CASE 4 CASE4 (TRAIN+IMPACT) LOAD

I	L(M)	B.M(T.M)	S.F(T)	A.F(T)
* * MEMBER 1 (1 - 2) * *				
1	0.000	.594	-.160	-.000
	1.330	.381	-.160	-.000
	2.430	.206	-.160	-.000
	3.717	-.000	-.160	-.000
	5.003	-.206	-.160	-.000
	6.103	-.381	-.160	-.000
2	7.433	-.594	-.160	-.000
* * MEMBER 2 (1 - 3) * *				
1	0.000	-.594	.000	-311.410
3	9.000	-.594	.000	-311.410
* * MEMBER 3 (2 - 4) * *				
2	0.000	-.594	.000	-301.380
4	9.000	-.594	.000	-301.380

CASE 5 CASE5 BRAKE LOAD

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	76.002	-24.931	8.814
	1.330	42.845	-24.931	8.814
	2.430	15.421	-24.931	8.814
	3.717	-16.665	-24.931	8.814
	5.003	-48.725	-24.931	8.814
	6.103	-76.149	-24.931	8.814
2	7.433	-109.306	-24.931	8.814
* * MEMBER 2 (1 - 3) * *				
1	0.000	-76.002	20.364	24.931
3	9.000	107.274	20.364	24.931
* * MEMBER 3 (2 - 4) * *				
2	0.000	31.084	2.736	-24.931
4	9.000	55.707	2.736	-24.931

CASE 6 CASE6 BRAKE LOAD

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-115.645	26.376	9.325
	1.330	-80.565	26.376	9.325
	2.430	-51.551	26.376	9.325
	3.717	-17.604	26.376	9.325
	5.003	16.316	26.376	9.325
	6.103	45.329	26.376	9.325
2	7.433	80.410	26.376	9.325
* * MEMBER 2 (1 - 3) * *				
1	0.000	-32.885	-2.895	-26.376
3	9.000	-58.939	-2.895	-26.376
* * MEMBER 3 (2 - 4) * *				
2	0.000	80.410	-21.545	26.376
4	9.000	-113.496	-21.545	26.376

CASE 7 CASE7 TRAIN LATERAL LOAD

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	19.469	-6.181	1.854
	1.330	11.249	-6.181	1.854
	2.430	4.449	-6.181	1.854
	3.717	-3.506	-6.181	1.854
	5.003	-11.455	-6.181	1.854
	6.103	-18.254	-6.181	1.854
2	7.433	-26.475	-6.181	1.854
* * MEMBER 2 (1 - 3) * *				
1	0.000	-19.469	5.304	6.181
3	9.000	28.266	5.304	6.181
* * MEMBER 3 (2 - 4) * *				
2	0.000	3.055	1.596	-6.181
4	9.000	17.419	1.596	-6.181

CASE 8 CASE8 TRAIN LATERAL LOAD

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-26.475	6.181	1.854
	1.330	-18.254	6.181	1.854
	2.430	-11.455	6.181	1.854
	3.717	-3.500	6.181	1.854
	5.003	4.449	6.181	1.854
	6.103	11.249	6.181	1.854
2	7.433	19.469	6.181	1.854
* * MEMBER 2 (1 - 3) * *				
1	0.000	-3.055	-1.596	-6.181
3	9.000	-17.419	-1.596	-6.181
* * MEMBER 3 (2 - 4) * *				
2	0.000	19.469	-5.304	6.181
4	9.000	-28.266	-5.304	6.181

CASE 9 CASE9 TEMPERTURE LOAD

	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-63.074	.000	-25.699
	1.330	-63.074	.000	-25.699
	2.430	-63.074	.000	-25.699
	3.717	-63.074	.000	-25.699
	5.003	-63.074	.000	-25.699
	6.103	-63.074	.000	-25.699
2	7.433	-63.074	.000	-25.699
* * MEMBER 2 (1 - 3) * *				
1	0.000	63.074	-25.699	-.000
3	9.000	-168.219	-25.699	-.000
* * MEMBER 3 (2 - 4) * *				
2	0.000	-63.074	25.699	.000
4	9.000	168.219	25.699	.000

CASE 10 CASE10 TEMPERATURE LOAD

	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	157.685	-.000	64.248
	1.330	157.685	-.000	64.248
	2.430	157.685	-.000	64.248
	3.717	157.685	-.000	64.248
	5.003	157.685	-.000	64.248
	6.103	157.685	-.000	64.248
2	7.433	157.685	-.000	64.248
* * MEMBER 2 (1 - 3) * *				
1	0.000	-157.685	64.248	.000
3	9.000	420.547	64.248	.000
* * MEMBER 3 (2 - 4) * *				
2	0.000	157.685	-64.248	-.000
4	9.000	-420.547	-64.248	-.000

CASE 11 CASE11 EARTHQUAKE LOAD

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	374.134	-113.875	25.979
	1.330	222.681	-113.875	25.979
	2.430	97.418	-113.875	25.979
	3.717	-49.139	-113.875	25.979
	5.003	-195.582	-113.875	25.979
	6.103	-320.845	-113.875	25.979
2	7.433	-472.299	-113.875	25.979
* * MEMBER 2 (1 - 3) * *				
1	0.000	-374.134	104.009	113.875
3	9.000	561.951	104.009	113.875
* * MEMBER 3 (2 - 4) * *				
2	0.000	-58.499	52.050	-113.875
4	9.000	409.955	52.050	-113.875

CASE 12 CASE12 EARTHQUAKE LOAD

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	848.835	-226.630	-3.475
	1.330	547.417	-226.630	-3.475
	2.430	298.124	-226.630	-3.475
	3.717	6.452	-226.630	-3.475
	5.003	-284.994	-226.630	-3.475
	6.103	-534.287	-226.630	-3.475
2	7.433	-835.704	-226.630	-3.475
* * MEMBER 2 (1 - 3) * *				
1	0.000	-379.685	145.215	226.630
3	9.000	927.249	145.215	226.630
* * MEMBER 3 (2 - 4) * *				
2	0.000	-421.904	152.165	-226.630
4	9.000	947.580	152.165	-226.630

CASE 13

I	---L(M)---	---B.M(T,M)---	---S.P(T)---	---A.P(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-106.325	62.449	-7.059
	1.330	-34.066	46.210	-7.059
	2.430	9.378	32.779	-7.059
	3.717	41.453	17.065	-7.059
	5.003	53.302	1.363	-7.059
	6.103	47.414	-12.068	-7.059
2	7.433	20.564	-28.307	-7.059
* * MEMBER 2 (1 - 3) * *				
1	0.000	106.325	-7.059	-91.809
3	9.000	42.795	-7.059	-250.839
* * MEMBER 3 (2 - 4) * *				
2	0.000	20.564	7.059	-1163.167
4	9.000	84.093	7.059	-1322.197

CASE 14

I	---L(M)---	---B.M(T,M)---	---S.P(T)---	---A.P(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-9.438	27.251	3.139
	1.330	17.416	13.130	3.139
	2.430	25.434	1.450	3.139
	3.717	18.507	-12.215	3.139
	5.003	-5.981	-25.870	3.139
	6.103	-40.862	-37.549	3.139
2	7.433	-100.193	-51.671	3.139
* * MEMBER 2 (1 - 3) * *				
1	0.000	9.438	16.183	-52.783
3	9.000	155.081	16.183	-191.075
* * MEMBER 3 (2 - 4) * *				
2	0.000	47.570	9.905	-1038.545
4	9.000	136.718	9.905	-1176.838

CASE 15

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-147.309	54.306	-28.486
	1.330	-84.473	40.184	-28.486
	2.430	-46.694	28.505	-28.486
	3.717	-18.802	14.840	-28.486
	5.003	-8.498	1.185	-28.486
	6.103	-13.618	-10.494	-28.486
2	7.433	-36.967	-24.616	-28.486
* * MEMBER 2 (1 - 3) * *				
1	0.000	147.309	-28.486	-79.838
3	9.000	-109.068	-28.486	-218.130
* * MEMBER 3 (2 - 4) * *				
2	0.000	-36.967	28.486	-1011.490
4	9.000	219.411	28.486	-1149.783

CASE 16

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	44.663	54.306	49.732
	1.330	107.499	40.184	49.732
	2.430	145.278	28.505	49.732
	3.717	173.170	14.840	49.732
	5.003	183.474	1.185	49.732
	6.103	178.354	-10.494	49.732
2	7.433	155.005	-24.616	49.732
* * MEMBER 2 (1 - 3) * *				
1	0.000	-44.663	49.732	-79.838
3	9.000	402.922	49.732	-218.130
* * MEMBER 3 (2 - 4) * *				
2	0.000	155.005	-49.732	-1011.490
4	9.000	-292.580	-49.732	-1149.783

CASE 17

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-59.142	25.070	-17.672
	1.330	-34.438	12.079	-17.672
	2.430	-27.060	1.334	-17.672
	3.717	-33.433	-11.237	-17.672
	5.003	-55.962	-23.799	-17.672
	6.103	-88.050	-34.544	-17.672
2	7.433	-142.633	-47.535	-17.672
* * MEMBER 2 (1 - 3) * *				
1	0.000	59.142	-5.672	-48.558
3	9.000	8.094	-5.672	-175.782
* * MEMBER 3 (2 - 4) * *				
2	0.000	-6.697	29.672	-955.423
4	9.000	260.351	29.672	-1082.647

CASE 18

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	117.466	25.070	54.286
	1.330	142.170	12.079	54.286
	2.430	149.547	1.334	54.286
	3.717	143.174	-11.237	54.286
	5.003	120.645	-23.799	54.286
	6.103	88.557	-34.544	54.286
2	7.433	33.974	-47.535	54.286
* * MEMBER 2 (1 - 3) * *				
1	0.000	-117.466	66.286	-48.558
3	9.000	479.106	66.286	-175.782
* * MEMBER 3 (2 - 4) * *				
2	0.000	169.910	-42.286	-955.423
4	9.000	-210.661	-42.286	-1082.647

CASE 19

	L(M)	B.M(T.M)	S.F(T)	A.F(T)
* * MEMBER 1 (1 - 2) * *				
1	0.000	190.074	-37.387	12.614
	1.330	133.150	-48.213	12.614
	2.430	75.191	-57.168	12.614
	3.717	-5.126	-67.644	12.614
	5.003	-98.848	-78.113	12.614
	6.103	-189.697	-87.067	12.614
2	7.433	-312.697	-97.894	12.614
* * MEMBER 2 (1 - 3) * *				
1	0.000	-190.074	64.637	17.812
3	9.000	391.659	64.637	-88.213
* * MEMBER 3 (2 - 4) * *				
2	0.000	-36.816	39.408	-653.682
4	9.000	317.857	39.408	-759.707

CASE 20

	L(M)	B.M(T.M)	S.F(T)	A.F(T)
* * MEMBER 1 (1 - 2) * *				
1	0.000	-37.143	43.835	-7.059
	1.330	10.358	27.595	-7.059
	2.430	33.326	14.164	-7.059
	3.717	41.443	-1.550	-7.059
	5.003	29.354	-17.252	-7.059
	6.103	2.990	-30.683	-7.059
2	7.433	-48.618	-46.922	-7.059
* * MEMBER 2 (1 - 3) * *				
1	0.000	37.143	-7.059	-1278.665
3	9.000	-26.386	-7.059	-1437.695
* * MEMBER 3 (2 - 4) * *				
2	0.000	-48.618	7.059	-1181.782
4	9.000	14.912	7.059	-1340.812

CASE 21

I	L(M)	B.M(T.M)	S.F(T)	A.F(T)
* * MEMBER 1 (1 - 2) * *				
1	0.000	50.723	11.064	3.139
	1.330	56.047	-3.058	3.139
	2.430	46.259	-14.737	3.139
	3.717	18.499	-28.402	3.139
	5.003	-26.806	-42.057	3.139
	6.103	-79.493	-53.737	3.139
2	7.433	-160.353	-67.858	3.139
* * MEMBER 2 (1 - 3) * *				
1	0.000	-50.723	16.183	-1084.872
3	9.000	94.920	16.183	-1223.165
* * MEMBER 3 (2 - 4) * *				
2	0.000	-12.591	9.905	-1054.733
4	9.000	76.558	9.905	-1193.025

CASE 22

I	L(M)	B.M(T.M)	S.F(T)	A.F(T)
* * MEMBER 1 (1 - 2) * *				
1	0.000	-155.887	66.431	3.583
	1.330	-76.925	52.309	3.583
	2.430	-25.809	40.629	3.583
	3.717	17.687	26.964	3.583
	5.003	43.583	13.310	3.583
	6.103	51.800	1.630	3.583
2	7.433	44.577	-12.492	3.583
* * MEMBER 2 (1 - 3) * *				
1	0.000	1.046	-10.044	-1140.239
3	9.000	-89.347	-10.044	-1278.531
* * MEMBER 3 (2 - 4) * *				
2	0.000	44.577	-17.210	-999.366
4	9.000	-110.309	-17.210	-1137.658

CASE 23

I	L(M)	B.M(T.M)	S.F(T)	A.F(T)
* * MEMBER 1 (1 - 2) * *				
1	0.000	-87.149	38.119	-28.486
	1.330	-45.842	23.997	-28.486
	2.430	-25.869	12.317	-28.486
	3.717	-18.810	-1.348	-28.486
	5.003	-29.323	-15.002	-28.486
	6.103	-52.249	-26.682	-28.486
2	7.433	-97.127	-40.804	-28.486
* * MEMBER 2 (1 - 3) * *				
1	0.000	87.149	-28.486	-1111.927
3	9.000	-169.229	-28.486	-1250.219
* * MEMBER 3 (2 - 4) * *				
2	0.000	-97.127	28.486	-1027.678
4	9.000	159.250	28.486	-1165.970

CASE 24

I	L(M)	B.M(T.M)	S.F(T)	A.F(T)
* * MEMBER 1 (1 - 2) * *				
1	0.000	104.823	38.119	49.732
	1.330	146.130	23.997	49.732
	2.430	166.103	12.317	49.732
	3.717	173.162	-1.348	49.732
	5.003	162.649	-15.002	49.732
	6.103	139.723	-26.682	49.732
2	7.433	94.845	-40.804	49.732
* * MEMBER 2 (1 - 3) * *				
1	0.000	-104.823	49.732	-1111.927
3	9.000	342.762	49.732	-1250.219
* * MEMBER 3 (2 - 4) * *				
2	0.000	94.845	-49.732	-1027.678
4	9.000	-352.740	-49.732	-1165.970

CASE 25

I	---L(M)---	---B.M(T,M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-3.796	10.178	-17.672
	1.330	1.102	-2.813	-17.672
	2.430	-7.902	-13.558	-17.672
	3.717	-33.441	-26.129	-17.672
	5.003	-75.120	-38.691	-17.672
	6.103	-123.590	-49.436	-17.672
2	7.433	-197.978	-62.427	-17.672
* * MEMBER 2 (1 - 3) * *				
1	0.000	3.796	-5.672	-998.042
3	9.000	-47.252	-5.672	-1125.266
* * MEMBER 3 (2 - 4) * *				
2	0.000	-62.042	29.672	-970.315
4	9.000	205.005	29.672	-1097.539

CASE 26

I	---L(M)---	---B.M(T,M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	172.811	10.178	54.286
	1.330	177.709	-2.813	54.286
	2.430	168.705	-13.558	54.286
	3.717	143.166	-26.129	54.286
	5.003	101.487	-38.691	54.286
	6.103	53.018	-49.436	54.286
2	7.433	-21.371	-62.427	54.286
* * MEMBER 2 (1 - 3) * *				
1	0.000	-172.811	66.286	-998.042
3	9.000	423.761	66.286	-1125.266
* * MEMBER 3 (2 - 4) * *				
2	0.000	114.565	-42.286	-970.315
4	9.000	-266.007	-42.286	-1097.539

CASE 27

J	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-193.870	61.114	-17.263
	1.330	-121.228	48.122	-17.263
	2.430	-74.203	37.378	-17.263
	3.717	-34.188	24.806	-17.263
	5.003	-10.364	12.244	-17.263
	6.103	-2.805	1.500	-17.263
2	7.433	-9.450	-11.492	-17.263
* * MEMBER 2 (1 - 3) * *				
1	0.000	51.422	-29.799	-1048.978
3	9.000	-216.771	-29.799	-1176.202
* * MEMBER 3 (2 - 4) * *				
2	0.000	-9.450	4.727	-919.380
4	9.000	33.095	4.727	-1046.604

CASE 28

J	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---
* * MEMBER 1 (1 - 2) * *				
1	0.000	-17.262	61.114	54.695
	1.330	55.379	48.122	54.695
	2.430	102.404	37.377	54.694
	3.717	142.420	24.806	54.695
	5.003	166.243	12.244	54.695
	6.103	173.802	1.500	54.695
2	7.433	167.157	-11.492	54.695
* * MEMBER 2 (1 - 3) * *				
1	0.000	-125.186	42.159	-1048.978
3	9.000	254.242	42.159	-1176.202
* * MEMBER 3 (2 - 4) * *				
2	0.000	167.157	-67.231	-919.380
4	9.000	-437.918	-67.231	-1046.604

CASE 29

	L(M)	B.M(T;M)	S.F(T)	A.F(T)
* * MEMBER 1 (1 - 2) * *				
1	0.000	540.759	-121.763	-7.023
	1.330	371.614	-132.590	-7.023
	2.430	220.841	-141.544	-7.023
	3.717	31.932	-152.021	-7.023
	5.003	-170.298	-162.489	-7.023
	6.103	-353.961	-171.444	-7.023
2	7.433	-589.181	-182.271	-7.023
* * MEMBER 2 (1 - 3) * *				
1	0.000	-227.976	92.109	-493.775
3	9.000	601.001	92.109	-599.800
* * MEMBER 3 (2 - 4) * *				
2	0.000	-313.301	106.154	-738.058
4	9.000	642.089	106.154	-844.084

CASE 30

	L(M)	B.M(T,M)	S.F(T)	A.F(T)
* * MEMBER 1 (1 - 2) * *				
1	0.000	-591.077	180.425	-2.389
	1.330	-358.312	169.598	-2.389
	2.430	-176.678	160.644	-2.389
	3.717	23.329	150.167	-2.389
	5.003	209.713	139.699	-2.389
	6.103	358.456	130.744	-2.389
2	7.433	525.147	119.918	-2.389
* * MEMBER 2 (1 - 3) * *				
1	0.000	278.295	-101.521	-795.963
3	9.000	-635.393	-101.521	-901.988
* * MEMBER 3 (2 - 4) * *				
2	0.000	249.266	-96.742	-135.870
4	9.000	-621.414	-96.742	-541.896

M O M E N T M A X I M U M

I	L(M)	B,M(T,M)	S,P(T)	A,F(T)	CASE NO.
* * MEMBER 1 (1 - 2) * *					
1	0,000	540,759	-121,763	-7,023	....CASE29
	1,330	371,614	-132,590	-7,023	....CASE29
	2,430	220,841	-141,544	-7,023	....CASE29
	3,717	173,170	14,840	49,732	....CASE16
	5,003	209,713	139,699	-2,389	....CASE30
	6,103	358,456	130,744	-2,389	....CASE30
2	7,433	525,147	119,918	-2,389	....CASE30
* * MEMBER 2 (1 - 3) * *					
1	0,000	278,295	-101,521	-795,963	....CASE30
3	9,000	601,001	92,109	-599,800	....CASE29
* * MEMBER 3 (2 - 4) * *					
2	0,000	249,266	-96,742	-435,870	....CASE30
4	9,000	642,089	106,154	-844,084	....CASE29

MOMENT MINIMUM

I	L(M)	B.M(T.M)	S.F(T)	A.F(T)	CASE NO.
* * MEMBER 1 (1 - 2) * *					
1	0.000	-591.077	180.425	-2.389	....CASE30
	1.330	-358.312	169.598	-2.389	....CASE30
	2.430	-176.678	160.644	-2.389	....CASE30
	3.717	-34.188	24.806	-17.263	....CASE27
	5.003	-170.298	-162.489	-7.023	....CASE29
	6.103	-353.961	-171.444	-7.023	....CASE29
2	7.433	-589.181	-182.271	-7.023	....CASE29
* * MEMBER 2 (1 - 3) * *					
1	0.000	-227.976	92.109	-493.775	....CASE29
3	9.000	-635.393	-101.521	-901.988	....CASE30
* * MEMBER 3 (2 - 4) * *					
2	0.000	-313.301	106.154	-738.058	....CASE29
4	9.000	-621.414	-96.742	-541.896	....CASE30

S - F O R C E M A X I M U M

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---N.F(T)---	---CASE NO.---
* * MEMBER 1 (1 - 2) * *					
1	0.000	-591.077	180.425	-2.389	....CASE30
	1.330	-358.312	169.598	-2.389	....CASE30
	2.430	-176.678	160.644	-2.389	....CASE30
	3.717	23.329	150.167	-2.389	....CASE30
	5.003	209.713	139.699	-2.389	....CASE30
	6.103	358.456	130.744	-2.389	....CASE30
2	7.433	525.147	119.918	-2.389	....CASE30
* * MEMBER 2 (1 - 3) * *					
1	0.000	-227.976	92.109	-493.775	....CASE29
3	9.000	601.001	92.109	-599.800	....CASE29
* * MEMBER 3 (2 - 4) * *					
2	0.000	-313.301	106.154	-738.058	....CASE29
4	9.000	642.089	106.154	-844.084	....CASE29

S - F O R C E M I N I M U M

I	---L(M)---	---B.M(T,M)---	---S.F(T)---	---A.F(T)---	---CASE NO.---
* * MEMBER 1 (1 - 2) * *					
1	0.000	540.759	-121.763	-7.023	....CASE29
	1.330	371.614	-132.590	-7.023	....CASE29
	2.430	220.841	-141.544	-7.023	....CASE29
	3.717	31.932	-152.021	-7.023	....CASE29
	5.003	-170.298	-162.489	-7.023	....CASE29
	6.103	-353.961	-171.444	-7.023	....CASE29
2	7.433	-589.181	-182.271	-7.023	....CASE29
* * MEMBER 2 (1 - 3) * *					
1	0.000	278.295	-101.521	-795.963	....CASE30
3	9.000	-635.393	-101.521	-901.988	....CASE30
* * MEMBER 3 (2 - 4) * *					
2	0.000	249.266	-96.742	-435.870	....CASE30
4	9.000	-621.414	-96.742	-541.896	....CASE30

A - F O R C E M A X I M U M

I	---L(M)---	---B.M(T.M)---	---S.F(T)---	---A.F(T)---	---CASE NO.---
* * MEMBER 1 (1 - 2) * *					
1	0.000	-17.262	61.114	54.695	....CASE28
	1.330	55.379	48.122	54.695	....CASE28
	2.430	102.404	37.377	54.694	....CASE28
	3.717	142.420	24.806	54.695	....CASE28
	5.003	166.243	12.244	54.695	....CASE28
	6.103	173.802	1.500	54.695	....CASE28
2	7.433	167.157	-11.492	54.695	....CASE28
* * MEMBER 2 (1 - 3) * *					
1	0.000	-190.074	64.637	17.812	....CASE19
3	9.000	391.659	64.637	-88.213	....CASE19
* * MEMBER 3 (2 - 4) * *					
2	0.000	249.266	-96.742	-435.870	....CASE30
4	9.000	-621.414	-96.742	-541.896	....CASE30

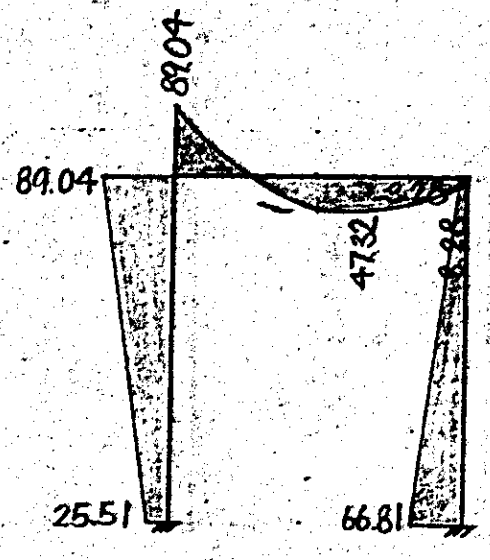
A - F O R C E M I N I M U M

I	---L(M)---	---B.M(T,M)---	---S.F(T)---	---A.F(T)---	---CASE NO.---
* * MEMBER 1 (1 - 2) * *					
1	0.000	-87.149	38.119	-28.486	....CASE23
	1.330	-45.842	23.997	-28.486	....CASE23
	2.430	-25.869	12.317	-28.486	....CASE23
	3.717	-18.810	-1.348	-28.486	....CASE23
	5.003	-29.323	-15.002	-28.486	....CASE23
	6.103	-52.249	-26.682	-28.486	....CASE23
2	7.433	-97.127	-40.804	-28.486	....CASE23
* * MEMBER 2 (1 - 3) * *					
1	0.000	37.143	-7.059	-1278.665	....CASE20
3	9.000	-26.386	-7.059	-1437.695	....CASE20
* * MEMBER 3 (2 - 4) * *					
2	0.000	-48.618	7.059	-1181.782	....CASE20
4	9.000	14.912	7.059	-1340.812	....CASE20

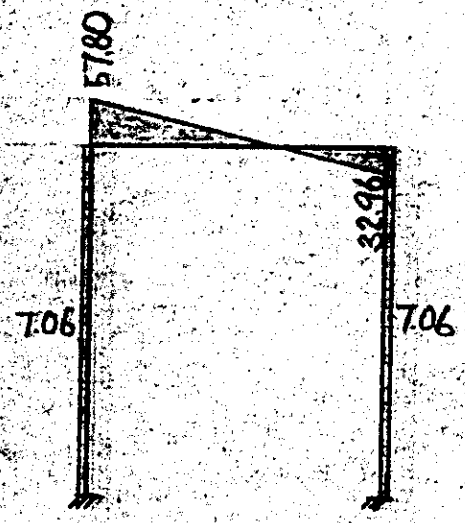
DIAGRAM OF FORCES

CASE 1

MOMENT DIAGRAM (UNIT: tm)

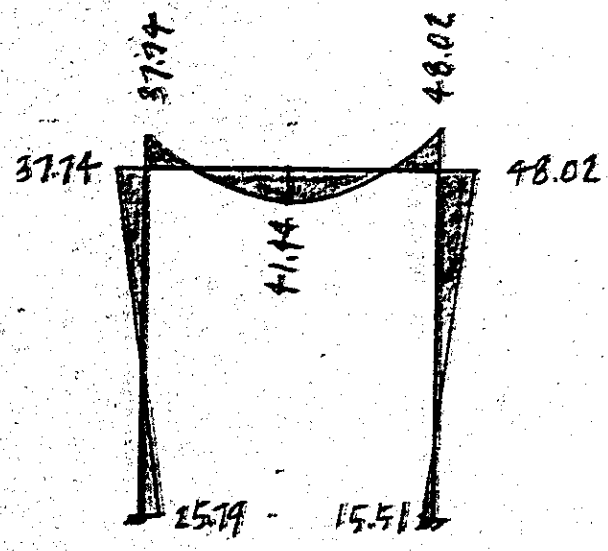


SHEAR DIAGRAM (UNIT: t)

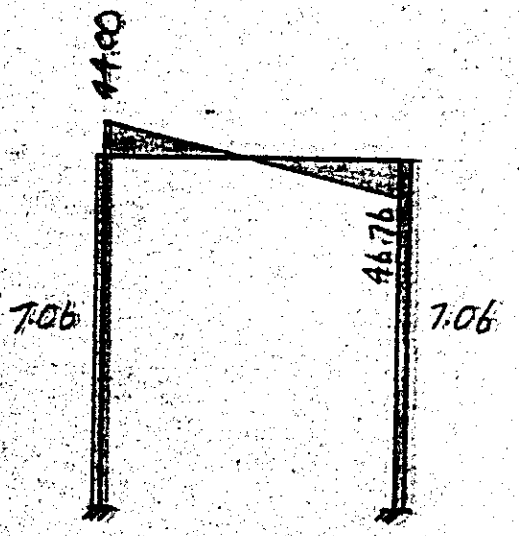


CASE 2

MOMENT DIAGRAM (UNIT: tm)

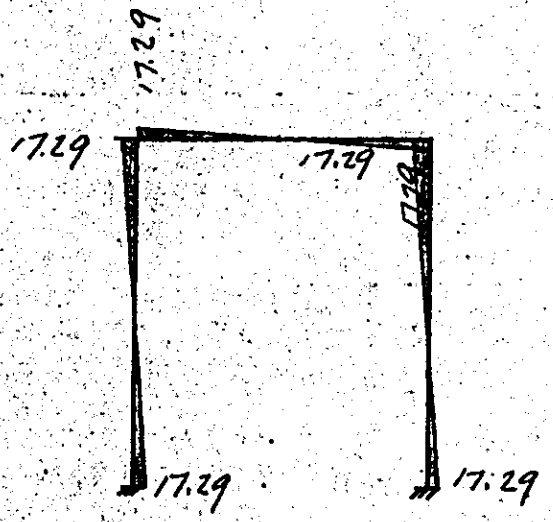


SHEAR DIAGRAM (UNIT: t)

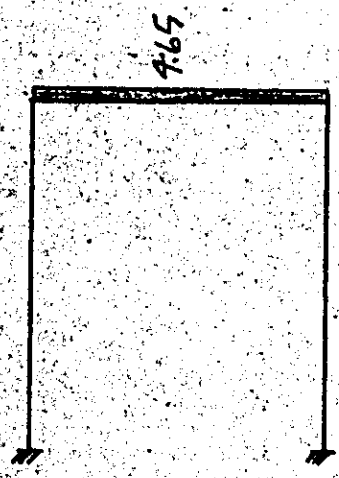


CASE 3

MOMENT DIAGRAM (UNIT: tm)

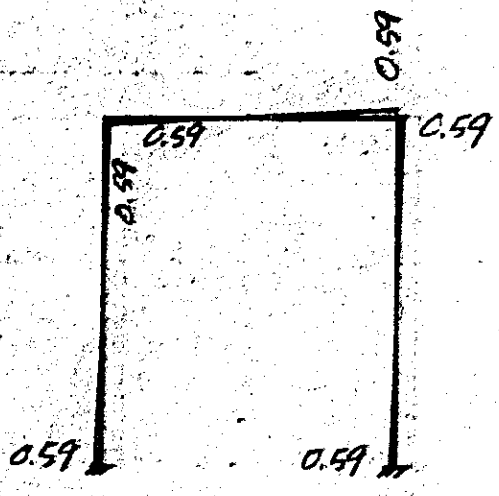


SHEAR DIAGRAM (UNIT: t)

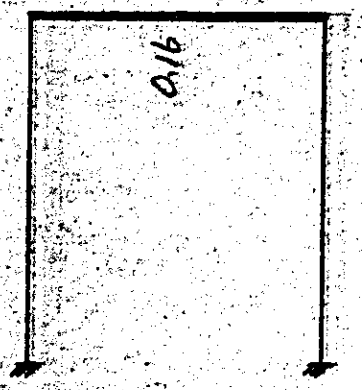


CASE 4

MOMENT DIAGRAM (UNIT: tm)

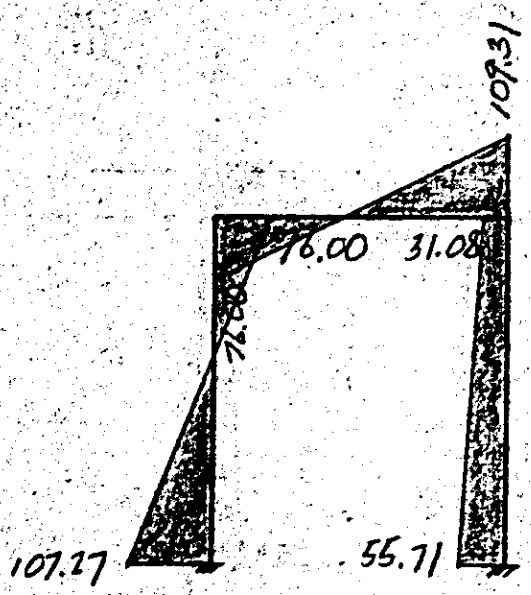


SHEAR DIAGRAM (UNIT: t)

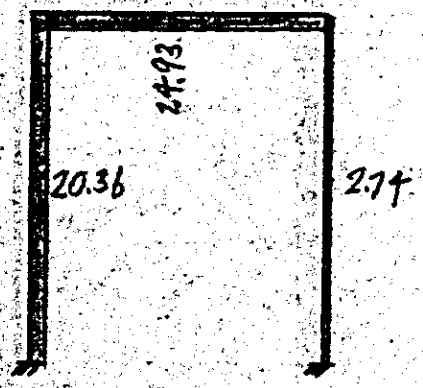


CASE 5

MOMENT DIAGRAM (UNIT: tm)

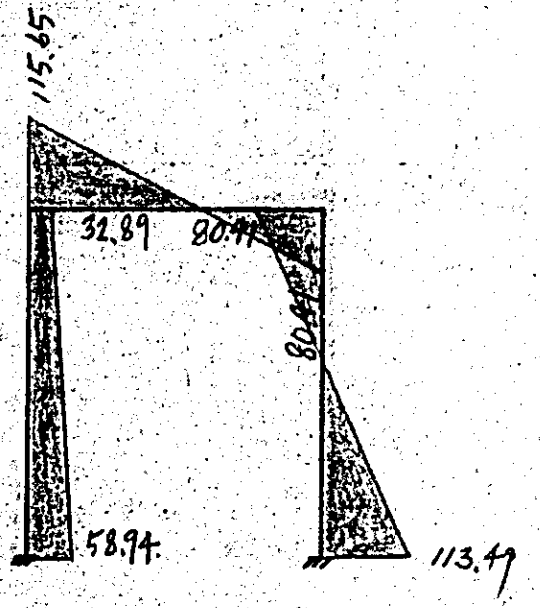


SHEAR DIAGRAM (UNIT: t)

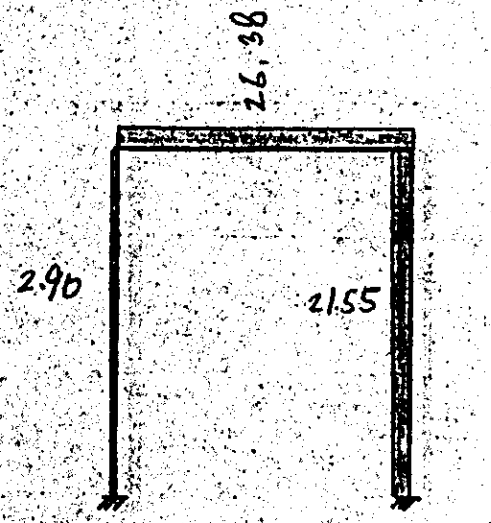


CASE 6

MOMENT DIAGRAM (UNIT: tm)

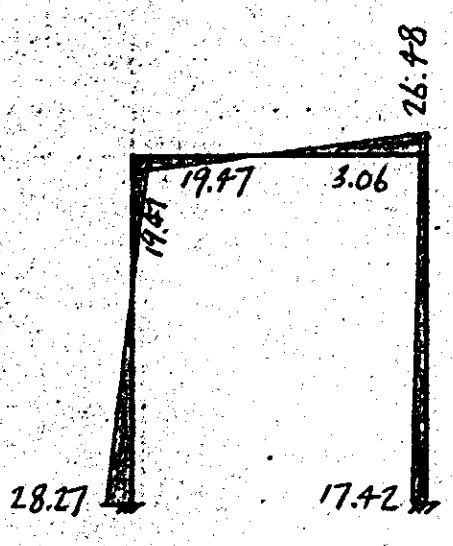


SHEAR DIAGRAM (UNIT: t)

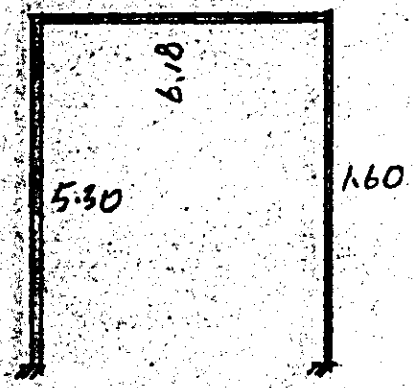


CASE 7

MOMENT DIAGRAM (UNIT: tm)

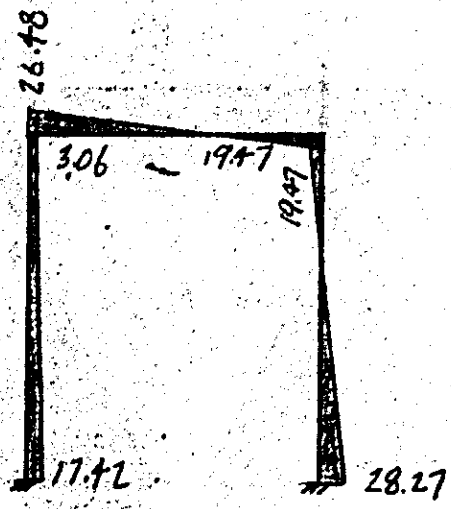


SHEAR DIAGRAM (UNIT: t)

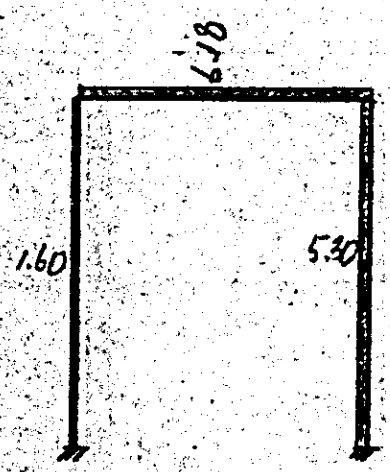


CASE 8

MOMENT DIAGRAM (UNIT: tm)

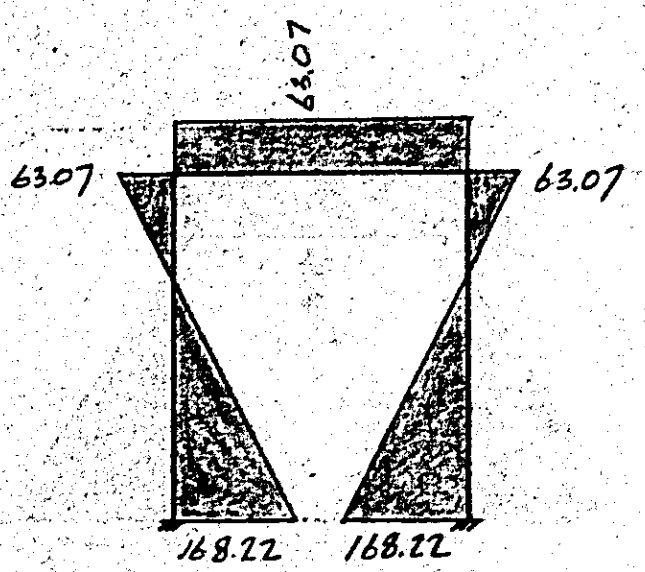


SHEAR DIAGRAM (UNIT: t)

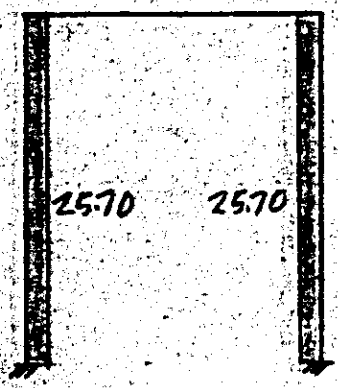


CASE 9

MOMENT DIAGRAM (UNIT: tm)

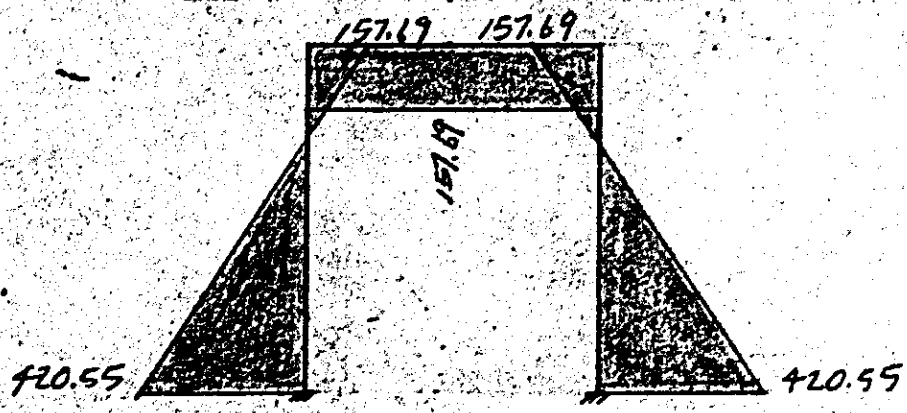


SHEAR DIAGRAM (UNIT: t)

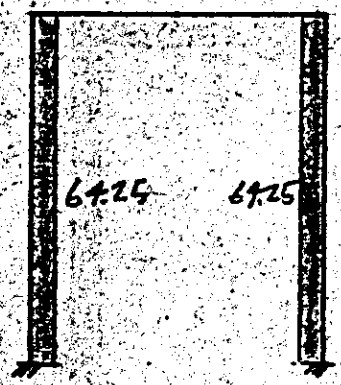


CASE 10

MOMENT DIAGRAM (UNIT: tm)

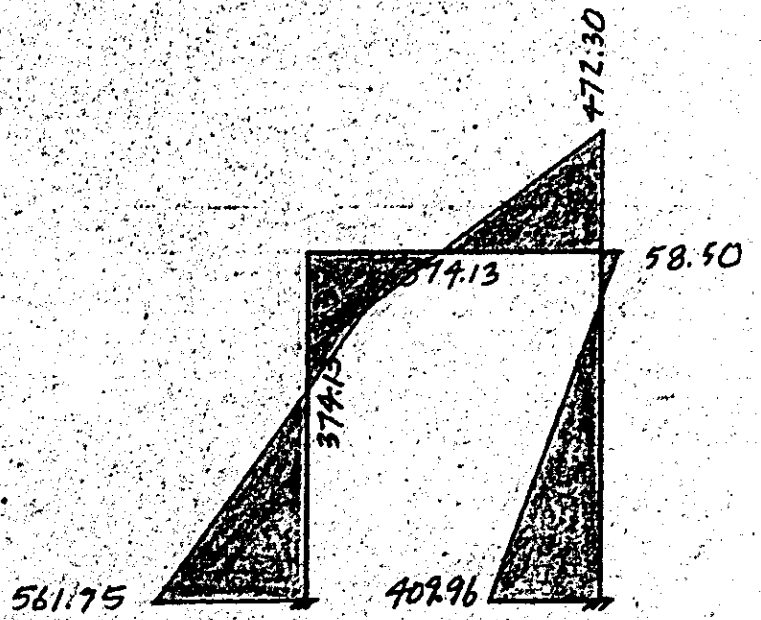


SHEAR DIAGRAM (UNIT: t)

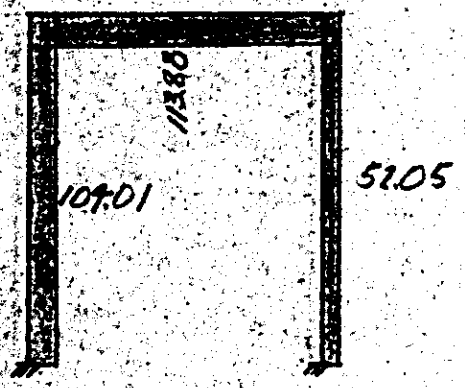


CASE 11

MOMENT DIAGRAM (UNIT: tm)

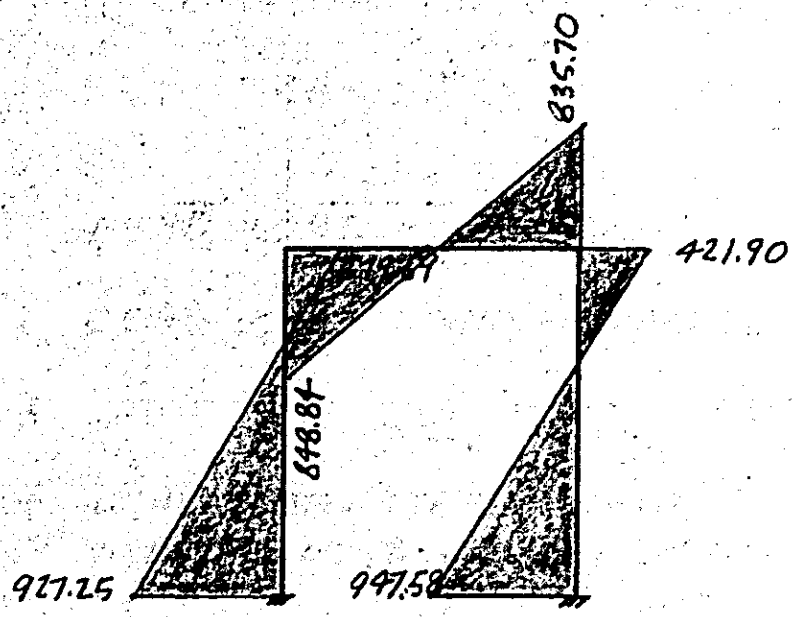


SHEAR DIAGRAM (UNIT: t)

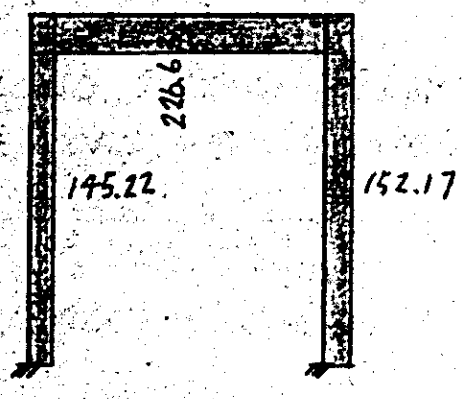


CASE 12

MOMENT DIAGRAM (UNIT:tm)



SHEAR DIAGRAM (UNIT:t)



5 CALCULATION ON STABILITY.

1. COMBINATION OF LOADS

1-1 TRANSVERSAL DIRECTION (Y-DIRECTION)

No.1	DEAD LOAD	(M.W.L)
No.2	DEAD LOAD + (TRAIN+IMPACT) LOAD	(M.W.L)
No.3	——— " ———	(H.W.L)
No.4	DEAD LOAD + (TRAIN + IMPACT) LOAD + BRAKE LOAD + TRAIN LATERAL LOAD	(M.W.L)
No.5	——— " ———	(H.W.L)
No.6	DEAD LOAD + EARTHQUAKE LOAD	(M.W.L)
No.7	DEAD LOAD	(M.W.L)
No.8	DEAD LOAD + (TRAIN+IMPACT) LOAD	(M.W.L)
No.9	——— " ———	(H.W.L)
No.10	DEAD LOAD + (TRAIN+IMPACT) LOAD + BRAKE LOAD + TRAIN LATERAL LOAD	(M.W.L)
No.11	——— " ———	(H.W.L)
No.12	DEAD LOAD + EARTHQUAKE LOAD	(M.W.L)

THE ABOVE LOADING COMBINATIONS ARE APPLIED NO.1 THRU No.6 FOR SINGLE-TRACK LOADING AND NO.7 THRU NO.12 FOR DOUBLE-TRACK LOADING.

1-2. LONGITUDINAL DIRECTION. (X-DIRECTION)

No.1. DEAD LOAD (M.W.L)

No.2. DEAD LOAD + (TRAIN + IMPACT) LOAD (M.W.L)

No.3. ——— " ——— (H.W.L)

No.4. DEAD LOAD + (TRAIN + IMPACT) LOAD
+ BRAKE LOAD + TRAIN LATERAL LOAD (M.W.L)

No.5. ——— " ——— (H.W.L)

No.6. DEAD LOAD + EARTHQUAKE LOAD (M.W.L)

ALL OF THE ABOVE LOADING COMBINATIONS ARE APPLIED FOR DOUBLE-TRACK LOADING.

2. TABLE OF FORCE AND MOMENT ACTING AT THE BOTTOM OF COLUMN IN TRANSVERSAL DIRECTION (Y-DIRECTION)

	CASE No.		③			④		
			M	H	N	M	H	N
1	1	D (M.W)	25.51	-7.06	246.19	66.81	7.06	1025.63
13	2	D+L+I (M.W)	42.80	-7.06	250.84	84.09	7.06	1322.20
"	3	D+L+I (H.W)	"	"	"	"	"	"
14	4	D+L+I+B+TL (M.W)	178.34	18.61	219.74	157.23	11.39	1353.36
"	5	D+L+I+B+TL (H.W)	"	"	"	"	"	"
19	6	D+E (M.W)	587.49	104.91	132.32	476.79	67.06	1139.56
2	7	D (M.W.)	-25.79	-7.06	1126.29	15.51	7.06	1039.43
20	8	D+L+I (M.W.)	-26.39	-7.06	1437.70	14.91	7.06	1340.81
"	9	D+L+I (H.W.)	"	"	"	"	"	"
22	10	D+L+I+B+TL (M.W)	-102.75	-11.55	1470.31	-126.86	-19.79	1308.31
"	11	D+L+I+B+TL (H.W)	"	"	"	"	"	"
30	12	D+E (M.W)	-953.09	-160.23	1352.98	-932.12	-153.06	812.84

3. TABLE OF FORCE AND MOMENT ACTING AT THE MID-POINT OF THE BOTTOM OF FOOTING IN LONGITUDINAL DIRECTION (X-DIRECTION)

CASE No.	AXIAL FORCE	MOMENT	HORIZONTAL FORCE
1	2646.72 + 446.95×3 + 351.63 = +339.20	(446.95 - 351.63) × 0.40 × sin 47°43'35" = 28.21	———
2	4339.20 + 311.57 + 301.22 = 4951.99	(164.16 + 153.81 - 147.41×2) × 0.40 × sin 47°43'35" + 28.21 = 35.06	———
3	4951.99 - 1180.27 = 3771.72	35.06	———
4	4951.99	464.31 + 97.06 + 35.06 = 596.43	26.87 + 6.27 = 33.14
5	3771.72	596.43	33.14
6	+339.20	472.20 + 2247.41 + 1653.25 + 28.21 = 4401.07	128.42 + 154.78 + 113.86 = 397.06

4. REACTION FORCE ACTING ON PILES

$$P = \frac{N}{n} \pm \frac{M}{I} \times Z$$

WHERE: P REACTION FORCE

n NUMBER OF PILES

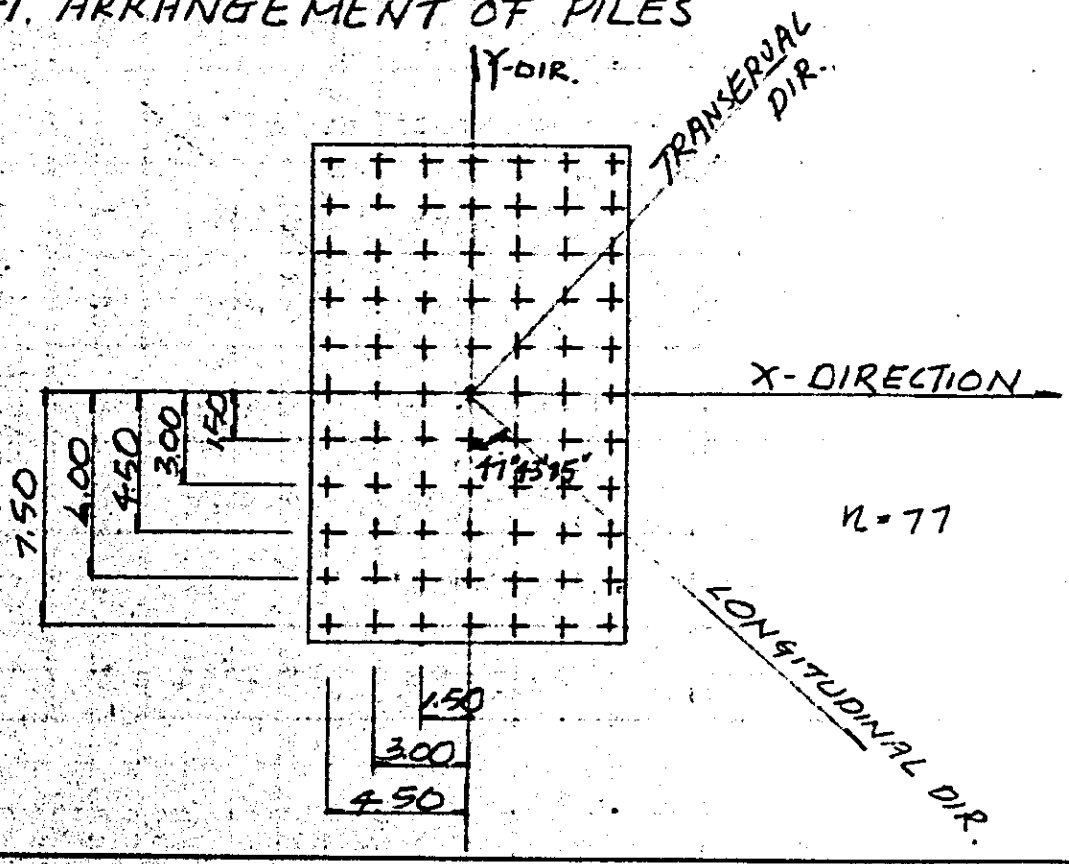
N AXIAL FORCE ACTING AT THE CENTER OF THE BOTTOM OF FOCTING

M MOMENT ACTING AT THE CENTER OF THE BOTTOM OF FOOTING

I MOMENT OF INERTIA OF THE GROUP OF PILES WITH RESPECT TO GEOMETRICAL CENTER

Z DISTANCE FROM THE GEOMETRICAL CENTER OF THE GROUP OF PILES TO THE CENTER OF THE PILE TO BE CALCULATED

4-1. ARRANGEMENT OF PILES



4-2. REACTION FORCE ACTING ON PILES DUE TO TRANSVERSAL LOAD (Y-DIRECTION)

REACTION FORCES ARE PICKED UP FROM THE ELECTRONIC COMPUTING DATA " DESIGN OF FOOTING."

	CASE No.	M_o (t·m)	N_o (t)	H_o (t)	P_{max} (t)	P_{min} (t)
SINGLE-TRACK	1	2991.85	3540.65	0	58.93	33.03
	2	4110.80	3841.87	0	67.70	32.09
	3	4111.72	2369.87	0	48.58	12.98
	4	4618.00	3841.87	30.00	69.89	29.90
	5	4618.99	2369.87	30.00	50.77	10.78
	6	5272.12	3540.71	253.07	68.81	23.16
DOUBLE-TRACK	7	332.59	4434.55	0	59.04	56.15
	8	373.50	5047.34	0	67.16	63.94
	9	351.03	3575.34	0	48.04	44.82
	10	903.49	5047.45	31.34	69.45	61.65
	11	901.01	3575.45	31.34	50.34	42.57
	12	4665.25	4434.65	394.39	77.79	37.39

4-3. REACTION FORCE ACTING ON PILES DUE TO LONGITUDINAL LOAD (X-DIRECTION)

CASE No.	N (t)	M (tm)	N/n (t)	M/I (t/m)	$x_{(m)}$	P_{max} (t)	P_{min} (t)
1	4339.20	28.21	56.35	0.041	x_1	56.53	56.17
					x_2	56.47	56.23
					x_3	56.41	56.29
2	4951.99	35.06	64.31	0.051	x_1	64.54	64.08
					x_2	64.46	64.16
					x_3	64.39	64.23
3	3771.72	35.06	48.98	0.051	x_1	49.21	48.76
					x_2	49.13	48.83
					x_3	49.06	48.90
4	4951.99	596.43	64.31	0.861	x_1	68.18	60.44
					x_2	66.89	61.73
					x_3	65.60	63.02
5	3771.72	596.43	48.98	0.861	x_1	52.85	45.11
					x_2	51.50	46.40
					x_3	50.27	47.69
6	4339.20	4401.07	56.35	6.351	x_1	84.93	27.77
					x_2	75.40	37.30
					x_3	65.88	46.82

$$I = (1.50^2 + 3.00^2 + 4.50^2) \times 11 \times 2 = 693.00 \ m^2$$

$x_1 = 4.50$ m

$x_2 = 3.00$ "

$x_3 = 1.50$

DESIGN OF FOOTING (SINGLE-TRACK) PAGE

** INPUT DATA **

1) KIHON DATA

HASHIRA HONSU= 2 (HON) KUI RETSUSU= 11 (RETSU) CASE SU= 6 (CASE)

NA= 1.000 (T) GANMA 1= 2.500 (T/M**3) GANMA 2= 1.800 (T/M**3)

2) FOOTING SUNPOU (M)

L1= 2.680 L2= 10.640 L3= 2.680

B1= 3.400 B2= 3.200 B3= 3.400

H1= 1.800 H2= .400 H3= 5.000

3) HASHIRA KYORI OYOBI DANMENSUNPOU (M)

HASHIRA NO.	CL	A	B	HASHIRA NO.	CL	A	B
1	4.280	1.330	1.330	2	11.720	1.330	1.330

4) KUI KYORI OYOBI HONSU (M) (HON)

KUI RETSU NO.	KL	NN	KUI RETSU NO.	KL	NN
1	.500	7	7	9.500	7
2	2.000	7	8	11.000	7
3	3.500	7	9	12.500	7
4	5.000	7	10	14.000	7
5	6.500	7	11	15.500	7
6	8.000	7			

DESIGN OF FOOTING (SINGLE-TRACK) PAGE

5) CASE DATA KH,ALPHA,BETA,HW HASHIRA KATAN NO ORYOKU (M) (TM) (T)

CASE 1 KH= 0.000 ALPHA= 1.0000 BETA= 1.000000 HW= 0.000 * D *

(M.W.)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	25.510	246.190	-7.060	2	66.810	1025.630	7.060

CASE 2 KH= 0.000 ALPHA= 1.0000 BETA= 1.000000 HW= 0.000 *D+L+I *

(M.W.)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	42.800	250.840	-7.060	2	84.090	1322.200	7.060

CASE 3 KH= 0.000 ALPHA= 1.0000 BETA= 1.000000 HW= 9.200 * D+L+I *

(H.W.)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	42.800	250.840	-7.060	2	84.090	1322.200	7.060

CASE 4 KH= 0.000 ALPHA= 1.1500 BETA= 1.000000 HW= 0.000 * D+L+I+B+LI *

(M.W.)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	178.340	219.740	18.610	2	157.230	1353.360	11.390

CASE 5 KH= 0.000 ALPHA= 1.1500 BETA= 1.000000 HW= 9.200 * D+L+I+B+TL *

(H.W.)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	178.340	219.740	18.610	2	157.230	1353.360	11.390

CASE 6 KH= .100 ALPHA= 1.5000 BETA= 1.000000 HW= 0.000 * D+E *

(M.W.)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	567.490	132.320	104.910	2	476.790	1139.560	67.060

DESIGN OF FOOTING (SINGLE-TRACK) PAGE

* CASE 1- 1 * (JYOUJI) NO 1 * D * (M.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TM) (T)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	25.510	246.190	-7.060	2	66.810	1025.630	7.060

2) FOOTING KAMEN ORYOKU (TM) (T) (M)

HO= 31317.006 NO= 3540.646 HO= 0.000 EO= 8.845 E= .845

M = 3540.646×0.845 = 2991.85

3) FOOTING JIJU OYOBI JUSINDAKASA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77 SIG KN= 77 PH = 0.000 KL = 8.000 I= 1732.500 KE = .845

P 1= 33.031 P 2= 35.621 P 3= 38.211 P 4= 40.802 P 5= 43.392 P 6= 45.982

P 7= 48.573 P 8= 51.163 P 9= 53.753 P10= 56.344 P11= 58.934

DESIGN OF FOOTING (SINGLE-TRACK) PAGE

* CASE 1- 1 * (JYOUJI) NO 1 * D * (M.W.) (DELTA N NASI)

5) FOOTING KAKUTEN MOMENT OYOBI SENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	SENDAN	M/ALPHA	S/ALPHA
.500	-17.789	-71.186	-17.789	-71.186
	-17.789	160.029	-17.789	160.029
2.000	61.503	-54.564	61.503	-54.564
	61.503	194.784	61.503	194.784
3.500	191.828	-21.129	191.828	-21.129
	191.828	246.351	191.828	246.351
3.615*	219.206	229.785	219.206	229.785
4.280**	342.809	141.953	342.809	141.953
	360.103	-104.237	360.103	-104.237
4.945*	261.582	-192.068	261.582	-192.068
5.000	250.800	-199.991	250.800	-199.991
	250.800	85.621	250.800	85.621
6.500	217.178	-130.451	217.178	-130.451
	217.178	173.294	217.178	173.294
8.000)	315.065	-42.779	315.065	-42.779
	315.065	279.098	315.065	279.098
9.500	571.658	63.026	571.658	63.026
	571.658	403.036	571.658	403.036
11.000	1014.158	186.964	1014.158	186.964
	1014.158	545.105	1014.158	545.105
11.055*	1043.922	537.183	1043.922	537.183
11.720**	1371.942	449.351	1371.942	449.351
	1446.968	-576.279	1446.968	-576.279
12.385*	1034.539	-664.111	1034.539	-664.111
12.500	957.215	-680.677	957.215	-680.677
	957.215	-304.403	957.215	-304.403
14.000	338.592	-520.315	338.592	-520.315
	338.592	-125.909	338.592	-125.909
15.500	-11.410	-340.502	-11.410	-340.502
	-11.410	72.037	-11.410	72.037

1446.968 × 1.9/1.4 = 1810.19 tm

DESIGN OF FOOTING (SINGLE-TRACK) PAGE 1

* CASE 2- 1 * (JYOUJI) NO 2 *D+L+I * (H.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TH) (T)

HASHIRA NO.	H	N	H	HASHIRA NO.	H	N	H
1	42.800	250.840	-7.060	2	84.090	1322.200	7.060

2) FOOTING KAHEN ORYOKU (TH) (T) (M)

MO= 34847.277 NO= 3841.866 HO= 0.000 EO= 9.070 E= 1.070

M= 3841.866×1.070 = 4110.80

3) FOOTING JIJU OYOBI JUBINDAKASA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77 SIG KN= 77 PH = 0.000 KL = 8.000 I= 1732.500 KE = 1.070

P 1= 32.092 P 2= 35.652 P 3= 39.213 P 4= 42.773 P 5= 46.334 P 6= 49.894

P 7= 53.455 P 8= 57.015 P 9= 60.576 P10= 64.136 P11= 67.697

* CASE 2- 1 * (JYOUJI) NO 2 *D+L+I * (M.N.) (DELTA N NASI)

5) FOOTING KAKUTEN MOMENT OYOBI SENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	SENDAN	M/ALPHA	S/ALPHA
.500	-17.789	-71.186	-17.789	-71.186
	-17.789	153.458	-17.789	153.458
2.000	51.646	-61.135	51.646	-61.135
	51.646	188.432	51.646	188.432
3.500	172.443	-27.481	172.443	-27.481
	172.443	247.010	172.443	247.010
3.615*	199.897	230.444	199.897	230.444
4.280**	323.939	142.612	323.939	142.612
	356.523	-108.228	356.523	-108.228
4.945*	257.348	-196.059	257.348	-196.059
5.000	246.347	-203.982	246.347	-203.982
	246.347	95.432	246.347	95.432
6.500	227.440	-120.640	227.440	-120.640
	227.440	203.697	227.440	203.697
8.000)	370.932	-12.375	370.932	-12.375
	370.932	336.886	370.932	336.886
9.500	714.207	120.814	714.207	120.814
	714.207	494.997	714.207	494.997
11.000	1294.647	278.926	1294.647	278.926
	1294.647	678.033	1294.647	678.033
11.055*	1331.724	670.110	1331.724	670.110
11.720**	1748.141	582.278	1748.141	582.278
	1840.446	-739.922	1840.446	-739.922
12.385*	1319.195	-827.754	1319.195	-827.754
12.500	1223.053	-844.319	1223.053	-844.319
	1223.053	-420.289	1223.053	-420.289
14.000	430.601	-636.201	430.601	-636.201
	430.601	-187.247	430.601	-187.247
15.500	-11.406	-401.840	-11.406	-401.840
	-11.406	72.037	-11.406	72.037

DESIGN OF FOOTING (SINGLE-TRACK) PAGE

* CASE 3-1 * (JYOUJI) NO 3 * D+L+I * (H.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TM) (T)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	42.800	250.840	-7.060	2	84.090	1322.200	7.060

2) FOOTING KAMEN ORYOKU (TM) (T) (M)

MO= 23071.275 NO= 2369.866 HO= 0.000 EO= 9.735 E= 1.735

M= 2369.866 × 1.735 = 4111.72

3) FOOTING JIJU OYOBI JUSINDAKASA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77 SIG KN= 77 PH = 0.000 KL = 8.000 I= 1732.500 KE = 1.735

P 1= 12.975 P 2= 16.536 P 3= 20.096 P 4= 23.657 P 5= 27.217 P 6= 30.777

P 7= 34.338 P 8= 37.898 P 9= 41.459 P10= 45.019 P11= 48.580

* CASE 3- 1 * (JYOUJI .) NO 3 * D+L+I * (H.W.) (DELTA N NASI)

5) FOOTING KAKUTEN MOMENT OYOBI SENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	SENDAN	M/ALPHA	S/ALPHA
.500	-6.289	-25.186	-6.289	-25.186
	-6.289	65.640	-6.289	65.640
2.000	34.919	-10.953	34.919	-10.953
	34.919	104.796	34.919	104.796
3.500	133.762	26.883	133.762	26.883
	133.762	167.556	133.762	167.556
3.615*	152.687	161.570	152.687	161.570
4.280**	251.269	134.918	251.269	134.918
	285.853	-115.922	285.853	-115.922
4.945*	199.904	-142.574	199.904	-142.574
5.000	191.983	-145.436	191.983	-145.436
	191.983	20.159	191.983	20.159
6.500	163.668	-57.913	163.668	-57.913
	163.668	132.606	163.668	132.606
8.000	304.024	54.534	304.024	54.534
	304.024	269.977	304.024	269.977
9.500	650.436	191.905	650.436	191.905
	650.436	432.270	650.436	432.270
11.000	1240.287	354.198	1240.287	354.198
	1240.287	619.487	1240.287	619.487
11.055*	1274.280	616.625	1274.280	616.625
11.720**	1675.473	589.973	1675.473	589.973
	1767.779	-732.227	1767.779	-732.227
12.385*	1271.986	-758.879	1271.986	-758.879
12.500	1184.372	-764.865	1184.372	-764.865
	1184.372	-474.652	1184.372	-474.652
14.000	413.874	-552.565	413.874	-552.565
	413.874	-237.429	413.874	-237.429
15.500	.093	-314.022	.093	-314.022
	.093	26.037	.093	26.037

DESIGN OF FOOTING (SINGLE-TRACK) PAGE

* CASE 4- 1 * (JYOUJI) NO 4 * D+L+I+B+LI * (M.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TM) (T)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	178.340	219.740	18.610	2	157.230	1353.360	11.390

2) FOOTING KAMEN ORYOKU (TM) (T) (M)

MO= 35354.043 NO= 3841.926 HO= 30.000 EO= 9.202 E= 1.202

3) FOOTING JIJU OYOBI JUSINDAKABA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77 SIG KN= 77 PH = .390 NL = 8.000 I= 1732.500 NE = 1.202

P 1= 29.901 P 2= 33.900 P 3= 37.899 P 4= 41.898 P 5= 45.896 P 6= 49.895

P 7= 53.894 P 8= 57.893 P 9= 61.892 P10= 65.890 P11= 69.889

* CASE 4- 1 * (JYOUJI) NO 4 * D+L+I+R+LI * (M.W.) (DELTA N NASI)

5) FOOTING KAKUTEN MOMENT OYOBI BENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	BENDAN	M/ALPHA	S/ALPHA
.500	-17.789	-71.186	-15.469	-61.901
	-14.963	138.121	-13.011	120.105
2.000	31.468	-76.472	27.363	-66.497
	34.294	160.827	29.821	139.850
3.500	113.684	-55.085	98.856	-47.900
	116.510	210.206	101.313	182.787
3.615*	139.732	193.640	121.506	168.383
4.280**	239.298	105.808	208.085	92.007
	439.294	-113.932	381.995	-99.071
4.945*	334.326	-201.764	290.718	-175.447
5.000	323.011	-209.686	280.879	-182.336
	325.837	83.596	283.337	72.692
6.500	289.177	-132.476	251.458	-115.196
	292.003	188.799	253.916	164.173
8.000)	413.147	-27.274	359.259	-23.716
	415.974	321.992	361.716	279.993
9.500	736.908	105.920	640.790	92.105
	739.734	483.178	643.247	420.155
11.000	1302.447	267.106	1132.563	232.266
	1305.273	672.356	1135.020	584.657
11.055*	1342.036	664.433	1166.988	577.768
11.720**	1754.680	576.601	1525.808	501.392
	1925.164	-776.759	1674.056	-675.442
12.385*	1379.414	-864.591	1199.490	-751.818
12.500	1279.035	-881.156	1112.204	-766.223
	1281.861	-447.915	1114.662	-389.491
14.000	447.967	-663.828	389.536	-577.241
	450.793	-202.595	391.994	-176.169
15.500	-14.232	-417.187	-12.376	-362.772
	-11.406	72.037	-9.918	62.641

DESIGN OF FOOTING (SINGLE-TRACK) PAGE 1

* CASE 5- 1 * (JYOUJI) NO 5 * D+L+I+B+TL * (H.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TH) (T)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	178.340	219.740	18.610	2	157.230	1353.360	11.390

2) FOOTING KAMEN ORYOKU (TH) (T) (M)

HO= 23578.043 NO= 2369.926 HO= 30.000 EO= 9.949 E= 1.949

3) FOOTING JIJU OYOBI JUSINDAKASA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77 SIG KN= 77 PH = .390 KL = 8.000 I= 1732.500 KE = 1.949

P 1= 10.784 P 2= 14.783 P 3= 18.782 P 4= 22.781 P 5= 26.779 P 6= 30.778

P 7= 34.777 P 8= 38.776 P 9= 42.775 P10= 46.774 P11= 50.772

DESIGN OF FOOTING (SINGLE-TRACK) PAGE

* CASE 5- 1 * (JYOUJI) NO 5 * D+L+I+B+TL * (H.W.) (DELTA N NASI)

5) FOOTING KAKUTEN MOMENT OYOBI SENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	SENDAN	M/ALPHA	S/ALPHA
.500	-6.289	-25.186	-5.469	-21.901
	-3.463	50.303	-3.011	43.742
2.000	14.741	-26.290	12.818	-22.861
	17.567	77.191	15.276	67.123
3.500	75.002	-.722	65.219	-.628
	77.828	130.751	67.677	113.696
3.615*	92.521	124.765	80.453	108.492
4.280**	166.628	98.113	144.894	85.316
	366.624	-121.627	318.804	-105.762
4.945*	276.881	-148.278	240.766	-128.938
5.000	268.647	-151.141	233.606	-131.427
	271.473	8.323	236.064	7.238
6.500	225.404	-69.749	196.003	-60.651
	228.230	117.707	198.461	102.354
8.000)	346.238	39.635	301.076	34.465
	349.064	255.083	303.534	221.811
9.500	673.135	177.011	585.335	153.923
	675.961	420.451	587.792	365.609
11.000	1248.083	-342.379	1085.290	297.721
	1250.910	613.810	1087.748	533.748
11.055*	1284.591	610.947	1117.036	531.258
11.720**	1682.008	584.295	1462.615	508.083
	1852.492	-769.065	1610.863	-668.752
12.385*	1332.202	-795.716	1158.437	-691.927
12.500	1240.352	-801.702	1078.567	-697.132
	1243.178	-502.279	1081.025	-436.764
14.000	431.241	-580.192	374.992	-504.514
	434.067	-252.777	377.450	-219.806
15.500	-2.735	-329.370	-2.379	-286.408
	.091	26.037	.079	22.641

DESIGN OF FOOTING (SINGLE-TRACK) PAGE

* CASE 6- 1 * (JISHINJI--->) NO 6 * D+E * (M.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TM) (T)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	587.490	132.320	104.910	2	476.790	1139.560	67.060

2) FOOTING KAHEN ORYOKU (TM) (T) (M)

MO= 33597.875 NO= 3540.706 HO= 253.065 EO= 9.489 E= 1.489

3) FOOTING JIJU OYOBI JUSINDAKASA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77 SIG KN= 77 PH = 3.287 KL = 8.000 I= 1732.500 KE = 1.489

P 1= 23.160 P 2= 27.724 P 3= 32.289 P 4= 36.854 P 5= 41.418 P 6= 45.983

P 7= 50.548 P 8= 55.113 P 9= 59.677 P10= 64.242 P11= 68.807

DESIGN OF FOOTING (SINGLE-TRACK) PAGE

* CASE 6- 1 * (JISHINJI--->) NO 6 * D+E * (H.W.) (DELTA N NASI)

5) FOOTING KAKUTEN MOMENT OYOBI SENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	SENDAN	M/ALPHA	S/ALPHA
.500	-17.789	-71.186	-11.860	-47.457
	6.052	90.932	4.035	60.621
2.000	-18.301	-123.661	-12.201	-82.441
	5.540	70.410	3.693	46.940
3.500	-50.697	-145.503	-33.798	-97.002
	-26.856	80.521	-17.904	53.680
3.615*	-18.548	63.955	-12.366	42.637
4.280**	-5.222	-23.877	-3.482	-15.918
	704.351	-156.197	469.567	-104.131
4.945*	571.276	-244.029	380.851	-162.686
5.000	557.637	-251.951	371.758	-167.967
	581.478	6.025	387.652	4.017
6.500	428.461	-210.047	285.641	-140.031
	452.302	79.883	301.535	53.255
8.000)	410.073	-136.189	273.382	-90.793
	433.915	185.693	289.276	123.795
9.500	550.400	-30.379	366.933	-20.253
	574.241	323.457	382.827	215.638
11.000	897.371	107.385	598.247	71.590
	921.212	493.173	614.141	328.782
11.055*	948.120	485.250	632.080	323.500
11.720**	1241.606	397.418	827.738	264.945
	1796.434	-742.142	1197.622	-494.761
12.385*	1273.707	-829.974	849.138	-553.316
12.500	1177.306	-846.539	784.870	-564.360
	1201.146	-428.798	800.764	-285.866
14.000	395.931	-644.711	263.954	-429.807
	419.771	-195.017	279.848	-130.011
15.500	-33.889	-409.610	-22.592	-273.073
	-10.047	72.037	-6.698	48.025

DESIGN OF FOOTING (DOUBLE-TRACK) PAGE

** INPUT DATA **

1) KIHON DATA

HASHIRA HONSU= 2 (HON) KUI RETSUSU= 11 (RETSU) CASE SU= 6 (CASE)

NA= 1.000 (T) GANMA 1= 2.500 (T/M**3) GANMA 2= 1.800 (T/M**3)

2) FOOTING SUNPOU (M)

L1= 2.680 L2= 10.640 L3= 2.680

B1= 3.400 B2= 3.200 B3= 3.400

H1= 1.800 H2= .400 H3= 5.000

3) HASHIRA KYORI OYOBI DANMENSUNPOU (M)

HASHIRA NO.	CL	A	B	HASHIRA NO.	CL	A	B
1	4.280	1.330	1.330	2	11.720	1.330	1.330

4) KUI KYORI OYOBI HONSU (M) (HON)

KUI RETSU NO.	KL	NN	KUI RETSU NO.	KL	NN
1	.500	7	7	9.500	7
2	2.000	7	8	11.000	7
3	3.500	7	9	12.500	7
4	5.000	7	10	14.000	7
5	6.500	7	11	15.500	7
6	8.000	7			

DESIGN OF FOOTING (DOUBLE-TRACK) PAGE

5) CASE DATA KH,ALPHA,BETA,HW HASHIRA KATAN NO ORYOKU (M) (TM) (T)

CASE 1 KH= 0.000 ALPHA= 1.0000 BETA= 1.000000 HW= 0.000 * D *

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-25.790	1126.290	-7.060	2	15.510	1039.430	7.060

CASE 2 KH= 0.000 ALPHA= 1.0000 BETA= 1.000000 HW= 0.000 * D+L+I *

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-26.390	1437.700	7.060	2	14.910	1340.810	-7.060

CASE 3 KH= 0.000 ALPHA= 1.0000 BETA= 1.000000 HW= 9.200 * D+L+I *

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-26.390	1437.700	7.060	2	14.910	1340.810	-7.060

CASE 4 KH= 0.000 ALPHA= 1.1500 BETA= 1.000000 HW= 0.000 * D+L+I+B+TL *

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-102.750	1470.310	-11.550	2	-126.860	1308.310	-19.790

CASE 5 KH= 0.000 ALPHA= 1.1500 BETA= 1.000000 HW= 9.200 * D+L+I+B+TL *

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-102.750	1470.310	-11.550	2	-126.860	1308.310	-19.790

CASE 6 KH= -.100 ALPHA= 1.5000 BETA= 1.000000 HW= 0.000 * D+E *

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-953.090	1352.980	-160.230	2	-932.120	812.840	-153.060

DESIGN OF FOOTING (DOUBLE-TRACK)

* CASE 1-1 * (JYOUJI) NO 1 * D * (M.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TH) (T)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-25.790	1126.290	-7.060	2	15.510	1039.430	7.060

2) FOOTING KAMEN ORYOKU (TH) (T) (M)

HO= 35142.969 NO= 4434.546 HO= 0.000 EO= 7.925 E= -.075

M=4434.546-0.075 = 332.59 tm

3) FOOTING JIJU OYOBI JUSINDAKASA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77 SIG KN= 77 PH = 0.000 KL = 8.000 I= 1732.500 KE = -.075

P 1= 59.035 P 2= 58.746 P 3= 58.457 P 4= 58.169 P 5= 57.880 P 6= 57.592

P 7= 57.303 P 8= 57.014 P 9= 56.726 P10= 56.437 P11= 56.148

CASE 1- 1 * (JYOUJI) NO 1 * D * (M.N.) (DELTA N NASI)

5) FOOTING KAKUTEN MOMENT OYOBI BENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	BENDAN	M/ALPHA	B/ALPHA
.500	-17,789	-71.186	-17,789	-71.186
	-17.789	342.057	-17.789	342.057
2,000	334.546	127.464	334.546	127.464
	334.546	538.687	334.546	538.687
3,500	980.726	322.775	980.726	322.775
	980.726	731.977	980.726	731.977
3.615*	1063.951	715.411	1063.951	715.411
4.280**	1510.495	627.580	1510.495	627.580
	1476.490	-498.710	1476.490	-498.710
4.945*	1115.643	-586.542	1115.643	-586.542
5.000	1083.166	-594.465	1083.166	-594.465
	1083.166	-187.283	1083.166	-187.283
6.500	640.186	-403.355	640.186	-403.355
	640.186	1.806	640.186	1.806
8.000)	480.842	-214.266	480.842	-214.266
	480.842	188.874	480.842	188.874
9.500	602.100	-27.198	602.100	-27.198
	602.100	373.922	602.100	373.922
11.000	1000.929	157.850	1000.929	157.850
	1000.929	556.950	1000.929	556.950
11.055*	1031.344	549.027	1031.344	549.027
11.720**	1367.242	461.195	1367.242	461.195
	1390.968	-578.235	1390.968	-578.235
12.385*	977.235	-666.067	977.235	-666.067
12.500	899.687	-682.632	899.687	-682.632
	899.687	-285.353	899.687	-285.353
14.000	309.341	-501.466	309.341	-501.466
	309.341	-106.408	309.341	-106.408
15.500	-11.410	-321.001	-11.410	-321.001
	-11.410	72.037	-11.410	72.037

1510.495 $\frac{1.8}{1.4}$ = 1942.07

DESIGN OF FOOTING (DOUBLE-TRACK) PAGE

* CASE 2- 1 * (JYOUJI) NO 2 * D+L+I * (H.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TM) (T)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-26.390	1437.700	7.060	2	14.910	1340.810	-7.060

2) FOOTING KAMEN ORYOKU (TM) (T) (M)

MO= 40006.777 NO= 5047.336 HO= 0.000 EO= 7.926 E= -.074

M= 5047.336 × 0.074 = 373.50 tm

3) FOOTING JIJU OYOBI JUSINDAKASA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77	SIG KN= 77	PH = 0.000	KL = 8.000	I= 1732.500	KE = -.074	
P 1= 67.160	P 2= 66.838	P 3= 66.516	P 4= 66.194	P 5= 65.872	P 6= 65.550	
P 7= 65.228	P 8= 64.906	P 9= 64.584	P10= 64.262	P11= 63.940		

* CASE 2- 1 * (JYOUJI) NO 2 * D+L+I * (M.W.) (DELTA N NASI)

5) FOOTING KAKUTEN MOMENT OYOBI SENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	SENDAN	M/ALPHA	S/ALPHA
.500	-17.789	-71.186	-17.789	-71.186
	-17.789	398.932	-17.789	398.932
2.000	419.859	184.340	419.859	184.340
	419.859	652.204	419.859	652.204
3.500	1236.314	436.292	1236.314	436.292
	1236.314	901.902	1236.314	901.902
3.615*	1339.081	885.337	1339.081	885.337
4.280**	1898.625	797.505	1898.625	797.505
	1880.451	-640.195	1880.451	-640.195
4.945*	1425.518	-728.027	1425.518	-728.027
5.000	1385.258	-735.950	1385.258	-735.950
	1385.258	-272.593	1385.258	-272.593
6.500	814.315	-488.665	814.315	-488.665
	814.315	-27.562	814.315	-27.562
8.000	610.918	-243.634	610.918	-243.634
	610.918	215.214	610.918	215.214
9.500	771.687	-.858	771.687	-.858
	771.687	455.737	771.687	455.737
11.000	1293.238	239.665	1293.238	239.665
	1293.238	694.006	1293.238	694.006
11.055*	1331.192	686.083	1331.192	686.083
11.720**	1758.233	598.252	1758.233	598.252
	1764.928	-742.558	1764.928	-742.558
12.385*	1241.920	-830.390	1241.920	-830.390
12.500	1145.478	-846.956	1145.478	-846.956
	1145.478	-394.869	1145.478	-394.869
14.000	391.151	-610.782	391.151	-610.782
	391.151	-160.949	391.151	-160.949
15.500	-11.402	-375.541	-11.402	-375.541
	-11.402	72.038	-11.402	72.038

DESIGN OF FOOTING (DOUBLE-TRACK) PAGE

* CASE 3- 1 * (JYOUJI) NO 3 * D+L+I * (H.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TM) (T)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-26.390	1437.700	7.060	2	14.910	1340.810	-7.060

2) FOOTING KAMEN ORYOKU (TM) (T) (M)

HO= 28230.777 NO= 3575.336 HO= 0.000 EO= 7.896 E= -.104

M= 3575.336 x 0.104 = 357.03

3) FOOTING JIJU OYOBI JUSINDAKASA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77 SIG KN= 77 PH = 0.000 KL = 8.000 I= 1732.500 KE = -.104

P 1= 48.043 P 2= 47.721 P 3= 47.399 P 4= 47.077 P 5= 46.755 P 6= 46.433

P 7= 46.111 P 8= 45.789 P 9= 45.467 P10= 45.145 P11= 44.823

DESIGN OF FOOTING (DOUBLE-TRACK) PAGE

* CASE 3- 1 * (JYOUJI) NO 3 * D+L+I * (H.W.) (DELTA N NASI)

5) FOOTING KAKUTEN MOMENT OYOBI SENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	SENDAN	M/ALPHA	S/ALPHA
.500	-6.289	-25.186	-6.289	-25.186
	-6.289	311.114	-6.289	311.114
2.000	403.131	234.521	403.131	234.521
	403.131	568.568	403.131	568.568
3.500	1197.632	490.655	1197.632	490.655
	1197.632	822.448	1197.632	822.448
3.615*	1291.870	816.462	1291.870	816.462
4.280**	1825.956	789.810	1825.956	789.810
	1807.781	-647.890	1807.781	-647.890
4.945*	1368.073	-674.541	1368.073	-674.541
5.000	1330.895	-677.404	1330.895	-677.404
	1330.895	-347.865	1330.895	-347.865
6.500	750.542	-425.937	750.542	-425.937
	750.542	-98.653	750.542	-98.653
8.000)	544.010	-176.725	544.010	-176.725
	544.010	148.306	544.010	148.306
9.500	707.915	70.234	707.915	70.234
	707.915	393.010	707.915	393.010
11.000	1238.875	314.938	1238.875	314.938
	1238.875	635.461	1238.875	635.461
11.055*	1273.749	632.598	1273.749	632.598
11.720**	1685.564	605.946	1685.564	605.946
	1692.259	-734.864	1692.259	-734.864
12.385*	1194.710	-761.516	1194.710	-761.516
12.500	1106.792	-767.501	1106.792	-767.501
	1106.792	-449.233	1106.792	-449.233
14.000	374.423	-527.146	374.423	-527.146
	374.423	-211.131	374.423	-211.131
15.500	.090	-287.724	.090	-287.724
	.090	26.037	.090	26.037

DESIGN OF FOOTING (DOUBLE-TRACK) PAGE

* CASE 4- 1 * (JYOUJI) NO 4 * D+L+I+B+TL * (M.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TM) (T)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-102.750	1470.310	-11.550	2	-126.860	1308.310	-19.790

2) FOOTING KAMEN ORYOKU (TM) (T) (M)

MO= 39478.371 NO= 5047.446 HO= -31.340 EO= 7.821 E= -.179

M= 5047.446×0.179 = 903.49

3) FOOTING JIJU OYOBI JUSINDAKASA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77 SIG KN= 77 PH = -.407 KL = 8.000 I= 1732.500 KE = -.179

P 1= 69.453 P 2= 68.672 P 3= 67.892 P 4= 67.112 P 5= 66.332 P 6= 65.551

P 7= 64.771 P 8= 63.991 P 9= 63.210 P10= 62.430 P11= 61.650

DESIGN OF FOOTING (DOUBLE-TRACK) PAGE

* CASE 4- 1 * (JYOUJI) NO 4 * D+L+I+B+TL * (M.W.) (DELTA N. NASI)

5) FOOTING KAKUTEN MOMENT OYOBI SENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	SENDAN	M/ALPHA	S/ALPHA
.500	-17.789	-71.186	-15.469	-61.901
	-20.742	414.982	-18.036	360.854
2.000	440.980	200.389	383.461	174.251
	438.027	681.095	380.893	592.256
3.500	1297.818	465.182	1128.538	404.506
	1294.866	940.426	1125.970	817.762
3.615*	1402.062	923.861	1219.185	803.357
4.280**	1987.226	836.029	1728.022	726.982
	1871.035	-634.281	1626.987	-551.549
4.945*	1420.034	-722.113	1234.812	-627.924
5.000	1380.100	-730.036	1200.087	-634.814
	1377.148	-260.253	1197.520	-226.307
6.500	824.713	-476.325	717.142	-414.196
	821.761	-12.005	714.575	-10.439
8.000)	641.699	-228.077	557.999	-198.328
	638.746	230.782	555.431	200.680
9.500	822.867	14.710	715.537	12.791
	819.915	468.107	712.969	407.050
11.000	1360.020	252.035	1182.626	219.161
	1357.067	699.970	1180.059	608.670
11.055*	1395.350	692.048	1213.348	601.781
11.720**	1826.355	604.216	1588.135	525.405
	1676.466	-704.094	1457.796	-612.256
12.385*	1179.037	-791.926	1025.250	-688.631
12.500	1087.015	-808.492	945.230	-703.036
	1084.062	-366.018	942.663	-318.277
14.000	373.018	-581.931	324.363	-506.027
	370.065	-144.919	321.796	-126.017
15.500	-8.453	-359.512	-7.351	-312.619
	-11.406	72.038	-9.918	62.642

0264

DESIGN OF FOOTING (DOUBLE-TRACK) PAGE

* CASE 5- 1 * (JYOUJI) NO 5 * D+L+I+B+TL * (H.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TM) (T)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-102.750	1470.310	-11.550	2	-126.860	1308.310	-19.790

2) FOOTING KAMEN ORYOKU (TM) (T) (M)

HO= 27702.371 NO= 3575.446 HO= -31.340 EO= 7.748 E= -.252

M = 3575.446 × 0.252 = 901.01

3) FOOTING JIJU OYOBI JUSINDAKASA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77 SIG KN= 77 PH = -.407 KL = 8.000 I= 1732.500 KE = -.252

P 1= 50.336 P 2= 49.555 P 3= 48.775 P 4= 47.995 P 5= 47.215 P 6= 46.434

P 7= 45.654 P 8= 44.874 P 9= 44.094 P10= 43.313 P11= 42.533

DESIGN OF FOOTING (DOUBLE-TRACK) PAGE

* CASE 5- 1 * (JYOUJI) NO 5 * D+L+I+B+TL * (H.W.) (DELTA N NASI)

5) FOOTING KAKUTEN MOMENT OYOBI SENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	SENDAN	M/ALPHA	S/ALPHA
.500	-6.289	-25.186	-5.469	-21.901
	-9.242	327.163	-8.036	284.490
2.000	424.252	250.570	368.915	217.887
	421.300	597.458	366.348	519.529
3.500	1259.136	519.546	1094.901	451.779
	1256.184	860.972	1092.334	748.671
3.615*	1354.851	854.986	1178.132	743.466
4.280**	1914.555	828.334	√1664.831	720.291
	1798.365	-641.976	1563.795	-558.240
4.945*	1362.589	-668.628	1184.860	-581.416
5.000	1325.736	-671.490	1152.814	-583.905
	1322.784	-335.526	1150.247	-291.762
6.500	760.940	-413.598	661.687	-359.651
	757.987	-83.096	659.119	-72.257
8.000)	574.789	-161.168	499.817	-140.146
	571.837	163.873	497.249	142.498
9.500	759.093	85.801	660.081	74.609
	756.141	405.379	657.514	352.504
11.000	1305.657	327.307	1135.354	284.615
	1302.704	641.424	1132.786	557.760
11.055*	1337.903	638.562	1163.394	555.271
11.720**	1753.684	611.910	1524.942	532.096
	1603.794	-696.400	1394.604	-605.565
12.385*	1131.826	-723.052	984.197	-628.741
12.500	1048.330	-729.038	911.591	-633.946
	1045.377	-420.382	909.023	-365.550
14.000	356.285	-498.295	309.813	-433.300
	353.333	-195.102	307.246	-169.654
15.500	3.044	-271.695	2.647	-236.256
	.091	26.037	.079	22.641

DESIGN OF FOOTING (DOUBLE-TRACK) PAGE

* CASE 6- 1 * (JISHINJI<---) NO 6 * D+E * (M.W.) (DELTA N NASI)

1) HASHIRA KATAN ORYOKU (TM) (T)

HASHIRA NO.	M	N	H	HASHIRA NO.	M	N	H
1	-953.090	1352.980	-160.230	2	-932.120	812.840	-153.060

2) FOOTING KAMEN ORYOKU (TM) (T) (M)

MO= 30810.721 NO= 4434.646 HO= -394.385 EO= 6.948 E= -1.052

M= 4434.646 × 1.05 = 4665.75 tm

3) FOOTING JIJU OYOBI JUSHINDAKASA (T) (M)

NF1= 720.000 NF2= 90.949 NG=1457.877 GH= 1.036

4) KUI HANRYOKU (T)

SKN= 77 SIG KN= 77 PH = -5.122 KL = 8.000 I= 1732.500 KE = -1.052

P 1= 77.794 P 2= 73.754 P 3= 69.713 P 4= 65.673 P 5= 61.633 P 6= 57.593

P 7= 53.553 P 8= 49.512 P 9= 45.472 P10= 41.432 P11= 37.392

DESIGN OF FOOTING (DOUBLE-TRACK) PAGE

* CASE 6- 1 * (JIBHINJI<---) NO 6 * D+E * (M.W.) (DELTA N NASI)

5) FOOTING KAKUTEN MOMENT OYOBI SENDANRYOKU (M) (TM) (T)

DISTANCE	MOMENT	SENDAN	M/ALPHA	S/ALPHA
.500	-17.789	-71.186	-11.860	-47.457
	-54.944	473.371	-36.629	315.581
2.000	494.361	258.778	329.574	172.519
	457.207	775.054	304.804	516.702
3.500	1457.936	559.141	971.957	372.761
	1420.781	1047.135	947.187	698.090
3.615*	1540.250	1030.570	1026.833	687.046
4.280**	2196.374	942.738	1464.250	628.492
	1056.825	-410.242	704.550	-273.495
4.945*	754.810	-498.074	503.207	-332.049
5.000	727.198	-505.997	484.799	-337.331
	690.044	-46.284	460.029	-30.856
6.500	458.563	-262.356	305.709	-174.904
	421.409	169.075	280.939	112.717
8.000)	512.968	-46.997	341.979	-31.331
	475.813	356.152	317.209	237.435
9.500	847.987	140.080	565.325	93.387
	810.833	514.949	540.555	343.299
11.000	1421.203	298.877	947.469	199.251
	1384.048	645.463	922.699	430.309
11.055*	1419.330	637.541	946.220	425.027
11.720**	1814.091	549.709	1209.394	366.473
	703.655	-263.131	469.237	-175.421
12.385*	499.668	-350.963	333.112	-233.975
12.500	458.355	-367.529	305.570	-245.019
	421.200	-49.223	280.800	-32.816
14.000	185.346	-265.136	123.564	-176.757
	148.190	24.888	98.794	16.592
15.500	24.383	-189.705	16.255	-126.470
	-12.771	72.037	-8.514	48.025

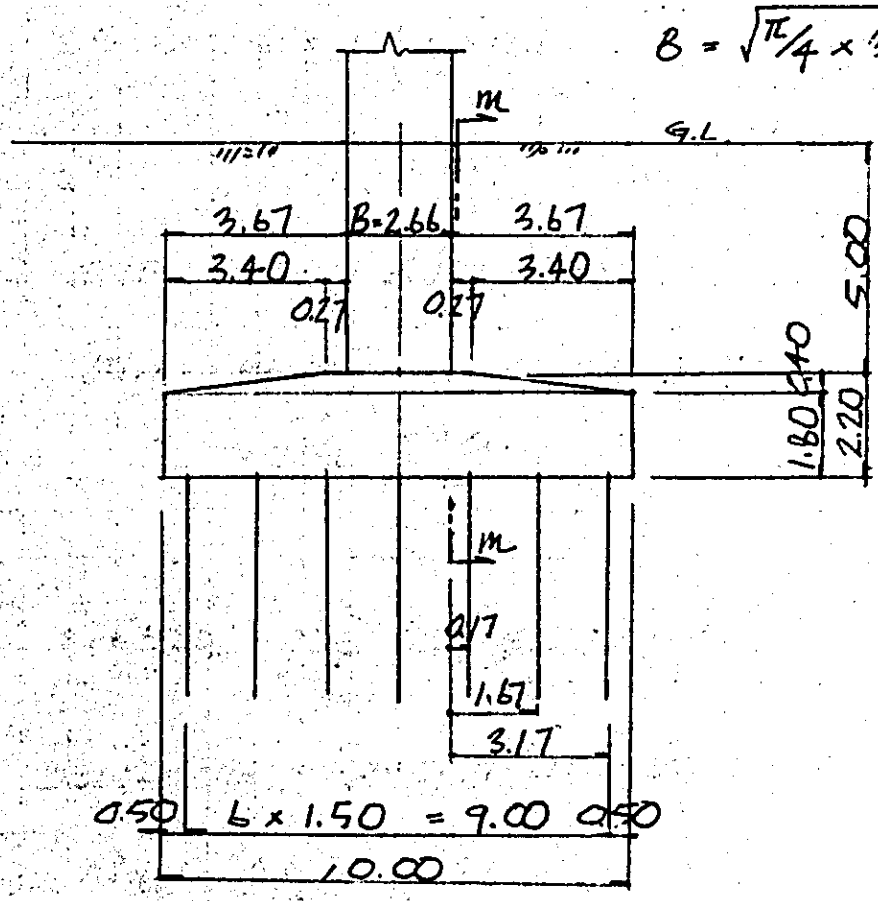
6 DESIGN OF FOOTING

1. DESIGN OF FOOTING AGAINST LONGITUDINAL LOADING

1-1 EXAMINATION OF SAFTY AGAINST BENDING MOMENT

a). BENDING MOMENT DUE TO OWN WEIGHT OF FOOTING AND WEIGHT OF EARTH COVER

$B = \sqrt{\pi/4 \times 3.00^2} \fallingdotseq 2.66^{m}$



WHERE ; m : SECTION WHERE MOMENT IS CALCULATED

M_m : BENDING MOMENT AT SECTION m

BENDING MOMENT AT SECTION ML

i) THE CASE NO BUOYANCY IS CONSIDERED

$1.8\ ^{t/m^3} \times 1/2 \times 5.00 \times 3.67^2$	=	60.61 $^{tm/m}$
$1.8\ " \times 1/2 \times 0.40 \times 3.40 \times 2.54$	=	3.11 "
$2.5\ " \times 1/2 \times 0.40 \times 0.27^2$	=	0.04 "
$2.5\ " \times 1/2 \times 0.40 \times 3.40 \times 1.40$	=	2.38 "
$2.5\ " \times 1/2 \times 1.80 \times 3.67^2$	=	30.31 "
	M_{ML} =	96.45 $^{tm/m}$

ii) THE CASE BUOYANCY IS CONSIDERED

$$M_{ML} = 96.45 - 1/2 \times 3.67^2 \times 7.20 \times 1.00$$

$$= 47.96\ ^{tm/m}$$

b) STRESS DUE TO REACTION FORCE ON PILES

BENDING MOMENT AT SECTION ML

No.1. $M_{ML} = (56.53 \times 3.27 + 56.47 \times 1.77 + 56.41 \times 0.27) \times 11/16.00 = 206.27$ $^{tm/m}$

No.2. $M_{ML} = (64.54 \times 3.27 + 64.46 \times 1.77 + 64.39 \times 0.27) \times 11/16.00 = 235.49$ "

No.3. $M_{ML} = (49.21 \times 3.27 + 49.13 \times 1.77 + 49.06 \times 0.27) \times 11/16.00 = 179.52$ "

No.4 $M_{ml} = (68.18 \times 3.27 + 66.89 \times 1.77 + 65.60 \times 0.27) \times 11/16.00 = 246.85$ t-m/ml

No.5 $M_{ml} = (52.85 \times 3.27 + 51.56 \times 1.77 + 50.27 \times 0.27) \times 11/16.00 = 190.89$ "

No.6 $M_{ml} = (84.93 \times 3.27 + 75.40 \times 1.77 + 65.88 \times 0.27) \times 11/16.00 = 294.91$ "

C) SUMMARY OF BENDING MOMENT ON FOOTING

No.1 $M_{ml} = (206.27 - 96.45) \times 1.8/1.4 = \boxed{141.20}$ t-m/ml

No.2 $M_{ml} = (235.49 - 96.45) \times 1/1.0 = 139.04$ "

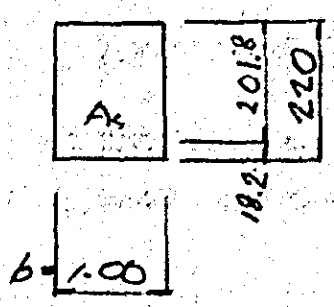
No.3 $M_{ml} = (179.52 - 47.96) \times$ " $= 131.56$ "

No.4 $M_{ml} = (246.85 - 96.45) \times 1/1.15 = 130.78$ "

No.5 $M_{ml} = (190.89 - 47.96) \times$ " $= 124.29$ "

No.6 $M_{ml} = (294.91 - 96.45) \times 1/1.5 = 132.31$ "

d) EXAMINATION OF SAFETY



$$M = \frac{16.00}{(2.66 + 2.018 \times 2) \times 2} \times 141.20$$

$$= 168.70 \ tm/m$$

$$As = 6.67 - 032 = 52.95 \ cm^2$$

$$p = \frac{52.95}{100 \times 201.8} = 0.00262$$

$$1/Lc = 8.93 \qquad 1/Ls = 415$$

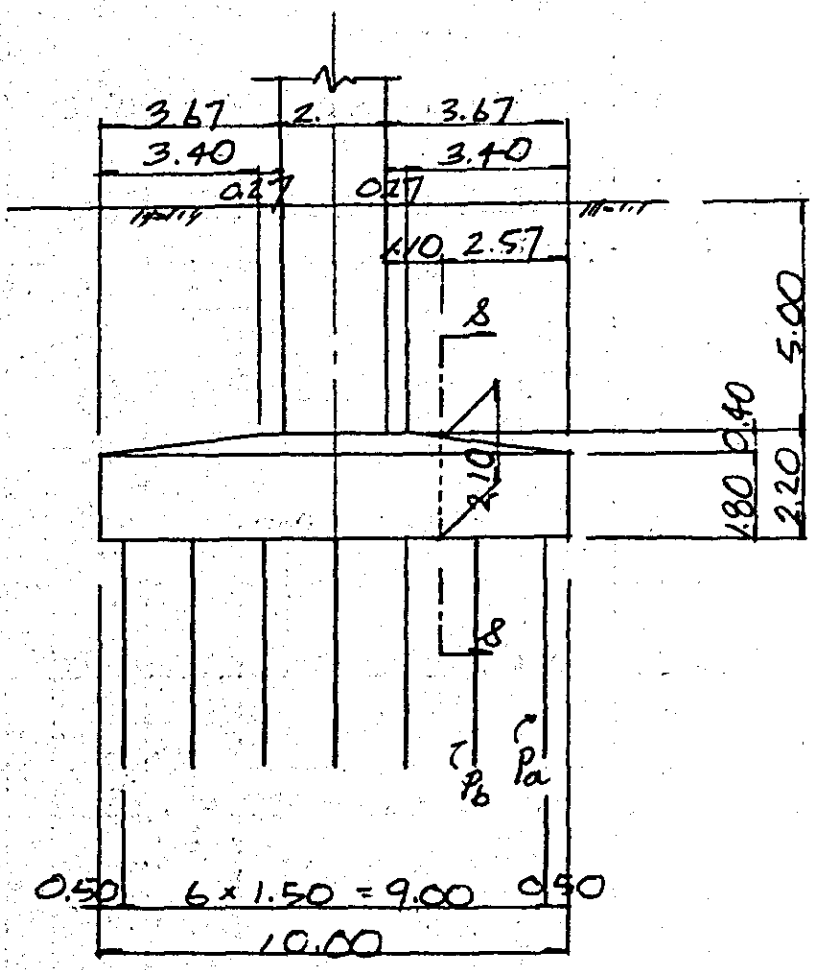
$$\sigma_c = \frac{168.70 \times 10^5}{100 \times 201.8^2} \times 8.93 = 37.0 \ kg/cm^2 < 80 \ kg/cm^2$$

$$\sigma_s = \text{"} \times 415 = 1720 \text{"} < 1800$$

1-2. EXAMINATION OF SAFETY AGAINST SHEARING FORCE

EXAMINATION OF SAFETY AGAINST COMBINATION No. 6

a) SHEARING FORCE DUE TO OWN WEIGHT OF FOOTING AND WEIGHT OF EARTH COVER



WHERE, x : SECTION WHERE SHEARING FORCE IS CALCULATED.

S_x : SHEARING FORCE AT SECTION x

SHEARING FORCE AT SECTION x

$\omega_1 = 1.8^{t/m^3} \times 5.40 + 2.5^{t/m^3} \times 1.80 = 14.22^{t/m^2}$

$$w_2 = (1.8 \times 5.10 + 2.5 \times 2.10) \times \frac{1.10}{2 \times (2.10 - 0.182)}$$

$$= 4.14 \ t/m^2$$

$$\therefore S_8 = \frac{1}{2} \times (14.22 + 4.14) \times 2.57 = 23.59 \ t/m$$

b) STRESS DUE TO REACTION FORCE ON PILES

SHEARING FORCE AT SECTION 8

$$P_a = 84.93 \times \frac{3.17}{2 \times (2.10 - 0.182)} = 70.18 \ t$$

$$P_b = 75.40 \times \frac{1.67}{2 \times (2.10 - 0.182)} = 32.83 \ "$$

$$S_8 = (70.18 + 32.83) \times \frac{11}{16.00} = 70.82 \ t/m$$

c) SUMMARY OF SHEARING FORCES ON FOOTING

$$S_8 = 70.82 - 23.59 = 47.23 \ t/m$$

d) EXAMINATION OF SAFETY

$$\tau = \frac{S_8}{b \cdot d} = \frac{47.23 \times 10^3}{100 \times (210 - 182)}$$

$$= 2.46 \ kg/cm^2 < 8.7 \ kg/cm^2$$

2. DESIGN OF FOOTING AGAINST TRANSVERSAL LOADING

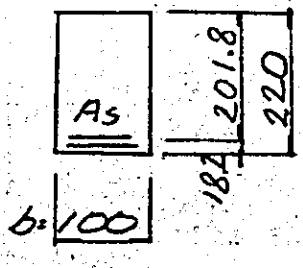
2-1. EXAMINATION OF SAFETY AGAINST BENDING MOMENT

THE FOLLOWING MAXIMUM BENDING MOMENT OF FOOTING IS PICKED UP FROM THE ELECTRONIC COMPUTING DATA "DISGN OF FOOTING"

$M_{max} = 1510.50$ tm (Case 7. DEAD LOAD)

$Be = 2.66 + 2.018 \times 2 \fallingdotseq 7.00$ m

$\therefore M = \dfrac{1510.50}{7.00} = 215.79$ tm/m



$As = \begin{matrix} 6.67 - 029 \\ 6.67 - 032 \end{matrix} > = 95.77$ cm²

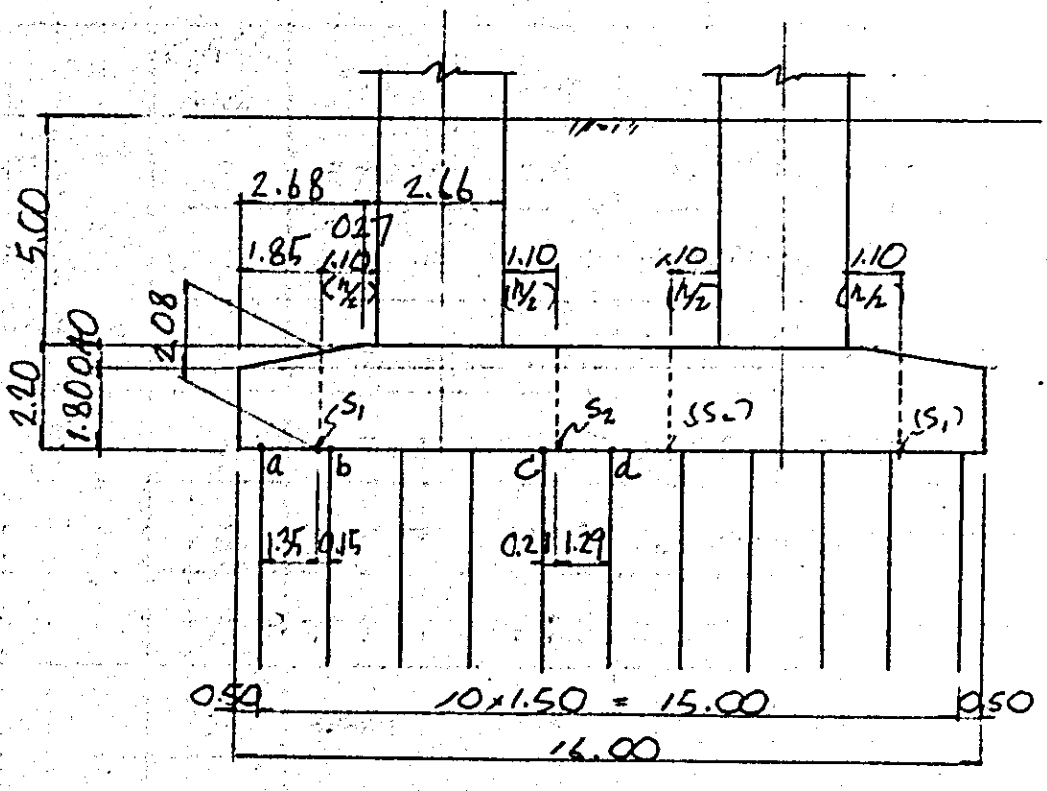
$p = \dfrac{As}{bd} = \dfrac{95.77}{100 \times 201.8} = 0.00475$

$1/Ec = 7.14$ $\quad$ $1/Es = 235$

$\therefore \sigma c = \dfrac{215.79 \times 10^5}{100 \times 201.8^2} \times 7.14 = 37.8$ Kg/cm² $<$ 80 Kg/cm²

$\sigma s =$ " $\times 235 = 1250$ " < 1400 "

2-2. EXAMINATION OF SAFETY AGAINST SHEARING FORCE



$$S_{S_1} = S_a - (S_a - S_b) \times \frac{1.35}{1.50} = 0.10\,S_a + 0.90\,S_b$$

$$S_{S_2} = S_d - (S_d - S_c) \times \frac{1.29}{1.50} = 0.86\,S_c + 0.14\,S_d$$

WHERE S_{S_1}, S_{S_2} ; SHEARING FORCE OF $h/2$

S_a, S_b, S_c, S_d ; SHEARING FORCE AT THE POINTS OF PILE, PICKED UP FROM ELECTRONIC COMPUTING DATA.

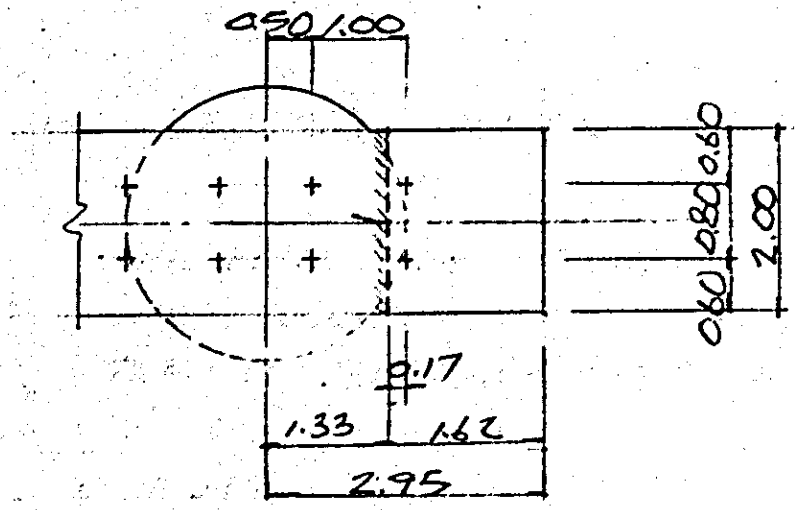
	CASE No.	S_a	S_b	S_{s1}	S_c	S_d	S_{s2}
		0.11	0.9		0.86	0.14	
SINGLE-TRACK	1	340.50	125.91	147.37	63.03	279.10	93.28
	2	401.84	187.25	208.71	120.81	336.89	151.06
	3	314.02	237.42	245.08	191.91	269.98	202.84
	4	417.19	202.60	224.06	105.92	321.99	136.17
	5	329.37	252.78	260.44	177.01	255.08	187.94
	6	409.61	195.02	216.98	185.69	136.19	140.63
DOUBLE-TRACK	7	342.06	127.46	148.92	27.20	-188.87	-3.05
	8	398.93	184.34	205.80	27.56	243.63	57.81
	9	311.11	234.52	242.18	98.65	176.73	109.58
	10	414.98	200.39	221.85	14.71	230.78	44.96
	11	327.16	250.57	258.23	85.80	163.87	96.73
	12	473.37	258.78	280.24	140.08	356.15	170.33

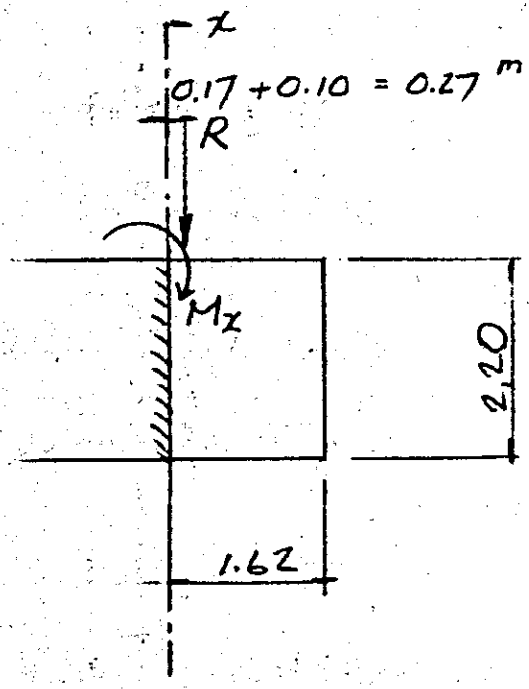
$$\tau = \frac{S_s}{b \cdot d}, \qquad b = 1000^{cm} \quad d = 220 - 18.2 - 201.8$$

$$= \frac{280.24 \times 10^3}{1000 \times 201.8} = 1.39^{kg/cm^2} < 3.7^{kg/cm^2}$$

7 DESIGN OF CANTILEVER BEAM

1. EXAMINATION OF SAFETY AGAINST BENDING MOMENT





WHERE, M_x : BENDING MOMENT AT SECTION x

x ; SECTION WHERE MOMENT IS CALCULATED

1-1. COMBINATION OF LOADS

No.1. DEAD LOAD

No.2. DEAD LOAD + (TRAIN + IMPACT) LOAD

1-2. BENDING MOMENT AT SECTION X

THE FOLLOWING FIGURES ARE REFERRED TO THE CALCULATION OF THE REACTION FORCES TRANSMITTED FROM THE SUPERSTRUCTURE.

a) COMBINATION NO.1

$$R_d = 114.13 \times 2 = 228.26^{T}$$

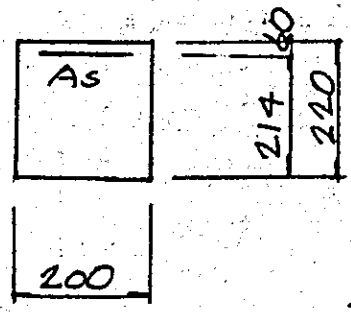
$$\therefore M_X = 228.26 \times 0.27 + 2.5^{T/m^3} \times 2.00 \times 2.20 \times 1.62^2 \times 1/2 = 76.06^{t\cdot m}$$

b) COMBINATION NO. 2

$$R_{eti} = 311.57 \times 1/4 = 77.89^{T}$$

$$\therefore M_X = (228.26 + 77.89) \times 0.27 + 2.5^{T/m^3} \times 2.00 \times 2.20 \times 1.62^2 \times 1/2 = 97.09^{t\cdot m}$$

1-3. EXAMINATION OF SAFETY



$Md = 76.06$ t·m

$As = 019 - 15 = 42.98$ cm²

$$p = \frac{42.98}{200 \times 214} = 0.00100$$

$1/Lc = 13.3$ $\quad 1/Ls = 1056$

$$\therefore \sigma_c = \frac{76.06 \times 10^5}{200 \times 214^2} \times 13.3 = 11.0 \text{ kg/cm}^2 < 80 \text{ kg/cm}^2$$

$\sigma_s =$ " $\times 1056 = 880$ " < 1200 "

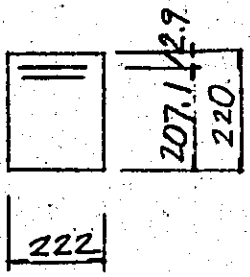
8 DESIGN OF CONNECTING BEAM.

1. EXAMINATION OF SAFETY AGAINST BENDING MOMENT

THE FOLLOWING BENDING MOMENTS ARE PICKED UP FROM THE ELECTRONIC COMPUTING DATA "ANALYSIS OF RIGID FRAME."

$M_{min} = -591.08$ t·m (CASE 30)

$M_{max} = 540.76$ " (CASE 29)



$A_s = 29 - 30 = 192.72$ cm²

$p = 192.72 / 222 \times 207.1 = 0.00419$

$1/L_c = 7.47$ $\quad 1/L_s = 265$

$$\therefore \sigma_c = \frac{591.08 \times 10^5}{222 \times 207.1^2} \times 7.47 = 46.4 \text{ kg/cm}^2 < 80 \text{ kg/cm}^2$$

$\sigma_s =$ " $\times 265 = 1640$ " < 1800 ✓

2. EXAMINATION OF SAFETY AGAINST SHEARING FORCE

$S_{h/2} = 162.49 \times 1.5 = 243.74^{t}$ (case 29)

$b = 222^{cm}$

$d = 207.1^{"}$

$\therefore \tau_{h/2} = \dfrac{243.74 \times 10^3}{222 \times 207.1} = 5.30^{kg/cm^2} > 3.70^{kg/cm^2}$

3. WEB REINFORCING BARS

a) SHEAR STRESS SHARED BY CONCRETE

$\tau_{ca} = 3.7^{kg/cm^2}$

$\therefore \tau_c = 1/2 \times \tau_{ca}$

$= 1/2 \times 3.7 = 1.85^{kg/cm^2}$

b) SHEAR STRESS SHARED BY STIRRUPS

$\tau_v = \tau_{h/2} - \tau_c$

$= 5.30 - 1.85$

$= 3.45^{kg/cm^2}$

c) TENSILE STRESS OF STIRRUPS

$$\sigma_s = \frac{1.15\,\tau_v \cdot B \cdot s}{A_v}$$

$$= \frac{1.15 \times 3.45 \times 22 \times 20}{11.916}$$

$$= 1478 \ \text{Kg/cm}^2 < 1800 \times 1.5 = 2700 \ \text{Kg/cm}^2$$

WHERE, B : WIDTH OF BEAM

s ; PITCH OF STIRRUPS, 20 cm

A_v ; AREA OF STIRRUPS

3 SETS OF D16 PER 20 cm PITCH

$A_v = 1.986 \times 6 = 11.916 \ \text{cm}^2$

[9] DESIGN OF COLUMN

EXAMINATION IS MADE ONLY TO THE CASE OF EARTHQUAKE LOADING.

1. TRANSVERSAL DIRECTION

BENDING MOMENTS AND AXIAL FORCES ARE PICKED UP FROM THE ELECTRONIC COMPUTING DATA "ANALYISIS OF RIGID FRAME"

CASE NO.	1 – ③			2 – ④		
	M	H	N	M	H	N
19	(587.49) 391.66	(96.96) 64.64	(132.32) 88.21	(476.79) 317.86	(59.12) 39.41	(1139.57) 759.71
29	(901.50) 601.00	(138.17) 92.11	(899.70) 599.80	(963.14) 642.09	(159.23) 106.15	(1266.12) 844.08
30	(953.09) 635.39	(152.28) 101.52	(1352.99) 901.99	(932.12) 621.41	(145.11) 96.74	(812.85) 541.90

2. LONGITUDINAL DIRECTION

a) AXIAL FORCES ARE REFERRED TO THE CASE OF DEAD LOAD IN TRANSVERSAL DIRECTION.

$N_{max} = N_3 = 1126.29$ t (CASE 2)

$N_{min} = N_4 = 1039.43$ " (")

b) BENDING MOMENT

THE FOLLOWING FIGURES ARE REFERRED TO THE CALCULATION OF "OWN WEIGHT OF SUBSTRUCTURE" AND "REACTION FORCES TRANSMITTED FROM SUPERSTRUCTURE"

· BEDING MOMENT DUE TO SUBSTRUCTURE.

① $5.70 \times \frac{1}{2} \times 0.1 \times 10.30 = 2.94$ tm

② $125.40 \times \frac{1}{2} \times 0.1 \times 9.00 = 56.43$ "

③ $54.46 \times \frac{1}{2} \times 0.1 \times 9.00 = 24.51$ "

④ $8.52 \times \frac{1}{2} \times 0.1 \times 9.00 = 3.83$ "

⑤ $279.21 \times \frac{1}{2} \times 0.1 \times 3.95 = 55.14$ "

$M_1 = 142.85$ tm/COLUMN

BENDING MOMENT DUE TO SUPERSTRUCTURE

$$M_2 = \{(44.70 \times 2 + 67.04) \times 10.10 + 52.74 \times 10.50\} \times 1/2$$

$$= 1066.91 \text{ tm/COLUMN}$$

$$\Sigma M = M_1 + M_2$$

$$= 142.85 + 1066.91 = 1209.76 \text{ tm}$$

3. EXAMINATION OF SAFETY

TRANSVERSAL DIRECTION

R(cm)	Rs(cm)	M(tm)	N(t)	D n(ホン) (cm2)	P
150.00	141.50	587.49	132.32	D25- 44.0=222.94	0.00315

e(m)	e/R	Rs/R	K	C	SigC	SigS
4.439	2.959	0.943	0.506	0.112	52.3	2225

$< 120 \text{ kg/cm}^2$ < 2700 "

LONGITUDINA DIRECTION

R(cm)	Rs(cm)	M(tm)	N(t)	D n(ホン) (cm2)	P
150.00	141.50	1209.76	1126.29	D25- 44.0=222.94	0.00315

e(m)	e/R	Rs/R	K	C	SigC	SigS
1.074	0.716	0.943	0.965	0.630	79.4	1206

$< 120 \text{ kg/cm}^2$ < 2700

10 DESIGN OF PILE

1. REACTION FORCES ACTING ON PILES

EXAMINATION IS MADE ONLY TO THE EARTHQUAKE LOADING

	LONGITUDINAL DIRECTION (1)	TRANSVERSAL DIRECTION	
		SINGLE TRACK (2)	DOUBLE TRACK (3)
WHOLE HORIZONTAL FORCE, ΣH (t)	397.06	253.07	394.39
HORIZONTAL FORCE PER PILE H (t)	5.16	3.29	5.12
VALUE OF β (m^{-1})	0.214	0.214	0.214
MAXIMUM MOMENT PER PILE (tm)	7.76	4.95	7.70
MAXIMUM AXIAL FORCE PER PILE (t)	84.93	68.81	77.79
MINIMUM AXIAL FORCE PER PILE (t)	27.77	23.16	37.39

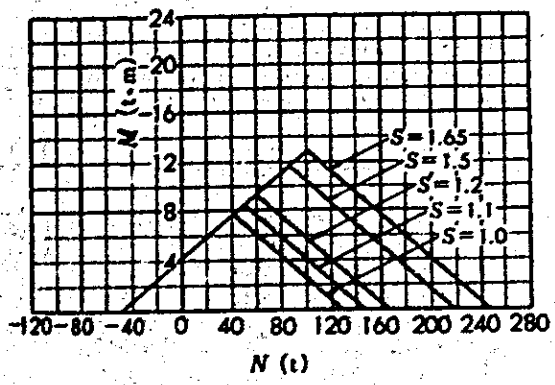
WHERE, $H = \Sigma H / n$ n ··· NUMBER OF PILE

$n = 77$

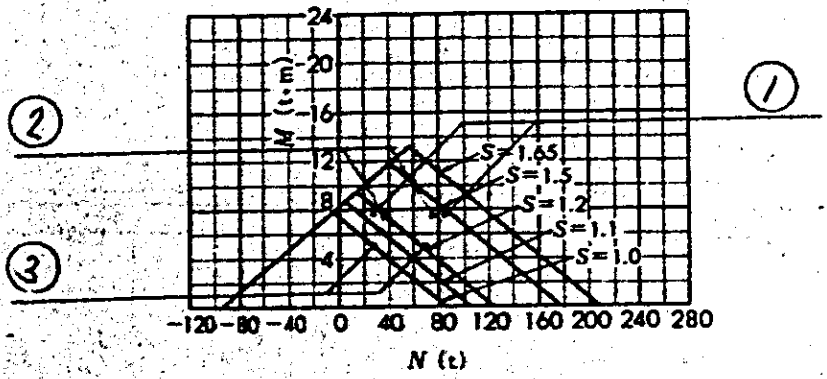
$$M_{max} = \frac{0.322 \cdot H}{\beta}$$

2. EXAMINATION OF SAFETY

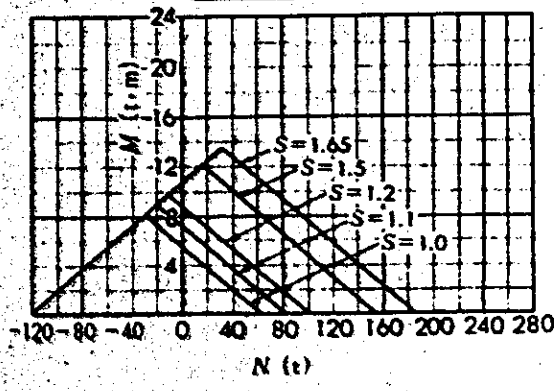
(13) D500-A



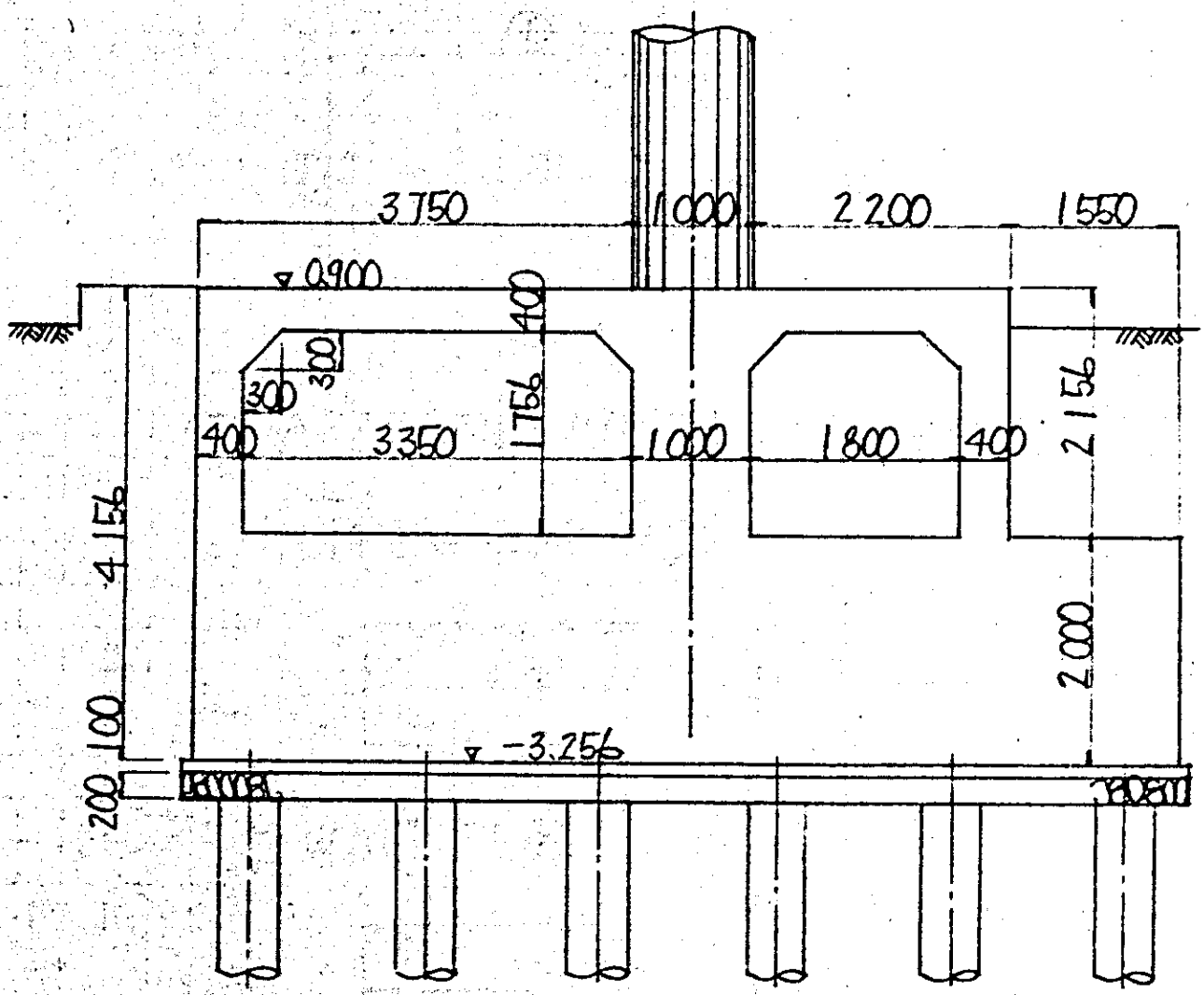
(14) D500-B



(15) D500-C



§7. Pier P24

[1] GENERA DIMENSIONS

(UNIT ; mm)