7.4 STRUCTURE CALCULATION

7.4.1 BRIDGE ABUTMENT CIREBON SIDE

3.1. DATA

3.1.1. EXISTING SUPERSTRUCTURE

- Type	Through Truss Girder
- Total Weight	67.00 ton-f
- Effective Span (c.t.c.)	31.20 m
- Total Length of Stringer or truss girder	32.16 m
- Center to center of Main Girder	4.60 m
- Construction Depth	1.33 m
- Distance between top of rail up to top of concrete beering	1.65 m
- Distance between top of rail up to elevation of HWL	2.33 m

3.1.2. TRACK CONDITION

- Track Plan : straight
- Track Elevation : Level

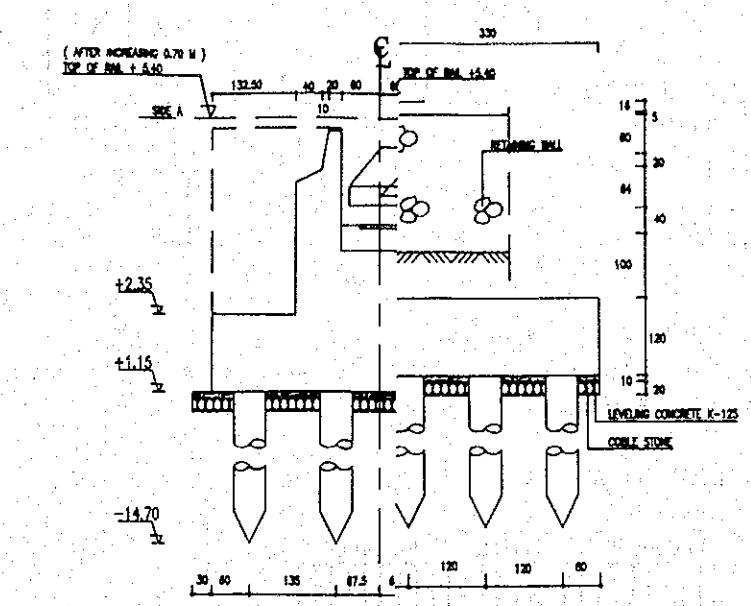
3.1.3. LOADINGS

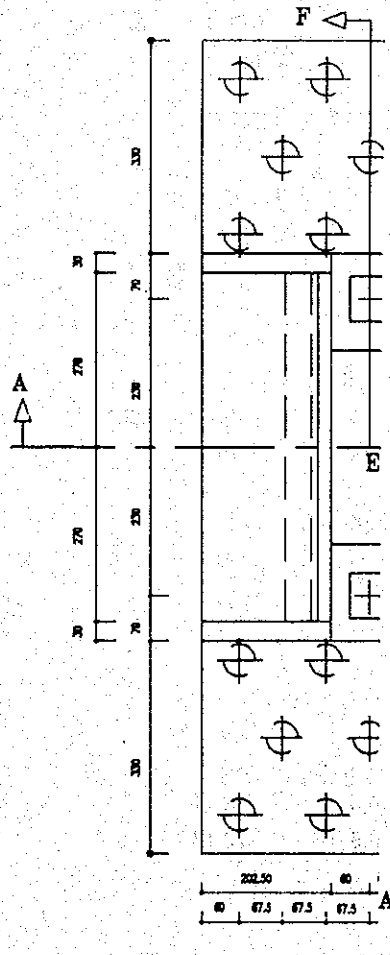
- Train Load : based on 100 % Load Scheme 1921.
- Impact Load : {0.2 + 25/(L+50)} x Train Load
- Longitudinal Load due to Long Rails : 1.00 tf / m' (per one track) , but max. 200 t f.
- Brake Load : 1 / 6 Locomotive + 1 / 10 Wagon
- Lateral Load : 1 / 10 Train Load
- Wind Load : 0.10 t f /m2.
- Earth Pressure : based on Coulomb's Theory
- Seismic Load : based on the equivalent static force and design seismic intensity expressed as followings :

  KH = 0.18

  KV = 0.00

3.2. DIMENSION OF ABUTMENT CIREE

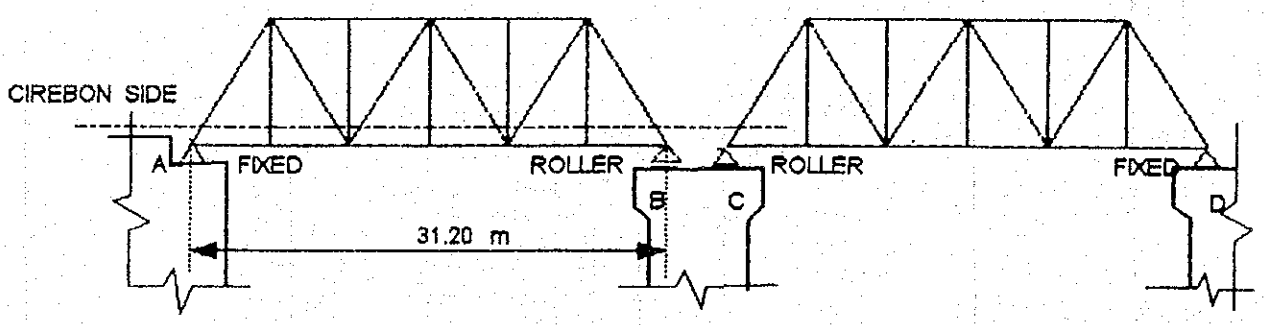




AWING OF ABUTMENT CIREBON SIDE

3.3. LOADINGS

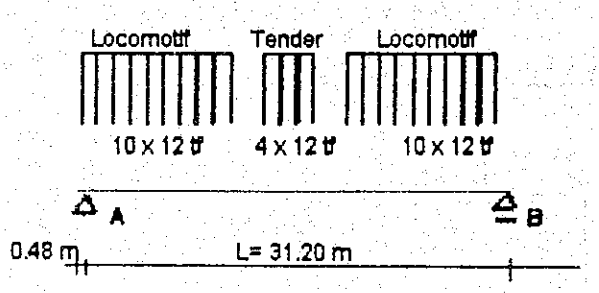
3.3.1. VERTICAL FORCE



a. DEAD LOAD

Vb = 33.50 =
Va = 33.50 tf.

b. TRAIN LOAD (LIVE LOAD)



Vb = 135.85 tf.
Va = 152.15 tf.

c. IMPACT LOAD

Impact Coefficient

$$I = 0.2 + \frac{26}{50 + 31.20} = 0.5079$$

Vb = 135.85 x 0.5079 = 69.00 tf.
Va = 152.15 x 0.5079 = 77.27 tf.

d. TRAIN LOAD FOR SEISMIC

$$q = \frac{12.00}{2.40} = 5.00 \text{ tf/m'}$$

Vb = 5.00 x 31.20 x 0.5 = 78 tf.
Va = 5.00 x 31.20 x 0.5 = 78 tf.

SUMMARY OF VERTICAL FORCE

ITEMS	Support B [ton-f]	Support A [ton-f]
Dead Load [DL]	33.50	33.50
Train Load [LL]	135.85	162.15
Impact [I]	69.00	77.27
Train for Seismic [LL]	78.00	78.00

3.3.2. LONGITUDINAL HORIZONTAL FORCE

a. DEAD LOAD + LONG RAIL LOAD

TOTAL HORIZONTAL FORCE

$$\Sigma H = 32.16 \times 1.00 = 32.16 \text{ tf}$$

HORIZONTAL FORCE ON SUPPORTING

$$Ha = \Sigma H - 1/2 \times \mu \times Vb$$
$$= 32.16 - 0.5 \times 0.10 \times 33.50$$
$$= 30.49 \text{ tf} > 1/2 \times 32.16 = 16.08 \text{ tf}$$

therefore

$$Ha = 30.49 \text{ tf}$$

VERTICAL FORCE

$$Va = \frac{32.16 \times 1.65}{31.20} = 1.70 \text{ tf}$$

b. LONG RAIL LOAD + BRAKE LOAD

TOTAL HORIZONTAL FORCE

$$\Sigma H = 0 \times 12.00 \times 0.1000 + 24 \times 12 \times 0.1667 + 32.16$$
$$= 80.16 \text{ tf}$$

HORIZONTAL FORCE ON SUPPORTING

$$Ha = \Sigma H - 1/2 \times \mu \times Vb$$
$$= 80.16 - 0.5 \times 0.10 \times (33.50 + 135.85)$$
$$= 71.69 \text{ tf} > 1/2 \times 80.16 = 40.08 \text{ tf}$$

therefore

$$Ha = 71.693 \text{ tf}$$

VERTICAL FORCE

$$Va = \frac{80.16 \times 1.65}{31.20} = 4.24 \text{ tf}$$

c. TRAIN LOAD + LONG RAIL LOAD

TOTAL HORIZONTAL FORCE

$$\Sigma H = 32.16 \times 1.00 = 32.16 \text{ tf}$$

HORIZONTAL FORCE ON SUPPORTING

$$Ha = \Sigma H - 1/2 \times \mu \times Vb$$
$$= 32.16 - 0.5 \times 0.10 \times (33.50 + 135.85)$$
$$= 23.69 \text{ tf} > 1/2 \times 32.16 = 16.08 \text{ tf}$$

therefore

$$Ha = 23.69 \text{ tf}$$

VERTICAL FORCE

$$Va = \frac{32.16 \times 1.65}{31.20} = 1.70 \text{ tf}$$

d. DEAD LOAD FOR SEISMIC

TOTAL HORIZONTAL FORCE

$$\Sigma H = 33.50 \times 2 \times 0.18 = 12.06 \text{ tf}$$

HORIZONTAL FORCE ON SUPPORTING

$$Ha = \Sigma H - 1/2 \times \mu \times Vb$$
$$= 12.06 - 0.5 \times 0.10 \times 33.50$$
$$= 10.39 \text{ tf} > 1/2 \times 12.06 = 6.03 \text{ tf}$$

therefore

$$Ha = 10.39 \text{ tf}$$

VERTICAL FORCE

$$Va = \frac{12.06 \times 1.65}{31.2} = 0.64 \text{ tf}$$

e. TRAIN LOAD FOR SEISMIC

TOTAL HORIZONTAL FORCE

$$\Sigma H = (33.50 + 78) \times 2 \times 0.18 = 40.14 \text{ tf}$$

HORIZONTAL FORCE ON SUPPORTING

$$Ha = \Sigma H - 1/2 \times \mu \times Vb$$
$$= 40.14 - 0.5 \times 0.10 \times (33.50 + 78)$$
$$= 34.57 \text{ tf} > 1/2 \times 40.14 = 20.07 \text{ tf}$$

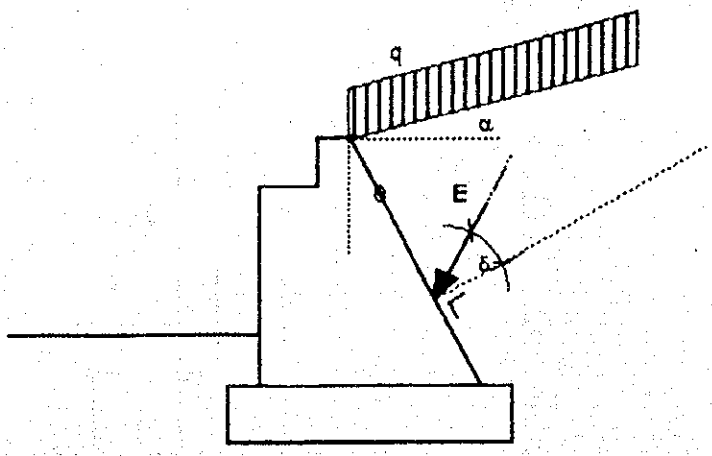
therefore

$$Ha = 34.57 \text{ tf}$$

VERTICAL FORCE

$$Va = \frac{40.14 \times 1.65}{31.20} = 2.12 \text{ tf}$$

f. EARTH PRESSURE



1) NORMAL CONDITION

COEFFICIENT OF EARTH PRESSURE :

$$Ka = \frac{\text{Cos}^2(\phi - \theta)}{\text{Cos}^2\theta \,\text{Cos}(\theta+\delta)\left[1+\sqrt{\frac{\text{Sin}(\phi+\delta)\;\text{Sin}(\phi-\alpha)}{\text{Cos}(\theta+\delta)\;\text{Cos}(\theta-\alpha)}}\right]^2}$$

$$Kp = \frac{\text{Cos}^2(\phi + \theta)}{\text{Cos}^2\theta \,\text{Cos}(\theta+\delta)\left[1-\sqrt{\frac{\text{Sin}(\phi-\delta)\;\text{Sin}(\phi+\alpha)}{\text{Cos}(\theta+\delta)\;\text{Cos}(\theta-\alpha)}}\right]^2}$$

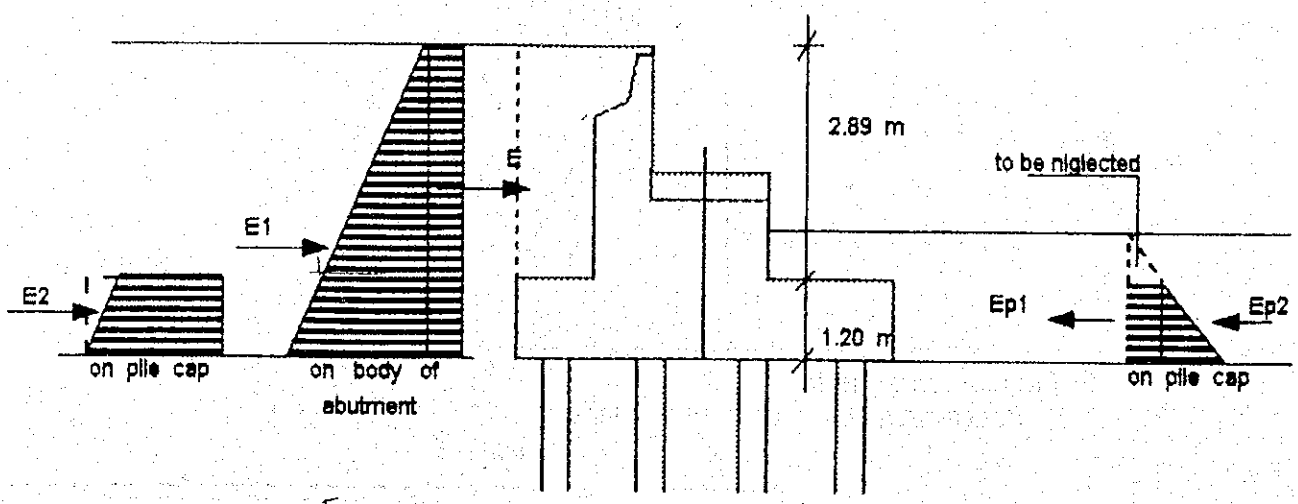
Fill Material		Soil	
θ =	0.00	θ =	0.00
φ =	30.00	φ =	3.00
δ =	20.00	δ =	2.00
α =	0.00	α =	0.00
Cos (φ − θ) =	0.8660	Cos (φ − θ) =	0.9986
Cos (φ + θ) =	0.8660	Cos (φ + θ) =	0.9986
Cos θ =	1.0000	Cos θ =	1.0000
Cos (θ + δ) =	0.9397	Cos (θ + δ) =	0.9994
Sin (φ + δ) =	0.7660	Sin (φ + δ) =	0.0872
Sin (φ − δ) =	0.7660	Sin (φ − δ) =	0.0872
Sin (φ − α) =	0.5000	Sin (φ − α) =	0.0523
Sin (φ + α) =	0.5000	Sin (φ + α) =	0.0523
Cos (θ + δ) =	0.9397	Cos (θ + δ) =	0.9994
Cos (θ − α) =	1.0000	Cos (θ − α) =	1.0000

Active Earth Pressure

$$Ka = \frac{0.8660 \times 0.8660}{1.0000 \times 0.9397 \times \left[1+\sqrt{\frac{0.7660 \times 0.5000}{0.9397 \times 1.0000}}\right]^2}$$

$$= 0.2973$$

a). Due to Earth Pressure



E

Active Earth Pressure

E 1	=	0.5 x	2.00 x	4.09 x	4.09 x	0.2973	=	4.97 tf/m
E 2	=	1.2 x	2.00 x	4.09 x	0.2973		=	2.92 tf/m

E 1h	= E1 cos δ	=	4.97 x	0.9397	=	4.67 tf/m
E 2h	= E2 cos δ	=	2.92 x	0.9397	=	2.74 tf/m
E 1v	= E1 sin δ	=	4.97 x	0.3420	=	1.70 tf/m
E 2v	= E2 sin δ	=	2.92 x	0.3420	=	1.00 tf/m

Total force per abutment

E 1h	=	4.67 x	6.00	=	28.04 tf	y 1	=	1.36 m
E 2h	=	2.74 x	6.60	=	18.10 tf	y 2	=	0.60 m
					46.14 tf	y	=	1.06 m
E 1v	=	1.70 x	6.00	=	10.21 tf	x 1	=	2.63 m
E 2v	=	1.00 x	6.60	=	6.59 tf	x 2	=	2.63 m
					16.79 tf	x	=	2.63 m

Passive Earth Pressure

$$Kp = \frac{0.9986 \times 0.9986}{1.0000 \times 0.9994 \times \left[1 - \sqrt{\frac{0.0872 \times 0.0523}{0.9994 \times 1.0000}}\right]^2}$$

$$= 1.1477$$

E p1	=	0.72 x	1.60 x	1.1477	=	1.322 tf/m2
E p2	=	1.92 x	1.60 x	1.1477	=	3.526 tf/m2
E p1	=	1.20 x	1.32		=	1.587 tf/m
E p2	=	0.50 x	1.20 x	2.204	=	1.322 tf/m

Ep1h	= Ep1 cos δ	=	1.59	x	0.9994	=	1.59 tf/m
Ep2h	= Ep2 cos δ	=	1.32	x	0.9994	=	1.32 tf/m
Ep1v	= Ep1 sin δ	=	1.59	x	0.0349	=	0.06 tf/m
Ep2v	= Ep2 sin δ	=	1.32	x	0.0349	=	0.05 tf/m

Total force per abutment

Ep1h	=	1.59	x	12.60	=	19.98 tf	y1 = 0.60 m
Ep2h	=	1.32	x	12.60	=	16.65 tf	y2 = 0.40 m
						36.63	y = 0.51 m
Ep1v	=	0.06	x	12.60	=	0.70 tf	x1 = 2.63 m
Ep2v	=	0.05	x	12.60	=	0.58 tf	x2 = 2.63 m
						1.28 tf	x = 2.63 m

b). Due to Live Load

Total force per abutment

E	=	8.75	x	0.2973	x	4.09	= 10.64 tf
Eh	= E cos δ	=	10.64	x	0.9397	=	10.00 tf-m
Ev	= E sin δ	=	10.64	x	0.3420	=	3.64 tf-m

2) EARTHQUAKE CONDITION

COEFFICIENT OF EARTH PRESSURE:

$$Kea = \frac{\cos^2(\phi - \theta_o - \theta)}{\cos\theta_o \cos^2\theta \cos(\theta_o + \theta + \delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\ \sin(\phi-\alpha-\theta_o)}{\cos(\theta+\theta_o+\delta)\ \cos(\theta-\alpha)}}\right]^2}$$

$$Kep = \frac{\cos^2(\phi - \theta_o + \theta)}{\cos\theta_o \cos^2\theta \cos(\theta - \theta_o + \delta)\left[1+\sqrt{\frac{\sin(\phi-\delta)\ \sin(\phi+\alpha-\theta_o)}{\cos(\theta-\theta_o+\delta)\ \cos(\theta-\alpha)}}\right]^2}$$

Fill Material		Soil	
θo =	10.20	θo =	10.20
θ =	0.00	θ =	0.00
φ =	30.00	φ =	3.00
δ =	0.00	δ =	0.00
α =	0.00	α =	0.00
Cos (φ - θo - θ) =	0.9409	Cos (φ - θo - θ) =	0.9921
Cos (φ - θo + θ) =	0.9409	Cos (φ + θo + θ) =	0.9921
Cos θo =	0.9842	Cos θo =	0.9842
Cos θ =	1.0000	Cos θ =	1.0000
Cos (θ + θo + δ) =	0.9842	Cos (θ + θo + δ) =	0.9842
Cos (θ - θo + δ) =	0.9842	Cos (θ - θo + δ) =	0.9842
Sin (φ + δ) =	0.5000	Sin (φ + δ) =	0.0523
Sin (φ + δ - θo =	0.3387	Sin (φ - δ - θo =	-0.1253
Sin (φ - δ) =	0.5000	Sin (φ - δ) =	0.0523
Sin (φ + α - θo =	0.3387	Sin (φ + α - θo =	-0.1253
Cos (θ - α =	1.0000	Cos (θ - α =	1.0000

Active Earth Pressure

$$Kea = \frac{0.9409 \times 0.9409}{0.9842 \times 1.0000 \times 0.9842 \times \left[1 + \sqrt{\frac{0.5000 \times 0.3387}{0.9842 \times 1.0000}}\right]^2}$$

$$= 0.4566$$

a). Due to Earth Pressure

E 1	=	0.5 x	1.80 x	4.09 x	4.09 x	0.4566 =	6.87 tf/m
E 2	=	1.2 x	1.80 x	4.09 x	0.4566	=	4.03 tf/m

E 1h	= E cos δ	=	6.87 x	1.0000 =	6.87 tf/m
E 2h	= E cos δ	=	4.03 x	1.0000 =	4.03 tf/m
E 1v	= E sin δ	=	6.87 x	0.0000 =	0.00 tf/m
E 2v	= E sin δ	=	4.03 x	0.0000 =	0.00 tf/m

Total force per abutment

E 1h	=	6.87 x	6.00 =	41.24 tf	y 1	=	1.36 m
E 2h	=	4.03 x	6.60 =	26.62 tf	y 2	=	0.60 m
				67.86 tf	y	=	1.06 m
E 1v	=	0.00 x	6.00 =	0.00 tf	x 1	=	2.63 m
E 2v	=	0.00 x	6.60 =	0.00 tf	x 2	=	2.63 m
				0.00 tf	x	=	2.63 m

Passive Earth Pressure

$$Kep = \frac{0.9409 \times 0.9409}{0.9842 \times 1.0000 \times 0.9842 \times \left[1 - \sqrt{\frac{0.0523 \times -0.1253}{0.9842 \times 1.0000}}\right]^2}$$

= not possible

SUMMARY DUE TO LONGITUDINAL HORIZONTAL FORCE

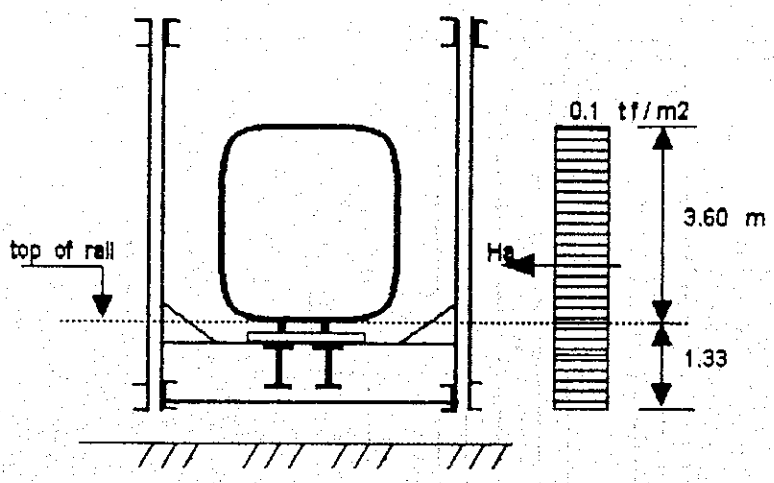
ITEMS	Support A	
	Ha [ton-f]	Va [ton-f]
Long Rail [DL]	30.49	1.70
Long [DL]+ Brake [B]	71.69 b	4.24 b
Long Rail [LL]	23.69 c	1.70 c
Seismic [DL]	10.39 d	0.64 d
Seismic [LL]	34.57 e	2.12 e

3.3.3. TRANSVERSAL HORIZONTAL FORCE

a. LATERAL LOAD

H a = 0.5 x 0.10 x 24 x 12.00 = 14.40 tf.

b. WIND LOAD



H a = 0.1 x 4.93 x 31.20 x 0.50 = 7.69 tf

c. DEAD LOAD FOR SEISMIIC LOAD

E a = 33.50 x 0.18 = 6.03 tf

d. LIVE LOAD FOR SEISMIIC LOAD

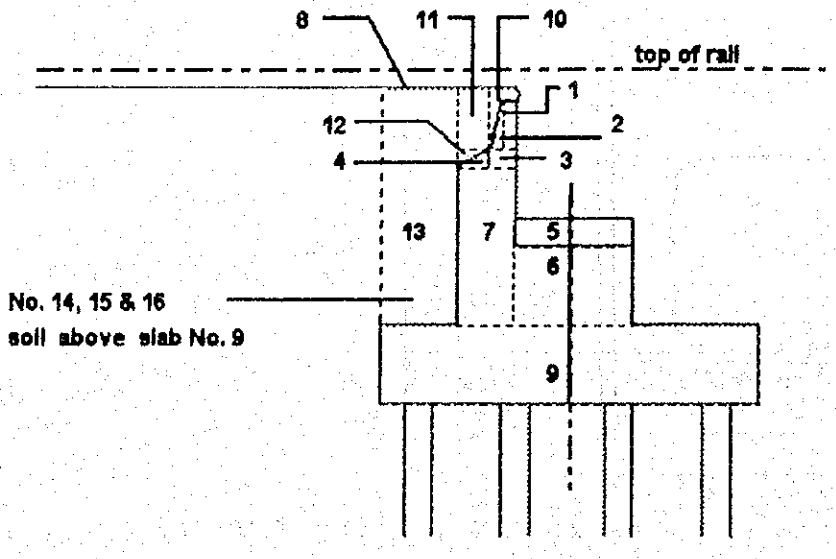
E a = 78 x 0.18 = 14.04 tf

SUMMARY DUE TO TRANSVERSAL HORIZONTAL FORCE

ITEMS	Support A	
	H	y
	[ton-f]	[m]
Lateral Load [Lr]	14.40	1.65
Wind Load [W]	7.69	2.79
Seismic [DL]	6.03	1.65
Seismic [LL]	14.04	1.65

3.4. EXTERNAL STABILITY CALCULATION.

3.4.1. WEIGHT OF ABUTMENT



Item	Weight of Abutment [tf]					x [m]	Mx [tf-m]	y [m]	My [tf-m]
1	0.200	x 0.600	x 5.400	x 2.400	= 1.555	-0.700	-1.089	3.740	5.816
2	0.050	x 0.600	x 5.400	x 2.400	= 0.389	-0.833	-0.324	3.640	1.416
3	0.300	x 0.200	x 5.400	x 2.400	= 0.778	-0.750	-0.583	3.340	2.597
4	0.200	x 0.200	x 5.400	x 2.400	= 0.518	-0.933	-0.484	3.307	1.714
5	1.250	x 0.400	x 2.800	x 2.400	= 3.360	0.025	0.084	2.400	8.064
6	1.250	x 1.000	x 6.000	x 2.400	= 18.000	0.025	0.450	1.700	30.600
7	0.700	x 2.040	x 5.400	x 2.400	= 18.507	-0.950	-17.582	2.218	41.039
8	2.025	x 4.090	x 0.600	x 2.400	= 11.926	-1.613	-19.231	2.645	31.545
9	5.250	x 1.200	x 12.600	x 2.400	= 190.512	0.000	0.000	0.600	114.307
10	0.050	x 0.650	x 6.400	x 2.000	= 0.361	-0.867	-0.304	3.870	1.368
11	0.400	x 0.650	x 5.400	x 2.000	= 2.808	-1.000	-2.808	3.765	10.572
12	0.200	x 0.200	x 6.400	x 2.000	= 0.432	-1.067	-0.461	3.373	1.457
13	1.325	x 2.890	x 5.400	x 2.000	= 41.356	-1.963	-81.161	2.645	109.386
14	2.025	x 2.170	x 6.600	x 1.600	= 46.403	-1.613	-74.826	3.005	139.442
15	5.250	x 2.170	x 2.600	x 1.600	= 47.393	0.000	0.000	3.005	142.415
16	5.250	x 0.690	x 6.600	x 1.600	= 38.264	0.000	0.000	1.905	72.873
	Total				422.542		-198.318		714.603

x = -0.47 m
y = 1.69 m

3.4.2. LOAD COMBINATIONS

a. IN LONGITUDINAL DIRECTION

1) Dead Load + Earth Pressure

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	0.00	0.00	0.00			
Eh				46.14	1.06	49.09
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	-1.28	2.63	-3.36			
Ha				0.00	2.60	0.00
Sub- total	49.02		-47.44	9.51		30.44
W [abutment]	422.64	-0.47	-198.32			
Total	471.56		-245.76			

$\Sigma M = -215.32$ tf-m

$\Sigma V = 471.56$ tf

$\Sigma H = 9.51$ tf

$e = M / N = -0.457$ m

2) Dead Load + Earth Pressure [LL]

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	0.00	0.00	0.00			
Eh				46.14	1.06	49.09
				10.00	2.05	20.45
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	3.64	-2.63	-9.56			
	-1.28	2.63	-3.36			
Ha				0.00	2.60	0.00
Sub- total	52.65		-56.99	19.51		50.89
W [abutment]	422.54	-0.47	-198.32			
Total	475.20		-255.31			

$\Sigma M = -204.42$ tf-m

$\Sigma V = 475.20$ tf

$\Sigma H = 19.51$ tf

$e = M / N = -0.43$ m

3) Dead Load + Train Load + Earth Pressure (LL)

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	152.15	0.00	0.00			
Eh				46.14	1.06	49.09
				10.00	2.05	20.45
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	3.64	-2.63	-9.55			
	-1.28	2.63	-3.36			
Ha				0.00	2.60	0.00
Sub- total	204.80		-56.99	19.51		50.89
W [abutment]	422.54	-0.47	-198.32			
Total	627.35		-255.31			

$\Sigma M = -204.42$ tf-m
$\Sigma V = 627.35$ tf
$\Sigma H = 19.51$ tf
$e = M / N = -0.33$ m

4) Dead Load + Train Load + Impact + Earth Pressure

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	152.15	0.00	0.00			
Va [I]	77.27	0.00	0.00			
Eh				46.14	1.06	49.09
				10.00	2.05	20.45
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	3.64	-2.63	-9.55			
	-1.28	2.63	-3.36			
Ha				0.00	2.60	0.00
Sub- total	282.08		-56.99	19.51		50.89
W [abutment]	422.54	-0.47	-198.32			
Total	704.62		-255.31			

$\Sigma M = -204.42$ tf-m
$\Sigma V = 704.62$ tf
$\Sigma H = 19.51$ tf
$e = M / N = -0.29$ m

6) Dead Load + Earth Pressure + Long Rail Load

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	0.00	0.00	0.00			
Va [Lr]	1.70	0.00	0.00			
Eh				46.14	1.06	49.09
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	-1.28	2.63	-3.36			
Ha				30.49	2.60	79.26
Sub- total	50.72		-47.44	40.00		109.70
W [abutment]	422.54	-0.47	-198.32			
Total	473.26		-245.76			

ΣM = -136.06 tf-m
ΣV = 473.26 tf
ΣH = 40.00 tf
e = M / N = -0.29 m

6) Dead Load + Train Load + Earth Pressure + Long Rail Load

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	152.15	0.00	0.00			
Va [Lr]	1.70	0.00	0.00			
Eh				46.14	1.06	49.09
				10.00	2.05	20.45
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	3.64	-2.63	-9.55			
	-1.28	2.63	-3.36			
Ha				30.49	2.60	79.26
Sub- total	206.50		-56.99	60.00		130.15
W [abutment]	422.54	-0.47	-198.32			
Total	629.05		-255.31			

ΣM = -125.16 tf-m
ΣV = 629.05 tf
ΣH = 50.00 tf
e = M / N = -0.20 m

7) Dead Load + Train Load + Impact + Earth Pressure + Long Rail Load

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	152.15	0.00	0.00			
Va [I]	77.27	0.00	0.00			
Va [Lr]	1.70	0.00	0.00			
Eh				46.14	1.06	49.09
				10.00	2.05	20.45
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	3.64	-2.63	-9.55			
	-1.28	2.63	-3.36			
Ha				23.69	2.60	61.60
Sub- total	283.76		-56.99	43.20		112.49
W [abutment]	422.54	-0.47	-198.32			
Total	706.32		-255.31			

$\Sigma M = -142.82$ tf-m
$\Sigma V = 706.32$ tf
$\Sigma H = 43.20$ tf
$e = M / N = -0.20$ m

8) Dead Load + Train Load + Brake Load + Long Rail Load + Earth Pressure

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	152.15	0.00	0.00			
Va [Lr]	4.24	0.00	0.00			
Eh				46.14	1.06	49.09
				10.00	2.05	20.45
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	3.64	-2.63	-9.55			
	-1.28	2.63	-3.36			
Ha				71.69	2.60	186.40
Sub- total	209.04		-56.99	91.20		237.29
W [abutment]	422.54	-0.47	-198.32			
Total	631.59		-255.31			

$\Sigma M = -18.02$ tf-m
$\Sigma V = 631.59$ tf
$\Sigma H = 91.20$ tf
$e = M / N = -0.03$ m

9) Dead Load + Train Load + Impact + Brake Load + Long Rail Load + Earth Pressure

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	152.16	0.00	0.00			
Va [I]	77.27	0.00	0.00			
Va [Lr]	1.70	0.00	0.00			
Eh				46.14	1.06	49.09
				10.00	2.05	20.45
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	3.64	-2.63	-9.55			
	-1.28	2.63	-3.36			
Ha				71.69	2.60	186.40
Sub- total	283.78		-56.99	91.20		237.29
W [abutment]	422.54	-0.47	-198.32			
Total	706.32		-255.31			

Σ M = -18.02 tf-m
Σ V = 706.32 tf
Σ H = 91.20 tf
e = M / N = -0.03 m

10) Dead Load + Earth Pressure + Seismic

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	0.00	0.00	0.00			
Va [Eq]	0.64	0.00	0.00			
Eh				46.14	1.06	49.09
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	-1.28	2.63	-3.36			
Ha				10.39	2.60	27.00
Sub- total	49.65		-47.44	19.90		57.44
W [abutment]	422.54	-0.47	-198.32	76.06	1.69	128.63
Total	472.19		-245.76	95.96		186.07

Σ M = -69.69 tf-m
Σ V = 472.19 tf
Σ H = 95.96 tf
e = M / N = -0.13 m

11) Dead Load + Earth Pressure + Seismic [LL]

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	78.00	0.00	0.00			
Va [Eq]	2.12	0.00	0.00			
Eh				46.14	1.06	49.09
				10.00	2.05	20.45
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	3.64	-2.63	-9.55			
	-1.28	2.63	-3.36			
Ha				34.57	2.60	89.87
Sub- total	132.78		-56.99	64.08		140.76
W [abutment]	422.54	-0.47	-198.32	76.06	1.69	128.63
Total	555.32		-255.31	130.13		269.39

ΣM = 14.07 tf-m
ΣV = 555.32 tf
ΣH = 130.13 tf
e = M / N = 0.03 m

b. IN TRANSVERSAL DIRECTION

1) Dead Load + Train Load + Impact + Lateral Load + Wind Load + Earth Pressure

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	152.15	0.00	0.00			
Va [Lr]	1.70	0.00	0.00			
Eh				46.14	1.06	48.09
				10.00	2.05	20.45
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	3.64	-2.63	-9.55			
	-1.28	2.63	-3.36			
Sub- total	206.50		-56.99	19.51		50.89
W [abutment]	422.54	-0.47	-198.32	0.00	0.00	0.00
Total	629.05		-255.31	19.51		50.89
H [Lr]				14.40	2.60	37.44
H [W]				7.69	2.60	20.00
Total				22.09		57.44

$\Sigma M = -204.42$ tf-m (longitudinal)

$\Sigma M = 67.44$ tf-m (transversal)

$\Sigma V = 629.05$ tf

$\Sigma H = 19.51$ tf (longitudinal)

$\Sigma H = 22.09$ tf (transversal)

$e = M / N = -0.32$ m (longitudinal)

$e = M / N = 0.09$ m (transversal)

2) Dead Load + Earth Pressure + Seismic

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.00	0.00			
Va [LL]	78.00	0.00	0.00			
Va [Eq]	0.64	0.00	0.00			
Eh				46.14	1.06	49.09
				-36.63	0.51	-18.65
Ev	16.79	-2.63	-44.08			
	-1.28	2.63	-3.36			
Eq [DL]				14.04	2.60	36.50
Sub- total	127.65		-47.44	23.55		66.95
W [abutment]	422.54	-0.47	-198.32	76.06	1.69	128.63
Total	550.19		-245.76	99.61		195.58
Eq [LL]				76.06	1.69	128.63

ΣM = -50.18 tf-m (longitudinal)

ΣM = 128.63 tf-m (transversal)

ΣV = 550.19 tf

ΣH = 99.61 tf (longitudinal)

ΣH = 76.06 tf (transversal)

e = M / N = -0.09 m (longitudinal)

e = M / N = 0.23 m (transversal)

3.4.3. CAPACITY OF PILE

ALLOWABLE CAPACITY OF PILE

1) MATERIAL

PRESTRESS CONCRETE PILE.

Quality		K - 500
Diameter	=	0.45 m
g	=	0.23 tf / m'
Area	=	0.159 m2 (End Pile)
Area	=	0.093 m2 (Body of Pile)
E	=	1400000 t-f / m2
I	=	0.002 m4
Pn	=	130 tf.

2) BEARING CAPACITY OF PILE

Elevation bottom of abutment = 1.15 m+

Refer to Boring Log R-17

Elevation of ground surface = 1.33 m+

a) End Bearing

N 1	=	58.00				
N 2	=	0.50 (	58.00 +	5.00)=	31.50	
N r	=	0.50 (	58.00 +	31.50)=	44.75	
therefore						
N r	=	39.25				
L e	=	0.70 m				

$$\frac{Le}{D} = 1.56$$

$$qd = 13.11 \times Nr = 13.11 \times 39.25 = 514.61 \text{ tf}$$

$$Pb = 514.61 \times 0.159 = 81.85 \text{ tf}$$

b) Friction

Elevtion [m+]	Soil Describtion	Thickness [m]	N r	f i	L i x f i [t-f / m]
+1.15 - 13.67	silty clay	14.82	4	4	59.28
-13.67 - 14.70	silty clay	1.03	40	12	12.36
		15.85		total	71.64

Efficiency Group of Pile.

$$Eg = 1 - \tan^{-1}\left(\frac{0.45}{1.20}\right) \times \frac{9 + 8}{90 \times 4 \times 3}$$

$$= 0.68$$

$$Pf = 0.68 \times 71.64 \times 1.4137 = 68.87 \text{ tf}$$

c) Allowable bearing capacity of pile.

- Normal Condition

Coefficient Factor

$$\alpha = 1 \longrightarrow Pa = \frac{81.85}{3} + \frac{68.87}{4} = 44.50 \text{ tf}$$

$$\alpha = 1.15 \longrightarrow Pa = 1.15 \times 44.50 = 51.17 \text{ tf}$$

$$\alpha = 1.25 \longrightarrow Pa = 1.25 \times 44.50 = 55.62 \text{ tf}$$

- Earthquake Condition

$$Pa = \frac{81.845}{2} + \frac{68.869}{3} = 63.88 \text{ tf}$$

d) Allowable Axial Pull - Out Capacity of Pile.

$$Pa = \frac{Pu}{SF} + W$$

- Normal Condition

$$Pu = 71.64 \times 1.4137 = 101.28 \text{ tf}$$

$$W\,pile = 15.85 \times 0.23 = 3.6455 \text{ tf}$$

$$Pa = \frac{101.28}{6} + 3.6455 = 20.525 \text{ tf}$$

- Earthquake Condition

$$Pa = \frac{101.28}{3} + 3.6455 = 37.405 \text{ tf}$$

3.4.4. PILE CALCULATION.

CONCRETE PILE CALCULATION
No : 1

PROJECT : RAILWAY BRIDGE ACROSS WEST FLOODWAY
LOCATION : BH. 10 , ABUTMENT CIREBON SIDE (DL+LL+I+E)

DISPLACEMENT METHOD

DATA OF PILE :

- NUMBER OF PILE	:	22
- LENGTH	:	15.85 m.
- DIAMETER	:	0.45 m.
- AREA	:	0.0930 m2.
- INERSIA	:	0.002000 m4
- MODULUS ELASTICITY [E]	:	1400000.00 tf/m2.

ANGLE AND COORDINATE OF PILE :

No. PILE	ANGLE TO THE VERTICAL AXIS [°]	DISTANCE TO THE POER AXIS [m]
1	0.00	-2.03
2	0.00	-2.03
3	0.00	-2.03
4	0.00	-2.03
5	0.00	-1.35
6	0.00	-1.35
7	0.00	-0.68
8	0.00	-0.68
9	0.00	-0.68
10	0.00	-0.68
11	0.00	0.00
12	0.00	0.00
13	0.00	0.68
14	0.00	0.68
15	0.00	0.68
16	0.00	0.68
17	0.00	1.35
18	0.00	1.35
19	0.00	2.03
20	0.00	2.03
21	0.00	2.03
22	0.00	2.03

EXTERNAL FORCE :

- MOMENT	:	-204.42 tf m.
- VERTICAL FORCE	:	704.62 tf.
- HORIZONTAL FORCE	:	19.51 tf.

N VALUE : 4

COEFFICIENT OF HORIZONTAL SUBGRADE REACTION :
Ko : 1.29 kg-f/cm3.
k : 4.08 kg-f/cm3 = 4076.98 t-f/m3.

CHRACTERISTIC VALUE OF PILE :
β : 0.63618 1/m.
Γ : 1.57 m.

SPRING CONSTANTS OF PILE :

k1	:	2883.82 tf/m.			
k2 = k3	:	2266.49 tf/rad.			
k4	:	3562.63 tm-f/rad.			
a	:	1.17	---->	kv :	9644.75 t/m.

DISPLACEMENT EQUATIONS :

(6.3E+04) δx+(0.0E+00) δy+(-5.0E+04) α = 19.51
(0.0E+00) δx+(2.1E+05) δy+(0.0E+00) α = 704.62
(-5.0E+04) δx+(0.0E+00) δy+(5.0E+05) α = -204.42

DISPLACEMENT AT CENTERLINE OF PILECAP :

δx : -0.00 cm
δy : 0.33 cm
α : -0.00041 rad

DISPLACEMENT AND AXIAL/ORTHOGONAL FORCE :

No. PILE	δ'x [cm]	δ'y [cm]	PH [tf]	PN [tf]
1	-0.00	0.42	0.89	40.04
2	-0.00	0.42	0.89	40.04
3	-0.00	0.42	0.89	40.04
4	-0.00	0.42	0.89	40.04
5	-0.00	0.39	0.89	37.37
6	-0.00	0.39	0.89	37.37
7	-0.00	0.36	0.89	34.70
8	-0.00	0.36	0.89	34.70
9	-0.00	0.36	0.89	34.70
10	-0.00	0.36	0.89	34.70
11	-0.00	0.33	0.89	32.03
12	-0.00	0.33	0.89	32.03
13	-0.00	0.30	0.89	29.36
14	-0.00	0.30	0.89	29.36
15	-0.00	0.30	0.89	29.36
16	-0.00	0.30	0.89	29.36
17	-0.00	0.28	0.89	26.69
18	-0.00	0.28	0.89	26.69
19	-0.00	0.25	0.89	24.02
20	-0.00	0.25	0.89	24.02
21	-0.00	0.25	0.89	24.02
22	-0.00	0.25	0.89	24.02

REACTION ON HEAD OF PILE :

No. PILE	H [tf]	N [tf]	Mt [tf-m]
1	0.89	40.04	-1.43
2	0.89	40.04	-1.43
3	0.89	40.04	-1.43
4	0.89	40.04	-1.43
5	0.89	37.37	-1.43
6	0.89	37.37	-1.43
7	0.89	34.70	-1.43
8	0.89	34.70	-1.43
9	0.89	34.70	-1.43
10	0.89	34.70	-1.43
11	0.89	32.03	-1.43
12	0.89	32.03	-1.43

13	0.89	29.36	-1.43
14	0.89	29.36	-1.43
15	0.89	29.36	-1.43
16	0.89	29.36	-1.43
17	0.89	26.69	-1.43
18	0.89	26.69	-1.43
19	0.89	24.02	-1.43
20	0.89	24.02	-1.43
21	0.89	24.02	-1.43
22	0.89	24.02	-1.43

ALLOWABLE HORZONTAL FORCE

δ = 1 cm (Normal Condition)
H all = 28.84 tf

CONCRETE PILE CALCULATION
No : 1

BH. 10-31

PROJECT : RAILWAY BRIDGE ACROSS FLOODWAY
LOCATION : BH. 10 , ABUTMENT CIREBON SIDE (DL+LL+I+E+Lr)

DISPLACEMENT METHOD

DATA OF PILE :

- NUMBER OF PILE	:	22
- LENGTH	:	15.85 m.
- DIAMETER	:	0.45 m.
- AREA	:	0.0930 m2.
- INERSIA	:	0.002000 m4
- MODULUS ELASTICITY [E]	:	1400000.00 tf/m2.

ANGLE AND COORDINATE OF PILE :

No. PILE	ANGLE TO THE VERTICAL AXIS [°]	DISTANCE TO THE POER AXIS [m]
1	0.00	-2.03
2	0.00	-2.03
3	0.00	-2.03
4	0.00	-2.03
5	0.00	-1.35
6	0.00	-1.35
7	0.00	-0.68
8	0.00	-0.68
9	0.00	-0.68
10	0.00	-0.68
11	0.00	0.00
12	0.00	0.00
13	0.00	0.68
14	0.00	0.68
15	0.00	0.68
16	0.00	0.68
17	0.00	1.35
18	0.00	1.35
19	0.00	2.03
20	0.00	2.03
21	0.00	2.03
22	0.00	2.03

EXTERNAL FORCE :

- MOMENT	:	-142.82 tf m.
- VERTICAL FORCE	:	706.32 tf.
- HORIZONTAL FORCE	:	43.20 tf.

N VALUE : 4

COEFFICIENT OF HORIZONTAL SUBGRADE REACTION :
Ko : 1.29 kg-f/cm3.
k : 4.08 kg-f/cm3 = 4076.98 t-f/m3.

CHRACTERISTIC VALUE OF PILE :
β : 0.63618 1/m.
r : 1.57 m.

SPRING CONSTANTS OF PILE :

k1	:	2883.82 tf/m.			
k2 = k3	:	2266.49 tf/rad.			
k4	:	3562.63 tm-f/rad.			
a	:	1.17 ---->	kv :	9644.75 t/m.	

DISPLACEMENT EQUATIONS :

(6.3E+04) δx+(0.0E+00) δy+(-5.0E+04) α = 43.20
(0.0E+00) δx+(2.1E+05) δy+(0.0E+00) α = 706.32
(-5.0E+04) δx+(0.0E+00) δy+(5.0E+05) α = -142.82

DISPLACEMENT AT CENTERLINE OF PILECAP :

δx	:	0.05 cm
δy	:	0.33 cm
α	:	-0.00024 rad

DISPLACEMENT AND AXIAL/ORTHOGONAL FORCE :

No. PILE	δ'x [cm]	δ'y [cm]	PH [tf]	PN [tf]
1	0.05	0.38	1.96	36.72
2	0.05	0.38	1.96	36.72
3	0.05	0.38	1.96	36.72
4	0.05	0.38	1.96	36.72
5	0.05	0.36	1.96	35.18
6	0.05	0.36	1.96	35.18
7	0.05	0.35	1.96	33.64
8	0.05	0.35	1.96	33.64
9	0.05	0.35	1.96	33.64
10	0.05	0.35	1.96	33.64
11	0.05	0.33	1.96	32.11
12	0.05	0.33	1.96	32.11
13	0.05	0.32	1.96	30.57
14	0.05	0.32	1.96	30.57
15	0.05	0.32	1.96	30.57
16	0.05	0.32	1.96	30.57
17	0.05	0.30	1.96	29.03
18	0.05	0.30	1.96	29.03
19	0.05	0.29	1.96	27.49
20	0.05	0.29	1.96	27.49
21	0.05	0.29	1.96	27.49
22	0.05	0.29	1.96	27.49

REACTION ON HEAD OF PILE :

No. PILE	H [tf]	N [tf]	Mt [tf-m]
1	1.96	36.72	-1.96
2	1.96	36.72	-1.96
3	1.96	36.72	-1.96
4	1.96	36.72	-1.96
5	1.96	35.18	-1.96
6	1.96	35.18	-1.96
7	1.96	33.64	-1.96
8	1.96	33.64	-1.96
9	1.96	33.64	-1.96
10	1.96	33.64	-1.96
11	1.96	32.11	-1.96
12	1.96	32.11	-1.96

13	1.96	30.57	-1.96
14	1.96	30.57	-1.96
15	1.96	30.57	-1.96
16	1.96	30.57	-1.96
17	1.96	29.03	-1.96
18	1.96	29.03	-1.96
19	1.96	27.49	-1.96
20	1.96	27.49	-1.96
21	1.96	27.49	-1.96
22	1.96	27.49	-1.96

ALLOWABLE HORZONTAL FORCE

δ = 1 cm (Normal Condition)
H all = 28.84 tf

CONCRETE PILE CALCULATION
No : 1

PROJECT : RAILWAY BRIDGE ACROSS WEST FLOODWAY
LOCATION : BH. 10 , ABUTMENT CIREBON SIDE (DL+LL+I+E+B+Lr)

DISPLACEMENT METHOD

DATA OF PILE :

- NUMBER OF PILE	:	22
- LENGTH	:	15.85 m.
- DIAMETER	:	0.45 m.
- AREA	:	0.0930 m2.
- INERSIA	:	0.002000 m4
- MODULUS ELASTICITY [E]	:	1400000.00 tf/m2.

ANGLE AND COORDINATE OF PILE :

No. PILE	ANGLE TO THE VERTICAL AXIS [°]	DISTANCE TO THE POER AXIS [m]
1	0.00	-2.03
2	0.00	-2.03
3	0.00	-2.03
4	0.00	-2.03
5	0.00	-1.35
6	0.00	-1.35
7	0.00	-0.68
8	0.00	-0.68
9	0.00	-0.68
10	0.00	-0.68
11	0.00	0.00
12	0.00	0.00
13	0.00	0.68
14	0.00	0.68
15	0.00	0.68
16	0.00	0.68
17	0.00	1.35
18	0.00	1.35
19	0.00	2.03
20	0.00	2.03
21	0.00	2.03
22	0.00	2.03

EXTERNAL FORCE :

- MOMENT	:	-18.02 tf m.
- VERTICAL FORCE	:	706.32 tf.
- HORIZONTAL FORCE	:	91.20 tf.

N VALUE : 4

COEFFICIENT OF HORIZONTAL SUBGRADE REACTION :
Ko : 1.29 kg-f/cm3.
k : 2.88 kg-f/cm3 = 2882.86 t-f/m3.

CHRACTERISTIC VALUE OF PILE :
β : 0.58338 1/m.
I : 1.71 m.

SPRING CONSTANTS OF PILE :

k1	:	2223.73 tf/m.			
k2 = k3	:	1905.89 tf/rad.			
k4	:	3266.95 tm-f/rad.			
a	:	1.17	---->	kv :	9644.75 t/m.

DISPLACEMENT EQUATIONS :

(4.9E+04) δx+	(0.0E+00) δy+	(-4.2E+04) α =	91.20
(0.0E+00) δx+	(2.1E+05) δy+	(0.0E+00) α =	706.32
(-4.2E+04) δx+	(0.0E+00) δy+	(4.9E+05) α =	-18.02

DISPLACEMENT AT CENTERLINE OF PILECAP :

δx	:	0.20 cm
δy	:	0.33 cm
α	:	0.00013 rad

DISPLACEMENT AND AXIAL/ORTHOGONAL FORCE :

No. PILE	δ'x [cm]	δ'y [cm]	PH [tf]	PN [tf]
1	0.20	0.31	4.15	29.54
2	0.20	0.31	4.15	29.54
3	0.20	0.31	4.15	29.54
4	0.20	0.31	4.15	29.54
5	0.20	0.32	4.15	30.39
6	0.20	0.32	4.15	30.39
7	0.20	0.32	4.15	31.25
8	0.20	0.32	4.15	31.25
9	0.20	0.32	4.15	31.25
10	0.20	0.32	4.15	31.25
11	0.20	0.33	4.15	32.11
12	0.20	0.33	4.15	32.11
13	0.20	0.34	4.15	32.96
14	0.20	0.34	4.15	32.96
15	0.20	0.34	4.15	32.96
16	0.20	0.34	4.15	32.96
17	0.20	0.35	4.15	33.82
18	0.20	0.35	4.15	33.82
19	0.20	0.36	4.15	34.67
20	0.20	0.36	4.15	34.67
21	0.20	0.36	4.15	34.67
22	0.20	0.36	4.15	34.67

REACTION ON HEAD OF PILE :

No. PILE	H [tf]	N [tf]	Mt [tf-m]
1	4.15	29.54	-3.34
2	4.15	29.54	-3.34
3	4.15	29.54	-3.34
4	4.15	29.54	-3.34
5	4.15	30.39	-3.34
6	4.15	30.39	-3.34
7	4.15	31.25	-3.34
8	4.15	31.25	-3.34
9	4.15	31.25	-3.34
10	4.15	31.25	-3.34
11	4.15	32.11	-3.34
12	4.15	32.11	-3.34

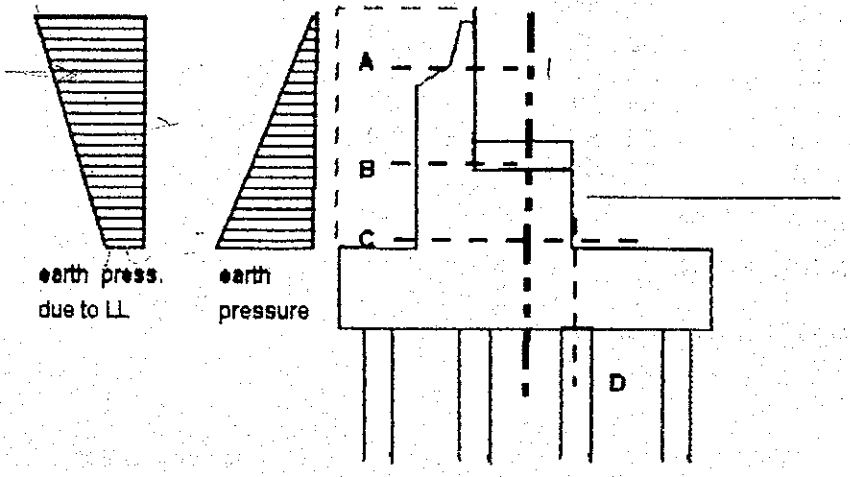
12	4.15	32.11	-3.34
13	4.15	32.96	-3.34
14	4.15	32.96	-3.34
15	4.15	32.96	-3.34
16	4.15	32.96	-3.34
17	4.15	33.82	-3.34
18	4.15	33.82	-3.34
19	4.15	34.67	-3.34
20	4.15	34.67	-3.34
21	4.15	34.67	-3.34
22	4.15	34.67	-3.34

ALLOWABLE HORZONTAL FORCE

δ = 1 cm (Normal Condition)
H all = 22.24 tf

3.5. REINFORCEMENT CALCULATION

3.5.1. SKETCH

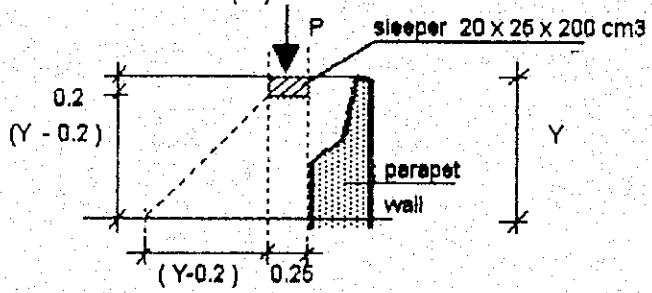


3.5.2. PARAPET WALL

a) EARTH PRESSURE

Y	=	0.00 m	ph	=	0.00 t/m2				
Y	=	0.60 m	ph	=	0.60	x 2.00	x 0.2973	=	0.357 t/m2
Y	=	1.84 m	ph	=	1.84	x 2.00	x 0.2973	=	1.094 t/m2
Y	=	2.89 m	ph	=	2.89	x 2.00	x 0.2973	=	1.718 t/m2

EARTH PRESSURE DUE TO LIVE LOAD (LL)



P = 20.00 tf
I = 1.50
PI = 1.50 x 20.00 = 30.00 tf

Y = 0.00 m

$$q = \frac{30.00}{2.00 \times 0.25} = 60.00 \text{ tf/m2}$$

ph = 0.2973 x 60.00 = 17.839 t/m2

Y = 0.60 m

$$q = \frac{30.00}{0.65 \times 2.80} = 16.48 \text{ tf/m2}$$

ph = 0.2973 x 16.48 = 4.901 t/m2

Y = 1.84 m

$$q = \frac{30.00}{1.89 \times 5.28} = 3.01 \text{ tf/m2}$$

ph = 0.2973 x 3.01 = 0.894 t/m2

Y = 2.89 m

$$q = \frac{30.00}{1.95 \times 5.40} = 2.85 \text{ tf/m2}$$

ph = 0.2973 x 2.85 = 0.847 t/m2

b) SECTION A - A

- Vertical Dead Load (concrete)

					V [tf]	X [m]	M [tf-m]
0.200	x 0.600	x 1.000	x 2.400	=	0.288	0.050	0.014
0.050	x 0.600	x 1.000	x 2.400	=	0.072	-0.083	-0.006
					0.360		0.008

- Horizontal Load

					V [tf]	X [m]	M [tf-m]
0.500	x 0.600	x 0.357	x 1.000	=	0.107	0.200	0.021
0.600	x 4.901	x 1.000		=	2.940	0.300	0.882
0.500	x 0.600	x 12.938	x 1.000	=	3.881	0.400	1.553
					6.929		2.456

M = 0.008 + 2.456 = 2.465 tf-m
V = 0.360 tf
H = 6.929 tf

h = 24 cm
b = 100 cm

$$\phi o = \frac{2250}{21 \times 75} = 1.4286$$

Cs = 5.0041
δ = 0.6
ϕ = 3.082
ϕ l = 5.207
ζ = 0.916
nw = 0.045 ——> A = 5.14 cm2
A' = 3.09 cm2
A min = 7.5 cm2
D 13 - 10.00 cm
D 13 - 20.00 cm

$$\tau = \frac{6.9289 \times 1000}{0.875 \times 100 \times 24} = 3.30 \text{ kg f/cm2}$$

b) SECTION B - B

- Vertical Dead Load (concrete)

					V [tf]	X [m]	M [tf-m]
0.200	x 0.600	x 1.000	x 2.400	=	0.288	0.250	0.072
0.050	x 0.600	x 1.000	x 2.400	=	0.072	0.117	0.008
0.300	x 0.200	x 1.000	x 2.400	=	0.144	0.200	0.029
0.200	x 0.200	x 1.000	x 2.400	=	0.096	-0.083	-0.008
0.700	x 1.040	x 1.000	x 2.400	=	1.747	0.000	0.000
					2.347		0.101

- Horizontal Load

					V [tf]	X [m]	M [tf-m]
0.600	x 1.840	x 1.094	x 1.000	=	1.007	0.613	0.617
1.840	x 0.894	x 1.000	x 0.000	=	1.645	0.920	1.513
0.600	x 1.840	x 16.945	x 1.000	=	15.589	1.227	19.123
					18.241		21.253

M = 0.1013 + 21.253 = 21.355 tf-m
V = 2.3472 tf
H = 18.241 tf

h = 64 cm
b = 100 cm

$$\phi o = \frac{2250}{21 \times 75} = 1.4286$$

Ca = 4.5333
δ = 0.4
ϕ = 2.704
ϕ l = 4.294
ζ = 0.909
nw = 0.055 ——> A = 16.76 cm2 D 16 - 10.00 cm
A' = 6.70 cm2 D 16 - 20.00 cm
A min = 7.5 cm2

$$\tau = \frac{18.241 \times 1000}{0.875 \times 100 \times 64} = 3.26 \text{ kg f/cm2}$$

3.5.3. BODY
SECTION C - C

- Vertical Dead Load (concrete)

					V [tf]	X [m]	M [tf-m]
0.200	x 0.600	x 6.000	x 2.400	=	1.728	-0.375	-0.648
0.050	x 0.600	x 6.000	x 2.400	=	0.432	-0.508	-0.219
0.300	x 0.200	x 6.000	x 2.400	=	0.864	-0.425	-0.367
0.200	x 0.200	x 6.000	x 2.400	=	0.576	-0.708	-0.408
1.250	x 0.400	x 6.000	x 2.400	=	7.200	0.360	2.520
1.250	x 1.000	x 6.000	x 2.400	=	18.000	0.350	6.300
0.700	x 2.040	x 6.000	x 2.400	=	20.563	-0.625	-12.852
					49.363	-0.115	-5.674

- Horizontal Load

					V [tf]	X [m]	M [tf-m]
0.500	x 2.890	x 1.718	x 6.000	=	14.899	0.963	14.353
2.890	x 0.847	x 6.000	x 0.000	=	14.688	1.445	21.224
0.500	x 2.890	x 16.992	x 6.000	=	147.319	1.927	283.834
					176.906	1.806	319.411

a) Dead Load + Earth Pressure [LL]

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.325	10.89			
Va [LL]	0.00	0.325	0.00			
Eh				176.91	1.81	319.41
Ha				0.00	1.40	0.00
Sub- total	33.50		10.89	176.91		319.41
W	49.36	-0.11	-5.67			
Total	82.86		5.21			

M = 324.62 x 0.1667 = 54.104 tf-m / m
V = 82.863 x 0.1667 = 13.811 tf / m
H = 176.91 x 0.1667 = 29.484 tf / m

b) Dead Load + Train Load + Impact + Earth Pressure

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.325	10.89			
Va [LL]	152.15	0.325	49.45			
Va [I]	77.27	0.325	25.11			
Eh				176.91	1.81	319.41
Ha				0.00	1.40	0.00
Sub- total	262.92		85.45	176.91		319.41
W	49.36	-0.11	-5.67			
Total	312.29		79.78			

M = 399.19 x 0.1667 = 66.531 tf-m
V = 312.29 x 0.1667 = 52.048 tf
H = 176.91 x 0.1667 = 29.484 tf

c) Dead Load + Earth Pressure + Long Rail Load

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.325	10.89			
Va [LL]	0.00	0.325	0.00			
Va [Lr]	1.70	0.325	0.55			
Eh				176.91	1.81	319.41
Ha				30.49	1.40	42.68
Sub- total	35.20		11.44	207.39		362.09
W	49.36	-0.11	-5.67			
Total	84.56		5.77			

M = 367.86 x 0.1667 = 61.309 tf-m
V = 84.564 x 0.1667 = 14.094 tf
H = 207.39 x 0.1667 = 34.565 tf

d) Dead Load + Train Load + Impact + Earth Pressure + Long Rail Load

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.325	10.89			
Va [LL]	152.16	0.325	49.46			
Va [I]	77.27	0.325	25.11			
Va [Lr]	1.70	0.325	0.55			
Eh				176.91	1.81	319.41
Ha				23.69	1.40	33.17
Sub- total	264.62		86.00	200.60		352.58
W	49.36	-0.11	-5.67			
Total	313.99		80.33			

M = 432.91 x 0.1667 = 72.152 tf-m
V = 313.99 x 0.1667 = 52.331 tf
H = 200.6 x 0.1667 = 33.433 tf

e) Dead Load + Train Load + Brake Load + Long Rail Load + Earth Pressure

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.325	10.89			
Va [LL]	152.15	0.325	49.45			
Va [Lr]	4.24	0.325	1.38			
Eh				176.91	1.81	319.41
Ha				71.69	1.40	100.37
Sub- total	189.89		61.71	248.60		419.78
W	49.36	-0.11	-5.67			
Total	239.25		56.04			

M = 475.82 x 0.1667 = 79.303 tf-m
V = 239.25 x 0.1667 = 39.875 tf
H = 248.6 x 0.1667 = 41.433 tf

f) Dead Load + Train Load + Impact + Brake Load + Long Rail Load + Earth Pressure

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.325	10.89			
Va [LL]	152.15	0.325	49.45			
Va [I]	77.27	0.325	25.11			
Va [Lr]	1.70	0.325	0.55			
Eh				176.91	1.81	319.41
Ha				71.69	1.40	100.37
Sub- total	264.62		86.00	248.60		419.78
W	49.36	-0.11	-5.67			
Total	313.99		80.33			

M = 500.11 x 0.1667 = 83.352 tf-m
V = 313.99 x 0.1667 = 52.331 tf
H = 248.6 x 0.1667 = 41.433 tf

g) Dead Load + Earth Pressure + Seismic [LL]

ITEMS	V [tf]	x [m]	M [tf-m]	H [t]	y [m]	M [tf-m]
Va [DL]	33.50	0.325	10.89			
Va [LL]	78.00	0.325	25.35			
Va [Eq]	2.12	0.325	0.69			
Eh				176.91	1.81	319.41
Ha				34.67	1.40	48.39
Sub- total	113.62		36.93	211.47		367.80
W	49.36	-0.11	-5.67			
Total	162.99		31.26			

M = 399.05 x 0.1667 = 66.509 tf-m
V = 162.99 x 0.1667 = 27.164 tf
H = 211.47 x 0.1667 = 35.245 tf

REINFORCEMENT ANALYSIS

ITEMS	CASE						
	A	B	C	D	E	F	G
Internal Force							
M [tf m]	54.10	66.53	61.31	72.15	79.30	83.35	66.51
V [tf]	13.81	52.05	14.09	52.33	39.88	52.33	27.16
HQ [tf]	29.48	29.48	34.57	33.43	41.43	41.43	35.25
b [m]	1.00	1.00	1.00	1.00	1.00	1.00	1.00
h [m]	1.95	1.95	1.95	1.95	1.95	1.95	1.95
d [m]	1.88	1.88	1.88	1.88	1.88	1.88	1.88
d' [m]	0.07	0.07	0.07	0.07	0.07	0.07	0.07
n	21	21	21	21	21	21	21
ϕ o	1.4286	1.4286	1.4286	1.4286	1.2190	1.2190	1.2190
e o1 [m]	3.92	1.28	4.35	1.38	1.99	1.59	2.46
e o2 [m]	0.07	0.07	0.07	0.07	0.07	0.07	0.07
e o [m]	3.98	1.34	4.42	1.44	2.05	1.66	2.51
e o / h	2.04	0.69	2.26	0.74	1.05	0.85	1.29
C	7.00	6.96	7.00	6.97	7.70	7.68	7.70
lk [m]	1.40	1.40	1.40	1.40	1.40	1.40	1.40
e 1 [m]	0.00	0.00	0.00	0.00	0.00	0.00	0.00
e 2 [m]	0.29	0.29	0.29	0.29	0.29	0.29	0.29
e [m]	4.28	1.64	4.71	1.74	2.35	1.95	2.81
e a [m]	5.18	2.54	5.61	2.64	3.25	2.86	3.71
N ea [tf m]	71.54	132.24	79.10	138.22	129.65	149.42	100.80
C a	7.276	5.351	6.919	5.234	6.446	6.004	7.309
δ	0.400	0.400	0.400	0.400	0.400	0.400	0.400
ϕ	4.556	3.255	4.405	3.167	4.000	3.651	4.556
ϕ !	10.250	5.667	9.000	5.429	8.000	6.826	10.250
ζ	0.180	0.235	0.190	0.240	0.200	0.215	0.180
ζ	0.938	0.920	0.935	0.918	0.932	0.927	0.938
C b	3.268	2.812	3.172	2.778	3.082	2.959	3.268
nw	0.021	0.039	0.022	0.041	0.027	0.032	0.021
Reinforcement							
l	1.516	3.132	1.456	2.885	2.169	2.567	1.906
A [cm]	12.40	11.15	13.53	12.72	11.15	11.16	9.87
A' [cm]	7.52	13.97	7.88	14.68	9.67	11.46	7.52
A min [cm2]	47.00	47.00	47.00	47.00	47.00	47.00	47.00
Therefore							
A [cm]	47.00	47.00	47.00	47.00	47.00	47.00	47.00
Rebar diameter	25	25	25	25	25	25	25
Distance [cm]	10	10	10	10	10	10	10
A' [cm2]	18.80	18.80	18.80	18.80	18.80	18.80	18.80
Rebar diameter	25	25	25	25	25	25	25
Distance [cm]	25	25	25	25	25	25	25
Checking Shear Stress							
τ [kgf/cm2]	1.79	1.79	2.10	2.03	2.52	2.52	2.14

3.5.4 FOOTING / PILE CAP.

Pararel with Track

SECTION D - D

a) Dead Load + Train Load + Impact + Earth Pressure

Vertical Force

Vd	=	1.975	x	1.20	x	3.00	x -2.40 =	-17.06	tf (concrete)
Vp	=					24.02	x 2 =	48.04	tf (pile reaction)
						26.69	x 1 =	26.69	tf (pile reaction)
						29.36	x 2 =	58.72	tf (pile reaction)
							total =	116.39	tf

Moment at section d - d

M vd	=	-17.06	x	-0.988			=	16.851	t f m
M pd	=	24.02	x	1.375	x	2	=	66.055	t f m
		26.69	x	0.70	x	1	=	18.683	t f m
		29.36	x	0.025	x	2	=	1.468	t f m
						total	=	103.06	t f m

therefore per m' .

V d	=	116.39	x	0.3333	=	38.795 t f / m'
M d	=	103.06	x	0.3333	=	34.352 t-f m / m'

h = 104 cm

b = 100 cm

$$\phi o = \frac{2250}{21 \times 75} = 1.4286$$

Ca	=	5.8081				
δ	=	0.4				
ϕ	=	3.345				
ϕ l	=	6.500				
ζ	=	0.925				
nw	=	0.033	---->	A	=	16.34 cm2
				A'	=	6.54 cm2
				A min	=	24.00 cm2 D 19 - 10.00 cm ✓

$$\tau = \frac{38.795 \times 1000}{0.875 \times 100 \times 104} = 4.26 \text{ kg f/cm2}$$

Check Punch

P = 29.36 t f

$$\tau = \frac{29.36 \times 1000}{3.14 \times (45 + 104) \times 104} = 0.60 \text{ kg f/cm2}$$

b) Dead Load + Train Load + Impact + Earth Pressure + Long rail

Vertical Force

Vd	=	1.975	x	1.20	x	3.00	x -2.40 =	-17.06 tf	(concrete)
Vp	=					27.49	x 2 =	54.98 tf	(pile reaction)
						29.03	x 1 =	29.03 tf	(pile reaction)
						30.57	x 2 =	61.14 tf	(pile reaction)
							total =	128.09 tf	

Moment at section d - d

Mvd	=	-17.06	x	0.9875	=	-16.85	tf m
Mpd	=	27.49	x	1.375	x 4 =	151.2	tf m
		29.03	x	0.70	x 2 =	40.642	tf m
		30.57	x	0.025	x 4 =	3.057	tf m
					total =	178.04	tf m

therefore per m' .

Vd	=	128.09	x 0.3333	=	42.695 tf / m'
Md	=	178.04	x 0.3333	=	59.348 t-f m / m'

h = 104 cm

b = 100 cm

$$\phi o = \frac{3200}{21 \times 125} = 1.219$$

Ca	=	5.2698				
δ	=	0.4				
ϕ	=	3.167				
ϕ l	=	5.429				
ζ	=	0.918				
nw	=	0.041	——>	A =	20.30	cm2
				A' =	8.12	cm2
				A min =	24.00	cm2

D 19 - 10.00 cm √

$$\tau = \frac{42.695 \times 1000}{0.875 \times 100 \times 104} = 4.69 \text{ kg f /cm2}$$

Check Punch

P = 30.57 tf

$$\tau = \frac{30.57 \times 1000}{3.14 \times (45 + 104) \times 104} = 0.63 \text{ kg f /cm2}$$

c) Dead Load + Train Load + Impact + Earth Pressure + Long rail + Brake

Vertical Force

Vd	=	1.975	x	1.20	x	3.00	x -2.40 =	-17.06 tf	(concrete)
Vp	=					34.67	x 2 =	69.34 tf	(pile reaction)
						33.82	x 1 =	33.82 tf	(pile reaction)
						32.96	x 2 =	65.92 tf	(pile reaction)
							total =	152.02 tf	

Moment at section d - d

M vd	=	-17.06	x	0.9875			=	-16.85 tf m
M pd	=	34.67	x	1.375	x	4	=	190.69 tf m
		33.82	x	0.70	x	2	=	47.348 tf m
		32.96	x	0.025	x	4	=	3.296 tf m
						total	=	224.48 tf m

therefore per m' .

V d	=	152.02	x	0.3333	= 50.672 tf / m'
M d	=	224.48	x	0.3333	= 74.826 t-f m / m'

h = 104 cm

b = 100 cm

$$\phi o = \frac{3200}{21 \times 125} = 1.219$$

Ca	=	4.6932				
δ	=	0.4				
ϕ	=	2.846				
ϕ 1	=	4.625				
ζ	=	0.912				
nw	=	0.05	---->	A	= 24.76 cm2	D 19 - 10.00 cm
				A'	= 9.90 cm2	
				A min	= 24.00 cm2	

$$\tau = \frac{50.672 \times 1000}{0.875 \times 100 \times 104} = 5.57 \text{ kg f/cm2}$$

Check Punch

P = 34.67 tf

$$\tau = \frac{34.67 \times 1000}{3.14 \times (45 + 104) \times 104} = 0.71 \text{ kg f/cm2}$$

Perpendicular with Track

- Vertical Dead Load

0.200	0.600	x	6.400	x	2.400	=	1.666 tf
0.050	0.600	x	5.400	x	2.400	=	0.389 tf
0.300	0.200	x	6.400	x	2.400	=	0.778 tf
0.200	0.200	x	5.400	x	2.400	=	0.518 tf
1.250	0.400	x	2.800	x	2.400	=	3.360 tf
1.250	1.000	x	6.000	x	2.400	=	18.000 tf
0.700	2.040	x	5.400	x	2.400	=	18.507 tf
2.025	4.090	x	0.600	x	2.400	=	11.926 tf
0.050	0.650	x	5.400	x	2.000	=	0.351 tf
0.400	0.650	x	5.400	x	2.000	=	2.808 tf
0.200	0.200	x	5.400	x	2.000	=	0.432 tf
1.325	2.890	x	5.400	x	2.000	=	41.356 tf
					Total	=	99.980 tf

$$q\,1 = \frac{99.980}{5.25 \times 6.000} = 3.174 \text{ tf/m'}$$

$$q\,2 = 1.200 \times 2.400 = 2.880 \text{ tf/m'}$$

2.025	2.17	x	6.6	x	1.6	= 46.403 tf
5.25	2.17	x	2.6	x	1.6	= 47.393 tf
5.25	0.69	x	6.6	x	1.6	= 38.254 tf
					total	= 132.05 tf

$$q\,3 = \frac{132.050}{5.25 \times 6.600} = 3.811 \text{ tf/m'}$$

$$q\,dl = \frac{33.5}{5.25 \times 6.00} = 1.063 \text{ tf/m'}$$

- Vertical Live Load + Impact

$$q\,ll = \frac{152.15 + 77.274}{5.25 \times 6.00} = 7.283 \text{ tf}$$

Field Moment

M	=	11.521	x	3	x	3	=	103.69 tf m/ m'
		0.125	x	2.88	x	8.4 x 4.2	=	12.701 tf m/ m'
		3.811	x	1.2	x	0.6	=	2.7439 tf m/ m'
							M =	119.13 tf m/ m'

$$Q = 11.521 \times 3 + 2.88 \times 4.2 + 3.811 \times 1.2$$
$$= 51.231 \text{ tf}$$

therefore per m' .

Vd = 51.231 tf / m'

Md = 119.13 t-f m / m'

h = 104 cm

b = 100 cm

$$\phi o = \frac{2250}{21 \times 75} = 1.4286$$

Ca = 3.1189

δ = 0.4

φ = 1.778

φ l = 2.462

ζ = 0.863

nw = 0.121 ----> A = 59.92 cm2 D 29 - 10.00 cm

A' = 23.97 cm2

A min = 30.00 cm2

$$\tau = \frac{51.231 \times 1000}{0.875 \times 100 \times 104} = 5.63 \text{ kg f/cm2} < \tau a$$

3.5.5. CHECKING STRESS ON PILE.

Data of pile

D = 45 cm

d = 29 cm

A = 930 cm2

W = 7403 cm3

σ ce = 82.9 kg / cm2

σ ce = 8030.9 kg / cm2

n = Ea / Eb = 15

Stress of Pile

1) Dead Load + Train Load + Impact + Earth Pressure ----> permanent load

α = 1.00

Force on head pile

M = 1.43 tf m

N = 40.04 tf

H = 0.89 tf

Compressive stress of concrete

$$\sigma c = \sigma ce + \frac{M}{W} + \frac{N}{A}$$

$$= 82.90 + 19.32 + 43.05$$

$$= 145.27 \text{ kg f / cm2} < 166 \text{ kg f / cm2}$$

Tensile stress of concrete

$$\sigma c' = \sigma ce - \frac{M}{W} + \frac{N}{A}$$

$$= 82.90 + 19.32 + 43.05$$

$$= 106.64 \text{ kg f / cm2} > 0 \text{ kg f / cm2}$$

Tensile stress of PC cable

$$\sigma p = \sigma pe + \frac{n \times M}{W} + \frac{n \times N}{A}$$

$$= 8030.94 + 289.75 - 646.81$$

$$= 7674.9 \text{ kg f / cm2} < 8700 \text{ kg f / cm2}$$

Stress on joint between pile and footing

Compressive stress

N = 40.04 tf

H = 0.89 tf

l = 10 cm

$$\sigma v = \frac{N}{0.25 \times 22/7 \times (D^2 - d^2)}$$

$$= \frac{40.04 \times 1000}{930} = 43.04 \text{ kg f / cm2} < 75 \text{ kg f /cm2}$$

$$\sigma h = \frac{H}{D.l}$$

$$= \frac{0.89 \times 1000}{45 \times 10} = 1.98 \text{ kg f / cm2} < 75 \text{ kg f /cm2}$$

Shear stress

h 1 = 110 cm (= distance between pile top and footing)

$$\tau = \frac{N}{22/7 \times (D \times h1)} = \frac{40.04 \times 1000}{15557} = 2.57 \text{ kg f / cm2} < 7.5 \text{ kgf/cm2}$$

2) Dead Load + Train Load + Impact + Earth Pressure + Long rail ——> temporary load

α = 1.15

Force on head pile

M = 1.96 tf m

N = 36.72 tf

H = 1.96 tf

Compressive stress of concrete

$$\sigma c = \sigma ce + \frac{M}{W} + \frac{N}{A}$$

$$= 82.90 + 26.48 + 39.48$$

$$= 148.86 \text{ kg f / cm2} < 1.15 \times 166 = 190.9 \text{ kg f / cm2} \quad \surd$$

Tensile stress of concrete

$$\sigma c' = \sigma ce - \frac{M}{W} + \frac{N}{A}$$

$$= 82.90 + 26.48 + 39.48$$

$$= 95.91 \text{ kg f / cm2} > 0 \text{ kg f / cm2}$$

Tensile stress of PC cable

$$\sigma p = \sigma pe + \frac{n \times M}{W} + \frac{n \times N}{A}$$

$$= 8030.94 + 397.14 - 592.26$$

$$= 7835.8 \text{ kg f / cm2} < 8700 \text{ kg f / cm2} \quad \surd$$

Stress on joint between pile and footing

Compressive stress

N = 36.72 tf

H = 1.96 tf

l = 10 cm

$$\sigma v = \frac{N}{0.25 \times 22/7 \times (D^2 - d^2)}$$

$$= \frac{36.72 \times 1000}{930.29} = 39.47 \text{ kg f / cm2} < 1.15 \times 75 = 86.25 \text{ kg f / cm2}$$

$$\sigma h = \frac{H}{D.l}$$

$$= \frac{1.96 \times 1000}{45 \times 10} = 4.36 \text{ kg f / cm2} < 1.15 \times 75 = 86.25 \text{ kg f / cm2}$$

Shear stress

h 1 = 110 cm (= distance between pile top and footing)

$$\tau = \frac{N}{22/7 \times (D \times h1)} = \frac{36.72 \times 1000}{15557} = 2.36 \text{ kg f / cm2} < 7.5 \text{ kgf/cm2}$$

c) Dead Load + Train Load + Impact + Earth Pressure + Long rail + Brake —temporary load

α = 1.15

Force on head pile

M = 3.34 tf m

N = 34.67 tf

H = 4.15 tf

Compressive stress of concrete

$$\sigma c = \sigma ce + \frac{M}{W} + \frac{N}{A}$$

$$= 82.90 + 45.12 + 37.28$$

$$= 165.30 \text{ kgf/cm2} < 1.25 \times 166 = 207.5 \text{ kgf/cm2}$$

Tensile stress of concrete

$$\sigma c' = \sigma ce - \frac{M}{W} + \frac{N}{A}$$

$$= 82.90 + 45.12 + 37.28$$

$$= 75.06 \text{ kgf/cm2} > 0 \text{ kgf/cm2}$$

Tensile stress of PC cable

$$\sigma p = \sigma pe + \frac{n \times M}{W} + \frac{n \times N}{A}$$

$$= 8030.94 + 676.75 - 559.19$$

$$= 8148.5 \text{ kgf/cm2} < 8700 \text{ kgf/cm2}$$

Stress on joint between pile and footing

Compressive stress

N = 34.67 tf

H = 4.15 tf

l = 10 cm

$$\sigma v = \frac{N}{0.25 \times 22/7 \times (D^2 - d^2)}$$

$$= \frac{34.67 \times 1000}{930.29} = 37.27 \text{ kgf/cm2} < 1.25 \times 75 = 93.75 \text{ kgf/cm2}$$

$$\sigma h = \frac{H}{D.l}$$

$$= \frac{4.15 \times 1000}{45 \times 10} = 9.22 \text{ kgf/cm2} < 1.25 \times 75 = 93.75 \text{ kgf/cm2}$$

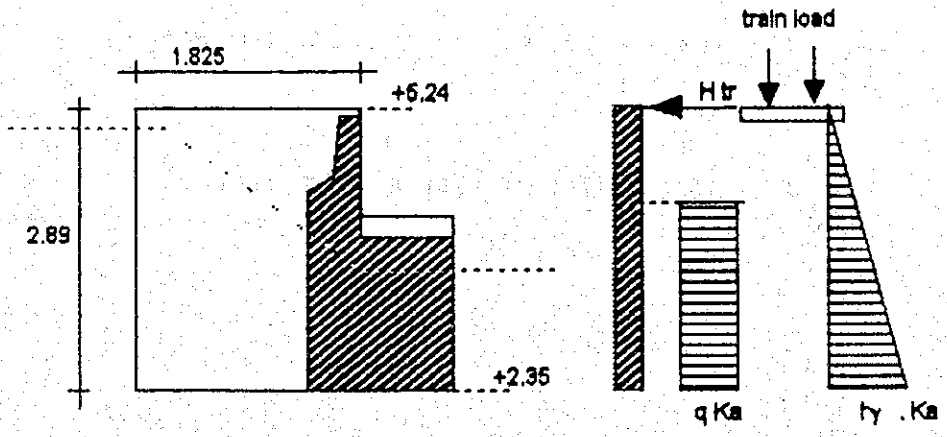
Shear stress

h 1 = 110 cm (= distance between pile top and footing)

$$\tau = \frac{N}{22/7 \times (D \times h1)} = \frac{34.67 \times 1000}{15557} = 2.23 \text{ kg f / cm2} < 7.5 \text{ kgf/cm2}$$

3.6.6 WING WALL .

a) Sketch



b) Lateral earth pressure

- data of soil

γ = 2.000 tf / m3

ϕ = 30.00 degree

Ko = 0.2973

- earth pressure

p1 = 2 x 2.89 x 0.2973 = 1.72 tf/m 2

Force.				P [tf]			x [m]	Mx [t-f m]
P1	=	0.50 x	2.89 x	1.72 x	1.825 =	4.53	0.9125	4.14

- earth pressure caused by train load

$$q\,Ka = \frac{5.75}{5.40} \times 0.2973 = 0.48 \text{ tf / m2}$$

Force.				P [tf]			x [m]	Mx [t-f m]
P1	=		0.48 x	2.89 x	1.825 =	2.54	0.9125	2.32

- Caused by Transversal Load.

H tr = 12.00 x 0.10 = 1.20 t-f / sleeper

friction coeficient between ballast and bottom of sleeper = 0.05

H' tr = 1.20 - 0.05 x 12.00 = 0.60 t-f / sleeper

for 1 m length of side wall

$$H'_{tr} = \frac{0.60}{1.20} = 0.60 \text{ t-f / m}$$

		P [t f]			x [m]	Mx [t-f m]
P	=	0.5 x	1.825 =	0.9125	0.9125	0.83

Total Force

$$M = \frac{1}{2.89}(4.14 + 2.32 + 0.83) = 2.52 \text{ t-f m / m'}$$

$$Q = \frac{1}{2.89}(4.53 + 2.54 + 0.91 = 2.76 \text{ t-f /m'}$$

c) Reinforcement

h	=	0.23 m				
b	=	1.00 m				
Ca	=	4.741				
δ	=	0.40				
ϕ	=	2.846				
ζ	=	0.912				
mw	=	0.05				
A	=	$\frac{0.06}{21}$ x	23 x	100 =	5.48 cm2	
Ar	=	0.0025 x	29 x	100 =	7.25 cm2	use D 16 - 250

$$\tau = \frac{2.763 \times 1000}{0.875 \times 23 \times 100} = 1.37 \text{ kg / cm2} \quad \text{ok.}$$