7.4.4 BOX CULVERT (LOCATION 0 + 816 M)

Table Contents

1. DESIGN CRITERIA

1.1. Regulation Reference.

- The Design Load are based on The Specification of Perumka Railway Bridge (AVBP 1932) and 100 % Load Scheme 1921.
- PD - 10
- Indonesian Concrete Code (PBI 1971)
- Elastic Analysis of Reinforced Concrete Section (PU)

1.2. Material

Concrete.
- Quality K - 225
- Concrete cover = 5 cm

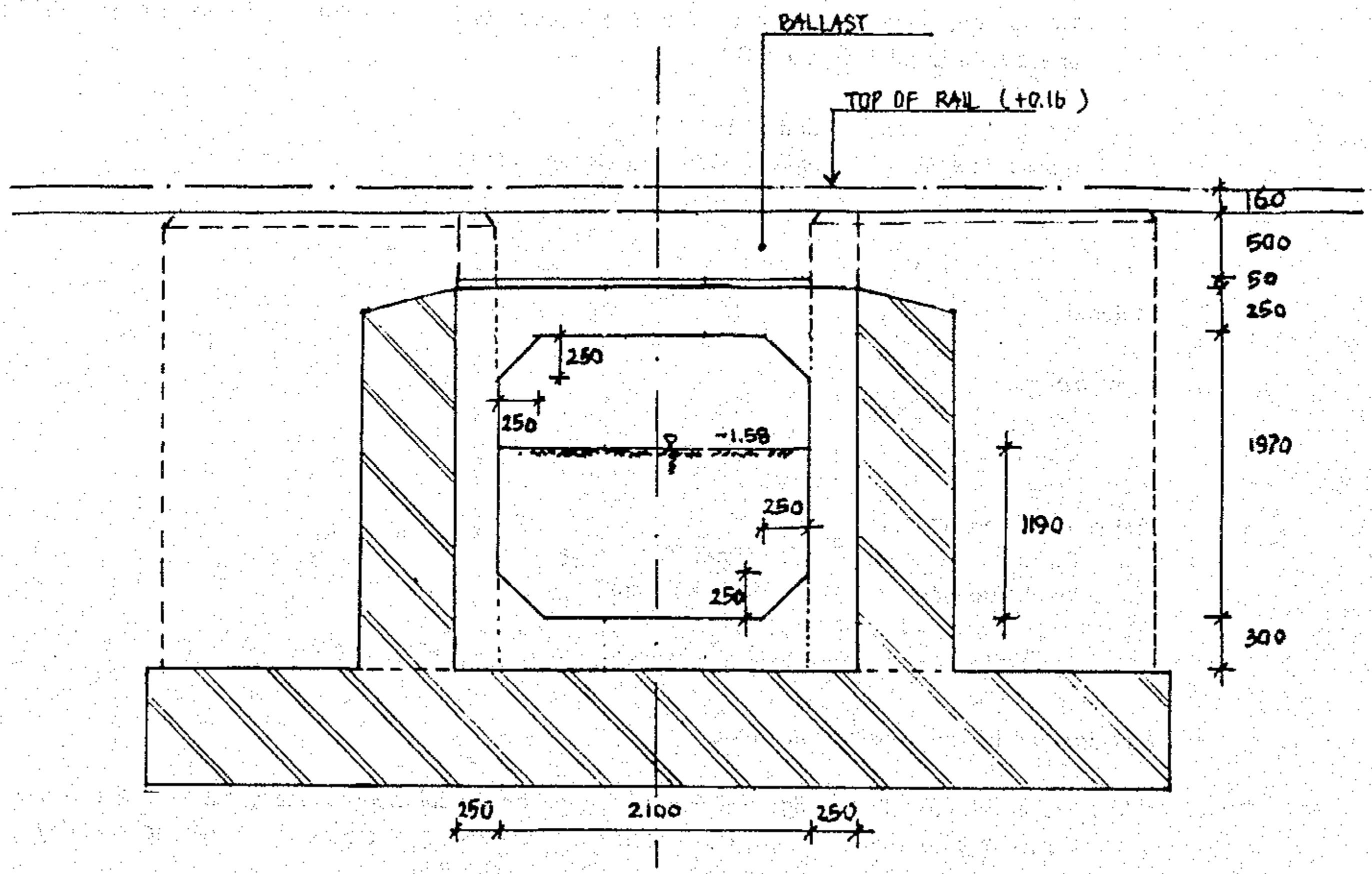
Rebar / Reinforcement
- Quality U - 39 (Deformed Steel rebar)
- Yield Strength = 3900 kg f / cm2

1.3. Requirement in The Construction Stage.

- Trains will pass this Bridge with low speed during the full period of excecution of the Works.
- Sufficient time shall be taken into account for Hardenning of the concrete material (28 days)
- Train Traffic shall not be disturbed during the Construction stage.
- Removal / Demolishing of a part of the existing sub-structures to be allowed except the existing footing of sub-structures.
  Contractor shall be improved and renewal / replaced if the existing footing are damaged or cracks

3. STABILITY ANALYSIS.

3.1. Stress On Brick Masonry



Dead Load

track weight	=					=	0.45 t f
ballast	=		0.50 x	2.60 x	2.00 x	3.50 =	9.10 t f
box culvert	=		0.025 x	2.60 x	2.20 x	3.50 =	0.50 t f
			0.25 x	2.60 x	2.40 x	3.50 =	5.46 t f
			0.25 x	1.97 x	2.40 x	3.50 =	4.14 t f
			0.25 x	1.97 x	2.40 x	3.50 =	4.14 t f
			0.30 x	2.60 x	2.40 x	3.50 =	6.55 t f
		0.50 x	0.25 x	0.25 x	2.40 x	3.50 =	0.26 t f
		0.50 x	0.25 x	0.25 x	2.40 x	3.50 =	0.26 t f
		0.50 x	0.25 x	0.25 x	2.40 x	3.50 =	0.26 t f
		0.50 x	0.25 x	0.25 x	2.40 x	3.50 =	0.26 t f
mud / soil	=		1.19 x	2.10 x	1.60 x	3.50 =	13.99 t f
uplift	=		0.30 x	2.60 x	-1.00 x	3.50 =	-2.73 t f
			0.25 x	1.19 x	-1.00 x	3.50 =	-1.04 t f
						=	41.61 t f

train Load

$$q_{tr} = 2 \times 19.000 \times \frac{2.100}{2.400} = 33.250 \ \text{tf}$$

Impact Coefficient

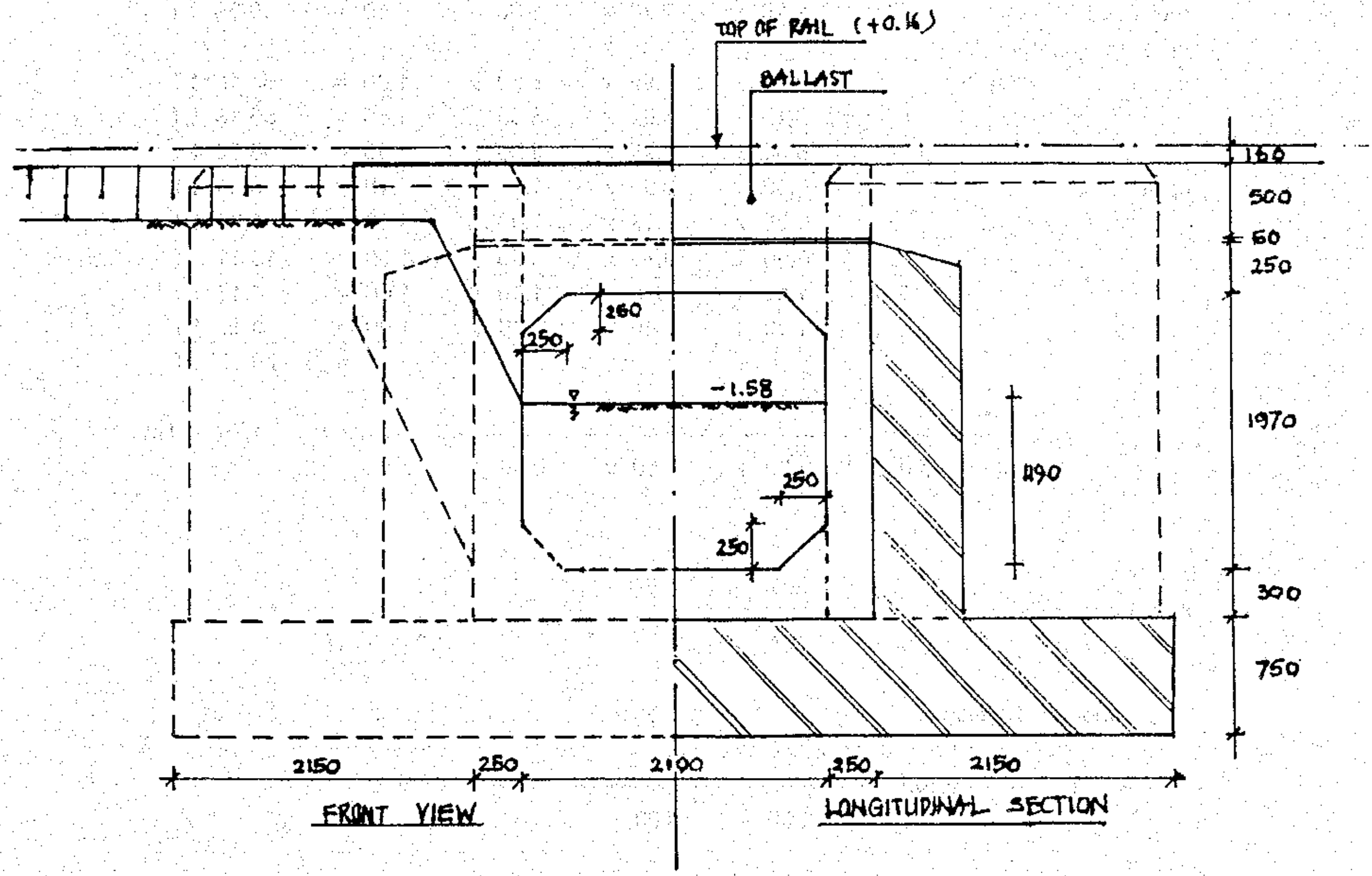
$$i = 0.100 + \frac{22.50}{2.600 + 50.00} = 0.528$$

$$V_{tr} = 33.25 \times 1.53 \times \frac{3.50}{4.10} = 43.36 \text{ tf}$$

Stress under box culvert (on brick masonry)

$$\sigma = \frac{(41.61 + 43.36) \quad 1000}{260.00 \times 350.00} = 0.93 \text{ kgf/cm2} < \sigma a = 15 \text{ kgf/cm2}$$

3.2. Stability of bearing capacity



Unit Weight

track weight	=						=	0.45 t f
ballast	=		0.50 x	2.60 x	2.00 x	3.50	=	9.10 t f
box culvert	=		0.025 x	2.60 x	2.20 x	3.50	=	0.50 t f
			0.25 x	2.60 x	2.40 x	4.10	=	6.40 t f
			0.25 x	1.97 x	2.40 x	4.10	=	4.85 t f
			0.25 x	1.97 x	2.40 x	4.10	=	4.85 t f
			0.30 x	2.60 x	2.40 x	4.10	=	7.68 t f
		0.50 x	0.25 x	0.25 x	2.40 x	4.10	=	0.31 t f
		0.50 x	0.25 x	0.25 x	2.40 x	4.10	=	0.31 t f
		0.50 x	0.25 x	0.25 x	2.40 x	4.10	=	0.31 t f
		0.50 x	0.25 x	0.25 x	2.40 x	4.10	=	0.31 t f
			0.375 x	5.10 x	2.40 x	0.55	=	2.52 t f
			0.375 x	5.10 x	2.40 x	0.55	=	2.52 t f
			1.250 x	0.45 x	0.60 x	2.40	=	0.81 t f
		0.50 x	1.250 x	1.77 x	0.60 x	2.40	=	3.19 t f
			1.250 x	0.45 x	0.60 x	2.40	=	0.81 t f
		0.50 x	1.250 x	1.77 x	0.60 x	2.40	=	3.19 t f
mud / soil	=		1.19 x	2.10 x	1.60 x	4.10	=	16.39 t f
brick masonry & soil	=		2.15 x	3.82 x	3.50 x	1.85	=	53.18 t f
			2.15 x	3.82 x	3.50 x	1.85	=	53.18 t f
			6.90 x	0.75 x	3.50 x	2.00	=	36.23 t f
uplift	=		0.30 x	2.60 x	-1.00 x	4.10	=	-3.20 t f
			0.25 x	1.19 x	-1.00 x	4.10	=	-1.22 t f
			6.90 x	0.75 x	3.50 x	-1.00	=	-18.11 t f
		2 x	1.40 x	1.49 x	1.00 x	-1.00	=	-4.17 t f
		2 x	1.40 x	1.49 x	1.00 x	-1.00	=	-4.17 t f
							=	176.19 t f

$$\gamma = \frac{176.19}{(6.90 \times 3.50 + 2.60 \times 0.60)\ 3.82} = 1.79 \text{ tf/m3}$$

train Load

Axle Load on structure

q tr = 6 x 17.000 = 102.000 tf

Impact Coefficient

$$I = 0.100 + \frac{22.50}{2.600 + 50.00} = 0.528$$

V tr = 102.00 x 1.53 = 155.83 tf

Uniform Load at the back side of structure

q tr = 8.75 t f / m'

Soil Properties

- Ballast Material

γ wet	=	2.00	tf/m3
γ dry	=	1.90	tf/m3
ϕ	=	35.00	degree
c	=	0.00	

- Material under ballast Layer and existing structure ----------> Soft Clay
settlement and consolidation have occured on this layer

γ wet	=	1.70	tf/m3	
γ dry	=	1.60	tf/m3	
ϕ	=	10.00	degree	
c	=	0.56	tf/m2	(c = N / 9 where as N = 5)

BEARING CAPACITY

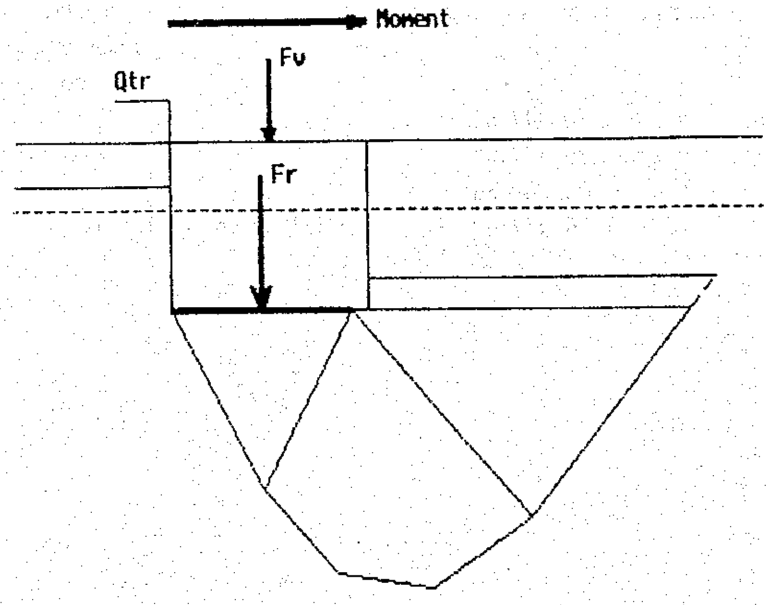
M = -141.50 kNm

Qtr = 24.04 kN/m

Fv = 505.48 kN

Fr = 818.60 kN

Forces per meter

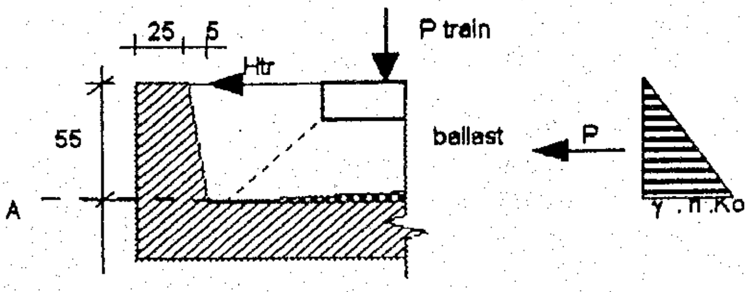


File : BH-5	Width wall = 6.90 m	Safety factor = 1.618 >1.500 (o.k)
	Height wall = 3.82 m	Load combination nr. : 1

4. STRUCTURAL CALCULATION

4.1. SIDE WALL FOR BALLAST.

4.1.a. Sketch



4.1.b. Earth Pressure caused by ballast.

γ = 2.000 tf / m3
ϕ = 35 degree
c = 0 tf / m2
K o = 0.244

4.1.c. Lateral earth pressure

- Caused by ballast.

P = 0.500 x 2.000 x 0.550 x 0.550 x 0.244
= 0.0738 tf / m

- 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

$$H'tr = \frac{0.60}{1.20} = 0.50 \text{ t-f / m}$$

4.1.d. Internal force

G [t f]						x [m]	Mx [tf m]
concrete :	0.500 x	0.050 x	0.550 x	2.400 =	0.033	-0.117	-0.004
		0.250 x	0.550 x	2.400 =	0.330	0.025	0.008
ballast :	0.500 x	0.050 x	0.550 x	2.000 =	0.028	-0.133	-0.004
					0.391	0.002	0.001

Therefore :

M = 0.0738 x 0.1833 + 0.50 x 0.55 + 0.391 x 0.002
= 0.289 t f-m /m
Q = 0.0738 + 0.50 = 0.574 t f
N = 0.391 t f

4.1.e. Reinforcement

$h = 0.24$ m

$b = 1.00$ m

$Ca = 14.61$

$\delta = 1.00$

$\phi = 8.09$

$\zeta = 0.963$

$nw = 0.0068$

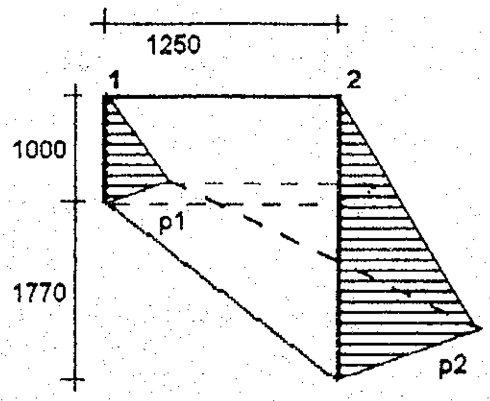
$$A = \frac{0.0068}{21} \times 29 \times 100 = 0.9404 \text{ cm2}$$

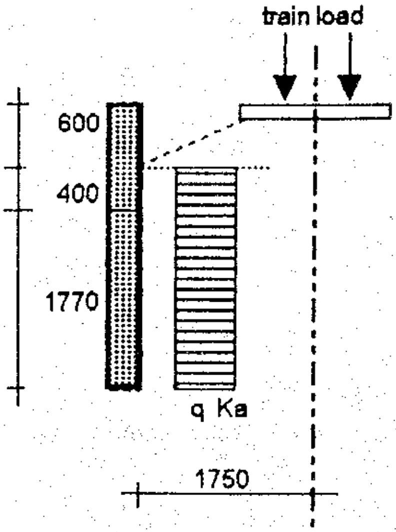
$$A\,min = 0.0025 \times 29 \times 100 = 7.25 \text{ cm2}$$ use D 16 - 250

$$\tau = \frac{0.574 \times 1000}{0.875 \times 29 \times 100} = 0.2261 \text{ kg / cm2}$$ ok.

4.2. WING WALL .

4.2.a. Sketch





4.2.b. Lateral earth pressure

γ = 1.800 t f / m3
K A = 0.500

- earth pressure

p1 = 1.8 x 1 x 0.5 = 0.9 t f /m 2
p1 = 1.8 x 2.77 x 0.5 = 2.493 t f /m 2

Force.	P [t f]	x [m]	Mx [t-f m]
P1 =	0.50 x 1.00 x 0.90 x 0.42 = 0.19	0.63	0.12
P2 =	0.90 x 1.77 x 0.42 = 0.66	0.42	0.28
	0.50 x 1.59 x 1.77 x 0.42 = 0.59	0.42	0.24
	1.44	0.44	0.64

- earth pressure caused by train load

$$q\ Ka = \frac{8.75}{3.5} \times 0.5 = 1.25 \text{ t f / m2}$$

Force.	P [t f]	x [m]	Mx [t-f m]
P1 =	1.25 x 0.40 x 1.25 = 0.63	0.63	0.39
P2 =	1.25 x 1.77 x 0.42 = 0.92	0.42	0.38
	1.55	0.50	0.77

- 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

$$H'tr = \frac{0.60}{1.20} = 0.50 \text{ t-f/m}$$

		P [tf]			x [m]	Mx [t-f m]
P	=	0.5 x	1.25 =	0.625	0.625	0.39

Total Force

$$M = \frac{1}{2.22}(0.64 + 0.77 + 0.39) = 0.81 \text{ t-f m/m'}$$

$$Q = \frac{1}{2.22}(1.44 + 1.55 + 0.63) = 1.63 \text{ t-f/m'}$$

4.2.c. Reinforcement

h = 0.23 m
b = 1.00 m
Ca = 8.352
δ = 0.40
ϕ = 5.25
ζ = 0.945
nw = 0.04

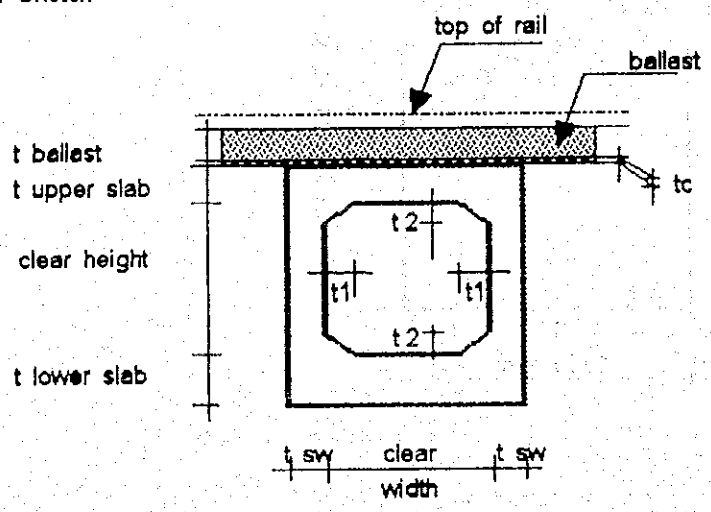
$$A = \frac{0.04}{21} \times 23 \times 100 = 4.381 \text{ cm2}$$

A min = 0.0025 x 29 x 100 = 7.25 cm2 use D 16 - 250

$$\tau = \frac{1.626 \times 1000}{0.875 \times 23 \times 100} = 0.8081 \text{ kg/cm2} \quad \text{ok.}$$

4.3. BOX CULVERT

4.3.a. Sketch



where is :

t ballast	=	500	mm
t soil	=	0	mm
t plain conc.	=	50	mm
t upper slab	=	250	mm
t lower slab	=	300	mm
clear height	=	1970	mm
t side wall (t sw)	=	250	mm
t side wall (t sw)	=	250	mm
clear width	=	2100	mm
t 1	=	250	mm
t 2	=	250	mm

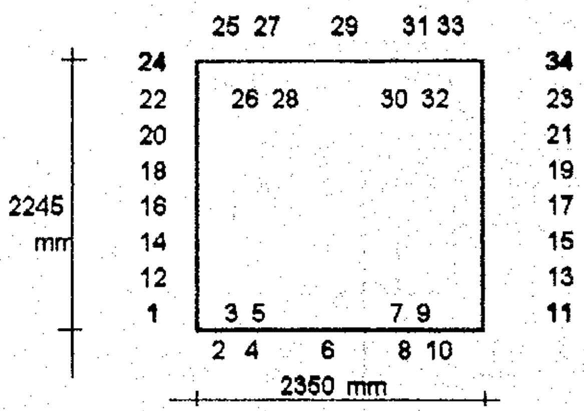
4.3.b. Unit Weight of Mass

Track Weight	=	0.450	tf / m'
Ballast	=	2.000	tf / m3
Filled Material (soil)	=	1.800	tf / m3
Plain Concrete	=	2.200	tf / m3
Reinforced Concrete	=	2.400	tf / m3

4.3.c. Reinforced Concrete Quality

Concrete	K - 225
Reinforcing Bar	U - 39 (deform steel)

4.3.d. Schematization of Rigid Frame Diagram.



4.3.e Property of Members

Member	Thickness [m]	Area [m2]	Inersia Moment [m4]	Young's Modulus [tf/m2]
upper slab	0.250	0.250	0.00130	2.7 x 10^6
lower slab	0.300	0.300	0.00225	2.7 x 10^6
side wall	0.250	0.250	0.00130	2.7 x 10^6
side wall	0.250	0.250	0.00130	2.7 x 10^6

4.3.f. Loadings

1. Track Load.

Track weight = 0.450 / 2 = 0.225 tf/m
Ballast / Gravel = 0.500 x 2.000 = 1.000 tf/m
q tr = 1.225 tf/m

2. Dead Load.

a. Upper slab load

- Lean concrete = 0.050 x 2.200 = 0.110 tf/m
- Top slab = 0.250 x 2.400 = 0.600 tf/m

q dl = 0.710 tf/m

b. Side Wall (q sw) = 0.250 x 2.400 = 0.600 tf/m

3. Earth and Water Pressure.

a. Soil data :

1. Fill Material at the back side of side wall

γ = 1.800 tf/m3
K o = 0.500 (assumption)
K' o = 1.000 (Water)

b. Intensity of earth pressure

1. Condition 100 % of earth pressure

P e1 = (	1.225 +	0.175 x	1.800) x	0.500 =	0.770	tf/m
P e2 =	0.770 +	2.245 x	1.800 x	0.500 =	2.791	tf/m

2. Condition of earth and water pressure

P e1 = (	1.225 +	0.175 x	0.800) x	0.500 =	0.683	tf/m
P e2 =	0.683 +	2.245 x	0.800 x	0.500 =	1.581	tf/m
P w1 =				=	0.000	tf/m
P w2 =	0.000 +	2.245 x	1.000 x	1.000 =	2.245	tf/m
P (e+w) 1 =		0.683 +	0.000	=	0.683	tf/m
P (e+w) 2 =		1.581 +	2.245	=	3.826	tf/m

4. Train Load.

a. Impact Coefficient

$$i = 0.100 + \frac{22.50}{2.350 + 50.00} = 0.530$$

b. Uniform Load

$$q\,tr = \frac{2 \times 19.000}{2.400 \times 3.200} = 4.948 \text{ tf/m}$$

$$q\,tr{+}i = 4.948 \times (1.000 + 0.530) = 7.569 \text{ tf/m}$$

5. Earth Pressure due to Train Load.

Ph = Ko x Pw

where is :

- Ph : Horizontal Pressure due to train load
- Ko : Earth pressure coefficient
- q : Distributed Train Load ——>

$$q = \frac{8.75}{4.00} = 2.188 \text{ t/m2}$$

$$P\,etr = 0.500 \times 2.188 \times 1.00 = 1.094 \text{ tf/m}$$

6. Spring Constants

Coefficient subgrade reaction

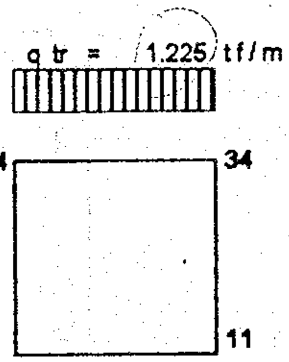
Kv = 2800 t/m3

Kh = 933 t/m3

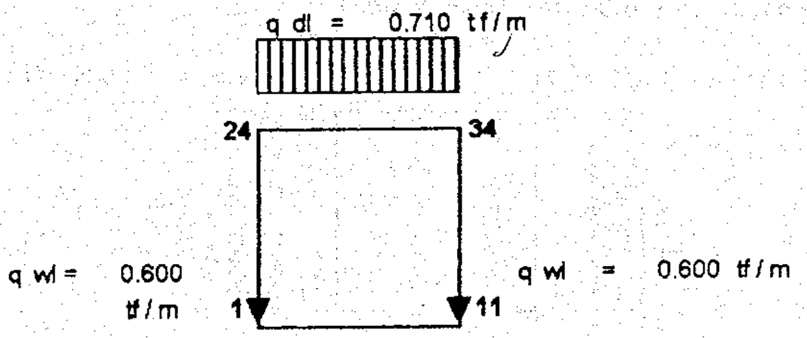
point 1 & 11	:	Kv	=	0.063 x	2800	=	175	t/m
		Kh				=	58	t/m
point 2 & 10	:	Kv	=	0.075 x	2800	=	210	t/m
		Kh				=	70	t/m
point 3 & 9	:	Kv	=	0.125 x	2800	=	350	t/m
		Kh				=	117	t/m
point 4 & 8	:	Kv	=	0.125 x	2800	=	350	t/m
		Kh				=	117	t/m
point 5 & 8	:	Kv	=	0.400 x	2800	=	1120	t/m
		Kh				=	373	t/m
point 6	:	Kv	=	0.775 x	2800	=	2170	t/m
		Kh				=	723	t/m

4.3.e. Load Model

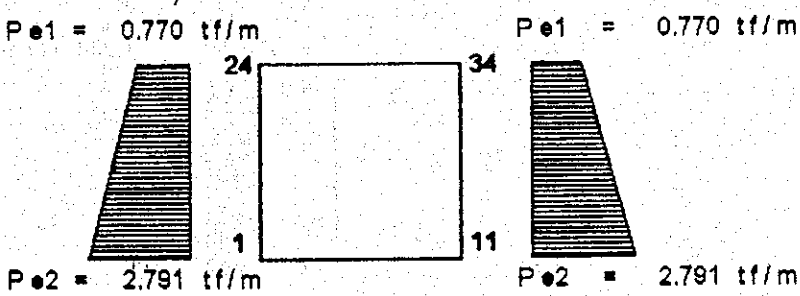
1. Track Load.



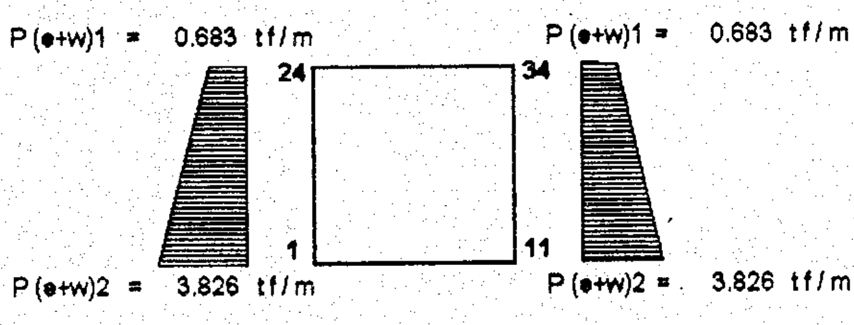
2. Dead Load.



3. Earth Pressure

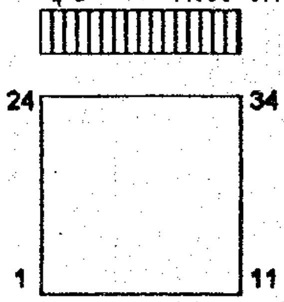


4. Earth and Water Pressure



5. Train Load.

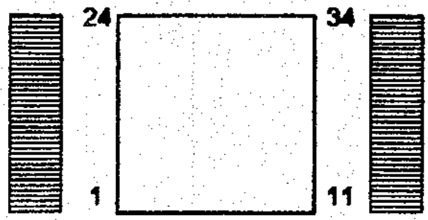
q tr = 7.569 tf/m



6. Earth Pressure caused by Train (both of side)

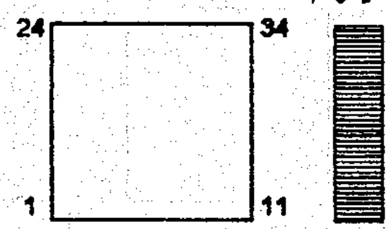
P e tr = 1.094 tf/m

P e tr = 1.094 tf/m



7. Earth Pressure caused by Train (one side only)

P e tr = 1.094 tf/m



4.3.f. Load Combination

1. Basic Case.

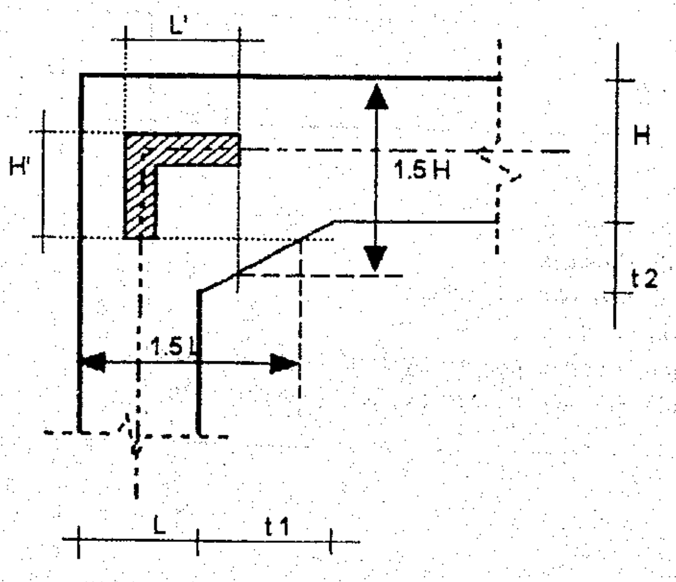
No.	Aplications	Note
1.	1. Track Load.	
2.	2. Dead Load.	
3.	3. Earth Pressure	
4.	4. Earth and Water Pressure	
5.	5. Train Load.	
6.	6. Earth Pressure caused by Train (both of side)	
7.	7. Earth Pressure caused by Train (one side only)	

2. Load Combination.

No.	Combination Case								Load Factor α	
1	1	2	3	7					1.00	
2	1	2	3	7	5				1.00	
3	1	2	3	6	5				1.00	
4	1	2	4	7					1.00	
5	1	2	4	7	5				1.00	
6	1	2	4	6	5				1.00	
7	1	2	4	7					1.00	α = 0.50 for load no. 4
8	1	2	4	7	5				1.00	α = 0.50 for load no. 4
9	1	2	4	6	5				1.00	α = 0.50 for load no. 4
9	1	2	5						1.00	

4.3.g. Check point at edge of box culvert

1. Bending Moment at Panel Point.



The effect of haunches may be neglected on rigid frames analysis if it's satisfied conditions of below.

$L'/L \leqslant 1.0$

$H'/H \leqslant 1.0$

Length of rigidity zone is 1.5 times the depth of member because inclination of haunch (θ) is 45 degrees

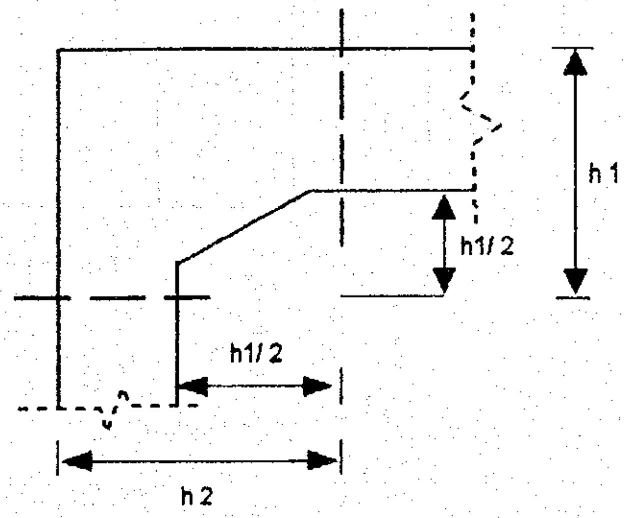
Rigidity structure analyze from this point :

$$L' = \frac{L}{2} + \left(t1 - \frac{0.5\,H \cdot t1}{t2} \right)$$

$$H' = \frac{L}{2} + \left(t2 - \frac{0.5\,H \cdot t2}{t1} \right)$$

2. Calculation of Shear Point.

Examination of shear is at drawing below beacuse that member support directory.



Rigid Length Calculation

Items	Joint Connection			
	Top Slab and Wall		Bottom Slab and Wall	
H [m]	0.250		0.300	
L [m]	0.250		0.250	
t1 [m]	0.250		0.250	
t2 [m]	0.250		0.250	
L' [m]	0.250		0.225	
H' [m]	0.250		0.275	
L' / L	1.000		0.900	
H' / H	1.000		0.917	

<= 1 (o.k.)
<= 1 (o.k.)

Calculation Stress Point.

Members	Distance from point I				
	x m1 [m]	x s1 [m]	x m2 [m]	x s2 [m]	x3 [m]
upper slab	0.125	0.125	0.375	0.375	1.175
lower slab	0.125	0.150	0.375	0.400	1.175
side wall	0.125	0.125	0.375	0.375	1.123
side wall	0.125	0.125	0.375	0.375	1.123

front rigid area

Members	Distance from point i				
	x 3 [m]	x s4 [m]	x m4 [m]	x s5 [m]	x m5 [m]
upper slab	1.175	1.975	1.975	2.225	2.225
lower slab	1.175	1.950	1.975	2.200	2.225
side wall	1.123	1.845	1.845	2.120	2.095
side wall	1.123	1.845	1.845	2.120	2.095

front rigid area

4.3.h. **Reinforcement Analysis**

- Concrete

K -	225	———>	allowable compressive stress	=	75	kg f /cm 2
			allowable tension stress	=	7	kg f /cm 2
			E b	=	140000	kg f /cm 2

- Steel Rebar

U -	39	———>	allowable compressive / tension stress	=	2250	kg f /cm 2
			E a	=	2100000	kg f /cm 2

ITEMS	TOP SLAB			BOTTOM SLAB			SIDE WALL		
	Section 25	Section 26	Section 29	Section 2	Section 4	Section 6	Section 12	Section 18	Section 22
Internal Force									
M [tf m]	1.93	1.67	3.89	0.94	2.62	5.34	1.87	1.90	3.03
N [tf]	2.55	2.55	1.64	4.08	1.83	0.44	12.43	11.62	11.62
Q [tf]	10.39	10.16	0.75	10.91	8.01	4.83	2.82	1.47	2.90
Dimension									
b [m]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
h [m]	0.33	0.25	0.25	0.38	0.30	0.30	0.33	0.25	0.25
d [m]	0.26	0.18	0.18	0.31	0.23	0.23	0.26	0.18	0.18
d' [m]	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Analysis									
n	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
σ o	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
e o1 [m]	0.76	0.65	2.37	0.23	1.43	12.14	0.15	0.16	0.26
e o2 [m]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
e o [m]	0.78	0.67	2.39	0.25	1.45	12.16	0.17	0.18	0.28
e o / h	2.33	2.70	9.57	0.65	4.84	40.52	0.51	0.73	1.12
C	7.00	7.00	7.00	6.95	7.00	7.00	6.92	6.94	7.00
e 1 [m]	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02
e 2 [m]	0.05	0.04	0.04	0.06	0.05	0.05	0.05	0.04	0.04
e [m]	0.84	0.73	2.44	0.32	1.51	12.21	0.23	0.24	0.33
e a [m]	0.94	0.78	2.50	0.44	1.59	12.29	0.33	0.29	0.39
N ea [tf m]	2.38	2.00	4.10	1.79	2.91	5.41	4.08	3.39	4.52
C a	5.562	4.170	2.910	7.658	4.414	3.237	4.265	3.202	2.772
delta	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.200
0	3.444	2.448	1.667	4.882	2.448	1.857	2.509	1.857	1.469
0 '	6.200	3.737	2.273	11.860	3.737	2.600	3.865	2.600	1.951
ksi	0.225	0.290	0.375	0.170	0.290	0.350	0.285	0.350	0.405
zeta	0.923	0.903	0.879	0.942	0.903	0.886	0.904	0.886	0.869
C b	2.864	2.482	2.095	3.372	2.482	2.199	2.506	2.199	2.105
nw	0.035	0.066	0.137	0.018	0.066	0.111	0.064	0.111	0.154
Reinforcement									
i	1.351	1.262	1.068	3.044	1.150	1.017	3.630	2.209	1.673
A [cm]	3.25	4.48	11.00	0.88	6.28	11.98	2.21	4.31	7.89
A' [cm]	1.76	2.26	4.70	1.07	2.89	4.86	3.21	3.81	2.64
A min [cm2]	6.58	4.50	4.50	7.83	5.75	5.75	6.58	4.50	4.50
A [cm]	6.58	4.50	11.00	7.83	6.28	11.98	6.58	4.50	4.50
Rebar diameter	16	16	16	16	16	16	16	16	16
Distance [cm]	25	33	17	20	25	14	25	33	33
A' [cm2]	3.56	2.27	4.70	9.53	2.89	4.86	9.55	3.86	1.51
Rebar diameter	16	16	16	16	16	16	16	16	16
Distance [cm]	33	50	33	17	50	33	17	33	50
Checking Shear Stress									
Load Factor	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Tb [kg f /cm2]	5.41	7.74	0.57	4.78	4.78	2.68	1.47	1.12	2.21
Tb-Ta [kg f/cm2]	1.41	3.74		0.78	0.78				
Ts [kg f /cm2]	4.78	4.78		4.78	4.78				

7.4.5 BOX CULVERT (LOCATION 1 KM + 177M)

Table Contents

1. DESIGN CRITERIA

1.1. Regulation Reference.

- The Design Load are based on The Specification of Perumka Railway Bridge (AVBP 1932) and 100 % Load Scheme 1921.
- PD - 10
- Indonesian Concrete Code (PBI 1971)
- Elastic Analysis of Reinforced Concrete Section (PU)

1.2. Material

Concrete.

- Quality K - 225
- Concrete cover = 5 cm

Rebar / Reinforcement

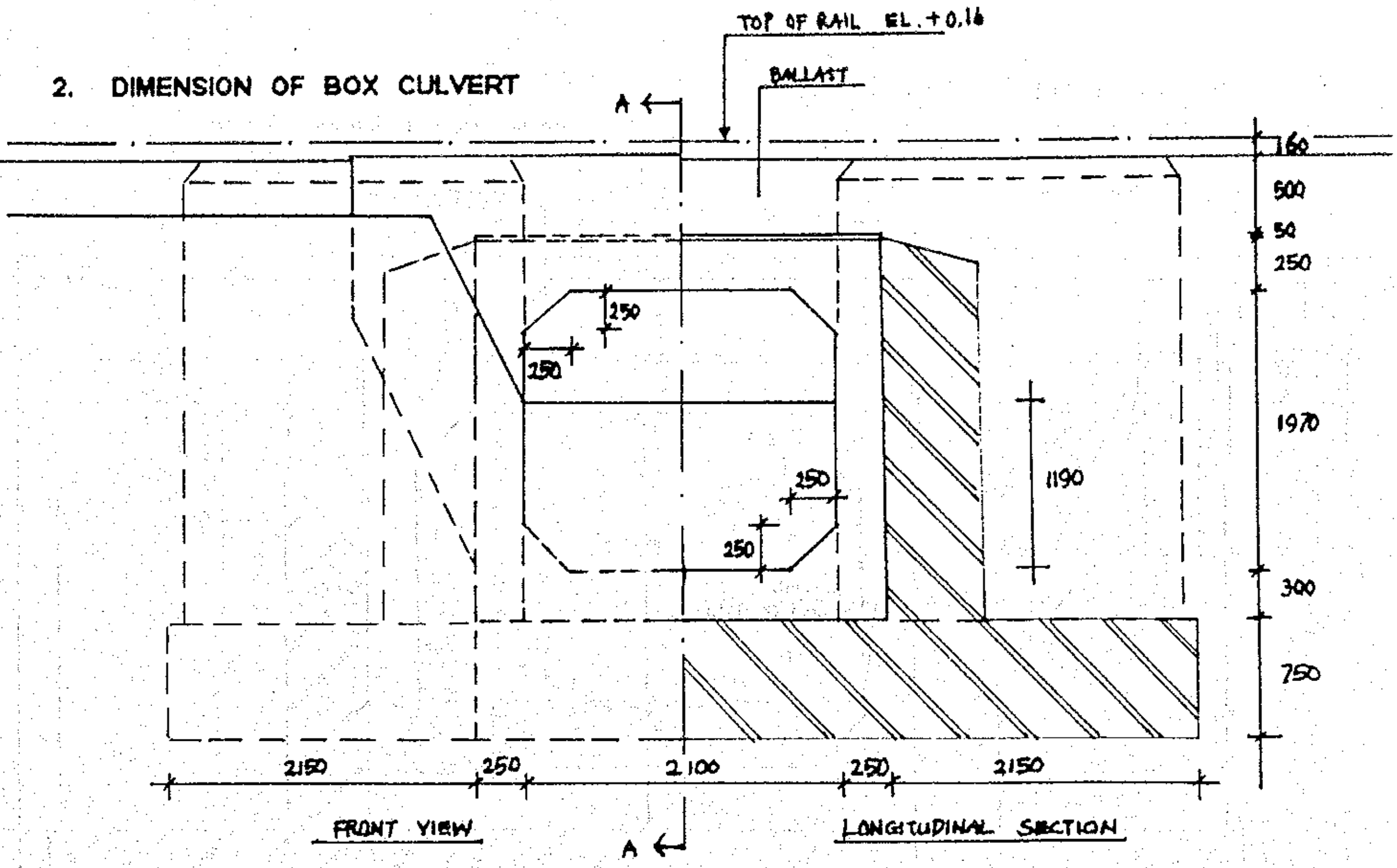
- Quality U - 39 (Deformed Steel rebar)
- Yield Strength = 3900 kg f / cm2

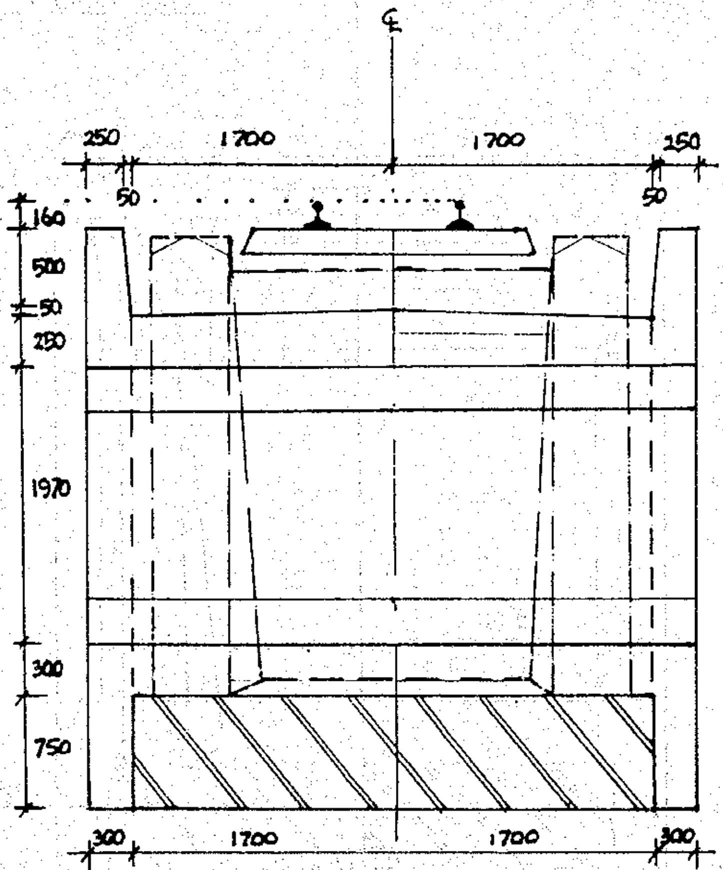
1.3. Requirement in The Construction Stage.

- Trains will pass this Bridge with low speed during the full period of excecution of the Works.
- Sufficient time shall be taken into account for Hardenning of the concrete material (28 days)
- Train Traffic shall not be disturbed during the Construction stage.
- Removal / Demolishing of a part of the existing sub-structures to be allowed except the existing footing of sub-structures.

  Contractor shall be improved and renewal / replaced if the existing footing are damaged or cracks

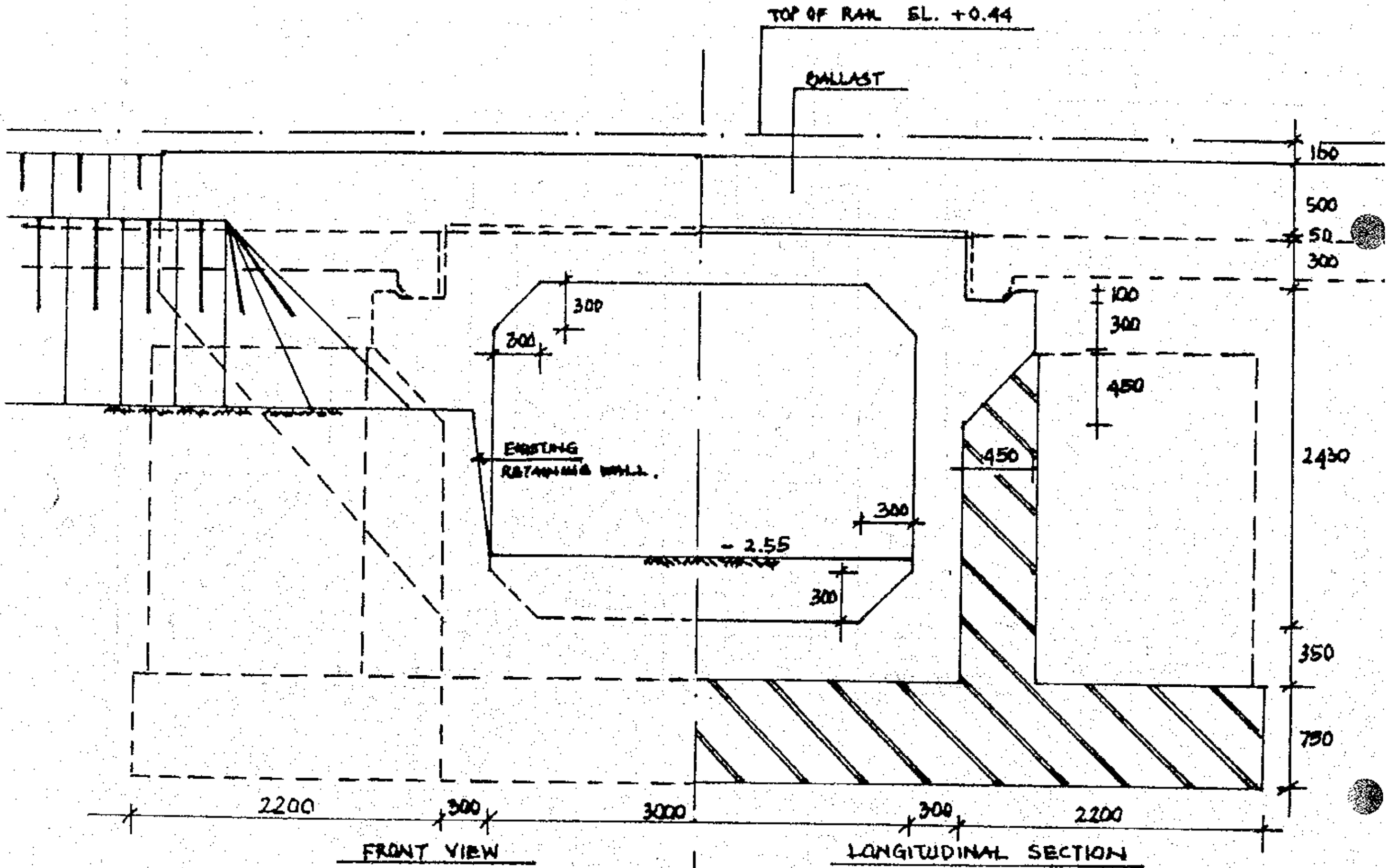
2. DIMENSION OF BOX CULVERT

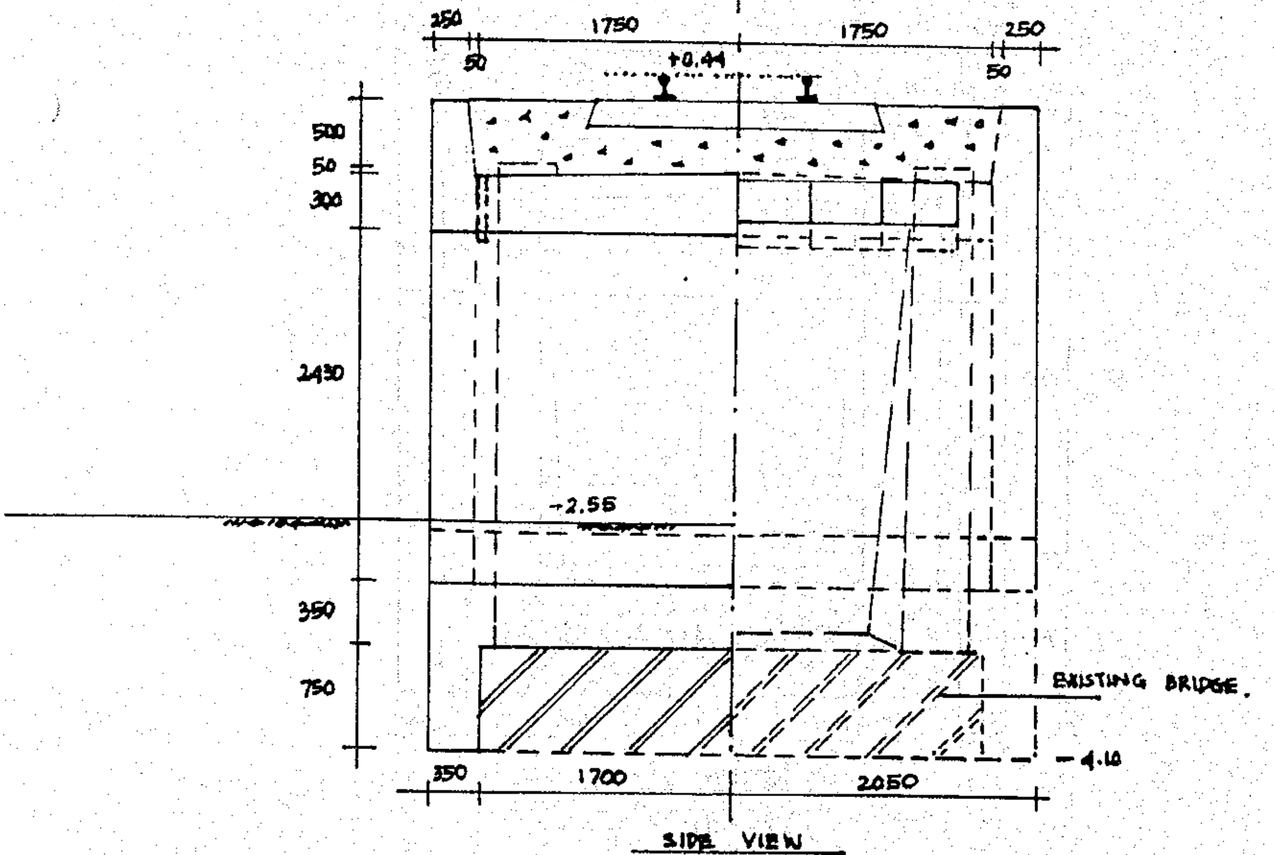




SECTION A - A

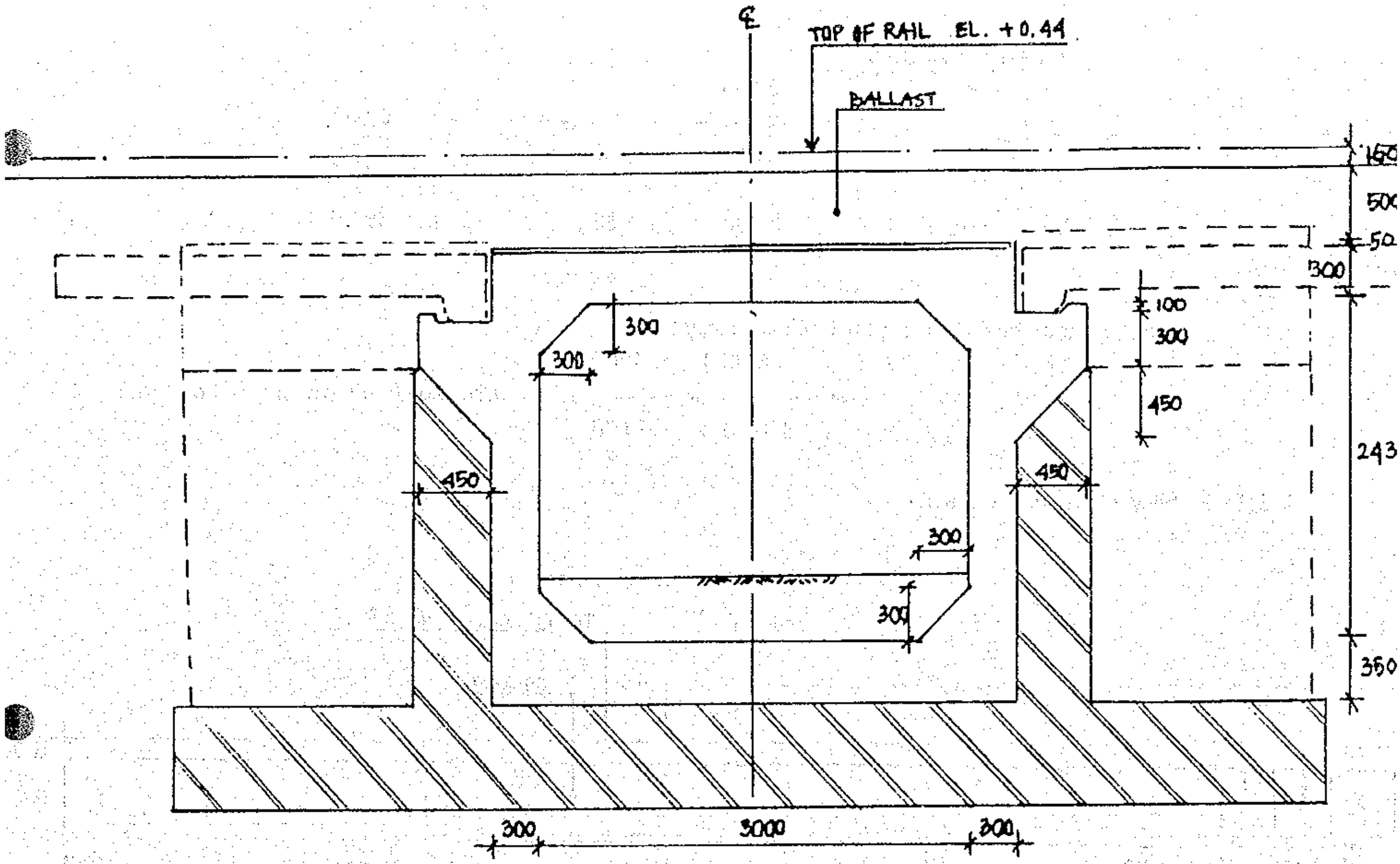
2. DIMENSION OF BOX CULVERT





3. STABILITY ANALYSIS.

3.1. Stress on existing brick masonry



Dead Load

track weight	=					=	0.45 t f
ballast	=		0.50 x	3.60 x	2.00 x	3.40 =	12.24 t f
box culvert	=		0.025 x	3.60 x	2.20 x	3.40 =	0.67 t f
	=		0.30 x	3.60 x	2.40 x	3.40 =	8.81 t f
			0.30 x	2.42 x	2.40 x	3.40 =	5.92 t f
			0.30 x	2.42 x	2.40 x	3.40 =	5.92 t f
			0.35 x	3.60 x	2.40 x	3.40 =	10.28 t f
		0.50 x	0.30 x	0.30 x	2.40 x	3.40 =	0.37 t f
		0.50 x	0.30 x	0.30 x	2.40 x	3.40 =	0.37 t f
		0.50 x	0.30 x	0.30 x	2.40 x	3.40 =	0.37 t f
		0.50 x	0.30 x	0.30 x	2.40 x	3.40 =	0.37 t f
mud / soil	=		0.45 x	2.10 x	1.60 x	3.40 =	5.14 t f
uplift	=		0.35 x	2.60 x	-1.00 x	3.40 =	-3.09 t f
			0.30 x	0.45 x	-1.00 x	3.40 =	-0.46 t f
			0.30 x	0.45 x	-1.00 x	3.40 =	-0.46 t f
						=	46.90 t f

train Load

$$q_{tr} = 2 \times 19.000 = 38.000 \text{ tf}$$

Impact Coefficient

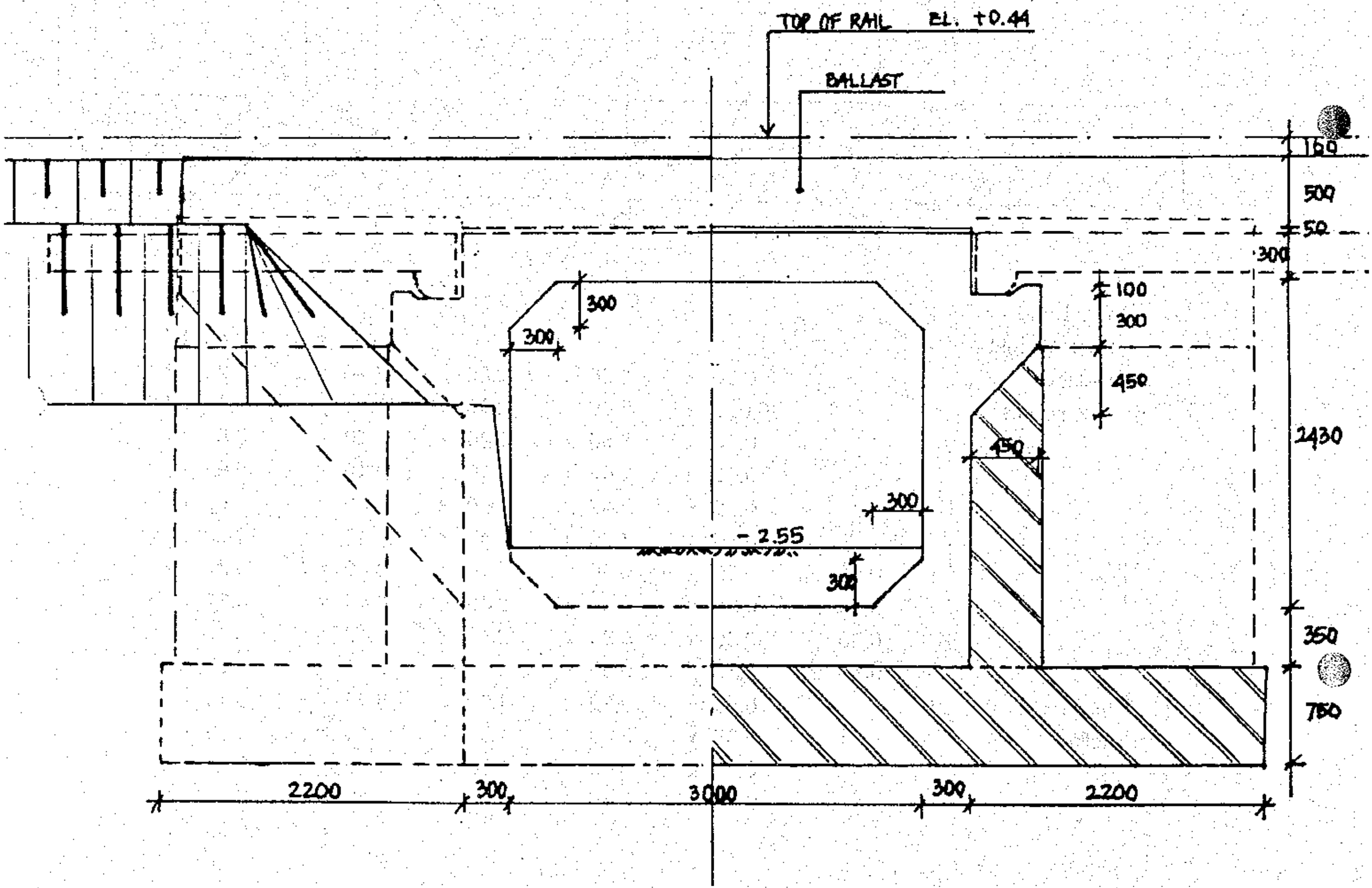
$$i = 0.100 + \frac{22.50}{2.600 + 50.00} = 0.528$$

$$V_{tr} = 38.00 \times 1.53 = 58.05 \text{ tf}$$

Stress under box culvert (on brick masonry)

$$\sigma = \frac{(46.90 + 58.05) \quad 1000}{360.00 \times 340.00} = 0.86 \text{ kgf/cm2} < \sigma a = 15 \text{ kgf/cm2}$$

3.2. Stability of bearing capacity



Unit Weight

track weight	=										=	0.46 t f
ballast	=			0.50	x	3.60	x	2.00	x	3.60	=	12.96 t f
box culvert	=			0.025	x	3.60	x	2.20	x	3.60	=	0.71 t f
	=			0.30	x	3.60	x	2.40	x	4.10	=	10.63 t f
				0.30	x	2.43	x	2.40	x	4.10	=	7.17 t f
				0.30	x	2.43	x	2.40	x	4.10	=	7.17 t f
				0.35	x	3.60	x	2.40	x	4.10	=	12.40 t f
		0.50	x	0.30	x	0.30	x	2.40	x	4.10	=	0.44 t f
		0.50	x	0.30	x	0.30	x	2.40	x	4.10	=	0.44 t f
		0.50	x	0.30	x	0.30	x	2.40	x	4.10	=	0.44 t f
		0.50	x	0.30	x	0.30	x	2.40	x	4.10	=	0.44 t f
		0.275	x	7.60	x	0.55	x	2.40	x	2	=	5.52 t f
		0.50	x	0.50	x	0.50	x	2.40	x	4.10	=	1.23 t f
		0.50	x	2.000	x	2.28	x	0.60	x	2.40	=	3.28 t f
		2	x	2.000	x	0.45	x	0.60	x	2.40	=	2.59 t f
mud / soil	=			0.45	x	3.00	x	1.60	x	4.10	=	8.86 t f
brick masonry	=			2.20	x	3.63	x	3.40	x	1.80	=	48.87 t f
				2.20	x	3.63	x	3.40	x	1.80	=	48.87 t f
				8.00	x	0.75	x	3.40	x	2.00	=	40.80 t f
uplift	=			0.35	x	3.60	x	-1.00	x	4.10	=	-5.17 t f
				0.30	x	0.45	x	-1.00	x	4.10	=	-0.55 t f
				0.30	x	0.45	x	-1.00	x	4.10	=	-0.55 t f
				8.00	x	0.75	x	3.40	x	-1.00	=	-20.40 t f
											=	186.62 t f

$$\gamma = \frac{186.62}{(\ 8.00 \times 3.40 + 3.60 \times 0.70\ )\ 4.38} = 1.43 \ \text{tf/m3}$$

train Load

$$q\,tr = 7 \times 15.000 = 105.000 \ \text{tf}$$

Impact Coefficient

$$i = 0.100 + \frac{22.50}{2.600 + 50.00} = 0.528$$

$$V\,tr = 105.00 \times 1.53 = 160.41 \ \text{tf}$$

Soil Properties

- Ballast Material

γ wet	=	2.00	tf / m3
γ dry	=	1.90	tf / m3
φ	=	35.00	degree
c	=	0.00	tf / m2

- Material under ballast and existing structure ——> Soft Clay
settlement and consolidation have occured on this layer

γ wet	=	1.70	tf / m3	
γ dry	=	1.60	tf / m3	
φ	=	10.00	degree	
c	=	0.56	tf / m2	(c = N / 9 where as N=5)

BEARING CAPACITY

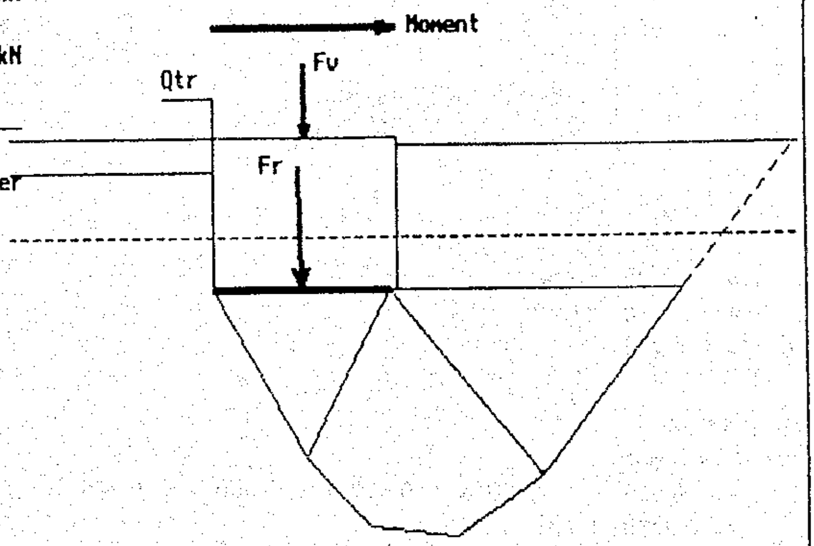
M = -190.74 kNm

Qtr = 24.04 kN/m

Fv = 532.45 kN

Fr = 911.11 kN

Forces per meter

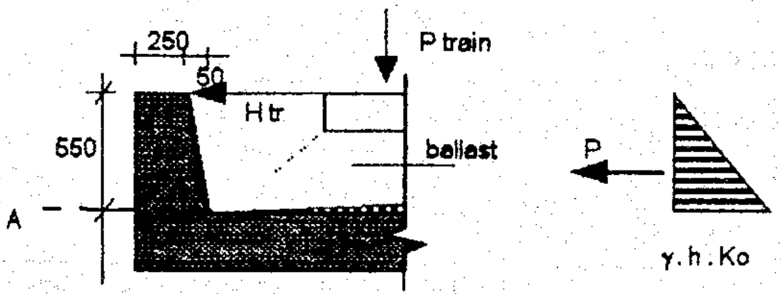


	Width wall = 8.00 m	Safety factor = 2.135 > 1.500 (o.k)
File : BH-6	Height wall = 4.38 m	Load combination nr. : 1

4. STRUCTURAL CALCULATION

4.1. SIDE WALL FOR BALLAST.

4.1.a. Sketch



4.1.b. Earth Pressure caused by ballast.

γ = 2.000 tf/m3
ϕ = 35 degree
c = 0 tf/m2
K o = 0.244

4.1.c. Lateral earth pressure

- Caused by ballast.

P = 0.500 x 2.000 x 0.550 x 0.550 x 0.244
= 0.0738 tf/m

- 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

$$H'tr = \frac{0.60}{1.20} = 0.50 \text{ t-f/m}$$

4.1.d. Internal force

G [tf]						x [m]	Mx [tfm]
concrete :	0.500 x	0.050 x	0.550 x	2.400 =	0.033	-0.117	-0.004
		0.250 x	0.550 x	2.400 =	0.330	0.025	0.008
ballast :	0.500 x	0.050 x	0.550 x	2.000 =	0.028	-0.133	-0.004
					0.391	0.002	0.001

Therefore :

M = 0.0738 x 0.1833 + 0.50 x 0.55 + 0.391 x 0.002
= 0.289 tf-m/m
Q = 0.0738 + 0.50 = 0.574 tf
N = 0.391 tf

4.1.e. Reinforcement

h	=	0.24 m
b	=	1.00 m
Ca	=	14.61
δ	=	1.00
φ	=	8.09
ζ	=	0.963
nw	=	0.0068

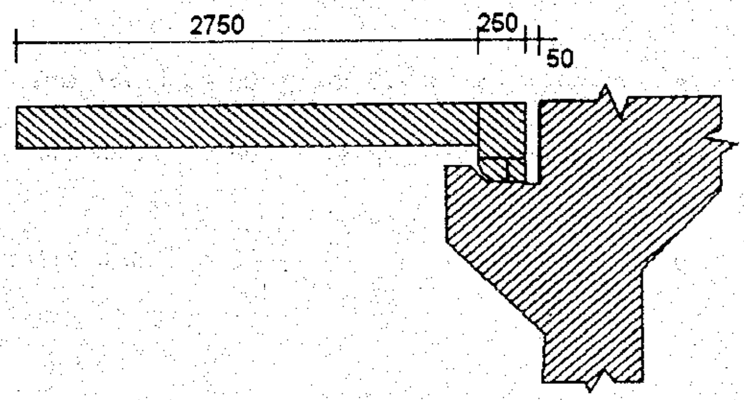
$$A = \frac{0.0068}{21} \times 29 \times 100 = 0.9404 \text{ cm2}$$

$$A\,min = 0.0025 \times 29 \times 100 = 7.25 \text{ cm2} \qquad \text{use D 16 - 250}$$

$$\tau = \frac{0.574 \times 1000}{0.875 \times 29 \times 100} = 0.2261 \text{ kg f / cm2} \qquad \text{ok.}$$

4.2. TRANSITION SLAB

4.2.a. Sketch



4.2.b. Loading

Dead Load

concrete	=	0.30 x	1.00 x	2.40	=	0.72	tf/m
ballast	=	0.55 x	1.00 x	2.00	=	1.10	tf/m
tracks	=	0.45 x	0.31		=	0.14	tf/m
						1.96	tf/m

Live Load

impact factor

$$i = 0.1 + \frac{22.5}{3 + 50} = 0.52$$

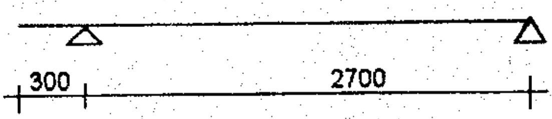
Live Load

$q = 8.75 \ tf/m$

Live Load + impact

$$q = \frac{8.75 \times 1.52}{3.2} = 4.16 \ tf/m$$

4.2.c. Reinforcement



$M = 0.125 \times 6.12 \times 7.29 - 0.5 \times 0.09 \times 1.96$

$= 5.49 \ tf \ m.$

$h = 0.23 \ m$

$b = 1.00 \ m$

$Ca = 3.22$

$\delta = 0.40$

$\phi = 1.857$

$\zeta = 0.886$

$nw = 0.111$

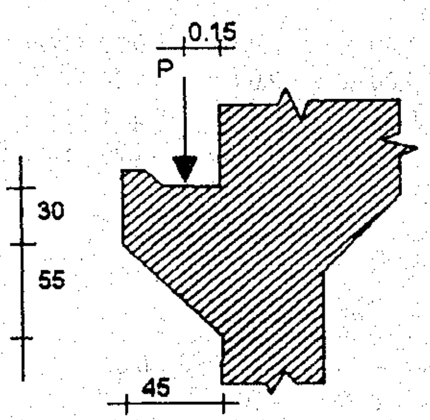
$$A = \frac{0.111}{21} \times 23 \times 100 = 12.157 \ cm2$$ use D 16 - 125

$A \ min = 0.0025 \times 29 \times 100 = 7.25 \ cm2$

$$\tau = \frac{8.26 \times 1000}{0.875 \times 23 \times 100} = 4.10 \ kgf/cm2$$ ok.

4.3. CONSOLE FOR TRANSITION SLAB

4.3.a. Sketch



4.3.b. Loading

Vertical Force

concrete =			0.30	x	0.55	x	2.40	=	0.40	tf/m
	0.5	x	0.55	x	0.55	x	2.00	=	0.30	tf/m
R b								=	8.26	tf/m
									8.96	tf/m

Moment

M = 8.26 x 0.15 + 0.40 x 0.275 + 0.3025 x 0.18

= 1.40 tf m/m

4.3.c. Reinforcement

M = 1.40 tf m.

h = 0.78 m

b = 1.00 m

Ca = 21.578

δ = 0.40

A min = 0.0025 x 78 x 100 = 19.5 cm2 use D 19 - 125

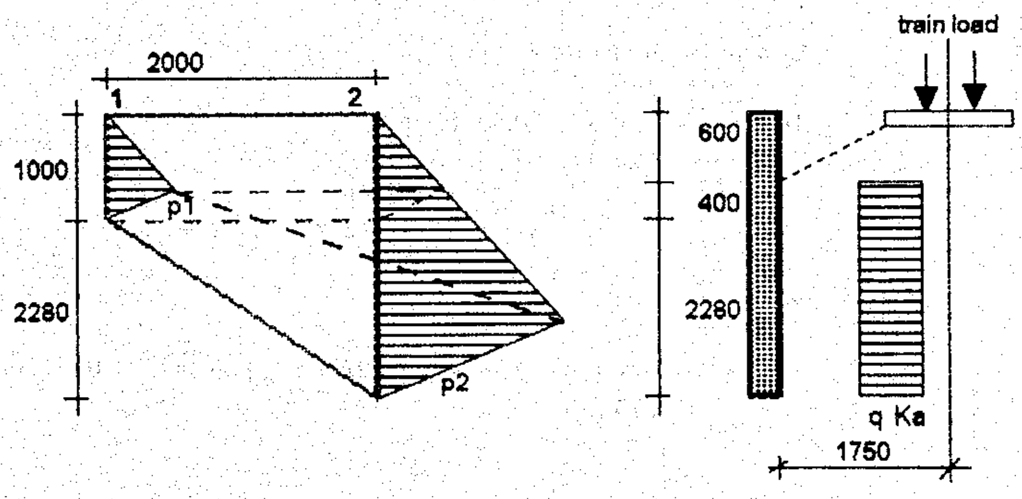
$$\tau = \frac{8.96 \times 1000}{0.875 \times 78 \times 100} = 1.31 \text{ kgf/cm2} \quad \text{ok.}$$

stirrup

$$A h = \frac{8.96 \times 1000}{2250 \times 1} = 3.98 \text{ cm 2} \quad \text{use D 13 - 250}$$

4.4. WING WALL .

4.4.a. Sketch



4.4.b. Lateral earth pressure

- data of soil

γ	=	1.800 tf/m3
φ	=	35.00 degree
K o	=	0.500 (assumption)

- earth pressure

p1	=	1.8	x	1	x	0.5	=	0.9 tf/m 2
p1	=	1.8	x	3.28	x	0.5	=	2.952 tf/m 2

Force.													P [tf]	x [m]	Mx [t-f m]
P1	=	0.50	x	1.00	x	0.90	x	0.67	=				0.30	1.00	0.30
P2	=			0.90	x	2.28	x	0.67	=				1.37	0.67	0.91
		0.50	x	2.05	x	2.28	x	0.67	=				1.56	0.67	1.04
													3.23	0.70	2.25

- earth pressure caused by train load

$$q\ Ka = \frac{8.75}{3.50} \times 0.5 = 1.25\ tf/m2$$

Force.								P [tf]	x [m]	Mx [t-f m]
P1	=	1.25	x	0.40	x	2.00	=	1.00	1.00	1.00
P2	=	1.25	x	2.28	x	0.67	=	1.90	0.67	1.27
								2.90	0.78	2.27

- 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

$$H'tr = \frac{0.60}{1.20} = 0.50\ t\text{-}f/m$$

						P [tf]	x [m]	Mx [t-f m]
P	=	0.5	x	2	=	1	1	1.00

Total Force

$$M = \frac{1}{2.73}(2.25 + 2.27 + 1.00) = 2.02\ t\text{-}f\,m/m'$$

$$Q = \frac{1}{2.73}(3.23 + 2.90 + 1.00 = 2.61\ t\text{-}f/m'$$

4.4.c. Reinforcement

$h = 0.23$ m

$b = 1.00$ m

$Ca = 5.295$

$\delta = 0.40$

$\phi = 3.255$

$\zeta = 0.92$

$nw = 0.04$

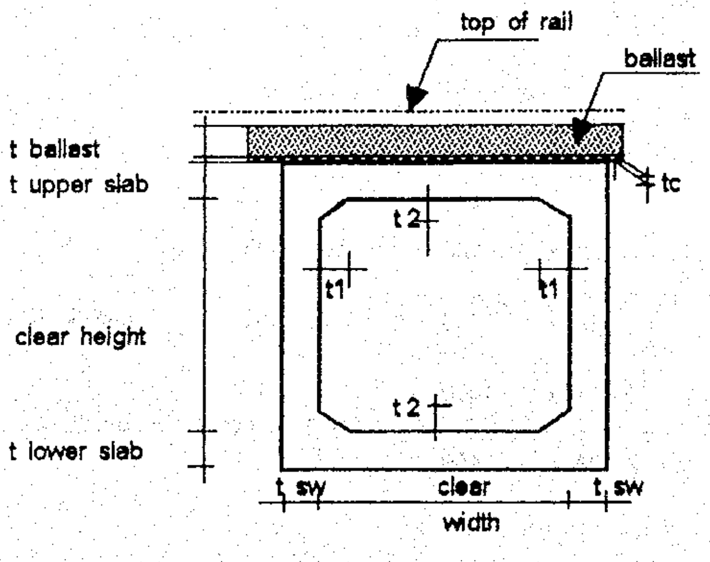
$$A = \frac{0.04}{21} \times 23 \times 100 = 4.381 \text{ cm2}$$

$$A\,min = 0.0025 \times 29 \times 100 = 7.25 \text{ cm2}$$ use D 16 - 250

$$\tau = \frac{2.611 \times 1000}{0.875 \times 23 \times 100} = 1.2975 \text{ kg / cm2}$$ ok.

4.5. BOX CULVERT

4.5.a. Sketch



where is :

t ballast	=	500	mm
t soil	=	0	mm
t plain conc.	=	50	mm
t upper slab	=	300	mm
t lower slab	=	350	mm
clear height	=	2430	mm
t side wall (t sw)	=	300	mm
t side wall (t sw)	=	300	mm
clear width	=	3000	mm
t 1	=	300	mm
t 2	=	300	mm

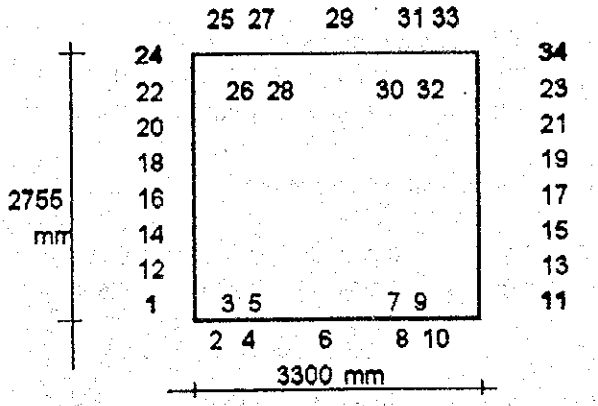
4.5.b. Unit Weight of Mass

Track Weight	=	0.450	tf / m'
Ballast	=	2.000	tf / m3
Filled Material	=	1.800	tf / m3
Plain Concrete	=	2.200	tf / m3
Reinforced Concrete	=	2.400	tf / m3

4.5.c. Reinforced Concrete Quality

Concrete	K - 225
Reinforcing Bar	U - 39 (deform steel)

4.5.d. Schematization of Rigid Frame Diagram.



4.5.e Property of Members

Member	Thickness [m]	Area [m2]	Inersia Moment [m4]	Young's Modulus [tf/m2]
upper slab	0.300	0.300	0.00225	2.7 x 10^6
lower slab	0.350	0.350	0.00357	2.7 x 10^6
side wall	0.300	0.300	0.00225	2.7 x 10^6
side wall	0.300	0.300	0.00225	2.7 x 10^6

4.5.f. Loadings

1. Track Load.

Track weight	=	0.450 /	2	=	0.225	tf/m
Ballast / Gravel	=	0.500 x	2.000	=	1.000	tf/m
			q tr	=	1.225	tf/m

2. Dead Load.

a. Upper slab load

- Lean concrete	=	0.050 x	2.200	=	0.110	tf/m
- Top slab	=	0.300 x	2.400	=	0.720	tf/m
			q dl	=	0.830	tf/m

b. Side Wall (q sw) = 0.300 x 2.400 = 0.720 tf/m

3. Earth and Water Pressure.

a. Soil data :

1. Fill Material at the back side of side wall

γ = 1.800 tf/m3

K o = 0.500 (assumption)

K' o = 1.000 (Water)

b. Intensity of earth pressure

1. Condition 100 % of earth pressure

P e1 = (	1.225 +	0.200 x	1.800) x	0.500 =	0.793	tf / m
P e2 =	0.793 +	2.755 x	1.800 x	0.500 =	3.272	tf / m

2. Condition of earth and water pressure

P e1 = (	1.225 +	0.200 x	0.800) x	0.500 =	0.693	tf / m
P e2 =	0.693 +	2.755 x	0.800 x	0.500 =	1.795	tf / m
P w1 =				=	0.000	tf / m
P w2 =	0.000 +	2.755 x	1.000 x	1.000 =	2.755	tf / m
P (e+w) 1	=	0.693 +	0.000	=	0.693	tf / m
P (e+w) 2	=	1.795 +	2.755	=	4.550	tf / m

4. Train Load.

a. Impact Coefficient

$$i = 0.100 + \frac{22.50}{3.300 + 50.00} = 0.522$$

b. Uniform Load

$$q\,tr = \frac{2 \times 19.000}{2.400 \times 3.200} = 4.948 \text{ tf / m}$$

$$q\,tr{+}i = 4.948 \times (1.000 + 0.522) = 7.531 \text{ tf / m}$$

5. Earth Pressure due to Train Load.

$$P h = K o \times P w$$

where is :

P h : Horizontal Pressure due to train load

K o : Earth pressure coefficient

q : Distributed Train Load ------->

$$q = \frac{8.75}{4.00} = 2.188 \text{ t / m2}$$

$$P e tr = 0.500 \times 2.188 \times 1.00 = 1.094 \text{ tf / m}$$

6. Spring Constants

Coefficient subgrade reaction

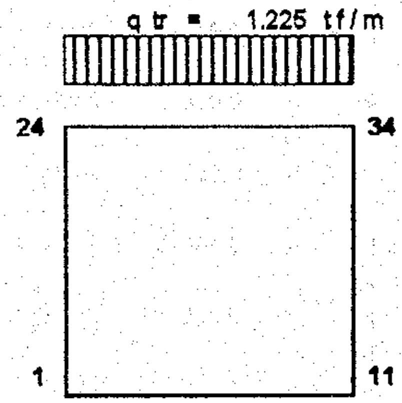
Kv = 2800 t/m3

Kh = 933 t/m3

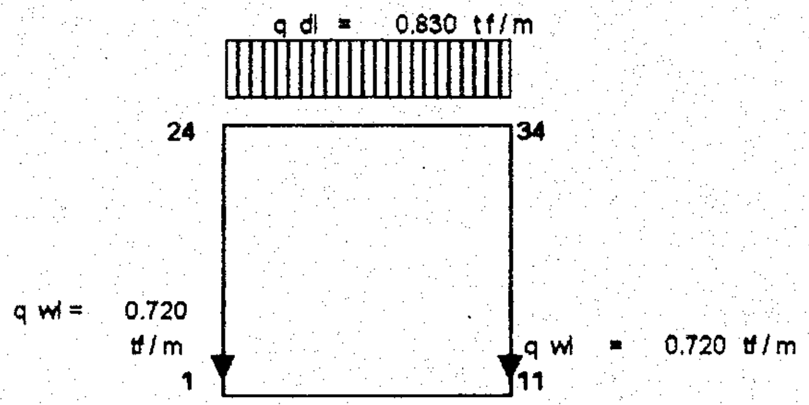
point 1 & 11	:	Kv	=	0.075 x	2800	=	210	t/m
		Kh				=	70	t/m
point 2 & 10	:	Kv	=	0.088 x	2800	=	246	t/m
		Kh				=	82	t/m
point 3 & 9	:	Kv	=	0.150 x	2800	=	420	t/m
		Kh				=	140	t/m
point 4 & 8	:	Kv	=	0.150 x	2800	=	420	t/m
		Kh				=	140	t/m
point 5 & 8	:	Kv	=	0.600 x	2800	=	1680	t/m
		Kh				=	560	t/m
point 6	:	Kv	=	1.175 x	2800	=	3290	t/m
		Kh				=	1097	t/m

4.5.e. Load Model

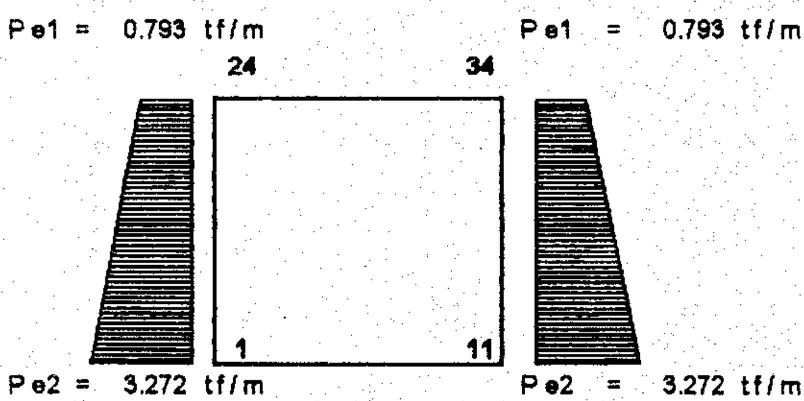
1. Track Load.



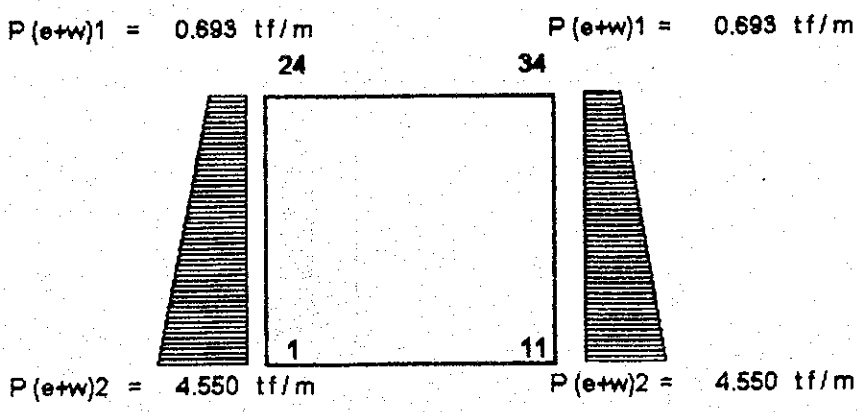
2. Dead Load.



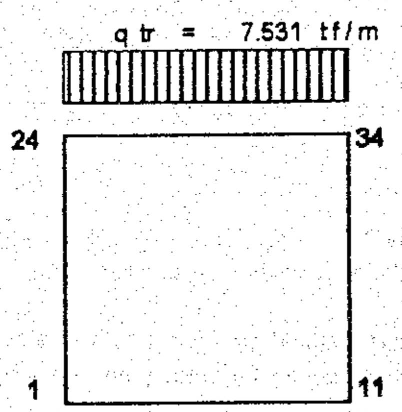
3. Earth Pressure



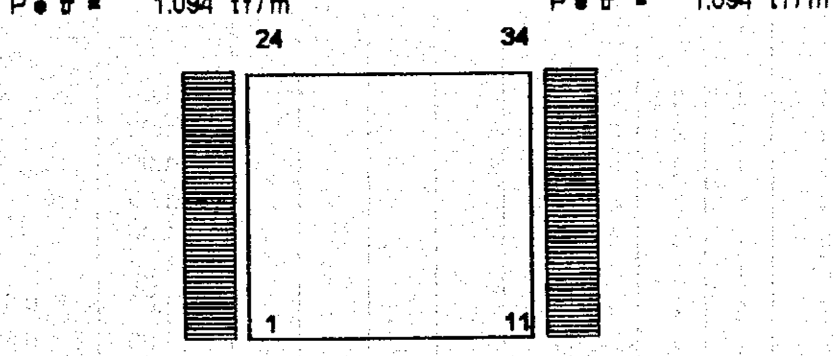
4. Earth and Water Pressure



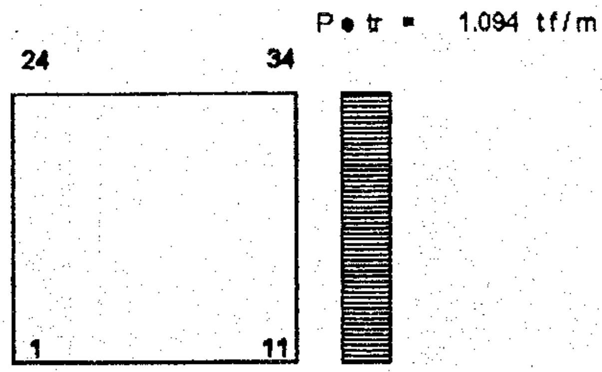
5. Train Load.



6. Earth Pressure caused by Train (both of side)



7. Earth Pressure caused by Train (one side only)



4.5.f. Load Combination

1. Basic Case.

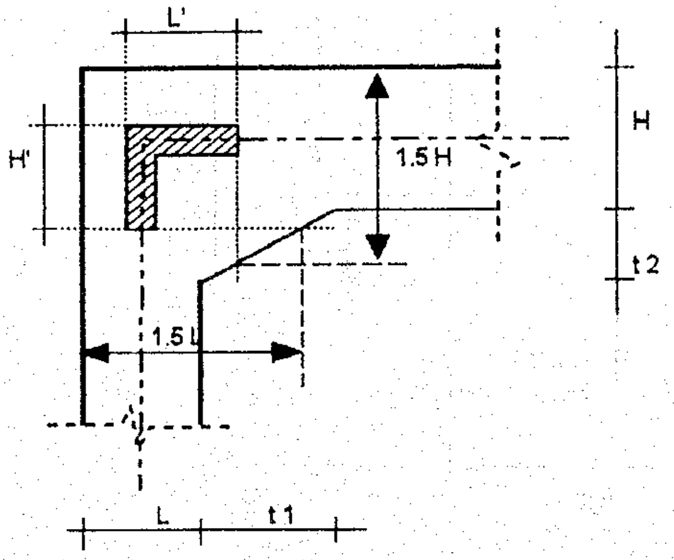
No.	Aplications	Note
1.	1. Track Load.	
2.	2. Dead Load.	
3.	3. Earth Pressure	
4.	4. Earth and Water Pressure	
5.	5. Train Load.	
6.	6. Earth Pressure caused by Train (both of side)	
7.	7. Earth Pressure caused by Train (one side only)	

2. Load Combination.

No.	Combination Case								Load Factor α	
1	1	2	3	7					1.00	
2	1	2	3	7	5				1.00	
3	1	2	3	6	5				1.00	
4	1	2	4	7					1.00	
5	1	2	4	7	5				1.00	
6	1	2	4	6	5				1.00	
7	1	2	4	7					1.00	α = 0.50 for earth pressure
8	1	2	4	7	5				1.00	α = 0.50 for earth pressure
9	1	2	4	6	5				1.00	α = 0.50 for earth pressure
10	1	2	5						1.00	

4.5.g. Check point at edge of box culvert

1. Bending Moment at Panel Point.



The effect of haunches may be neglected on rigid frames analysis if it's satisfied conditions of below.

$L'/L \leqslant 1.0$

$H'/H \leqslant 1.0$

Length of rigidity zone is 1.5 times the depth of member because inclination of haunch (θ) is 45 degrees

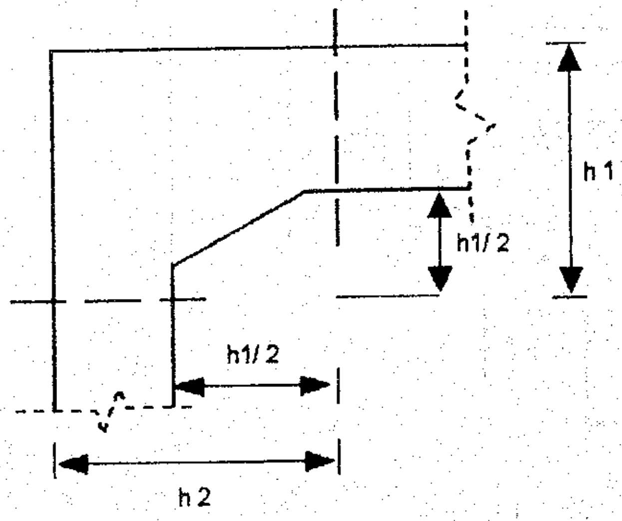
Rigidity structure analyze from this point :

$$L' = \frac{L}{2} + \left(t1 - \frac{0.5\,H \cdot t1}{t2} \right)$$

$$H' = \frac{L}{2} + \left(t2 - \frac{0.5\,H \cdot t2}{t1} \right)$$

2. Calculation of Shear Point.

Examination of shear is at drawing below beacuse that member support directory.



Rigid Length Calculation

Items	Joint Connection			
	Top Slab and Wall		Bottom Slab and Wall	
H [m]	0.300		0.350	
L [m]	0.300		0.300	
t1 [m]	0.300		0.300	
t2 [m]	0.300		0.300	
L' [m]	0.300		0.275	
H' [m]	0.300		0.325	
L' / L	1.000		0.917	
H' / H	1.000		0.929	

≤ 1 (o.k.)
≤ 1 (o.k.)

Calculation Stress Point.

Members	Distance from point i				
	x m1 [m]	x s1 [m]	x m2 [m]	x s2 [m]	x3 [m]
upper slab	0.150	0.150	0.450	0.450	1.650
lower slab	0.150	0.175	0.450	0.475	1.650
side wall	0.150	0.150	0.450	0.450	1.378
side wall	0.150	0.150	0.450	0.450	1.378

front rigid area

Members	Distance from point i				
	x 3 [m]	x s4 [m]	x m4 [m]	x s5 [m]	x m5 [m]
upper slab	1.650	2.850	2.850	3.150	3.150
lower slab	1.650	2.825	2.850	3.125	3.150
side wall	1.378	2.280	2.280	2.605	2.580
side wall	1.378	2.280	2.280	2.605	2.580

front rigid area

4.5.h. **Reinforcement Analysis**

- Concrete

K -	225	------->	allowable compressive stress	=	75	kg f /cm 2
			allowable tension stress	=	7	kg f /cm 2
			E b	=	140000	kg f /cm 2

- Steel Rebar

U -	39	------->	allowable compressive / tension stress	=	2250	kg f /cm 2
			E a	=	2100000	kg f /cm 2

ITEMS	TOP SLAB			BOTTOM SLAB			SIDE WALL		
	Section 25	Section 26	Section 29	Section 2	Section 4	Section 6	Section 12	Section 18	Section 22
Internal Force									
M [tf m]	3.38	0.71	7.99	1.63	3.23	8.35	3.59	3.13	3.56
N [tf]	3.69	2.92	0.77	3.95	3.04	3.82	17.69	16.59	16.09
Q [tf]	14.60	11.73	0.22	15.59	11.77	5.32	4.37	1.54	3.85
Dimension									
b [m]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
h [m]	0.40	0.30	0.30	0.45	0.35	0.35	0.40	0.30	0.30
d [m]	0.33	0.23	0.23	0.38	0.28	0.28	0.33	0.23	0.23
d' [m]	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Analysis									
n	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
Ø o	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
e o1 [m]	0.92	0.24	10.38	0.41	1.06	2.19	0.20	0.19	0.22
e o2 [m]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
e o [m]	0.94	0.26	10.40	0.43	1.08	2.21	0.22	0.21	0.24
e o / h	2.34	0.88	34.68	0.96	3.09	6.30	0.56	0.70	0.80
C	7.00	6.99	7.00	7.00	7.00	7.00	6.93	6.96	6.98
e 1 [m]	0.02	0.03	0.03	0.02	0.02	0.02	0.01	0.02	0.02
e 2 [m]	0.06	0.05	0.05	0.07	0.05	0.05	0.06	0.05	0.05
e [m]	1.02	0.33	10.47	0.52	1.16	2.28	0.30	0.27	0.30
e a [m]	1.15	0.41	10.55	0.67	1.26	2.38	0.43	0.35	0.38
N ea [tf m]	4.23	1.21	8.12	2.65	3.84	9.11	7.54	5.83	6.19
C a	5.255	6.851	2.642	7.634	4.680	3.036	3.934	3.119	3.029
delta	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
0	3.167	4.263	1.500	4.714	2.774	1.740	2.333	1.817	1.740
0 '	5.429	9.000	2.000	11.000	4.454	2.396	3.500	2.529	2.396
ksi	0.240	0.190	0.400	0.175	0.265	0.365	0.300	0.355	0.365
zeta	0.918	0.935	0.873	0.940	0.911	0.882	0.900	0.885	0.884
C b	2.778	3.172	2.000	3.319	2.621	2.136	2.430	2.178	2.027
mw	0.041	0.023	0.170	0.019	0.053	0.130	0.073	0.116	0.140
Reinforcement									
i	1.360	2.084	1.019	2.134	1.253	1.115	3.301	2.378	2.126
A [cm]	4.74	1.21	18.26	1.61	5.64	15.54	3.48	5.34	7.21
A' [cm]	2.58	1.01	7.45	1.38	2.83	6.93	4.59	5.09	6.13
A min [cm2]	8.25	5.75	5.75	9.50	7.00	7.00	8.25	5.75	5.75
A [cm]	8.25	5.75	18.26	9.50	7.00	15.54	8.25	5.75	7.21
Rebar diameter	16	16	19	16	16	19	16	16	16
Distance [cm]	20	25	14	17	25	17	20	25	20
A' [cm2]	4.49	4.79	7.45	6.11	3.51	6.93	10.89	5.47	6.13
Rebar diameter	16	16	16	16	16	16	16	16	16
Distance [cm]	33	33	20	20	33	25	17	25	25
Checking Shear Stress									
Load Factor	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Tb [kg f /cm2]	6.07	6.99	0.13	5.63	5.76	2.61	1.82	0.92	2.30
Tb-Ta [kg f/cm2]	2.07	2.99		1.63	1.76				
Ts [kg f /cm2]	4.78	4.78		4.78	4.78				