CHAPTER 5

CONVEYANCE SEWER CONSTRUCTION PROJECT

(Package D)

5.1

Civil Design

5.1.1

Box Culvert

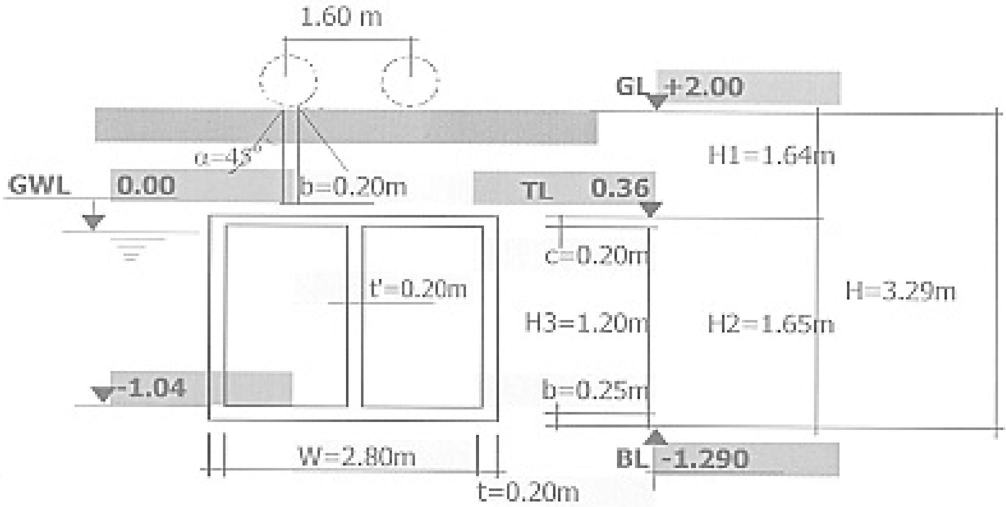
Calculation for conveyance sewer type 1

(Use Wooden piles)

(The calculation based on Japanese standard - JIS1999)

1-Geometry dimensions for calculation

(Calculation made for one m long of conveyance sewer):



2-Material properties and soil conditions:

Ground water level:	GWL=	0.00
Concrete: Grade 210,	Rn =	70 (Kg/cm2)
	RS=	3.6 (Kg/cm2)
Reinforcement type JIS:	Ra=	1600 (Kg/cm2)

Back fill sand: γ_s= 1.80T/m3 ; Coeficient of earth pressure at rest K_o= 0.5

Internal friction 30deg

3-Loading and calculation scheme:

3.1 Vehicle load:

Vehicle type: H30 So design load is calculated as following formula:

$P_{de} = (1+i)2P/W_o$

Where: P, weight of back wheel 12.00T

W_o, width of occupied area of vehicle W_o= 2.75 m

i, impact coefficient, i= 0.3

P_{de} = 11.35T/m

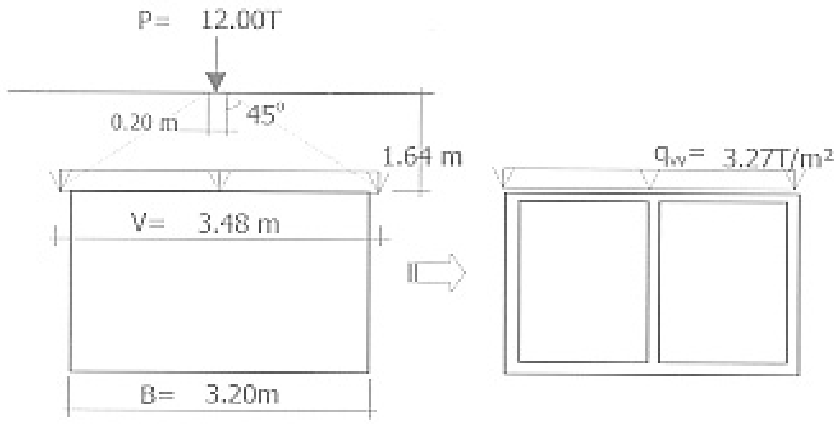
Because B<V so uniform distributed vehicle load calculated as below

q_{vv} = Pde/V = 3.27T/m²

Horizontal vehicle load from both sides of the sewer:

p_{hv} = $1.0xK_o$ = 0.50T/m²

Where: 1.0 T/m² is vertical uniform load due to vehicle for wall calculation



3.2- Soil load:

3.2.1 In case of ground water level at 0.00 (Permanent case):

-Vertical uniform distributed load due to cover soil :

q_{cs}=H1*γs= 2.95T/m2

-Horizontal side uniform distributed load due to cover soil from both side of the sewer:

$p_{cs1}=q_{cs}xK_o$= 1.48T/m2

-Horizontal triangle load due to earth from both side of the sewer under ground water level:

p_{21}=γs(TL-GWL)Ko+(γ_s-1)x(GWL-BL)xK_o+(GWL-BL)x1.0 = 2.13T/m2

-Horizontal triangle load due to earth from both side of the sewer above ground water level:

$p_{31}=\gamma_s(TL-GWL)K_o$= 0.32T/m2

-Uplift pressure for this case:

p_{uplift}=(GWL-BL)x1.0= 1.29T/m2

3.2.2 In case of ground water level at +2.00 (Soil submerged by ground water):

-Vertical uniform distributed load due to submerged cover soil:

$q'_{cs}=H_1x(\gamma_s-1)+H_1x1.0$= 2.95T/m2

-Horizontal uniform distributed load due to submerged cover soil from both side of the sewer:

$p_{cs2}=H_1x(\gamma_s-1)xK_o+H_1x1.0$= 2.30T/m2

-Horizontal triangle load due to submerged soil from both side of the sewer:

$p_{22}=H_2x\gamma_w+(\gamma_s-\gamma_w)xH_2xK_o$

$p_{22}=H_2x1+(\gamma_s-1)xH_2xK_o$= 2.31T/m2

-Uplift pressure due to ground water:

$p_{uplift}=H_2x1.0$= 1.65T/m2

3.3-Self load:

-Load due to cover slab:

$Q_{coverslab}$ = 2.5x(W+2t)x1x0.2 =1.60Ton

-Load due to walls:

Q_{wall} = 3x2.5x(0.20 x1.20x1.0) =1.80Ton

-Load due to bottom slab:

qbs= 2.5x0.25 = 0.63T/m2

qself= 1.69T/m2

3.4-Live load (with full of water in sewer):

-Uniform load: qw = 1.20T/m2

3.5-Total loads:

3.5.1 In case of ground water level at 0.00:

a. Vertical uniform distributed load due to vehicle load:

q_{vv} = 3.27T/m

b. Total vertical uniform distributed load transfered from ground surface down to coverslab:

$q_{11} = q_{cs}$ = 2.95T/m2

c. Total horizontal uniform distributed loads from both side of the sewer:

$p_{11}= p_{hv}+p_{cs1}$ = 1.98T/m2

d. Total horizontal triangle loads from both side of the sewer (Consideration for under ground water level):

p_{21}= 2.13T/m2

e. Total horizontal triangle loads from both side of pipe gallery (Consideration for above ground water level):

p_{31}= 0.32T/m2

3.5.2 In case of ground water level upto +2.00 :

a. Vertical uniform distributed load due to vehicle load:

q_{vv} = 3.27T/m

b. Total vertical uniform distributed load transfered from ground surface down to coverslab:

$q_{12} = q'_{cs}$ = 2.95T/m2

b. Total horizontal uniform distributed loads from both side of the sewer:

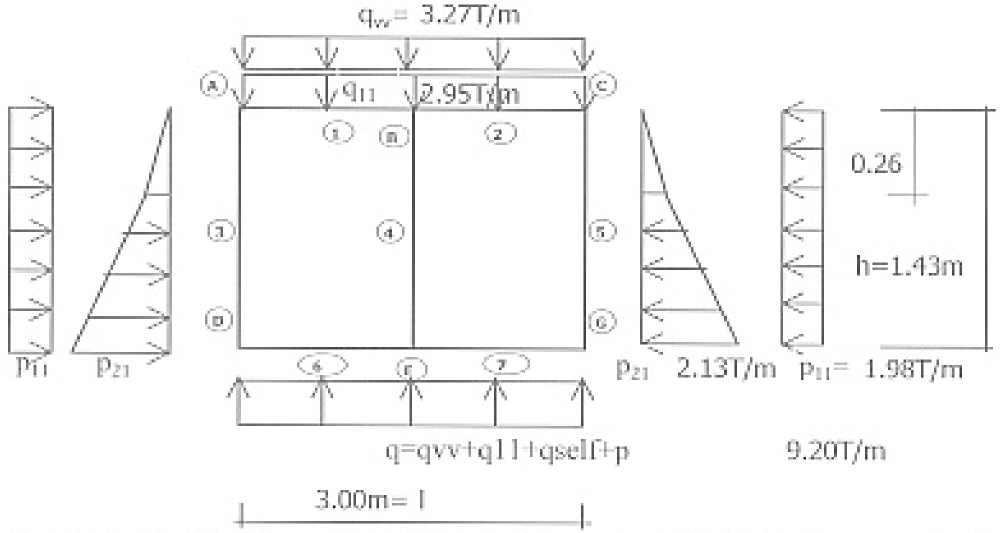
$p_{12} = p_{hv} + p_{cs2}$ = 2.80T/m2

c. Total horizontal triangle loads from both side of the sewer :

p_{22}= 2.31T/m2

3.6-Calculation scheme for conveyance sewer: (for 1m long)

3.6.1 In case of ground water level at 0.00 (Without water in sewer):



4-Checking pressure to soil base , compare to capacity of soil under the bottom of sewer:

Total pressure to base soil:

$p_s = q_{cs} + q_{vv} + (Q_{coverslab} + Q_{wall})/[(W+2t)x1.0] + qw + qbs$ =9.11 T/m2

So at the depth of 3.29m Strength of base soil must be bigger than 0.91Kg/cm2

(Assumming dimensions of wooden pile DxL=0.1mx5m)

Use 25 wooden piles/m²

5-Checking uplift that due to ground water: (For most dangerous case, ground water is up to ground surface level, and the sewer is empty in side)

P_{uplift}= 1.65T/m2

5.1 Cover soil submerged:

p_{soil} = 2.95T/m2

5.2 Self load of sewer:

$$p_{self} = \frac{2.5x(0.25x\ 1.0x3.20 + 0.20x1.0\ x3.2 + 3\ x1.0x0.20\ x1.20)}{1.0x(2.80 + 2x0.20)}$$

p_{self}= 1.50T/m2

Total pressure: $p_s = p_{soil} + p_{self}$ = 4.45T/m2

* So that $p_s > p_{uplift}$ **OK!!!**

6-Calculation for stresses and forces for scheme 3.6.1:

(Results and inlustrated diagram attached at the end of this calculation)

7-Calculation for bar arrangement:

Factor related to Moment, bearing area and compress capacity:

$A_o = M/R_n b h_o^2$

Where, M: Maximum bending moment(T.m)

h_o: Effective depth of bearing area(cm)

h_o= (Element thickness-Cover thickness)

b: Width of calculated area(cm)

Required area of reinforcement:

Fa= M/γRaho   Where: $\gamma = 0.5 + ((1-2Ao)^{1/2})/2$

Moments	Values (T.m)	Ao	γ	Fa (cm^2)	Bar arrangement	
					φ(mm)	a(mm)
M_{B-1}	1.440	0.1217	0.935	7.41	12	125
M_{1-1}	0.770	0.0651	0.966	3.83	12	250
M_{A-1}	0.810	0.0685	0.965	4.04	12	250
M_{A-3}	0.810	0.0685	0.965	4.04	12	250
M_{3-3}	0.020	0.0017	0.999	0.10	12	250
M_{D-3}	0.750	0.0331	0.983	2.65	12	250
M_{D-6}	0.750	0.0331	0.983	2.65	12	250
M_{6-6}	1.040	0.0459	0.977	3.70	12	250
M_{E-6}	2.010	0.0886	0.954	7.32	12	125

8-Checking for shearing forces:

-Height of hand for supporting coverslab   s = 0.00 m   , so the section need to be checked

shear bearing capacity is [t/2+(c+s)/2]=   0.200 m   far from center of wall

Shears	Values (T)	Shearing stresses (Kg/cm2)	Degn Shearing stress (Kg/cm2)	Compare &Conclude
V_{B-1}	4.80	3.20	3.60	OK!!!
V_{E-6}	6.40	3.20	3.60	OK!!!

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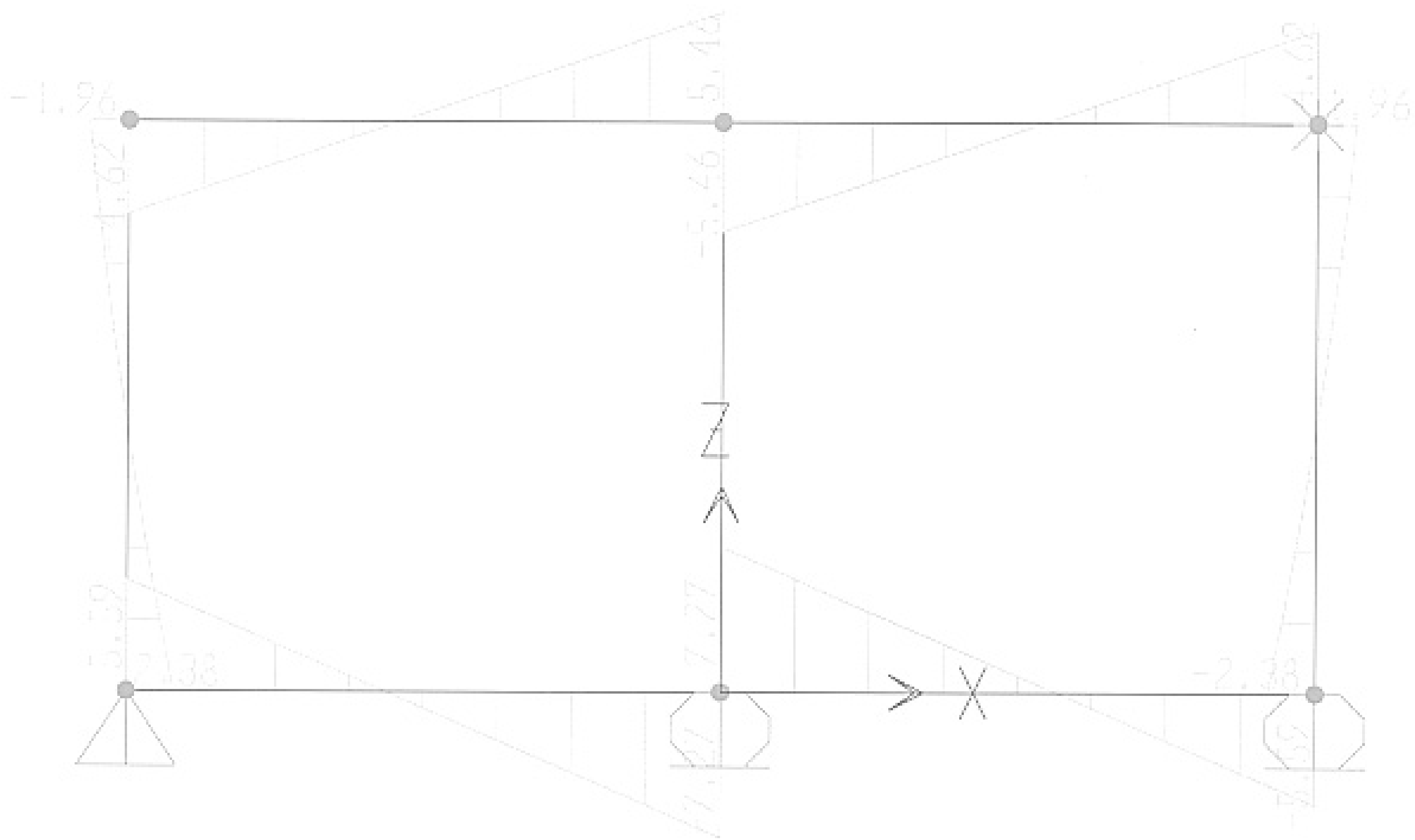

SAP2000 v6.11 - File:ConSewer1 - Shear Force 2-2 Diagram (LOAD1) - Ton-m Units

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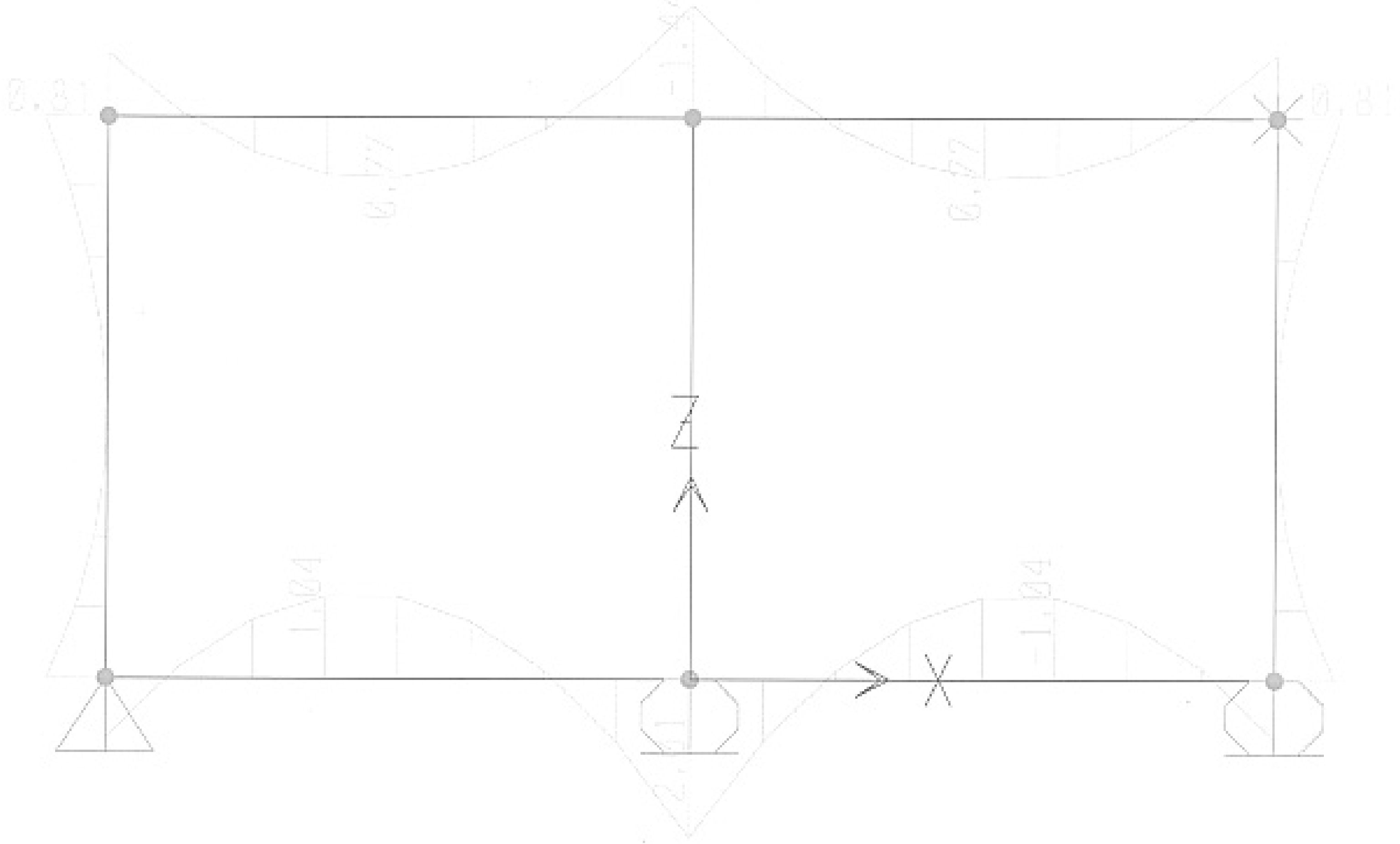
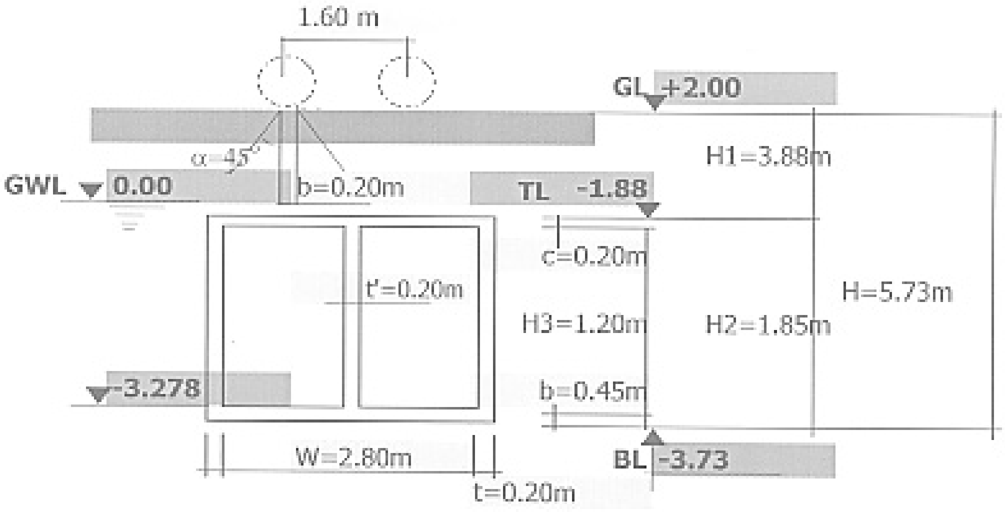


SAP2000 v6.11 - File:ConSewer1 - Moment 3-3 Diagram (LOAD1) - Ton-m Units

Calculation for conveyance sewer type 2

(Use RC.piles)
(The calculation based on Japanese standard - JIS1999)

1-Geometry dimensions for calculation
(Calculation made for one m long of conveyance sewer):



2-Material properties and soil conditions:

Ground water level:	GWL=	0.00 m
Concrete: Grade 210,	Rn =	70 (Kg/cm2)
	RS=	3.6 (Kg/cm2)
Reinforcement type JIS:	Ra=	1600 (Kg/cm2)
Back fill sand: γ_s=	1.80T/m3	; Coeficient of earth pressure at rest K_o= 0.5
Internal friction		30deg

3-Loading and calculation scheme:

3.1 Vehicle load:

Vehicle type: H30 So design load is calculated as following formula:

$P_{de} = (1+i)2P/W_o$

Where: P, weight of back wheel 12.00T

W_{o}, width of occupied area of vehicle W_o= 2.75 m

i, impact coefficient, i= 0.3

P_{de} = 11.35T/m

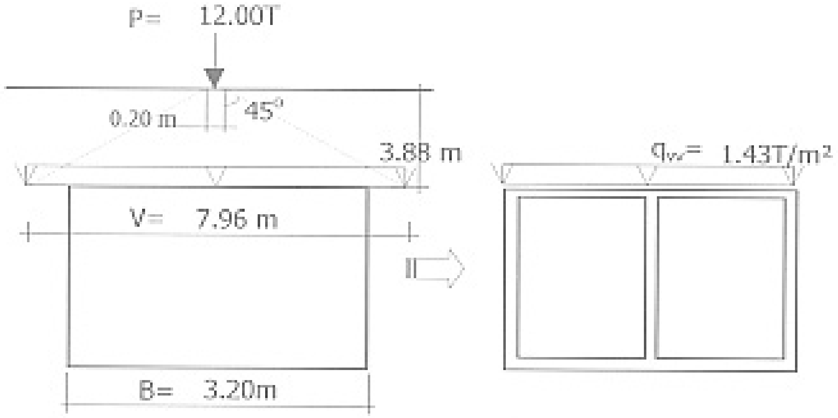
Because B<V so uniform distributed vehicle load calculated as below

q_{vv} = Pde/V = 1.43T/m²

Horizontal vehicle load from both sides of the sewer:

p_{hv} = $1.0xK_o$ = 0.50T/m²

Where: 1.0 T/m² is vertical uniform load due to vehicle for wall calculation



3.2- Soil load:

3.2.1 In case of ground water level at 0.00 (Permanent case):

-Vertical uniform distributed load due to cover soil :

q_{cs} = (GL-GWL)*γs+(GWL-TL)*(γs-1)+(GWL-TL)*1 = 6.98T/m2

-Horizontal uniform distributed load due to cover soil from both side of the sewer:

p_{cs1}=((GL-GWL)*γs+(GWL-TL)*(γs-1))*Ko+(GWL-TL)*1 = 4.43T/m2

-Horizontal triangle load due to earth from both side of the sewer under ground water level:

$p_{21}=(\gamma_s-1)xH2xK_o+H2x1.0$ = 2.59T/m2

-Uplift pressure for this case:

p_{uplift}=H2x1.0= 2.04T/m2

3.2.2 In case of ground water level at +2.00 (Soil submerged by ground water):

-Vertical uniform distributed load due to submerged cover soil:

$q'_{cs}=H_1x(\gamma_s-1)+H_1x1.0$= 6.98T/m2

-Horizontal uniform distributed load due to submerged cover soil from both side of the sewer:

$p_{cs2}=H_1x(\gamma_s-1)xK_o+H_1x1.0$= 5.43T/m2

-Horizontal triangle load due to submerged soil from both side of the sewer:

$p_{22}=H_2x\gamma_w+(\gamma_s-\gamma_w)xH_2xK_o$

$p_{22}=H_2x1+(\gamma_s-1)xH_2xK_o$= 2.59T/m2

-Uplift pressure due to ground water:

$p_{uplift}=H_2x1.0$= 2.04T/m2

3.2.3 In case no ground water outside :

-Vertical uniform distributed load due to cover soil :

$q_{cs}=H_1x\gamma_s$= 6.98T/m2

-Horizontal uniform distributed load due to cover soil from both side of the sewer:

$p_{cs3}=q_{cs}xK_o$= 3.49T/m2

-Horizontal triangle load due to earth from both side of the sewer

$p_{23}=\gamma_sxH_2xK_o$= 1.67T/m2

3.3-Self load:

-Load due to cover slab:

$Q_{coveslab}$ = 2.5(0.20 x3.20x1.0) =1.60Ton

-Load due to walls:

Q_{wall} = 3x2.5x(0.20 x1.20x1.0) =1.80Ton

-Load due to bottom slab:

qbs= 2.5xb = 1.125 T/m2

qself= 2.19T/m2

3.4-Live load (with full of water in sewer):

-Uniform load: qw = 1.20T/m2

3.5-Total loads:

3.5.1 In case of ground water level at 0.00 :

a. Vertical uniform distributed load due to vehicle load:

q_{vv} = 1.43T/m

b. Total vertical uniform distributed load transfered from ground surface down to coverslab:

$q_{11} = q_{cs} =$ 6.98T/m2

c. Total horizontal uniform distributed loads from both side of the sewer:

$p_{11} = p_{hv} + p_{cs1} =$ 4.93T/m2

d. Total horizontal triangle loads from both side of the sewer :

$p_{21} =$ 2.59T/m2

3.5.2 In case of ground water level upto +2.00 :

a. Vertical uniform distributed load due to vehicle load:

$q_{vv} =$ 1.43T/m

b. Total vertical uniform distributed load transfered from ground surface down to coverslab

$q_{12} = q'_{cs} =$ 6.98T/m2

b. Total horizontal uniform distributed loads from both side of the sewer:

$p_{12} = p_{hv} + p_{cs2} =$ 5.93T/m2

c. Total horizontal triangle loads from both side of the sewer :

$p_{22} =$ 2.59T/m2

3.5.3 In case of no ground water outside:

a. Vertical uniform distributed load due to vehicle load:

$q_{vv} =$ 1.43T/m

b. Total vertical uniform distributed load transfered from ground surface down to coverslab

$q_{13} = q_{cs} =$ 6.98T/m2

b. Total horizontal uniform distributed loads from both side of the sewer:

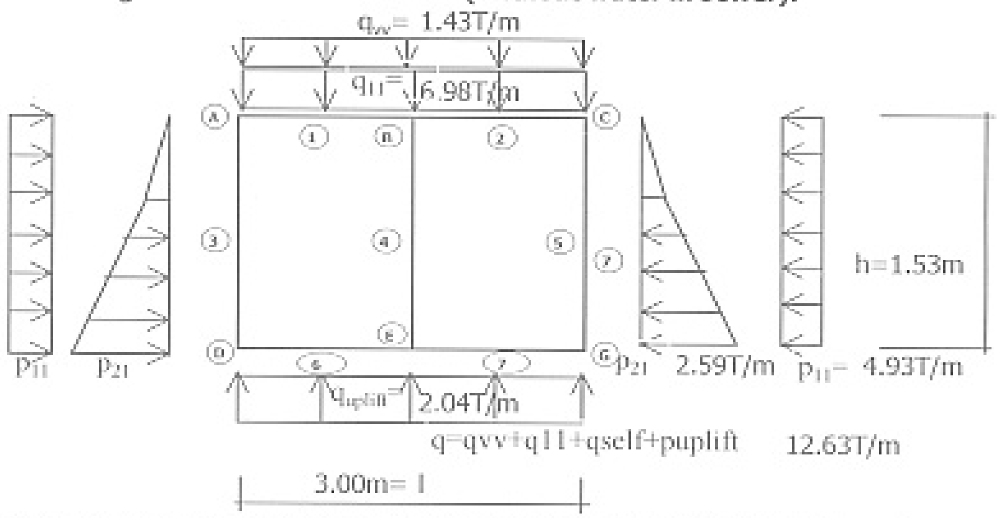
$p_{13} = p_{hv} + p_{cs3} =$ 3.99T/m2

c. Total horizontal triangle loads from both side of the sewer :

$p_{23} =$ 1.67T/m2

3.6-Calculation scheme for conveyance sewer: (for 1m long)

3.6.1 In case of ground water level at 0.00 (Without water in sewer):



4-Checking pressure to soil base, compare to capacity of soil under the bottom of sewer:

Total pressure to base soil:

$p_s = q_{cs} + q_{vv} + (Q_{coverslab} + Q_{wall})/[(W+2t)x1.0] + qw + qbs$ =11.80 T/m2

So at the depth of 5.73m Strength of base soil must be bigger than 1.18Kg/cm2

5-Checking uplift that due to ground water: (For most dangerous case, ground water is up to ground surface level, and the sewer is empty inside and without considering pile capacity)

$P_{uplift} =$ 2.04T/m2

5.1.1 Cover soil submerged:

$p_{soil} = H1x(\gamma_s - 1) + H1x1.0 =$ 6.98T/m2

5.1.2 Self load of sewer:

$$p_{self} = \frac{2.5x(0.45x\ 1.0x3.20 + 0.20x1.0\ x3.20 + 2\ x1.0x0.20\ x1.20)}{1.0x(2.80 + 2x0.20)}$$

$p_{self} =$ 2.00T/m2

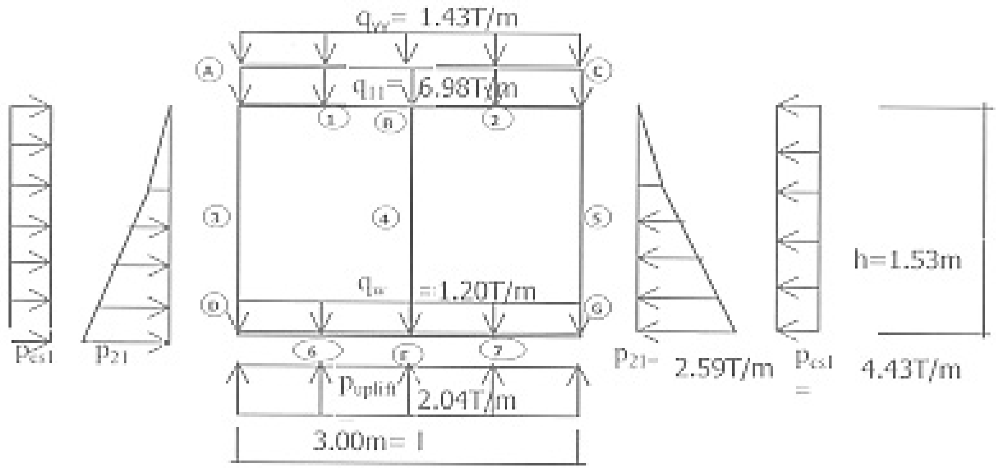
Total pressure: $p_s = p_{soil} + p_{self} =$ 8.98T/m2

* So that $p_s > p_{uplift}$ OK!!!

6-Checking for pile capacity (Checking for 1 m long of sewer):

6.1 In case of ground water level at 0.00 (With full of water in sewer and vehicle load)

(Excluding the ground water pressure):



The negative skin friction from both side of sewer walls due to settlement of embankment caused by earth pressures (Excluding the ground water pressure):

-Horizontal uniform distributed load due to cover soil from both side of the sewer:

p_{cs1}=((GL-GWL)*γs+(GWL-TL)*(γs-1))*Ko+(GWL-TL)*1 = 4.43T/m2

-Horizontal side triangle ditributed pressure due to earth under ground water level

$p_{21}=(\gamma_s-1)xH2xK_o+H2x1.0$ = 2.59T/m

Total negative friction force:

N= $p_{cs1}xH_2x1.0+0.5xp21xH2x1$ =10.59T

μ= tan(2ϕ/3)= 0.36

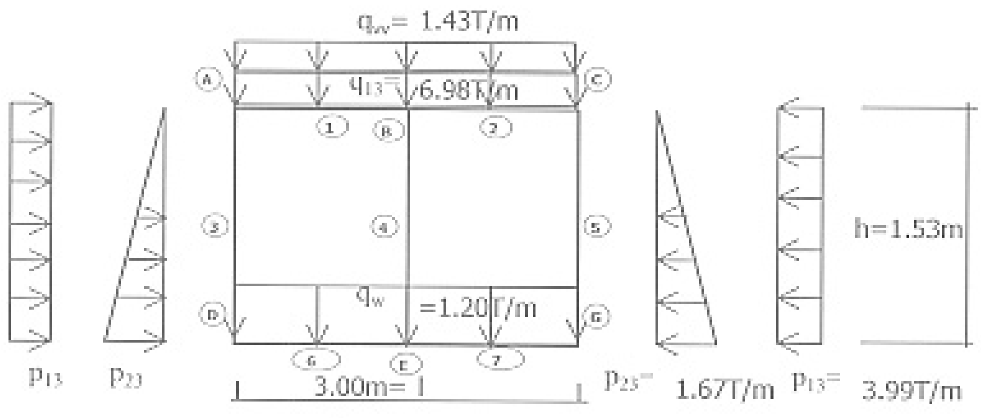
$F_{friction}$ = 2μN = 7.71Ton

Total pressure to piles:

p_{to} =q_{11}+qw+qbs+q_{vv}+$F_{friction}$/((W+2xt)x1) - p_{uplift}= 11.98T/m2

6.2 In case of no ground water outside

(With full of water in sewer and vehicle load) :



Total pressure to piles:

p_{to} = q_{13}+qw+qbs+q_{vv} = 9.61T/m2

6.3 Pile arrangement:

(Assumming dimensions of RC pile DxL=0.3mx0.3mx30m)

Applying formula

$$Qa = \frac{1}{3}(\alpha NaAp + (0.2NsLs + CLc)\pi d)$$

α =	30	
Na=	29	
Ap=	0.09	m^2
Ns1(Ns2)=	7(25)	
Ls1(Ls2)=	2.3(2)	m
C=	0.7	T/m^2
Lc=	25	m
πd =	1.2	m
Qa=	38.388	T

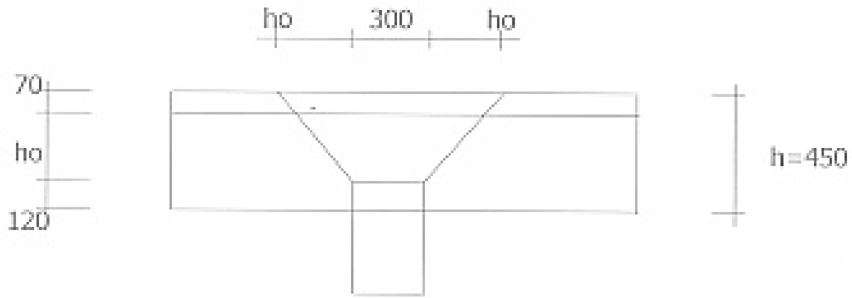
So that 1 R.C pile (300x300) can be used for the area as calculated below:

F=38.39/ 11.98 = **3.20 m2**

Number of piles in one row of cross direction: 2

So distance between 2 rows in longitudinal direction is 2xFmin/ (W+2xt)= 2.00 m

6.4Checking for punching condition of bottom slab



Np= 35.95 T

Rp= 8.5 Kg/cm²

ho= 0.26

$$b_{tb} = \frac{4*0.3+4*(2ho+0.3)}{2} \qquad =2.24 \text{ m}$$

$$0.75 * Rp * h_o * b_{tb} = \qquad 37.128 \text{ T}$$

So that $Np \le 0.75 * Rp * h_o * b_{tb}$

7-Calculation for stresses and forces for scheme 3.6.1:

(Results and inlustrated diagram attached at the end of this calculation)

8-Calculation for bar arrangement:

Factor related to Moment, bearing area and compress capacity:

$A_o = M/R_n b h_o^2$

Where, M: Maximum bending moment(T.m)

h_o: Effective depth of bearing area(cm)

h_o= (Element thickness-Cover thickness)

b: Width of calculated area(cm)

Required area of reinforcement:

$Fa = M/\gamma Raho$ Where: $\gamma = 0.5 + ((1-2Ao)^{1/2})/2$

Moments	Values (T.m)	Ao	γ	Fa (cm^2)	Bar arrangement	
					ϕ(mm)	a(mm)
M_{B-1}	1.740	0.1471	0.920	9.09	14	150
M_{1-1}	0.920	0.0778	0.959	4.61	12	250
M_{A-1}	1.420	0.1200	0.936	7.29	16	250
M_{A-3}	1.420	0.1200	0.936	7.29	16	250
M_{3-3}	0.490	0.0064	0.997	0.93	12	250
M_{D-3}	1.210	0.0120	0.994	2.00	12	250
M_{D-6}	1.210	0.0120	0.994	2.00	12	250
M_{5-6}	1.360	0.0135	0.993	2.25	12	250
M_{E-6}	2.540	0.0251	0.987	4.23	12	250

9-Checking for shearing forces:

-Height of hand for supporting coverslab s = 0.15 m , so the section need to be checked

shear bearing capacity is [t/2+(c+s)/2]= 0.275 m far from center of wall

Shears	Values (T.m)	Shearing stresses (Kg/cm2)	Degn Shearing stress (Kg/cm2)	Compare &Conclude
V_{B-1}	4.37	2.90	3.60	OK!!!

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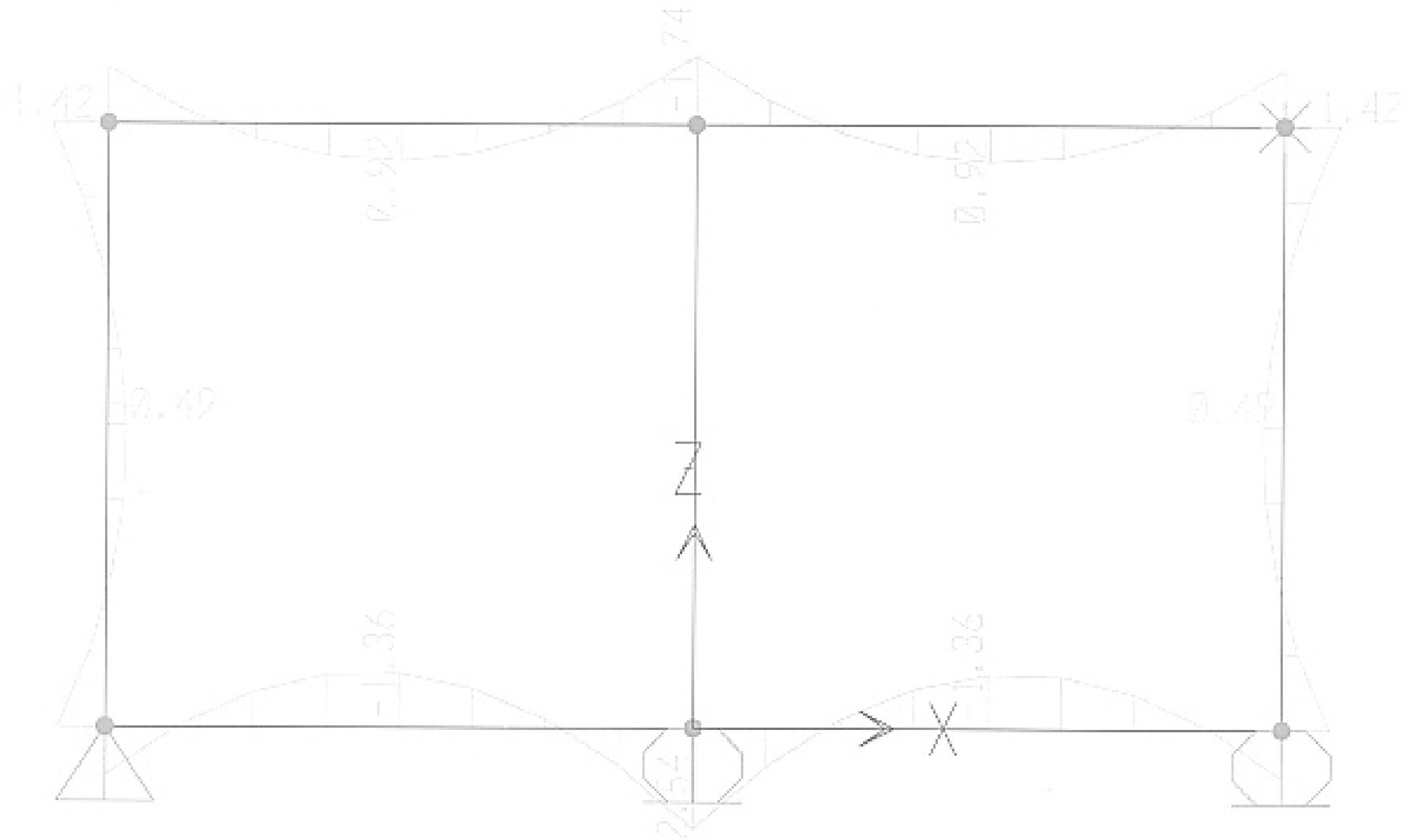
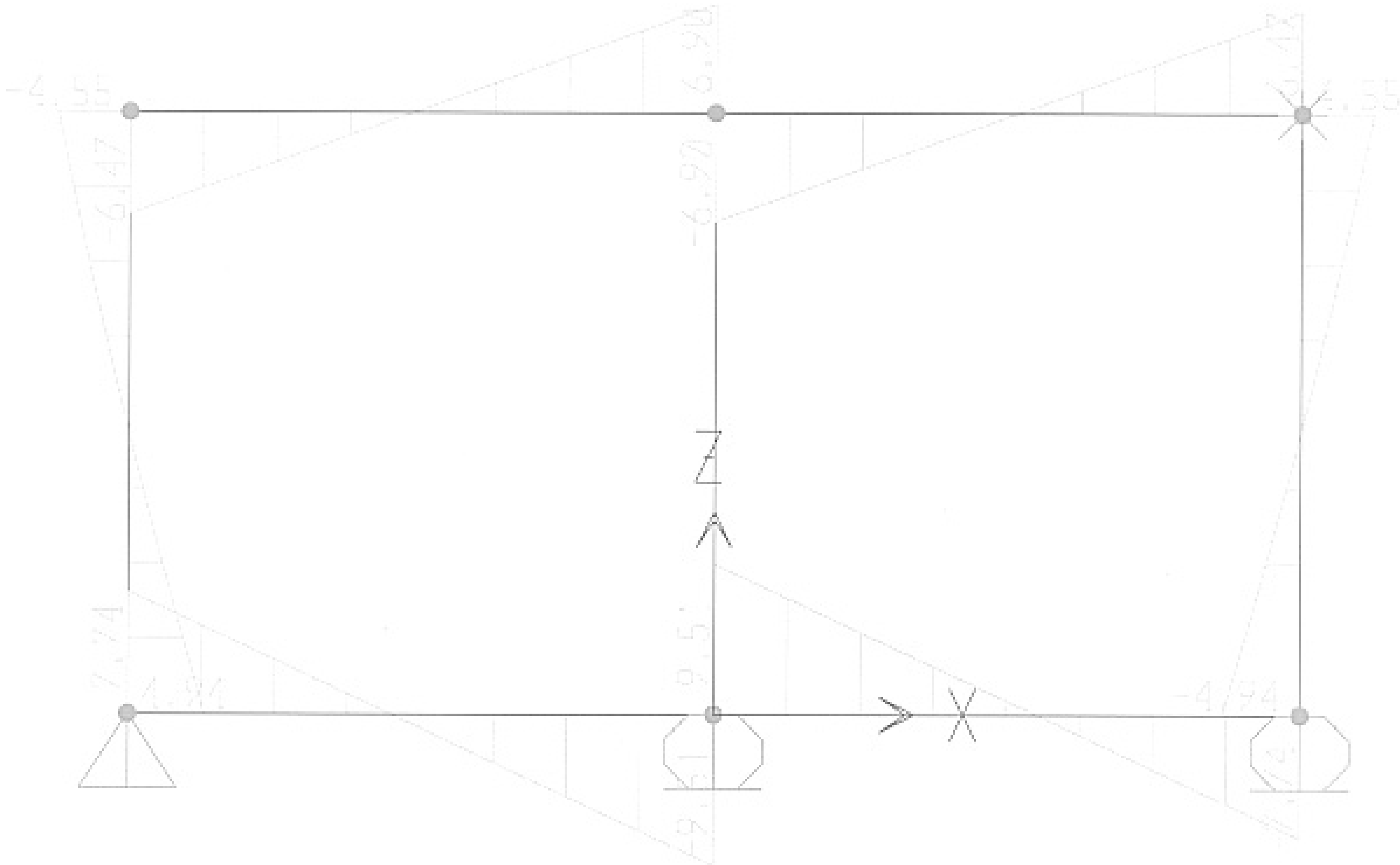


SAP2000 v6.11 - File:ConSewer2 - Moment 3-3 Diagram (LOAD1) - Ton-m Units



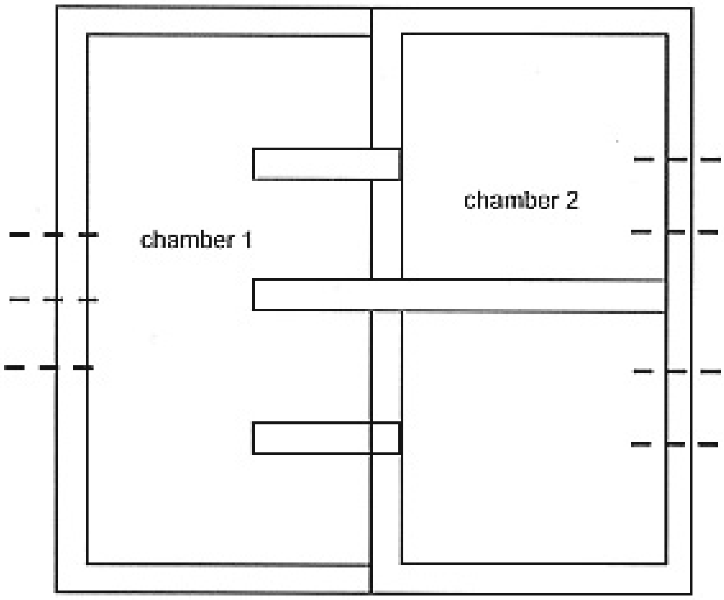
SAP2000 v6.11 - File:ConSewer2 - Shear Force 2-2 Diagram (LOAD1) - Ton-m Units

5.1.2

Siphon Chamber

CALCULATION FOR CHAMBER OF SIPHON

PLAN



I. CALCULATING FOR COVER SLAB OF CHAMBER :

Span of slab: L= 3.6 m

Thickness of slab: dn= 0.25 m

Grade of concrete: 210

R_n^n = 70 (Kg/cm²)

Weight of concrete: γ = 2.5 (T/m³)

Steel stress: R_a = 1600 (Kg/cm²)

Live pressure of vehicles:(H10)

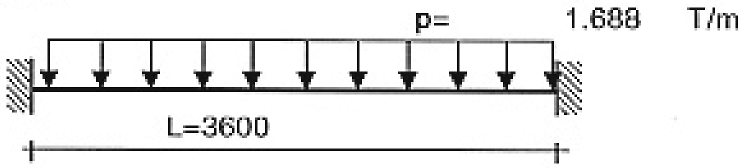
q_1 = 1 (T/m²)

Self cover slab weight:

$q_2 = n.\gamma.d_n =$ 0.6875 (T/m²)

Uniform distributed loads p= 1.688 T/m

Diagram calculation for analysis:



Internal force and selection reinforce table:

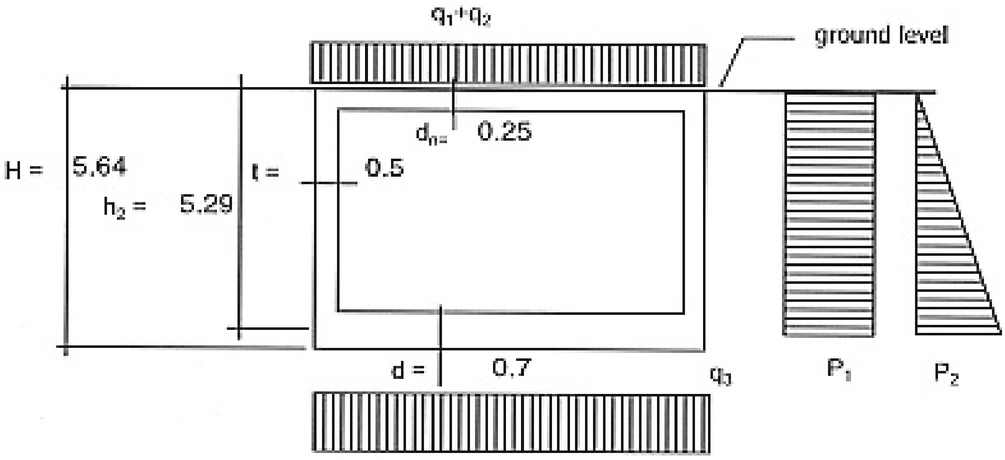
MOMENT	VALUE (Tm)	A_o	γ	fa cm²	SET REINFORCED FOR FORMAT	
					Ø(mm)	a(mm)
M1	1.8225	0.13536	0.92699	6.1439	14	250
M2	0.91125	0.06768	0.96493	2.9512	12	250

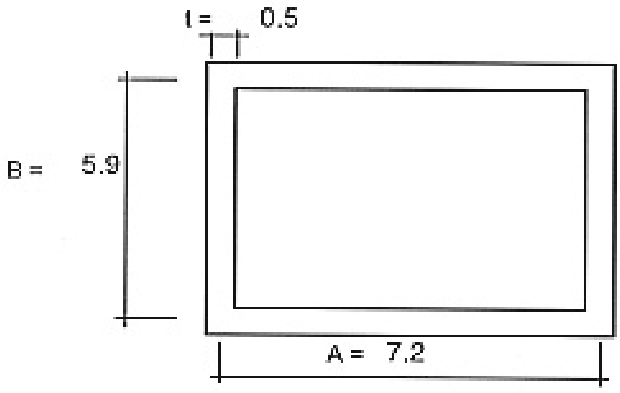
III. CHAMBER 1 :

1.CALCULATION PARAMETER:

A.Geometry dimension

Height of chamber 1	*H =*	*5.29*	m
Depth of chamber 1	*D=*	*5.64*	m
Width of chamber 1	*B =*	*5.9*	m
Length of chamber 1	*c =*	*7.2*	m
Thickness of cover slab	d_n =	*0.25*	m
Thickness of wall slab	*t =*	*0.5*	m
Thickness of bottom slab	*d =*	*0.7*	m





B.Material parameter :

Grade of concrete			210	
	R_n^n	=	70	kg/cm²
Weight of concrete:	γ	=	2.5	T/m³
Steel stress:	R_a	=	1600	kg/cm²

C.Geology conditions :

Weight of soil: γ = 1.8 (T/m³)

Soil internal friction angle : φ = 20^0 = 0.349 (RAD)

$$K_o = tg^2(45^o - \frac{\varphi}{2}) = 0.490291$$

2. OPERATING LOAD:in case of ground water is up to ground surface level(+2.00)

A. Horizontal thrust:

+Triangular distributed loads:

Horizontal pressures of soil at bottom of chamber 1 :

$$P_2 = \gamma_{dn} h_2 K_o + \gamma_n h_2 = \quad 7.36 \text{ (T/m}^2\text{)}$$

\+ Uniform distributed loads:

Pressure of vehicles : (assuming above live vehicles is H10)

Calculating for horizontal pressure of vehicles to chamber 1 wall,

We can take : 1 T/m^2 as uniform distributed loads

This load is equivalent to layer soil weight with thickness:

h_{td} = 0.55556 m

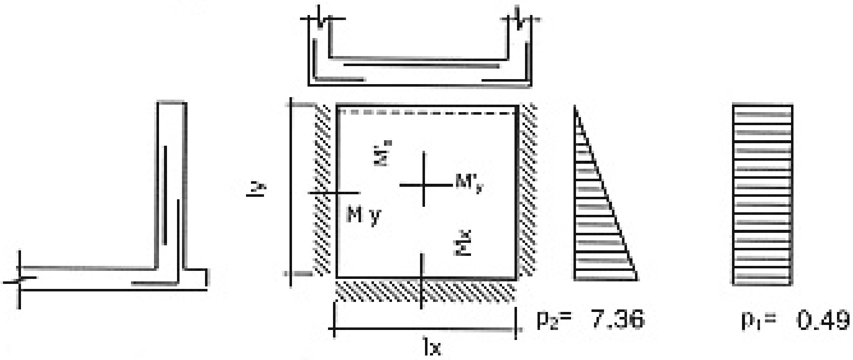
Pressure of vehicles are changed to horizontal pressure:

$$P_1 = \gamma h_{td} K_o = \quad 0.49029 \text{ (T/m}^2\text{)}$$

3. CALCULATING FOR WALLS OF CHAMBER 1

A.The slab is in the direction A:

Diagram calculation for analysis:



-Width of slab: Lx= 7.2 m

-Length of slab Ly= 5.29 m

-Triangular distributed loads p_2= 7.36 T/m

-Uniform distributed loads p_1= 0.49 T/m

-Thickness of slab d= 0.5 m

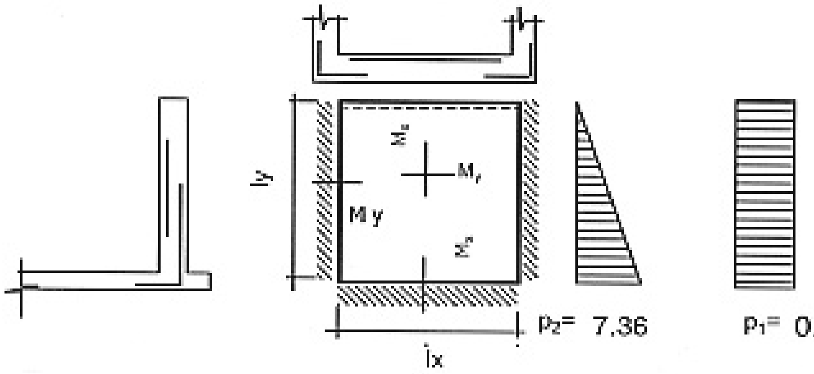
-Ratio of Lx and Ly : Lx/Ly= 1.3611

Internal force and selection reinforce table:

COEFFICIENT MULTIPLY 1	COEFFICIENT MULTIPLY 2	MOMENT	VALUE (Tm)	A_o	γ	fa cm^2	SET REINFORCED FOR FORMAT Ø(mm)	a(mm)
0.0652	0.0599	Mx	10.2634	0.06929	0.96406	15.4738	16	125
0.0357	0.0332	My	5.62717	0.03799	0.98063	8.341	12	125
0.0271	0.0289	M'x	4.34066	0.02931	0.98513	6.4044	14	250
0.0120	0.0138	M'y	1.94079	0.0131	0.99341	2.8396	12	250

B.The slab is in the direction B:

Diagram calculation for analysis:



-Width of slab: Lx= 5.9 m

-Length of slab Ly= 5.29 m

-Triangular distributed loads p_2= 7.36 T/m

-Uniform distributed loads p_1= 0.49 T/m

-Thickness of slab d= 0.5 m

-Ratio of Lx and Ly : Lx/Ly= 1.1153

Internal force and selection reinforce table:

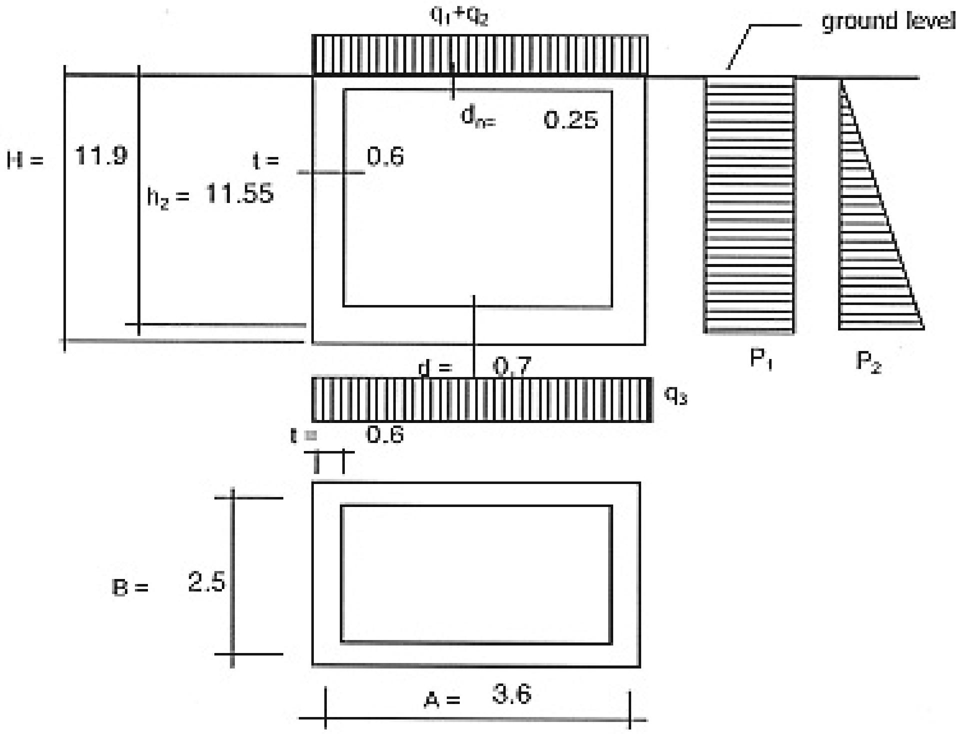
COEFFICIENT MULTIPLY 1	COEFFICIENT MULTIPLY 2	MOMENT	VALUE (Tm)	A_0	γ	f_a cm^2	SET REINFORCED FOR FORMAT	
							Ø(mm)	a(mm)
0.0623	0.0507	Mx	7.93617	0.06132	0.96834	11.9123	14	125
0.0458	0.0511	My	6.04589	0.04671	0.97607	9.0031	12	125
0.022	0.0238	Mx	2.89273	0.02235	0.9887	4.2526	12	250
0.0168	0.0206	My	2.47597	0.01913	0.99034	3.6339	12	250

IV. CHAMBER 2 :

1.CALCULATION PARAMETER:

A.Geometry dimension

High of chamber 2	=	*11.55*	m
Depth of chamber 2	=	*11.9*	m
Width of chamber 2	*B =*	*2.5*	m
Length of chamber 2		*3.6*	m
Thickness of cover slab	d_n =	*0.25*	m
Thickness of wall slab	*t =*	*0.6*	m
Thickness of bottom slab	*d =*	*0.7*	m



B.Material parameter :

Grade of concrete			210	
	R_n^{u}	=	70	kg/cm²
Weight of concrete:	γ	=	2.5	T/m³
Steel stress:	$m_a R_a$	=	1600	kg/cm²

C. Geology conditions :

Weight of soil:	γ	=	1.8 T/m³
Soil inter friction angle :	φ	=	20^0 = 0.349066 (RAD)

$$K_a = tg^2(45^0 - \frac{\varphi}{2}) = \quad 0.490291$$

2. OPERATING LOAD:in case of ground water is up to ground surface level(+2,00)

A. Horizontal thrust:

+Triangular distributed loads:

Horizontal pressures of soil at bottom chamber 2 :

$$P_2 = \gamma_{dn} h_2 K_a + \gamma_n h_2 = \quad 16.08029 \text{ (T/m}^2\text{)}$$

+ Uniform distributed loads:

Pressure of vehicles : (assuming above live vehicles is H10)

Calculating for horizontal pressure of vehicles to chamber 2 wall,

We can take : 1 T/m² as uniform distributed loads

This load is equivalent to layer soil weight with thickness:

h_{td} = 0.55556 m

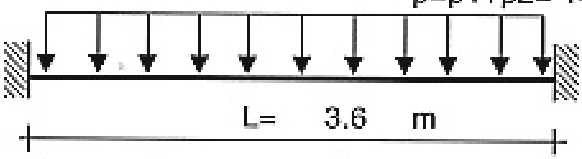
Pressure of above layer soil and pressure of vehicles are changed to horizontal pressure:

$$P_1 = \gamma . h_{nd} K_0 = \quad 0.49029\ (T/m^2)$$

3. CALCULATING FOR WALL OF CHAMBER 2

A.The slab is in the direction A:

Diagram calculation for analysis:



-Uniform distributed loads p= 16.571 T/m

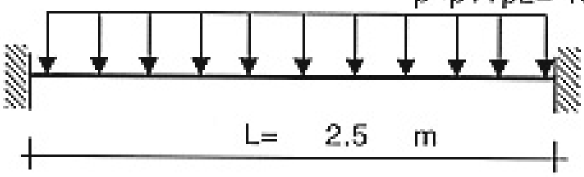
-Thickness of slab: d= 0.6 m

Internal force and selection reinforce table:

MOMENT	VALUE (Tm)	A_0	γ	fa cm^2	SET REINFORCED FOR FORMAT	
					Ø(mm)	a(mm)
M1	17.89622	0.12625	0.93229	22.64	20	125
M2	8.948111	0.06313	0.96737	10.908	14	125

B.The slab is in the direction B:

Diagram calculation for analysis:



-Uniform distributed loads p= 16.57 T/m

-Thickness of slab: d= 0.6 m

Internal force and selection reinforce table:

MOMENT	VALUE (Tm)	A_0	γ	fa cm^2	SET REINFORCED FOR FORMAT	
					Ø(mm)	a(mm)
M1	8.630508	0.06089	0.96857	10.51	14	125
M2	4.315254	0.03044	0.98454	5.169	14	250

V. CHECKING UPLIFT THAT DUE TO GROUND WATER :

For most dangerous case, ground water is up to ground surface level(+2.00), and the chamber is empty in side

A. Pressure by self load of chamber :

P_{self}= (Qcover slab+Qwall+Qbottom slab)/S=3.16 T/m²

P_{self}= 3.16 T/m²

B. Pressure by ground water :

p_{uplift}= (11.9*3.2*7.9+5.64*3.3*7.7)/(7.9*3.2+7.7*3.3)= 8.76T/m2

* So that $p < p_{uplift}$

So piles need to be used for preventing chamber from uplift

VI. CHECKING FOR PRESSURE AT BOTTOM OF CHAMBER :

Pd=(Qcover slab+Qwall+Qbottom slab+Qwater+Qvehicle)/S

Pd= 9.165 T/m^2= 0.917 kg/cm^2

Assumming dimensions of foundation is 1m x1m

Data of geological condition:

$\varphi =$ 4

$c^{lc} =$ 0.5 (T/m^2)

$\gamma_o =$ 1.6 (T/m^3)

$R^{cl} =$ $m[(Ab + Bh)\gamma_o + Dc^{lc}]$

With m = 1

A = 0.06

B = 1.25

D = 3.51

$R^{cl} =$ 4.851 T/m^2 = 0.485 Kg/cm^2 <Pd= 0.917 Kg/cm^2

Use RC pile

VII. CALCULATION OF RC PILE :

(Assumming dimensions of pile 0.4m x0.4mx20m)

Applying formula

$$Qa = \frac{1}{3}(\alpha Na Ap + (0.2 Ns Ls + C Lc)\pi d)$$

α = 30

Na= 12

Ap= 0.16 m^2

C= 0.8 T/m^2

Lc= 16 m

πd = 1.6 m

Qa= 26.0267 T

Use 18 RC piles

VIII. CALCULATION OF BOTTOM SLAB OF CHAMBER :

Because RC piles set directly under the wall of chamber so no need to check puching condition for bottom slab due to RC pile so according to structure Reinforcement will be arranged

CHAPTER 6
EXISTING COMBINED SEWER IMPROVEMENT PROJECT (PACKAGE D)

6.1

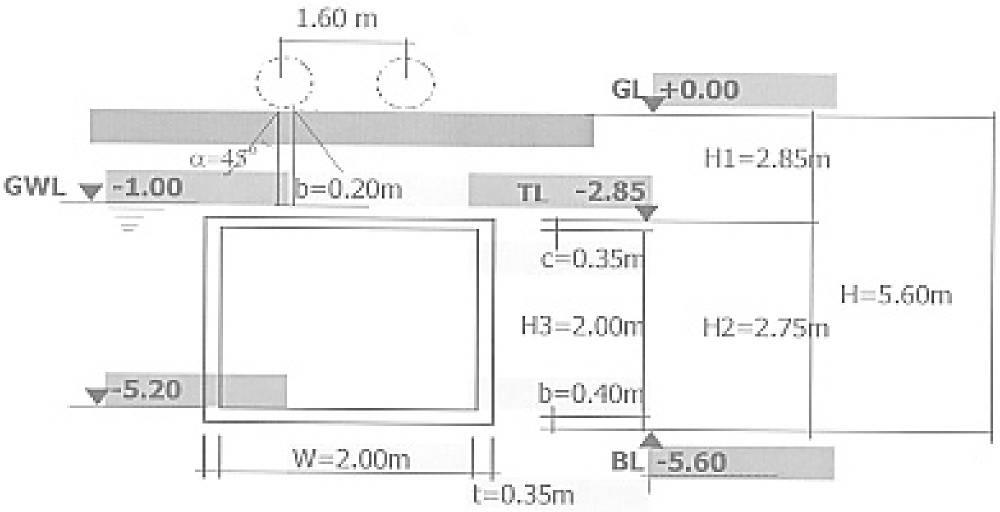
Civil Design

Calculation for typical manhole of box culvert 2000x2000

(The calculation based on Japanese standard - JIS1999)

1-Geometry dimensions for calculation

(Calculation made for one m long of culvert):



2-Material properties and soil conditions:

Ground water level:	GWL=	-1.00 m
Concrete: Grade 210,	Rn =	70 (Kg/cm2)
	RS=	3.6 (Kg/cm2)
Reinforcement type JIS:	Ra=	1600 (Kg/cm2)

Back fill sand: γ_s= 1.80T/m3 ; Coeficient of earth pressure at rest K_o= 0.5

Internal friction 30deg

3-Loading and calculation scheme:

3.1 Vehicle load:

Vehicle type: H30 So design load is calculated as following formula:

$P_{de} = (1+i)2P/W_o$

Where: P, weight of back wheel 12.00T

W_o, width of occupied area of vehicle W_o= 2.75 m

i, impact coefficient, i= 0.3

P_{de} = 11.35T/m

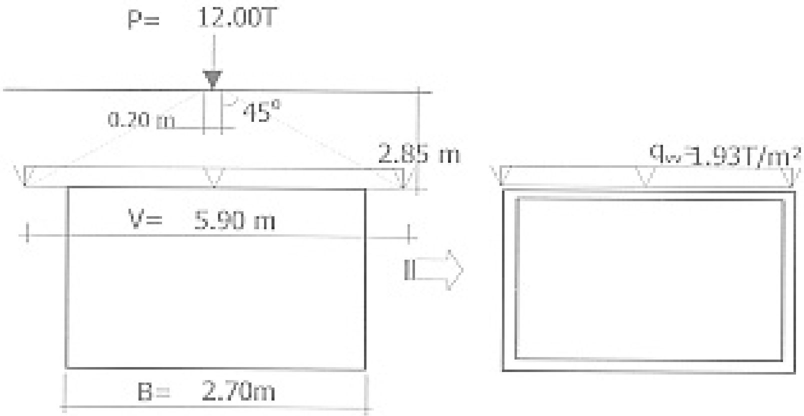
Because B<V so uniform distributed vehicle load calculated as below

q_{vv} = Pde/V = 1.93T/m²

Horizontal vehicle load from both sides of the culvert:

p_{hv} = 1.0xK_o = 0.50T/m²

Where: 1.0 T/m² is vertical uniform load due to vehicle for wall calculation



3.2- Soil load:

3.2.1 In case of ground water level at -1.00 (Permanent case):

-Vertical uniform distributed load due to cover soil :

q_{cs} = (GL-GWL)*γs+(GWL-TL)*(γs-1)+(GWL-TL)*1 = 5.13T/m2

-Horizontal uniform distributed load due to cover soil from both side of the culvert:

p_{cs1}=((GL-GWL)*γs+(GWL-TL)*(γs-1))*Ko+(GWL-TL)*1 = 3.49T/m2

-Horizontal triangle load due to earth from both side of the culvert under ground water level:

$p_{21}=(\gamma_s-1)xH2xK_o+H2x1.0$ = 3.85T/m2

-Uplift pressure for this case:

p_{uplift}=1.1xH2x1.0= 3.03T/m2

3.2.2 In case of ground water level at +2.00 (Soil submerged by ground water):

-Vertical uniform distributed load due to submerged cover soil:

$q'_{cs}=H_1x(\gamma_s-1)+H_1x1.0$= 5.13T/m2

-Horizontal uniform distributed load due to submerged cover soil from both side of the culvert:

$p_{cs2}=H_1x(\gamma_s-1)xK_o+H_1x1.0$= 3.99T/m2

-Horizontal triangle load due to submerged soil from both side of the culvert:

$p_{22}=H_2x\gamma_w+(\gamma_s-\gamma_w)xH_2xK_o$

$p_{22}=H_2x1+(\gamma_s-1)xH_2xK_o$= 3.85T/m2

-Uplift pressure due to ground water:

$p_{uplift}=1.1xH_2x1.0$= 3.03T/m2

3.3-Self load:

-Load due to cover slab:

$Q_{coverslab}$ = 2.5(0.35 x2.70x1.0) =2.36Ton

-Load due to walls:

Q_{wall} = 2x2.5x(0.4 x2.00x1.0) =3.50Ton

-Load due to bottom slab:

qbs= 2.5xb = 1 T/m2

pself= 3.17T/m2

3.4-Live load (with full of water in culvert):

-Uniform load: qw = 2.00T/m2

3.5-Total loads:

3.5.1 In case of ground water level at -1.00 :

a. Vertical uniform distributed load due to vehicle load:

q_{w} = 1.93T/m

b. Total vertical uniform distributed load transfered from ground surface down to coverslab:

$q_{11} = q_{cs}$ = 5.13T/m2

c. Total horizontal uniform distributed loads from both side of the culvert:

$p_{11}= p_{hv}+p_{cs1}$ = 3.99T/m2

d. Total horizontal triangle loads from both side of the culvert:

p_{21}= 3.85T/m2

3.5.2 In case of ground water level upto +2.00 :

a. Vertical uniform distributed load due to vehicle load:

q_{vv} = 1.93T/m

b. Total vertical uniform distributed load transfered from ground surface down to coverslab

$q_{12} = q'_{cs}$ = 5.13T/m2

b. Total horizontal uniform distributed loads from both side of the culvert:

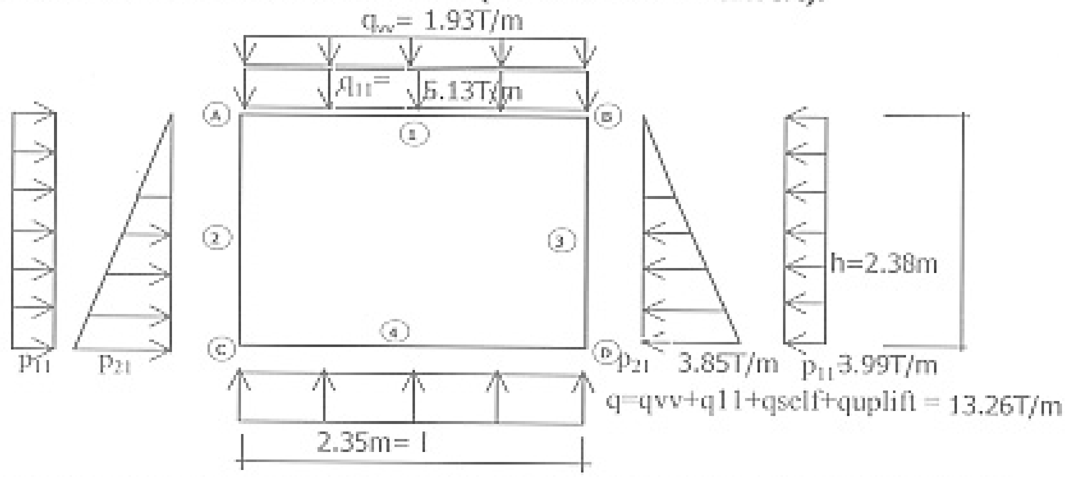
$p_{12} = p_{hv} + p_{cs2}$ = 4.49T/m2

c. Total horizontal triangle loads from both side of the culvert :

p_{22}= 3.85T/m2

3.6-Calculation scheme for culvert: (for 1m long)

3.6.1 In case of ground water level at -1.00 (Without water in culvert):



4-Checking pressure to soil base, compare to capacity of soil under the bottom of culvert:

Total pressure to base soil:

$p_s = q_{cs} + q_{vv} + (Q_{coverslab} + Q_{wall})/[(W+2t)x1.0] + qw + qbs$ =12.23 T/m2

So at the depth of 5.60m Strength of base soil must be bigger than 1.22Kg/cm2

5-Checking uplift that due to ground water: (For most dangerous case, ground water is up to ground surface level, and the culvert is empty inside)

P_{uplift}= 3.03T/m2

5.1.1 Cover soil submerged:

$p_{soil} = H1x(\gamma_s-1)+H1x1.0=$ 5.13T/m2

5.1.2 Self load of culvert:

$$p_{ser} = \frac{2.5x(0.40x\ 1.0x2.70 + 0.35x1.0\ x2.70 + 2\ x1.0x0.35\ x2.00)}{1.0x(2.00 + 2x0.35)}$$

p_{ser}= 3.17T/m2

Total pressure: $p_s = p_{soil} + p_{self}$ = 8.30T/m2

* So that $p_s > p_{uplift}$ **OK!!!**

6-Calculation for stresses and forces for scheme 3.6.1:

(Results and inlustrated diagram attached at the end of this calculation)

7-Calculation for bar arrangement:

Factor related to Moment, bearing area and compress capacity:

$A_o = M/R_n b h_o^2$

Where, M: Maximum bending moment(T.m)

h_o: Effective depth of bearing area(cm)

h_o= (Element thickness-Cover thickness)

b: Width of calculated area(cm)

Required area of reinforcement:

$Fa = M/\gamma Raho$ Where: $\gamma = 0.5 + ((1-2Ao)^{1/2})/2$

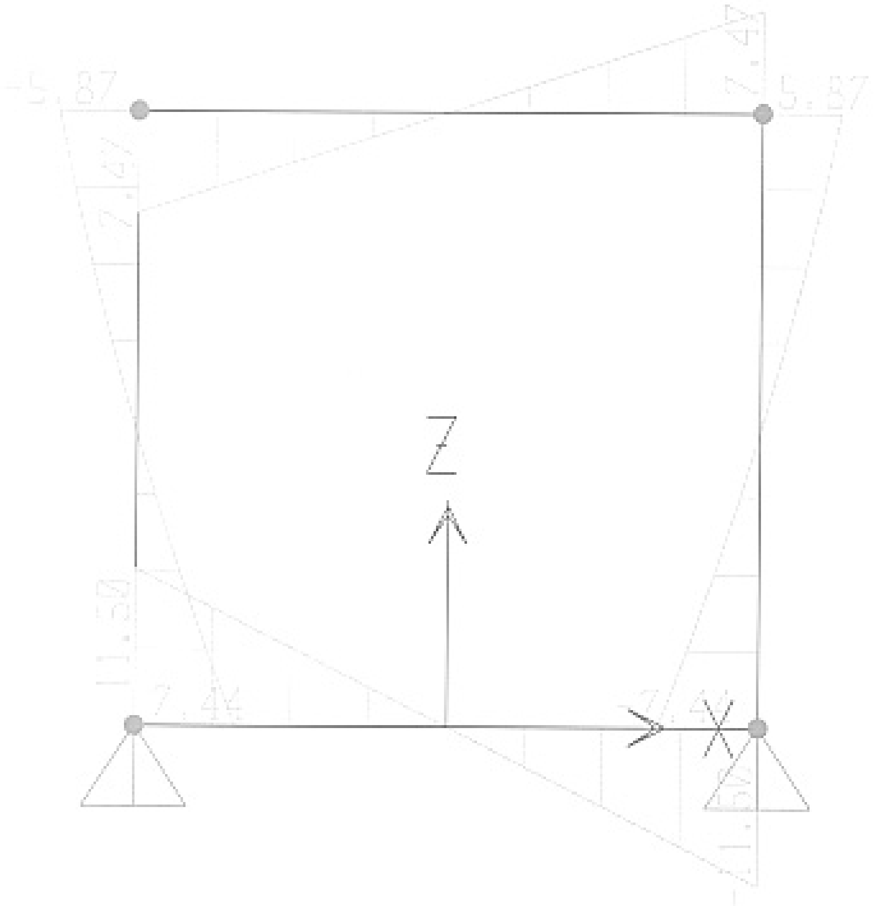
Moments	Values (T.m)	Ao	γ	Fa (cm^2)	Bar arrangement	
					ϕ(mm)	a(mm)
M_{1-1}	1.680	0.0306	0.984	3.81	12	250
M_{A-1}	2.620	0.0477	0.976	5.99	14	250
M_{A-2}	2.620	0.0477	0.976	5.99	14	250
M_{2-2}	1.050	0.0191	0.990	2.37	12	250
M_{C-2}	2.760	0.0362	0.982	5.33	14	250
M_{C-4}	2.760	0.0362	0.982	5.33	14	250
M_{4-4}	3.850	0.0505	0.974	7.49	14	250

8-Checking for shearing forces:

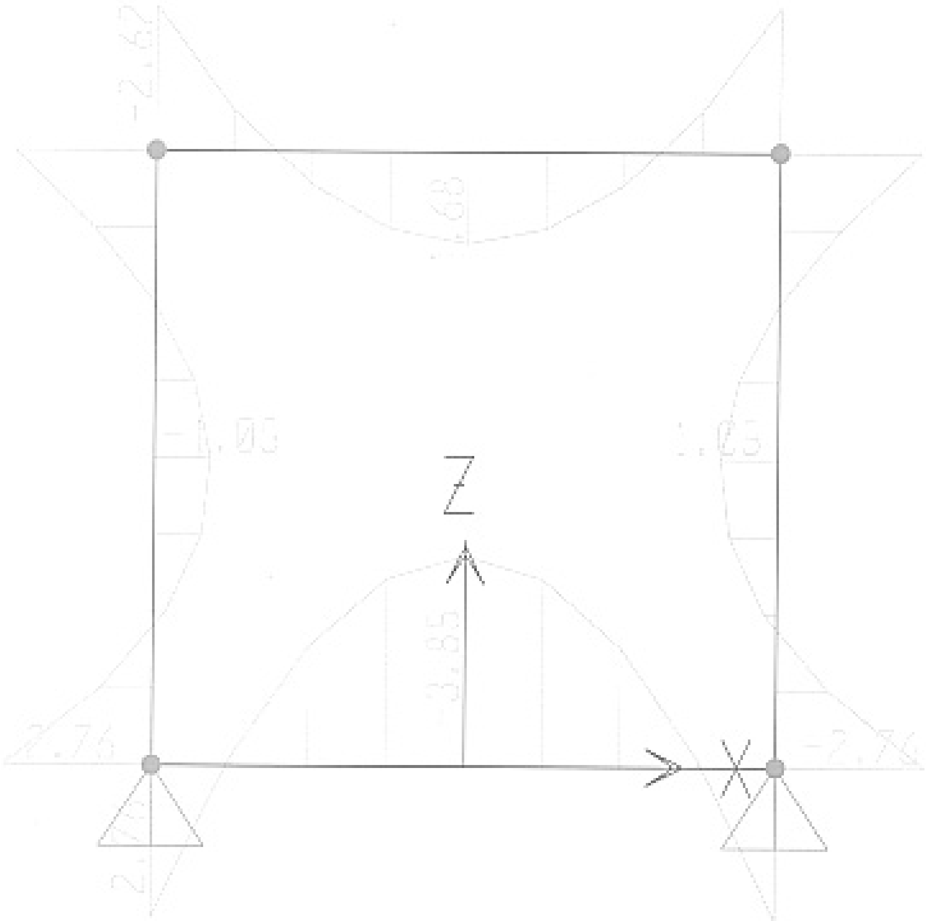
-Height of hand for supporting coverslab   s = 0.20 m   , so the section need to be

shear bearing capacity is [t/2+(c+s)/2]=   0.450 m   checked far from center of wall

Shears	Values (T.m)	Shearing stresses (Kg/cm2)	Design Shearing stress (Kg/cm2)	Compare &Conclude
V_{B-1}	4.67	1.60	3.60	OK!!!
V_{C-4}	7.19	2.10	3.60	OK!!!



SAP2000 v6.11 - File:culvert2000x2000x3000 - Shear Force 2-2 Diagram (LOAD1) - Ton-m Units



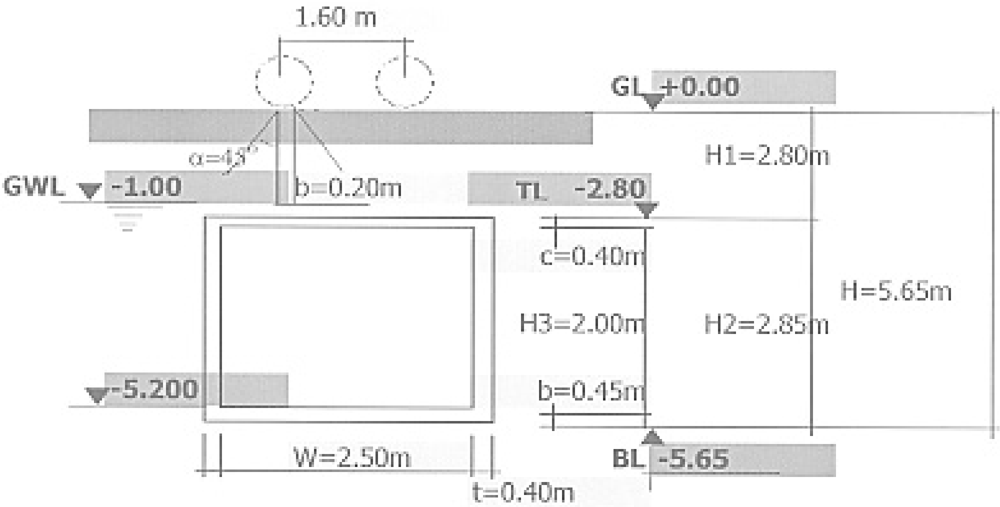
SAP2000 v6.11 - File:culvert2000x2000x3000 - Moment 3-3 Diagram (LOAD1) - Ton-m Units

Calculation for typical manhole of box culvert 2500x2000

(The calculation based on Japanese standard - JIS1999)

1-Geometry dimensions for calculation

(Calculation made for one m long of culvert):



2-Material properties and soil conditions:

Ground water level:	GWL=	-1.00	m
Concrete: Grade 210,	Rn =	70	(Kg/cm2)
	RS=	3.6	(Kg/cm2)
Reinforcement type JIS:	Ra=	1600	(Kg/cm2)

Back fill sand: γ_s= 1.80T/m3 ; Coeficient of earth pressure at rest K_o= 0.5

Internal friction 30deg

3-Loading and calculation scheme:

3.1 Vehicle load:

Vehicle type: H30 So design load is calculated as following formula:

$P_{de} = (1+i)2P/W_o$

Where: P, weight of back wheel 12.00T

W_{o}, width of occupied area of vehicle W_o= 2.75 m

i, impact coefficient, i= 0.3

P_{de} = 11.35T/m

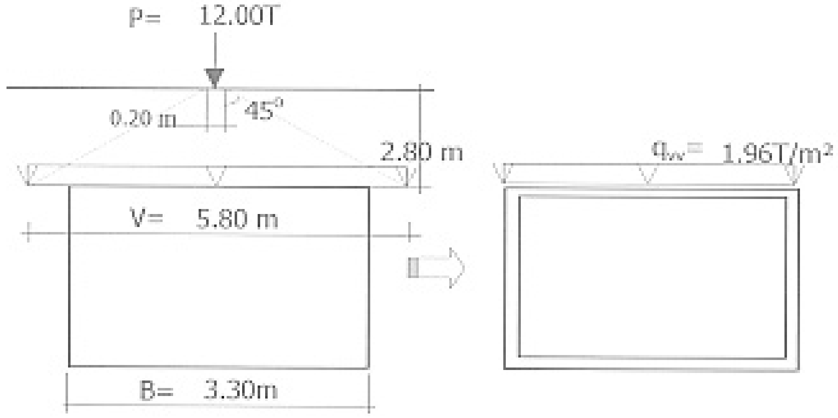
Because B<V so uniform distributed vehicle load calculated as below

q_{vv} = Pde/V = 1.96T/m²

Horizontal vehicle load from both sides of the culvert:

p_{hv} = 1.0xK_o = 0.50T/m²

Where: 1.0 T/m² is vertical uniform load due to vehicle for wall calculation



3.2- Soil load:

3.2.1 In case of ground water level at -1.00 (Permanent case):

-Vertical uniform distributed load due to cover soil :

q_{cs} = (GL-GWL)*γs+(GWL-TL)*(γs-1)+(GWL-TL)*1 = 5.04T/m2

-Horizontal uniform distributed load due to cover soil from both side of the culvert:

p_{cs1}=((GL-GWL)*γs+(GWL-TL)*(γs-1))*Ko+(GWL-TL)*1 = 3.42T/m2

-Horizontal triangle load due to earth from both side of the culvert under ground water level:

$p_{21}=(\gamma_s-1)xH2xK_o+H2x1.0$ = 3.99T/m2

-Uplift pressure for this case:

p_{uplift}=1.1xH2x1.0= 3.14T/m2

3.2.2 In case of ground water level at +2.00 (Soil submerged by ground water):

-Vertical uniform distributed load due to submerged cover soil:

$q'_{cs}=H_1x(\gamma_s-1)+H_1x1.0$= 5.04T/m2

-Horizontal uniform distributed load due to submerged cover soil from both side of the culvert:

$p_{cs2}=H_1x(\gamma_s-1)xK_o+H_1x1.0$= 3.92T/m2

-Horizontal triangle load due to submerged soil from both side of the culvert:

$p_{22}=H_2x\gamma_w+(\gamma_s-\gamma_w)xH_2xK_o$

$p_{22}=H_2x1+(\gamma_s-1)xH_2xK_o$= 3.99T/m2

-Uplift pressure due to ground water:

$p_{uplift}=1.1xH_2x1.0$= 3.14T/m2

3.3-Self load:

-Load due to cover slab:

$Q_{coveslab}$ = 2.5(0.40 x3.30x1.0) =3.30Ton

-Load due to walls:

Q_{wall} = 2x2.5x(0.4 x2.00x1.0) =4.00Ton

-Load due to bottom slab:

qbs= 2.5xb = 1.125 T/m2

pself= 3.34T/m2

3.4-Live load (with full of water in culvert):

-Uniform load: qw = 2.00T/m2

3.5-Total loads:

3.5.1 In case of ground water level at -1.00 :

a. Vertical uniform distributed load due to vehicle load:

q_{vv} = 1.96T/m

b. Total vertical uniform distributed load transfered from ground surface down to coverslab:

$q_{11} = q_{cs}$ = 5.04T/m2

c. Total horizontal uniform distributed loads from both side of the culvert:

$p_{11}= p_{hv}+p_{cs1}$ = 3.92T/m2

d. Total horizontal triangle loads from both side of the culvert:

p_{21}= 3.99T/m2

3.5.2 In case of ground water level upto +2.00 :

a. Vertical uniform distributed load due to vehicle load:

q_{vv} = 1.96T/m

b. Total vertical uniform distributed load transfered from ground surface down to coverslab

$q_{12} = q'_{cs}$ = 5.04T/m2

b. Total horizontal uniform distributed loads from both side of the culvert:

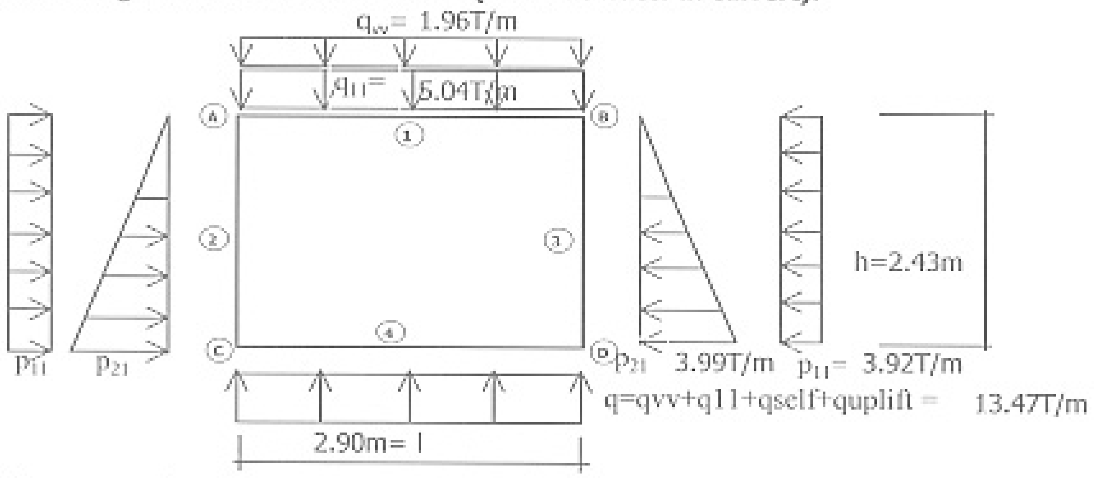
$p_{12} = p_{hv} + p_{cs2}$ = 4.42T/m2

c. Total horizontal triangle loads from both side of the culvert :

p_{22}= 3.99T/m2

3.6-Calculation scheme for culvert: (for 1m long)

3.6.1 In case of ground water level at -1.00 (Without water in culvert):



4-Checking pressure to soil base, compare to capacity of soil under the bottom of culvert:

Total pressure to base soil:

$p_s = q_{cs} + q_{vv} + (Q_{coverslab} + Q_{wall})/[(W+2t)x1.0] + qw + qbs$ =12.34 T/m2

So at the depth of 5.65m Strength of base soil must be bigger than 1.23Kg/cm2

5-Checking uplift that due to ground water: (For most dangerous case, ground water is up to ground surface level, and the culvert is empty inside)

P_{uplift}= 3.14T/m2

5.1.1 Cover soil submerged:

$p_{soil} = H1x(\gamma_s-1)+H1x1.0$= 5.04T/m2

5.1.2 Self load of culvert:

$$p_{self} = \frac{2.5x(0.45x\ 1.0x3.30 + 0.40x1.0\ x3.30 + 2\ x1.0x0.40\ x2.00)}{1.0x(2.50 + 2x0.40)}$$

p_{self}= 3.34T/m2

Total pressure: $p_s = p_{soil} + p_{self}$ = 8.38T/m2

* So that $p_s > p_{uplift}$ **OK!!!**

6-Calculation for stresses and forces for scheme 3.6.1:

(Results and inlustrated diagram attached at the end of this calculation)

7-Calculation for bar arrangement:

Factor related to Moment, bearing area and compress capacity:

$A_o = M/R_n b h_o^2$

Where, M: Maximum bending moment(T.m)

h_o: Effective depth of bearing area(cm)

h_o= (Element thickness-Cover thickness)

b: Width of calculated area(cm)

Required area of reinforcement:

Fa= M/γRaho Where: $\gamma = 0.5 + ((1\text{-}2Ao)^{1/2})/2$

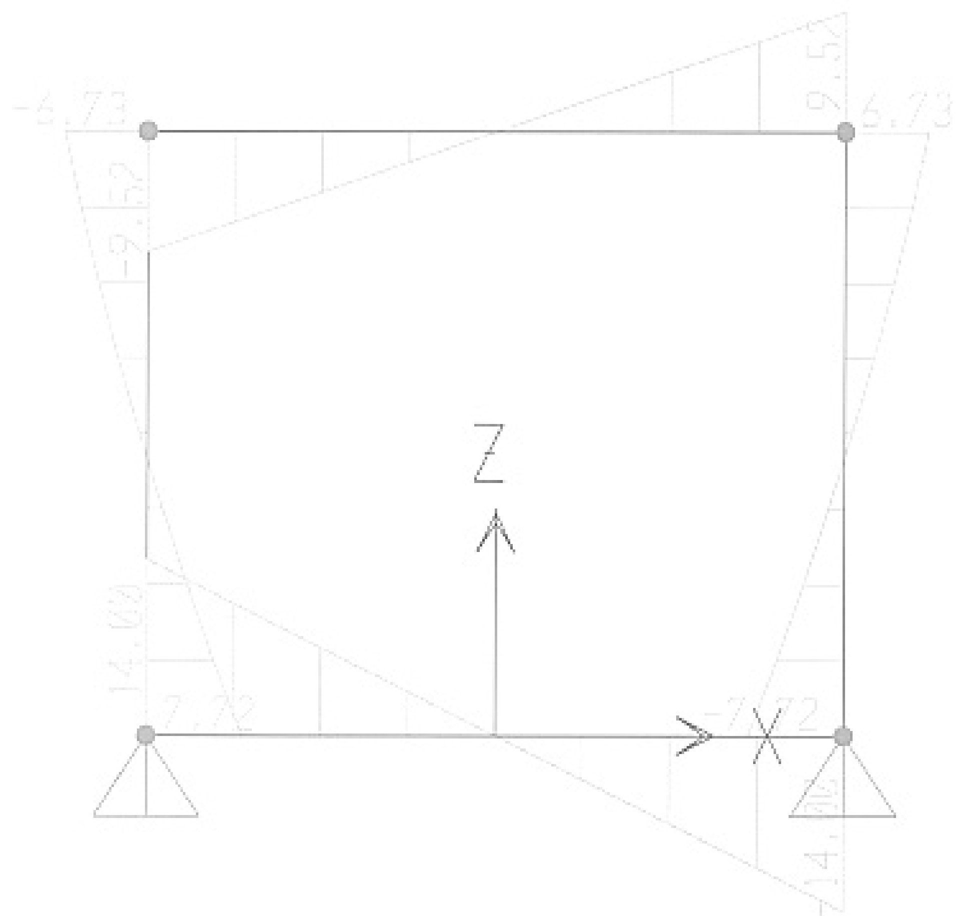
Moments	Values (T.m)	Ao	γ	Fa (cm^2)	Bar arrangement	
					ϕ(mm)	a(mm)
M_{1-1}	2.890	0.0379	0.981	5.58	12	250
M_{A-1}	3.770	0.0495	0.975	7.33	12	125
M_{A-2}	3.770	0.0495	0.975	7.33	12	125
M_{2-2}	0.880	0.0115	0.994	1.68	12	250
M_{C-2}	3.140	0.0311	0.984	6.04	14	250
M_{C-4}	3.140	0.0311	0.984	5.25	12	250
M_{4-4}	6.660	0.0659	0.966	12.31	14	125

8-Checking for shearing forces:

-Height of hand for supporting coverslab s = 0.25 m , so the section need to be

shear bearing capacity is [t/2+(c+s)/2]= 0.525 m checked far from center of wall

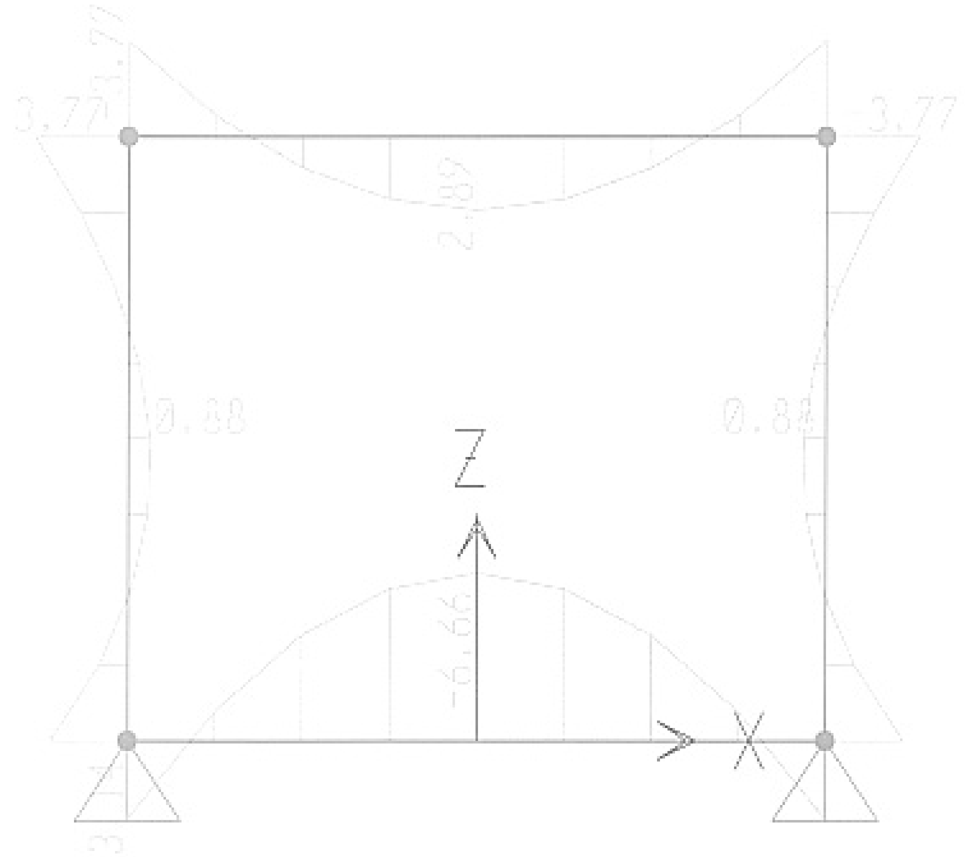
Shears	Values (T.m)	Shearing stresses (Kg/cm2)	Design Shearing stress (Kg/cm2)	Compare &Conclude
V_{0-1}	6.07	1.80	3.60	OK!!!
V_{C-4}	8.93	2.50	3.60	OK!!!



SAP2000 v6.11 - File:culvert2500x2000x3000 - Shear Force 2-2 Diagram (LOAD1) - Ton-m Units

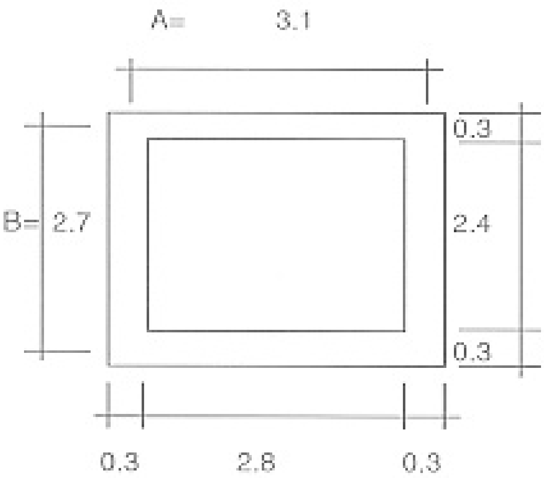
SAP2000

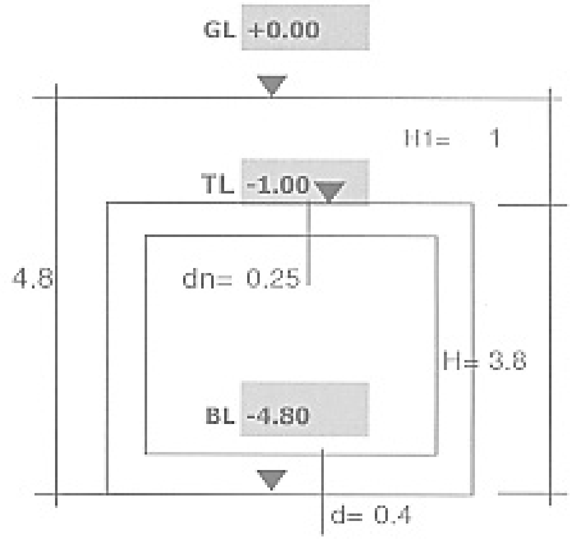
March 22,2001 10:34



SAP2000 v6.11 - File:culvert2500x2000x3000 - Moment 3-3 Diagram (LOAD1) - Ton-m Units

CALCULATION FOR SPECIAL MANHOLE 1

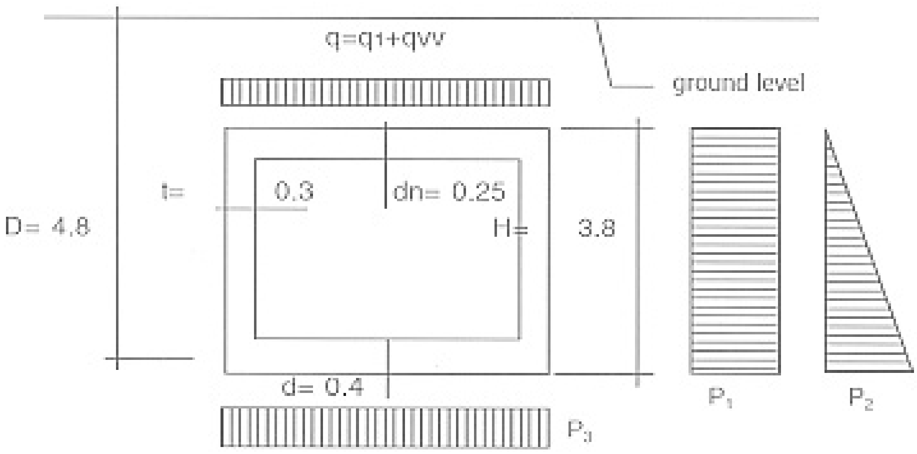




1.CALCULATION PARAMETER :

A.Geometry dimension :

High of manhole	*H =*	*3.8*	m
Depth of manhole	*D=*	*4.8*	m
Width of manhole	*B =*	*2.7*	m
Length of manhole	*A=*	*3.1*	m
Thickness of cover slab	d_n =	*0.25*	m
Thickness of wall	*t =*	*0.3*	m
Thickness of bottom slab	*d =*	*0.4*	m



B.Material parameter :

Grade of concrete:	210		
	Rn=	70	kg/cm²
	Rs=	3.6	kg/cm²
Weight of concrete:	γ =	2.5	T/m³
Steel stress:	Ra=	1600	kg/cm²

C. Geology conditions :

Ground water level:		+ 0.00	
Weight of soil:	γ =	1.8	T/m³

Soil internal friction angle : φ = 20^0 = 0.349066 (RAD)

$$K_0 = tg^2(45^0 - \frac{\varphi}{2}) = 0.5$$

2. OPERATING LOAD : ground water is up to ground surface level (permanent case)

A. Vehicle load :

Vehicle type: H30 So design load is calculated as following formula:

$P_{de} = (1+i)2P/W_o$

Where: P, weight of back wheel = 12 Ton

W_o, width of occupied area of vehicle W_o= 2.75 m

i, impact coefficient, i= 0.3

P_{de} = 11.35T/m

q_{vv} = Pde/B 4.36 T/m²

Horizontal vehicle load from both sides of the manhole:

p_{hv} = $1.0xK_o$ = 0.5 T/m²

Where: 1.0 T/m² is vertical uniform load due to vehicle for wall calculation

B. Cover soil load :

-Vertical uniform distributed load due to submerged cover soil:

$q_1=H_1x(\gamma_s-1)+H_1x1.0=$ 1.8 T/m²

-Horizontal uniform distributed load due to submerged cover soil from both side of the manhole:

$p_{11}=H_1x(\gamma_s-1)xK_o+H_1x1.0=$ 1.4 T/m²

-Horizontal triangle load due to submerged soil from both side of the manhole:

$p_{22}=Hx\gamma_w+(\gamma_s-\gamma_w)xHxK_o$ 5.32 T/m²

-Horizontal triangle load due to submerged soil from both side of the operating open:

$p_{33}=H1x\gamma_w+(\gamma_s-\gamma_w)xH1xK_o$ 1.4 T/m²

-Uplift pressure due to ground water:

$p_u=Hx1.0=$ 3.8 T/m²

C. Self load :

-Load due to cover slab:

Q_c = 2.5xAxBxdn= 5.23 Ton

-Load due to walls:

Q_w = 2.5x(A+B)x2x(H-dn-d)xt= 27.41 Ton

-Load due to bottom slab:

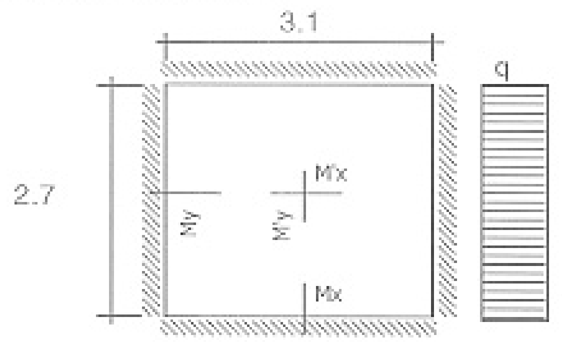
Q_b = 2.5x(A+t)x(B+t)xd= 10.20 Ton

D. Live load (with full of water in manhole) :

qw = 3.15 T/m²

3. CALCULATING FOR COVER SLAB OF MANHOLE :

Diagram calculation for analysis :



$q = q_1 + q_{vv} + 2.5 x d_n =$ 6.19 T/m²

-Thickness of cover slab : 0.25 m

-Factor related to Moment, bearing area and compress :

$A_o = M/R_n b h_o^2$

Where, M: Maximum bending moment(T.m)

h_o: Effective depth of bearing area(cm)

h_o= (Element thickness-Cover thickness)

b: Width of calculated area(cm)

-Required area of reinforcement :

Fa= $M/\gamma R_a h_o$ Where: $\gamma = 0.5 + ((1-2A_o)^{1/2})/2$

Reinforcement arrangement:

-Ratio of A and B : A/B= 1.15

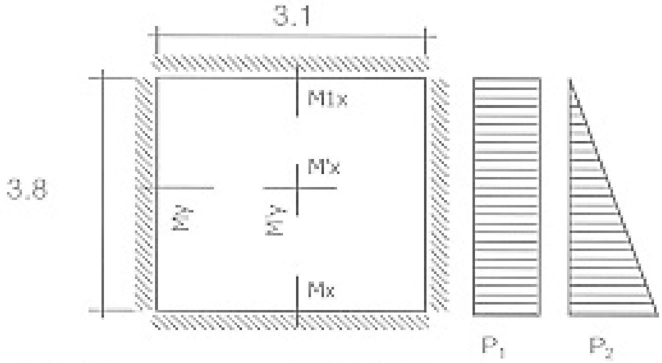
Internal force and selection reinforce table :

COEFFICIENT MULTIPLY	MOMENT	VALUE (Tm)	A_o	γ	fa cm²	SET REINFORCED FOR FORMAT	
						D(mm)	@(mm)
0.045	Mx	1.66049	0.0593	0.96941	4.65	12	250
0.0372	My	1.607	0.05741	0.97042	4.50	12	250
0.0194	M'x	1.005	0.03589	0.98172	3.20	12	250
0.0161	M'y	0.834	0.02978	0.98488	2.65	12	250

4. CALCULATING FOR WALL OF MANHOLE :

A.The wall is in the direction A :

Diagram calculation for analysis :



$P_1 = p_{hv} + p_{11} =$ 1.90 T/m²

$P_2 = p_{22} =$ 5.32 T/m²

-Thickness of wall: 0.3 m

Reinforcement arrangement:

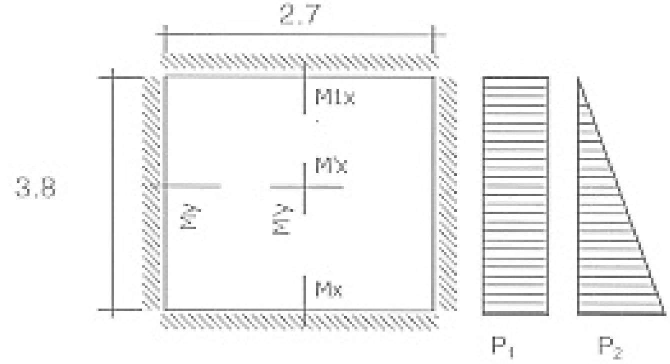
-Ratio of A and B : A/B= 0.82

Internal force and selection reinforce table :

COEFFICIENT MULTIPLY1	COEFFICIENT MULTIPLY2	MOMENT	VALUE (Tm)	A_o	γ	fa cm²	SET REINFORCED FOR FORMAT	
							D(mm)	@(mm)
0.0471	0.0579	Mx	1.36222	0.03114	0.98418	3.46	12	250
0.0471	0.0366	M1x	1.2489	0.02855	0.98552	3.17	12	250
0.0314	0.0354	My	0.89112	0.02037	0.98971	2.25	12	250
0.0205	0.0228	M'x	0.58013	0.01326	0.99333	1.46	12	250
0.0136	0.0125	M'y	0.3709	0.00848	0.99574	0.93	12	250

B.The wall is in the direction B :

Diagram calculation for analysis :



$P_1 = p_{hv} + p_{11} =$ 1.90 T/m²

$P_2 = p_{22} =$ 5.32 T/m²

-Thickness of wall: 0.3 m

Reinforcement arrangement:

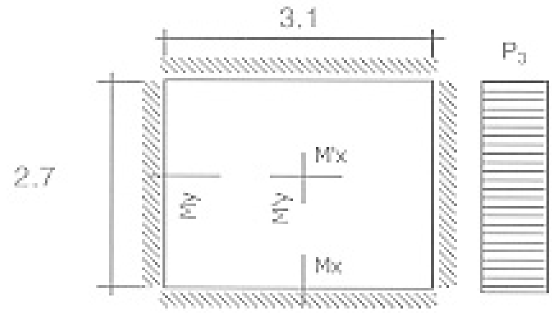
-Ratio of A and B : A/B= 1.41

Internal force and selection reinforce table :

COEFFICIENT MULTIPLY1	COEFFICIENT MULTIPLY2	MOMENT	VALUE (Tm)	A_o	γ	f_a cm²	SET REINFORCED FOR FORMAT	
							D(mm)	@(mm)
0.0371	0.0531	Mx	1.00572	0.02299	0.98837	2.54	12	250
0.0371	0.0301	M1x	0.88336	0.02019	0.9898	2.23	12	250
0.0452	0.0478	My	1.13542	0.02595	0.98685	2.88	12	250
0.0159	0.0189	M'x	0.4105	0.00938	0.99529	1.03	12	250
0.0195	0.0207	M'y	0.49026	0.01121	0.99437	1.23	12	250

5. CALCULATING FOR BOTTOM SLAB OF MANHOLE :

Diagram calculation for analysis :



$P_3 = q_1 + q_{vv} + p_u + (Q_c + Q_w + Q_b)/[(A+t)x(B+t)] =$ 11.16 T/m²

-Thickness of bottom slab: 0.4 m

Reinforcement arrangement:

-Ratio of A and B : A/B= 1.15

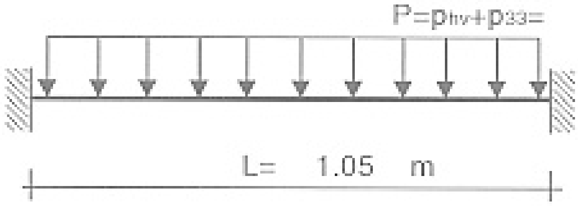
Internal force and selection reinforce table :

COEFFICIENT MULTIPLY	MOMENT	VALUE (Tm)	A_o	γ	f_a cm²	SET REINFORCED FOR FORMAT	
						D(mm)	@(mm)
0.045	Mx	2.75412	0.03212	0.98367	4.60	12	250
0.0372	My	2.58612	0.03016	0.98469	4.32	12	250
0.0194	M'x	1.8127	0.04143	0.97884	3.13	12	250
0.0161	M'y	1.50433	0.03438	0.9825	2.59	12	250

6. CALCULATING FOR WALL OF OPERATING OPEN :

A.The wall is in the direction A & B :

Diagram calculation for analysis :



-Uniform distributed loads : 1.90 T/m

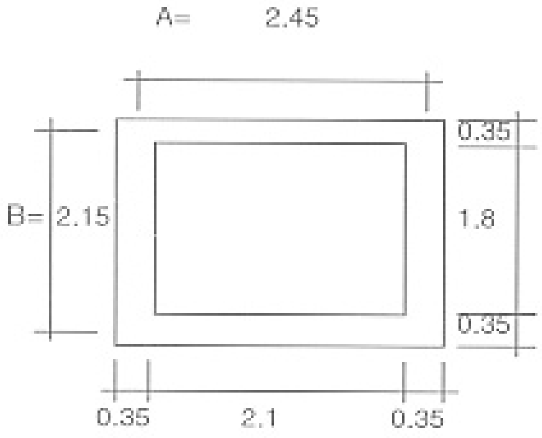
-Thickness of wall : 0.2 m

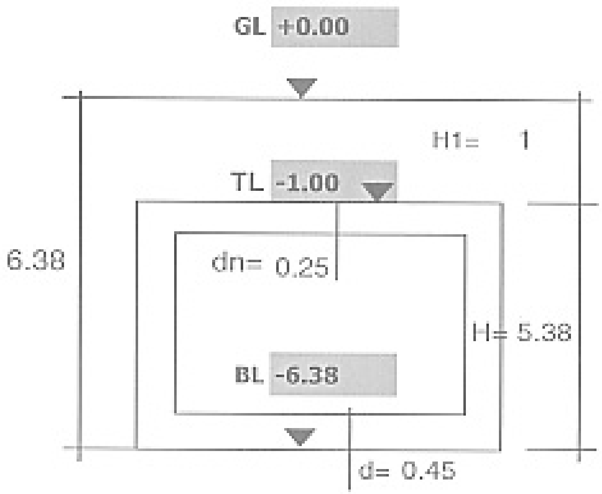
Reinforcement arrangement :

Internal force and selection reinforce table :

MOMENT	VALUE (Tm)	A_o	γ	f_a cm^2	SET REINFORCED FOR FORMAT	
					D(mm)	@(mm)
M1	0.174563	0.01108	0.99443	0.73	12	250
M2	0.087281	0.00554	0.99722	0.36	12	250

CALCULATION FOR SPECIAL MANHOLE 2

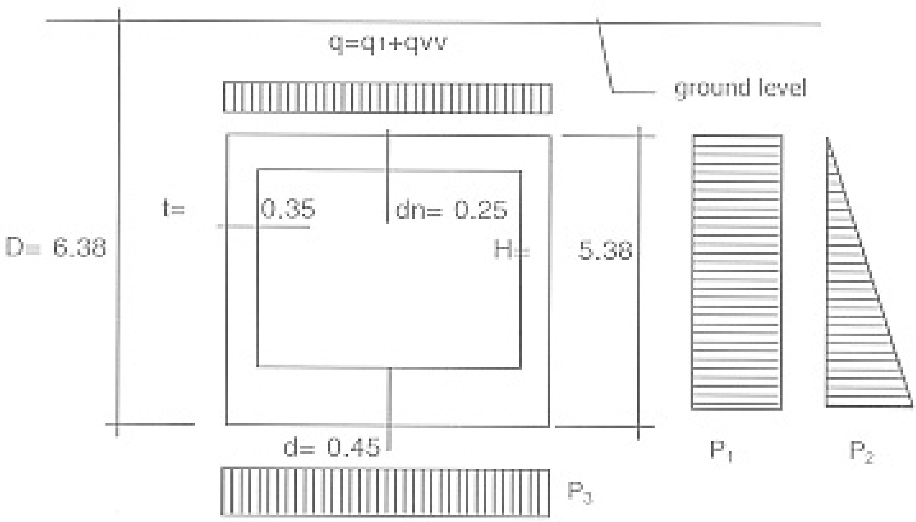




1.CALCULATION PARAMETER :

A.Geometry dimension :

High of manhole	*H =*	*5.38*	m
Depth of manhole	*D=*	*6.38*	m
Width of manhole	*B =*	*2.15*	m
Length of manhole	*A=*	*2.45*	m
Thickness of cover slab	$d_n =$	*0.25*	m
Thickness of wall	*t =*	*0.35*	m
Thickness of bottom slab	*d =*	*0.45*	m



B.Material parameter :

Grade of concrete:	210		
	Rn=	70	kg/cm²
	Rs=	3.6	kg/cm²
Weight of concrete:	γ =	2.5	T/m³
Steel stress:	Ra=	1600	kg/cm²

C. Geology conditions :

Ground water level:		+ 0.00	
Weight of soil:	γ =	1.8	T/m³

Soil internal friction angle : φ = 20^0 = 0.349066 (RAD)

$$K_o = tg^2(45^\circ - \frac{\varphi}{2}) = 0.5$$

2. OPERATING LOAD : ground water is up to ground surface level (permanent case)

A. Vehicle load :

Vehicle type: H30 So design load is calculated as following formula:

$P_{de} = (1+i)2P/W_o$

Where: P, weight of back wheel = 12 Ton

W_o, width of occupied area of vehicle W_o= 2.75 m

i, impact coefficient, i= 0.3

P_{de} = 11.35T/m

q_w = Pde/(B+t) 4.54 T/m²

Horizontal vehicle load from both sides of the manhole:

p_{hv} = $1.0xK_o$ = 0.5 T/m²

Where: 1.0 T/m² is vertical uniform load due to vehicle for wall calculation

B. Cover soil load :

-Vertical uniform distributed load due to submerged cover soil:

$q_1=H_1x(\gamma_s-1)+H_1x1.0=$ 1.8 T/m²

-Horizontal uniform distributed load due to submerged cover soil from both side of the manhole:

$p_{11}=H_1x(\gamma_s-1)xK_o+H_1x1.0=$ 1.4 T/m²

-Horizontal triangle load due to submerged soil from both side of the manhole:

$p_{22}=(H-d)x\gamma_w+(\gamma_s-\gamma_w)x(H-d)xK_o$ 6.902 T/m²

-Horizontal triangle load due to submerged soil from both side of the operating open:

$p_{31}=H1x\gamma_w+(\gamma_s-\gamma_w)xH1xK_o$ 1.4 T/m²

-Uplift pressure due to ground water:

p_u=Hx1.0= 5.38 T/m²

C. Self load :

-Load due to cover slab:

Q_c = 2.5x(A+t)x(B+t)xdn= 4.38 Ton

-Load due to walls:

Q_w = 2.5x(A+B)x2x(H-dn-d)xt= 37.67 Ton

-Load due to bottom slab:

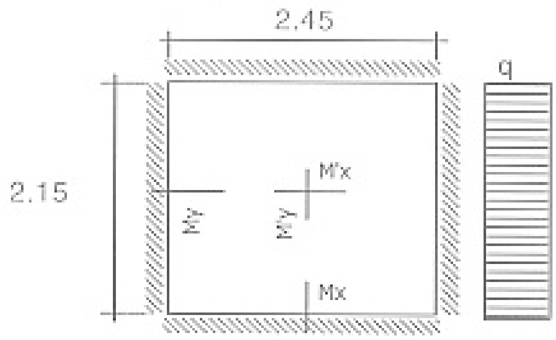
Q_b = 2.5x(A+t)x(B+t)xd= 7.88 Ton

D. Live load (with full of water in manhole) :

qw = 4.68 T/m²

3. CALCULATING FOR COVER SLAB OF MANHOLE :

Diagram calculation for analysis :



$q = q_1 + q_{vv} + 2.5 x d_n =$ 6.96 T/m²

-Thickness of cover slab : 0.25 m

-Factor related to Moment, bearing area and compress :

$A_o = M/R_n b h_o^2$

Where, M: Maximum bending moment(T.m)

h_o: Effective depth of bearing area(cm)

h_o= (Element thickness-Cover thickness)

b: Width of calculated area(cm)

-Required area of reinforcement :

$Fa = M/\gamma R_a h_o$ Where: $\gamma = 0.5 + ((1-2Ao)^{1/2})/2$

Reinforcement arrangement:

-Ratio of A and B : A/B= 1.14

Internal force and selection reinforce table :

COEFFICIENT MULTIPLY	MOMENT	VALUE (Tm)	A_o	γ	fa cm²	SET REINFORCED FOR FORMAT	
						D(mm)	@(mm)
0.0458	Mx	1.67988	0.06	0.96904	4.71	12	250
0.0349	My	1.28008	0.04572	0.97659	4.10	12	250
0.02	M'x	0.7336	0.0262	0.98672	2.32	12	250
0.015	M'y	0.55018	0.01965	0.99008	1.74	12	250

4. CALCULATING FOR WALL OF MANHOLE :

A. Calculation for wall at level : -5.93

-Uniform distributed loads :

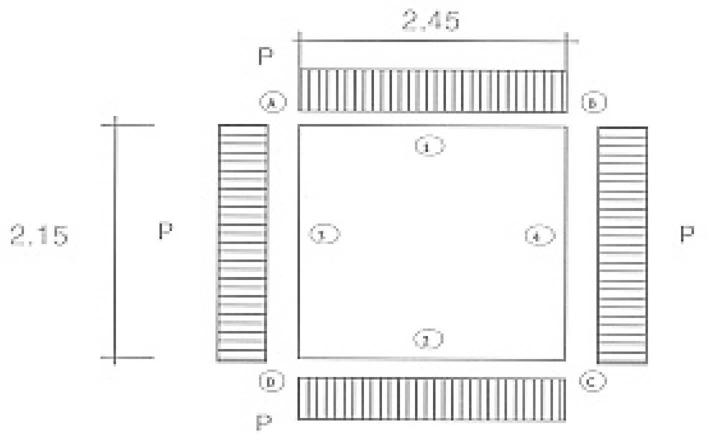
$P_1 = p_{hv} + p_{11} =$ 1.90 T/m²

$P_2 = p_{22} =$ 6.90 T/m²

$P = P_1 + P_2 =$ 8.80 T/m²

Thickness of wall: 0.35 m

Diagram calculation for analysis :



Calculation for stresses and forces for the above scheme :

(Results and inlustrated diagram attached at the end of this calculation)

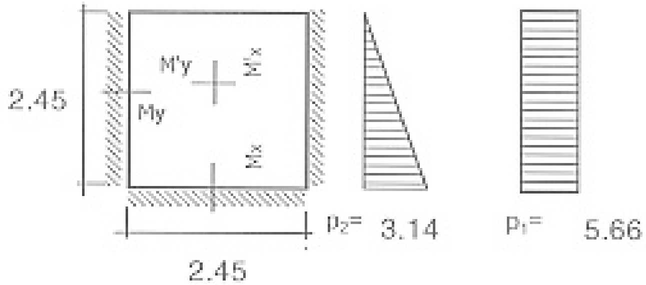
Reinforcement arrangement:

Internal force and selection reinforce table :

MOMENT	VALUE (Tm)	A_o	γ	f_a cm^2	SET REINFORCED FOR FORMAT	
					D(mm)	@(mm)
M_1	2.25	0.041	0.97906	2.71	12	250
M_A	3.58	0.06523	0.96624	4.37	12	250
M_3	1.28	0.02332	0.9882	1.53	12	250

Compare with three fix sides diagram:

Diagram calculation for analysis in the direction A :



-Width of slab: A 2.45 m

-Length of slab B 2.45 m

-Triangular distributed loads p_2= 3.14 T/m

-Uniform distributed loads p_1= 5.66 T/m

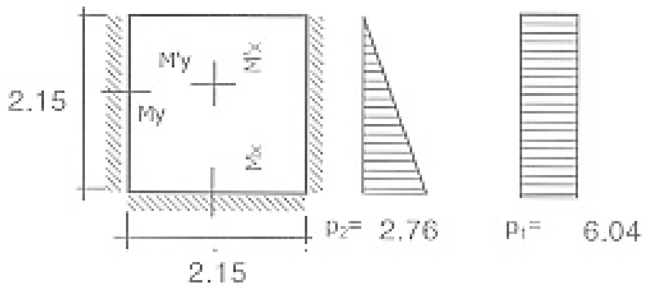
-Thickness of bottom slab d= 0.35 m

-Ratio of A and B : A/B= 1

Internal force and selection reinforce table:

COEFFICIENT MULTIPLY 1	COEFFICIENT MULTIPLY 2	MOMENT	VALUE (Tm)	A_o	γ	f_a cm^2	SET REINFORCED FOR FORMAT	
							Ø(mm)	a(mm)
0.0598	0.0559	Mx	2.17055	0.04	0.97982	4.3267	12	250
0.0538	0.0664	My	2.33027	0.04	0.9783	4.5113	12	250
0.0172	0.0084	M'x	0.44758	0.01	0.99591	1.0032	12	250
0.0246	0.0257	M'y	1.10502	0.02	0.98983	2.4919	12	250

Diagram calculation for analysis in the direction B :



-Width of slab: A 2.15 m

-Length of slab B 2.15 m

-Triangular distributed loads p_2= 2.76 T/m

-Uniform distributed loads p_1= 6.04 T/m

-Thickness of bottom slab d= 0.6 m

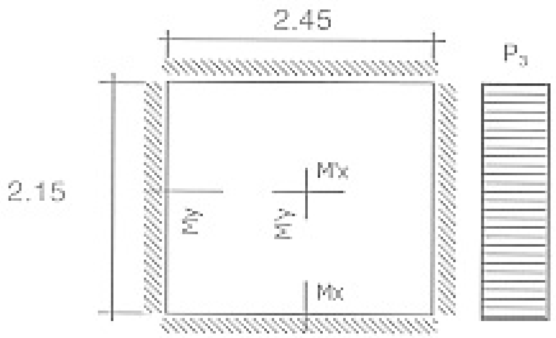
-Ratio of A and B : A/B= 1

Internal force and selection reinforce table:

COEFFICIENT MULTIPLY 1	COEFFICIENT MULTIPLY 2	MOMENT	VALUE (Tm)	A_o	γ	f_a cm^2	SET REINFORCED FOR FORMAT	
							Ø(mm)	a(mm)
0.0598	0.0559	Mx	1.94292	0.04	0.98197	3.8644	12	250
0.0538	0.0664	My	2.19801	0.04	0.97956	4.3826	12	250
0.0172	0.0084	M'x	0.34432	0.01	0.99685	0.7710	12	250
0.0246	0.0257	M'y	0.87481	0.02	0.99197	1.9685	12	250

5. CALCULATING FOR BOTTOM SLAB OF MANHOLE :

Diagram calculation for analysis :



$P_3 = q_1+q_{vv}+p_u+(Q_c+Q_w+Q_b)/[(A+t)x(B+t)]=$ 16.55 T/m²

-Thickness of bottom slab: 0.45 m

Reinforcement arrangement:

-Ratio of A and B : A/B= 1.14

Internal force and selection reinforce table :

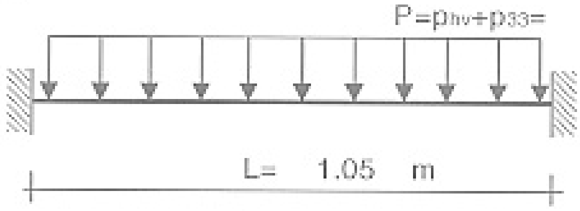
COEFFICIENT MULTIPLY	MOMENT	VALUE (Tm)	A_o	γ	f_a cm^2	SET REINFORCED FOR FORMAT	
						D(mm)	@(mm)
0.0458	Mx	2.86523	0.02558	0.98704	4.54	12	250
0.0349	My	2.414	0.02156	0.9891	3.81	12	250
0.02	M'x	1.744	0.01557	0.99215	2.89	12	250
0.015	M'y	1.308	0.0117	0.99413	2.16	12	250

6. CALCULATING FOR WALL OF OPERATING OPEN :

A.The wall is in the direction A & B :

Diagram calculation for analysis :

$P=p_{hv}+p_{33}=$ 1.90 T/m



-Uniform distributed loads : 1.90 T/m

-Thickness of wall : 0.25 m

Reinforcement arrangement :

Internal force and selection reinforce table :

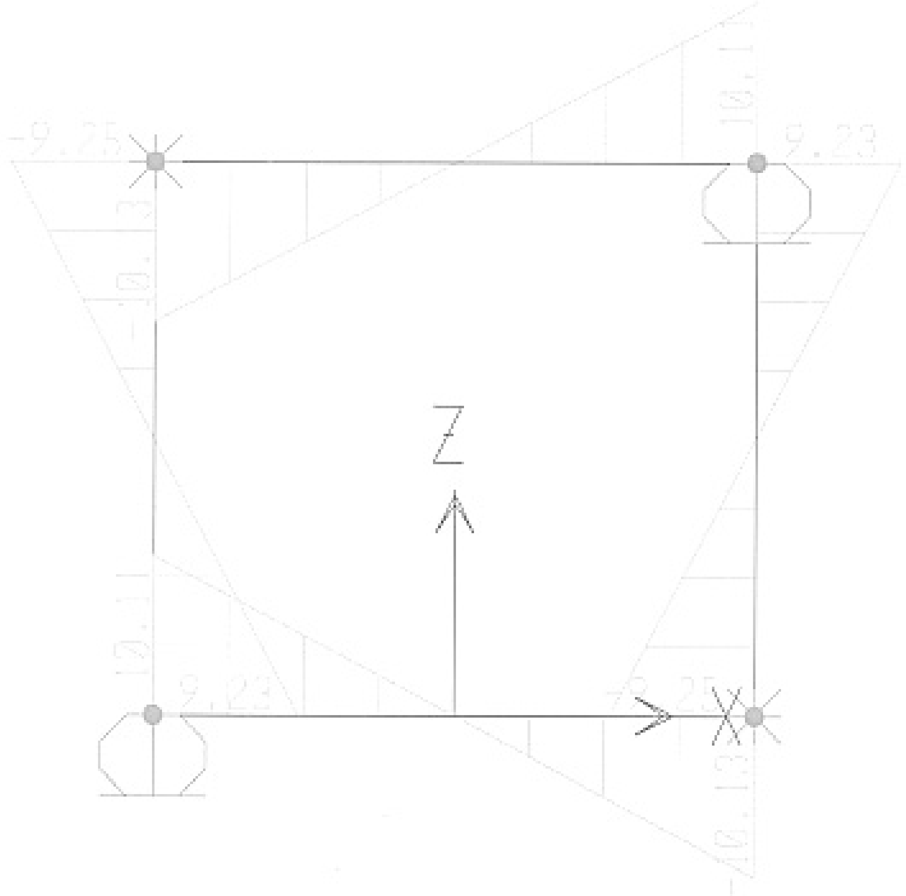
MOMENT	VALUE (Tm)	A_o	γ	f_a cm^2	SET REINFORCED FOR FORMAT	
					D(mm)	@(mm)
M1	0.174563	0.01108	0.99443	0.55	12	250
M2	0.087281	0.00554	0.99722	0.27	12	250

7-Checking for shearing forces of wall:

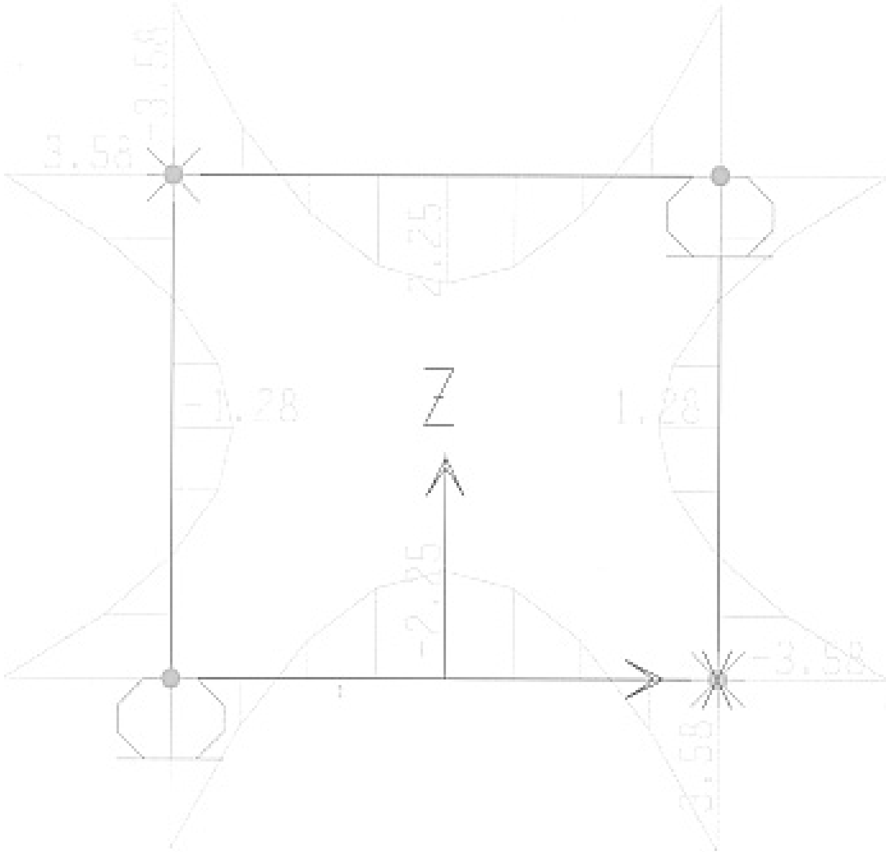
At level -2.23

-Height of hand for supporting wall s= 0 , so the section need to be checked shear bearing capacity is [t+s/2]= 0.35 m far from center of wall

Shears	Values (T)	Shearing stresses (Kg/cm2)	Degn Shearing stress (Kg/cm2)	Compare &Conclude
V	7.23	2.50	3.60	OK!!!



SAP2000 v6.11 - File:SpecialManhole2 - Shear Force 2-2 Diagram (LOAD1) - Ton-m Units



SAP2000 v8.11 - File:SpecialManhole2 - Moment 3-3 Diagram (LOAD1) - Ton-m Units