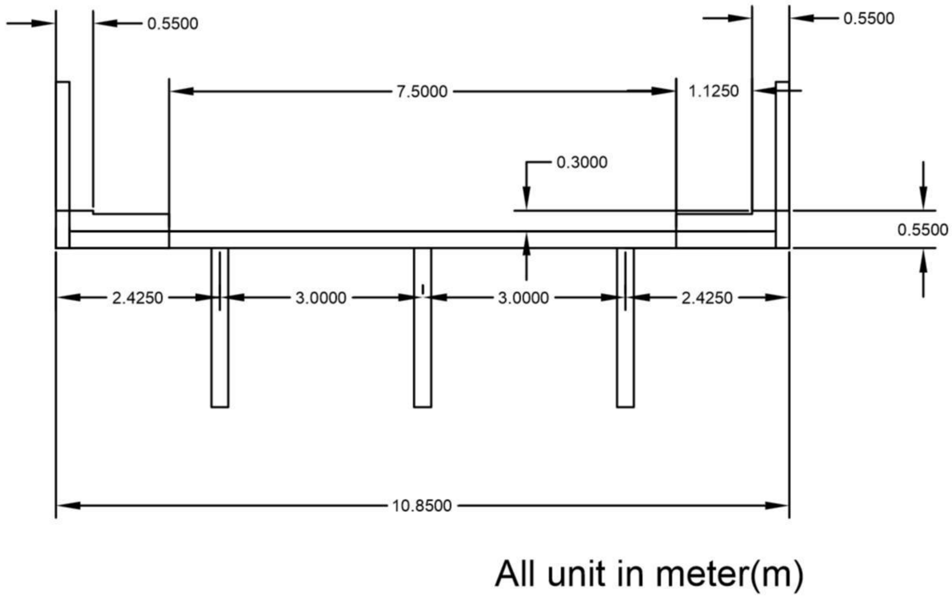
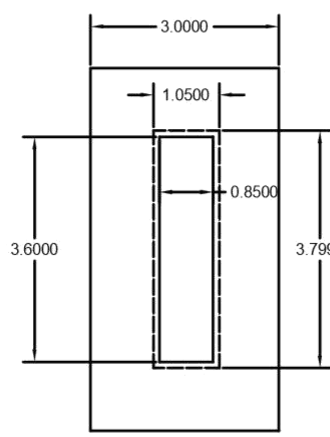
Structural Design of Bridge Khadi Khad, Pathankot



DECK SLAB



Thickness of slab = 0.25

Wearing Coat = 0.1 m

Grade of Concrete = M30

Dead Load = 6.25 KN/ m²

DL of Wearing Coat = 2.2 KN/ m²

Total DL = 8.5 KN/ m²

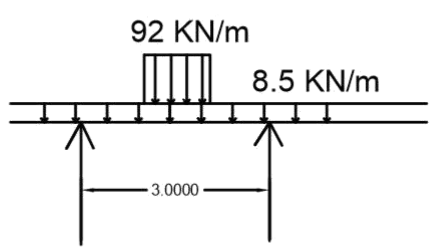
Class AA Tracked Vehicle

Wheel Division:-

l = 0.85 m

b = 3.6 m

u = 0.85 + 0.2 = 1.05 m v = 3.6 + 0.2 = 3.8 m



One Way Slab:-

Impact factor = 0.25 m

Wheel Load / m = 350/3.80 = 92 KN/ m DL = 8.5 KN/ m

B.M = $8.5 \times 3^2/8 + (92/2 \times 3/2 - 92/2 \times 1.05/4) \times 1.25 = 9.56 + 56.92 \times 1.25 = 80.7$ KN-m

Continuity Effect:-

B.M at support = $9.56 \times 8/10 + 56.92 \times 4/8 \times 1.25 = 43.25$ KN-m

S.F = $8.5 \times 3/2 + 92 \times 1.05/2 \times 1.25 = 73.13$ KN-m

Mu = 64.87 KN-m

Vu = 109.7 KN

Provide ϕ12@100mm c/c main(cross)

Provide ϕ10@100mm c/c distance (long.)

CANTILEVER SLAB

$b_e = 1.2x + bw. = 1.2*0.2 + (0.25 + 2 \times 0.1) = 0.69$ m

Live Load/m = $57 \times 1.5/0.69 = 123.9$ kN/m

Maximum moment due to L.L = $123.9 \times 0.2 + 5*1.125 * 0.763 = 29.64$ KNm

Moment due to D.L = $1.7 \times 1.4 + 0.55 \times 0.55 \times 2 \times 25 + 0.26 \times 25 \times 2.275^2/2 + 0.1 \times 0.6 \times 0.3 \times 20$

$= 2.436 + 15.13 + 16.82 + 0.36 = 34.746$ KN-m

Total B.M = $29.64 + 34.69 = 64.33$ KN-m

S.F = $(123.9 \times 0.45) + 5 * 1.125 + (7.6 + 14.8 + 1.8) = 85.58$ KN

Mu = 96.5 KN-m

Vu = 128.4 KN-m

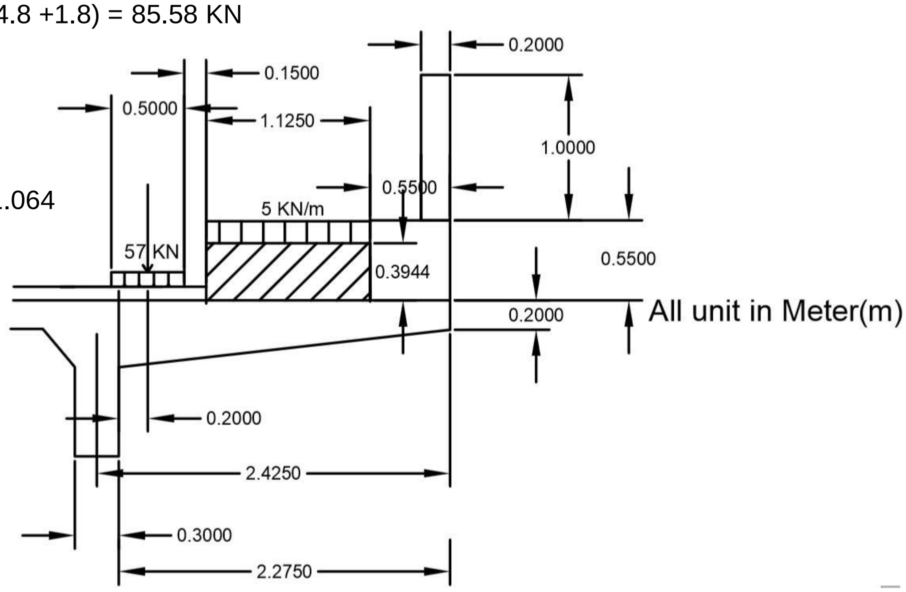
$Mu/bd^2 = 96.5 \times 10^6/1000 \times 300^2 = 1.064$

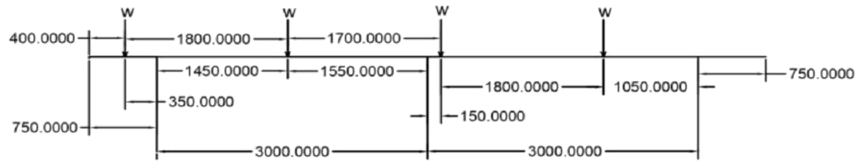
Pt = 0.265%

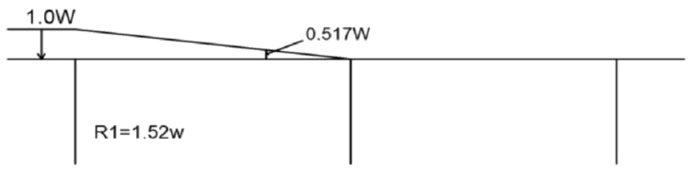
Ast = $7.95 cm^2$

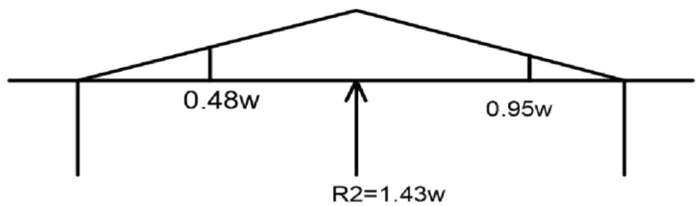
Provide ϕ12@ 100 c/c main

Provide ϕ 10 @ 150 c/c dist.









Longitudinal Girders:-

DL (Intermediate Girder/m length):

Sr No.	Item	Details	Weight (KN)
1.	Wearing Coat	3.0 × 0.1 × 22	6.6
2.	Deck Slab	3.0 × 0.25 × 25	18.75
3.	T Beam	0.4 × 3.0 × 25	30
4.	Cross Beams	(3.0 × 2.0 × 25 × 0.5)/41	2.57(say)
			= 57.92 KN/m
			≈ 60 KN/m

Maximum B.M due to DL = $50 \times 41^2/8 = 10506$ KN-m

Maximum S.F due to DL = $50 \times 41/2 = 1025$ KN

D.L in end Girder/m length:-

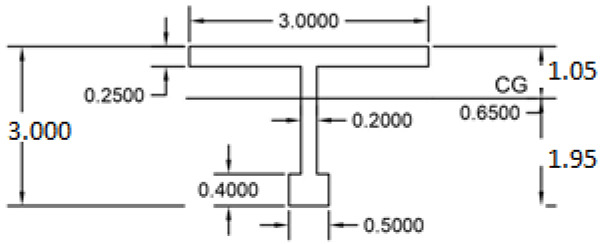
Sr No.	Item	Details	Weight (KN)
1.	Wearing Coat	0.75 × 0.1 × 22	4.96
2.	Deck Slab	0.263 × 2.425 × 25	15.94
3.	End beam	0.55 × 0.55 × 25	7.56
4.	Parapet	0.2 × 1 × 25	5
5.	Front Path	0.3 × 1.125 × 20	6.75
6.	Self weight	0.4 × 3.0× 25	30
7.	Cross Beam		1.29 (say)
			= 71.5 KN/m ≈ 75KN/m

Live Load Calculations:-

Impact Load = $4.5/(6 + 41) = 0.1$

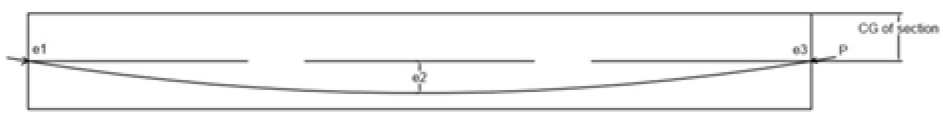
Max. Wheel Load(W) = Axle Load/2 × 1.1 × 1.52 = Axle Load × 0.836

Analysis of Girder with Staad Pro:-



All units in meter(m)

P= 11000 kN , e1 =e3 = 0 ,e2 = 1.60 m



P =11000 KN, e1 = e3 = 0, e2 =1.6m

Using Freyssinet system drainage type 27K15 (27 stands of 15.0 mm diameter) in 110 mm cable ducts.

Permissible Tensile Capacity of each cable = 27×0.75×265 = 5366 kN

The cables are arranged in parabolic profile with end eccentricity zero and central eccentricity is 1600 mm.

Post stressing force required = 11000 kN

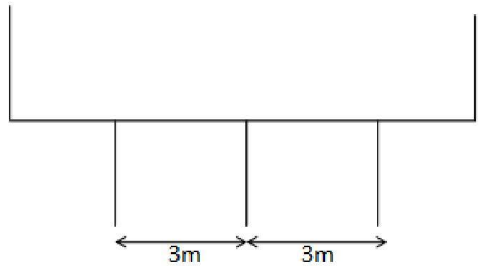
Post stressing force at Jack Level = 11000x1.1 = 12100 kN

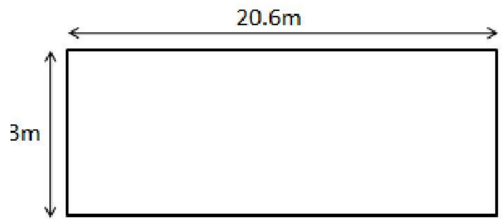
Provide 3 cables

Post stressing force in each cable = 4035 kN < 5366 kN

Safe

Design Cross Beam



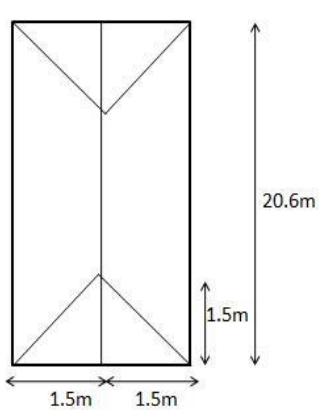


Given

Depth of beam	=	1.4	m
Thickness of beam	=	0.4	m
Density of concrete, γ_c	=	25	kN/m^3
Thickness of slab	=	0.25	m
Thickness of W.C.	=	0.1	m
Density of W.C.	=	22	kN/m^3
Length of span, l_x	=	20.6	m

Step1:- Dead Load:

Spacing of Main girder / Beam	=	3	m
Weight of rib of x- beam	=	2.4 x 0.4 x 25	
	=	24	kN/m
Weight of (Slab + W.C.)	=	0.25x25+0.1x22	
	=	8.45	kN/mm^2
Total load of deck slab	=	8.45x 2x 0.5x 3x 3/2	
	=	38.03	kN



This load is assumed length

Load per meter run due to deck slab

= 38.025/3

= 12.68 kN/m

Total dead load per meter run = 24+38.025 = 36.7 kN/m

This load is assumed uniformly distributed along

This cross – gird

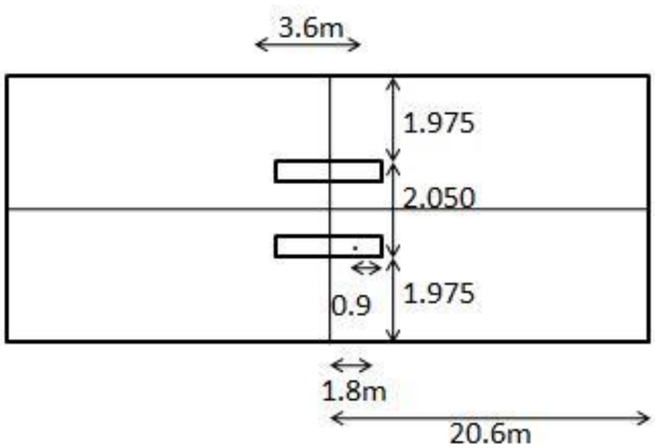
The reaction on each longitudinal girder

= 36.7*2*3/3

= 73.4 kN

Step2:- Live Load:

Class AA (tracked) vehicle produce maximum B.M. and S.F. in x- girder.



This position reaction to x – girder.

Magnitude of reaction = 700*19.7/20.6

= 670kN

No. of long. Beam 3

Because x-girder is rigid,reaction on each longitudinal girder

= 700/3= 233.3 kN

Maximum bending moment occurs under track load,

= 700*1.975/3

460.8 kN-m

Impact factor = 1.1

Including, Impact factor +ve B.M. due to live load

= 460.83*1.1

= 507 kN-m

B.M. due to dead load at a distance of 1.975 from support

= 73.4*1.975-(26.675(1.975/2)^2)

= 100 kN-m

Total Bending Moment = 507+100

= 607 kN-m

Step3:- Live Load shear inculding Impact = 700*1.1/3=257

= 257 kN

Dead Load shear = 73.4 kN

Total shear for depth = 73.4+257

= 330.4 kN

Clear cover = 40 mm

Diameter = 25 mm

Step4:- Effective depth = 1650-(40+25/2)

= 1598 mm

= 0.16 m

Step5:- Check for shear:

b = 400 mm

τ_v = 330.4*1000/400*1597.5

= 0.52 N/mm^2

Spacing of 12Φmm , 2 – legged s

Using 12mm diameter bar = 12 mm

Asv = 2*0.785*12^2

= 226 mm^2

σ_{sv} = 200

Spacing of stirrups . Sv = 200*226*1597.5/310.35*1000

232.7 mm^2

Area of steel required :-

Ast = 587*10^6/0.9*1597.5*200

= 2041 mm^2

Minimum shear reinforcement = 226/400*.0015

= 377 mm^2

Provide 2L- 12 dia @100mm c/c

Provide 4-25 dia throughout at top & bottom provide 4-25 dia at mid span at bottom provide 4-25 dia at top on supports

Design of Parapet:-

Horizontal load = 150 kg/m2

Width of wall considered = 1 m

B.M. = 0.5*150*1 = 75 kg-m

Mu = 1.125 kN-m

M.O.R. = 0.136*fck*b*

d required = 16.6 mm

Provide nominal 100mm thick parapet with 10dia @ 150 c/c vertically on each face and 8 dia @ 150 c/c horizontally on each face.

Seismic analysis:

T= 2.0√D/1000F

D= DL+ 0.2LL =5650 + 0.2*(365*3) = 5869 kN

Here F=D*6EI/L^3

=(1)*6*31.22*1.083*10^{12}/5000^3=1623 kN

T = 2.0√5869/1000*1623 = 0.12 sec

Sa/g = 2.5

Ah = Z/2 * 2 *I *Sa/g =0.24/2*(1.2*2.5)= 0.36

H = 0.36 * 5869 = 2113 kN

M = 2133 * 5 = 10564 kN

Total Horizontal force = 1700+2113 = 3813 kN

Total moment = 690 + 10564 = 11254 kN m

Design of Abutment (width 10m) :-

1.5 (DL+LL):

M= 690 KN- m

Mu =1035 KN-m

V = 170 KN

Vu = 255 KN

Mu/bd^2 = 1035 ×10^6/(1000×950^2) =1.15

Pt = 0.33%

1.2 (DL+LL+EQ):

M=11254/10 = 1125.4 KN- m

Mu =1350 KN-m

V = 3813/10 = 381.3 KN

Vu = 458 kN

Mu/bd^2 = 1688 ×10^6/(1000×950^2) = 1.87

Pt= 0.50% Ast = 4750 mm^2

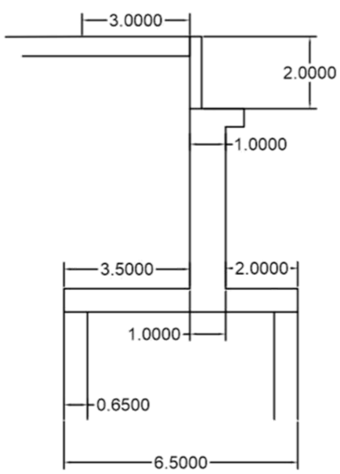
τ_u = 381.3 × 10^3/1000 × 950 = 0.40 N/ mm^2

τ_c = 0.48 N/mm^2 **SAFE**

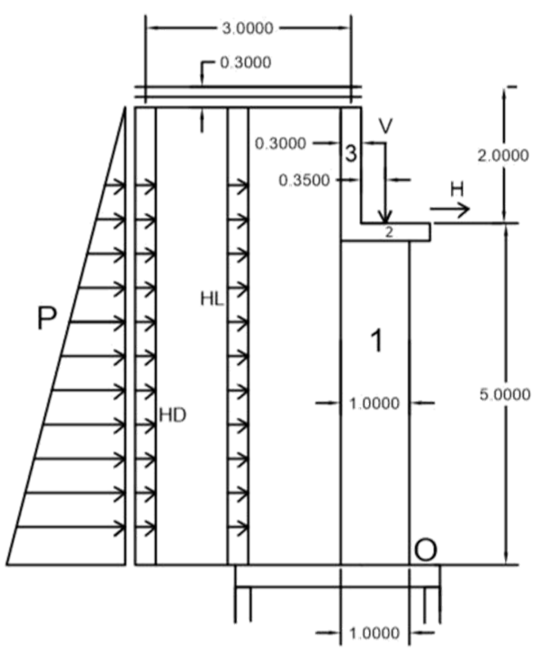
Provide 25Ø @ 125 c/c main steel on Earth force

Provide 20Ø @ 160 c/c main steel on Free force

Provide 12Ø @ 100 c/c Distribution steel



All units in Meter(m)



Loads on Abutment

Forces and moments about base/m length of Abutment :

Sr No.	Details	Vertical Forces (KN)	Horizontal Forces(KN)	Lever Arm (m)	Moment About 0 KNm
1.	Dead Load For Structure	1880*3/10 =555	--	0.15	84
2.	Active Earth Pressure	---	45	2.23	100.35
3.	Horizontal Force Due to live load Surcharge	---	80	3.35	268
4.	Vertival force due to Live load surcharge	75	---	1.85	139
5.	Self weight 1 2 3 4 **Total:**	125 -- 13 -- **138 KN**	---	0 -- -0.35 --	0 -- -4.55 --
6.	Live load for structure	365*3/10 =110	--	0.15	16.5
7.	Horizontal Bending moment	---	15	5.71	86
	Total	878	170		690 kNm

Total vertical load at base = 878*10 = 8780 KN

Total horizontal load at base = 170 * 10 = 1700 kN

Total bending moment at base = 690*10 = 6900 KNm

MEAN SCOUR DEPTH

Clear waterway = 39.8 m

Silt factor(f) =2.96

Q = 454 cumec

Unit discharge(q) =454/39.8 = 11.41 cumec/m width

Mean Scour Depth = $1.34(q^2/f)^{1/3}$ = 4.56m

Max. Scour Depth = 2×4.71 = 9.12m

Grip Length = ⅓(max ≈scour depth =3.04 m(provide =5.78m)

Depth of Foundation below HFL = 9.12 + 3.04 = 12.16 m (provide = 15.2m)

Depth of foundation Below =12.16 - 2.2 =9.96m (provide= 13m)

DESIGN OF WELL

Design Loads

i) DL+LL

Assuming outer dia of well =15.0m.

Self weight of well = 45000 kN

V=8780+45000+3904=57684 kN

H=1700 kN

M=1700*18=30600 kN

ii) DL+LL+EQ

V=8780+45000+3904=57684 kN

H=3813 kN

M=3813*18=68634kN

Base Pressure Calculations (neglecting friction)

A= $\pi/4*15^2$= 176.7 m^2

I= $\pi/64*15^4$ = 2485 m^4

Z= 2485/7.5=331.33 m^3

Base pressures

i) DL+LL

Stress =57684/176.7 ± 30600/331.33=326.5+/- 92.4

=418.9;234.1 kN/m^2 <428 kN/m^2

ii) DL+LL+EQ

Stress =57684/176.7 ± 68634/331.33=326.5+/- 207.2

=533.7;119.3 kN/m^2 <1.5*428 kN/m^2

Steining

Min thickness of stiening = 500 mm

Thickness = $h = Kd\sqrt{L}$ =0.030 ×15 ×√13 =1.62 m (Provide 1700mm)

Bearing Pressure

Self Weight of well :

Area of cross section of well= $\pi/4(6.5^2 - 5^2) + 6.5*0.75*2+0.75*5.2 = 27.2\ m^2$

Internal area of well = 75.43 –27.2 = 48.23 m^2

Area of base = $\pi/4*6.5^2+6.5*6.5=75.43m^2$

Weight of well = (27.2 × 13 ×25) + (48.23 ×11×18) + 48.23 ×2 ×2 × 25 = 23386 KN

Weight of soil on cap = (13 + 6.5)/2 * 6.7 * 3.5 * 18 = 3904 KN

Total load at base = 5768 + 23386 + 3904 = 33058 KN

Bearing pressure = 33058/75.73 = 438.3 KN/m^2 (Neglecting friction)

Reinforcement

Vertical reinforcement (0.12%)
Ast= 0.12*1700*1000/100=2040 mm^2/m

Provide 16 ϕbars @ 180 c/c on each face vertically

Horizontal reinforcement (0.2%)

Ast= 0.2*1700*1000/100=3400 mm^2/m

Provide 16Ø @100c/c on each face horizontally

Bottom Plug

Thickness of bottom plug is

$t = \sqrt{(1.18 \times r^2 q/ fc)} = \sqrt{1.18 \times 7.5^2 \times 428/ 7000} = 2.02$ m say 2100 mm

Check For Section adopted

Distance of zero shear (max. BM) for scour level

$X = \sqrt{(2FH/(\gamma(Kp - Ka)B)}$

Assuming Ø = 30° , δØ/ 2= 15° , θ ° = 45

$Ka=(\cos Ø/(\sqrt{\cos\delta} + \sqrt{\sin(\theta+\delta)\times\sin Ø})^2$

$Kp= (\cos Ø/(\sqrt{\cos\delta - \sin(\theta+\delta)\times\sin Ø})^2$

Ka = .30 ,Kp = 5.0

Therefore x^2 = 2 * 2 * 3777/(9.5(5-0.3)15) = 22.56

X = 4.75m

Max BM is Mmax = Mo + 2/3 Hx

Permissible tilt = 50 mm

Tilt at scour level = 50 × 3.14/15.5 = 10.13 mm = 11mm

Moment to tilt = 0.011 × 57684 = 634.5 KN-m

Mmax = 634.5+ 2/3 × 3813 × 4.75 = 12709 KN-m

$A = \pi/4*(15^2-11.6^2) = 71.03\ m^2$
$I = \pi/64*(15^4-11.6^4) = 1596.3 m^4$

Max Stress in steining

σmax = 57684/71.03± 12709*7.5/1596.3

812±59.7 KN/m² = 872.;753 KN / m² < 1.33*6.0 N/ mm² (M30)

V= 5768 KN, H = 1275 KN , M = 6518 KN

Upward Pressure = μP ;

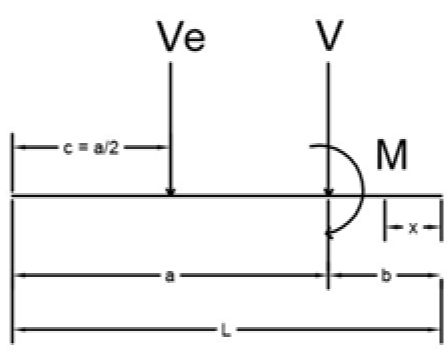
$P = \gamma(Kp–Ka)LD^2/6$

P= 9.5(5-0.3) 15.78² /6 =3729 kN

Total vertical load = (57684-3232)= 54452 KN

Bearing pressure = 54452/176.7 = 308.2 KN/m²

Design of well cap



L=13.3m; a=8.8m; b=2.8m; c=4.4m

(At x = b)

BM = Ve cb/L + Mb/L + Vab/L

S.F = Ve c/L + M/L + Va/L

M=6900 kN; V=8780 kN;

Ve= 15*8.8*7*18/2=8316 kN

BM = 25421 kN-m

S.F = 10013 KN

BM/Width = 25421/13.3=1911 kN-m ,

Mu = 2867 kN-m/m

S.F/Width = 10013/13.3=752 kN/m ,

Vu = 1129 kN/m

Tu = 1129 × 10^3/1000×1450 = 0.77 M/mm²

Mu/bd² = 2867 × 10^6 /1000×1450² =1.32
Pt=0.33%

Ast = 4950 mm²/m

Provide depth D=1500mm

Provide = 25ϕ@ 100 c/c bathway at bottom Provide 16 ϕ@100 c/c bathway at top.

Check of Well with Elastic Theory

		DL+LL	DL+LL+Bϱ	
W=	V	57689	57684	KN
	H	1700	3813	KN
	M	30600	68634	KN
	IB			2485
	KH			1
	K			1
	M=		KH/K	1
	IV		L*(D2)^3/12	241m4
	μ			0.5
	D1			15
	D2			5.78m
	α=		D1/∏*D2	0.83
	I=		IB+m*IV(1+2μ` α)	2925

	r=	D1*I/2m*IV	110.2 m

Ensure

H>(M/r)(1+ηm')-m'W

H=	381.3	
(M/r)(1+ηm')-m'W	-19.87396497	
	381.3>-19.87	Safe
H<(M/r)(1-ηm')+m'W	21119.59111	
	381.3<21119.5	safe

Check for elastic sate

mM/I<r(KP-KA)

mM/I	19.48	
r(KP-KA)	297.54	
	19.48<297.54	safe

Design of Return Wall

Earth pressure =0.33*19*6= 37.62 kN/m^2

Surcharge =80 kN/m^2

M=37.62*6/3+80*6/2=315.24 kN- m

Mu =473 KN-m

V = 37.62*6/2+80=192.9 kN

Vu = 290 kN

$Mu/bd^2 = 473 \times 10^6/(1000 \times 625^2) = 1.2$

Pt= 0.50% Ast = 3125 mm^2

$\tau u = 290 \times 10^3/1000 \times 625 = 0.45$ N/ mm^2

$\tau c = 0.48$ N/mm^2 **SAFE**

Provide 20Ø @ 100 c/c main steel on Earth face

Provide 12Ø @ 200 c/c main steel on free face

Provide 12Ø @ 200 c/c Distribution steel