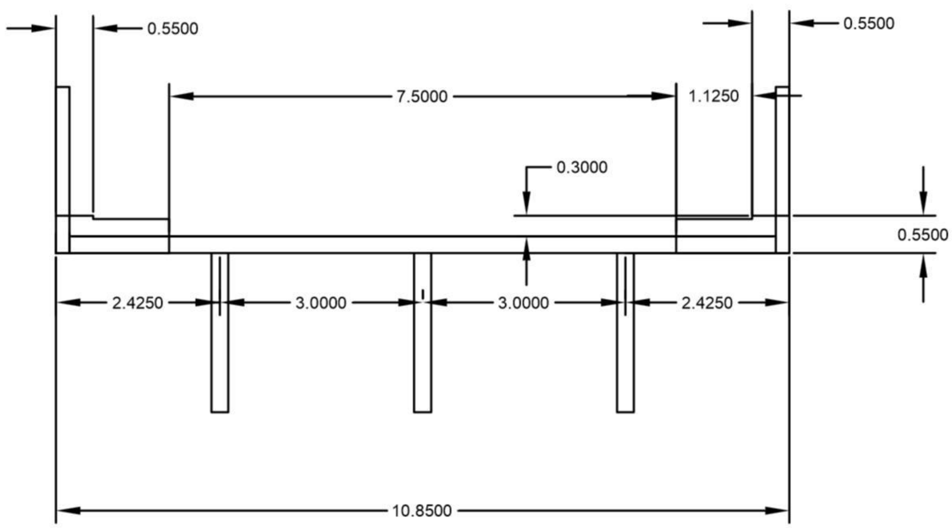
Structural Design of Bridge Khadi Khad, Pathankot



All unit in meter(m)

DECK SLAB

Thickness of slab = 0.25

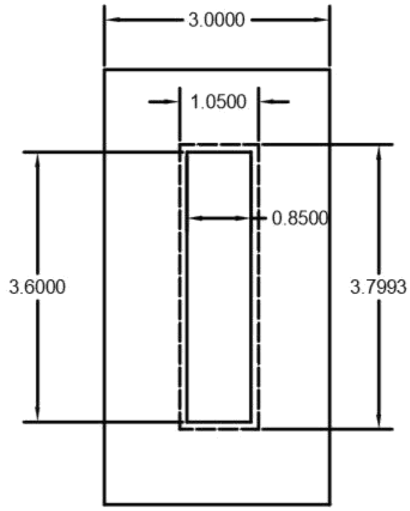
Wearing Coat = 0.1 m

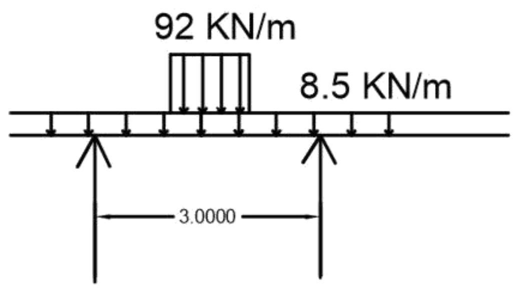
Grade of Concrete = M30

Dead Load = 6.25 KN/ m^2

DL of Wearing Coat = 2.2 KN/ m^2

Total DL = 8.5 KN/ m^2





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 = 350/0.380 = 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 × 8/10 + 56.92 × 4/8 × 1.25 = 43.25 KN-m

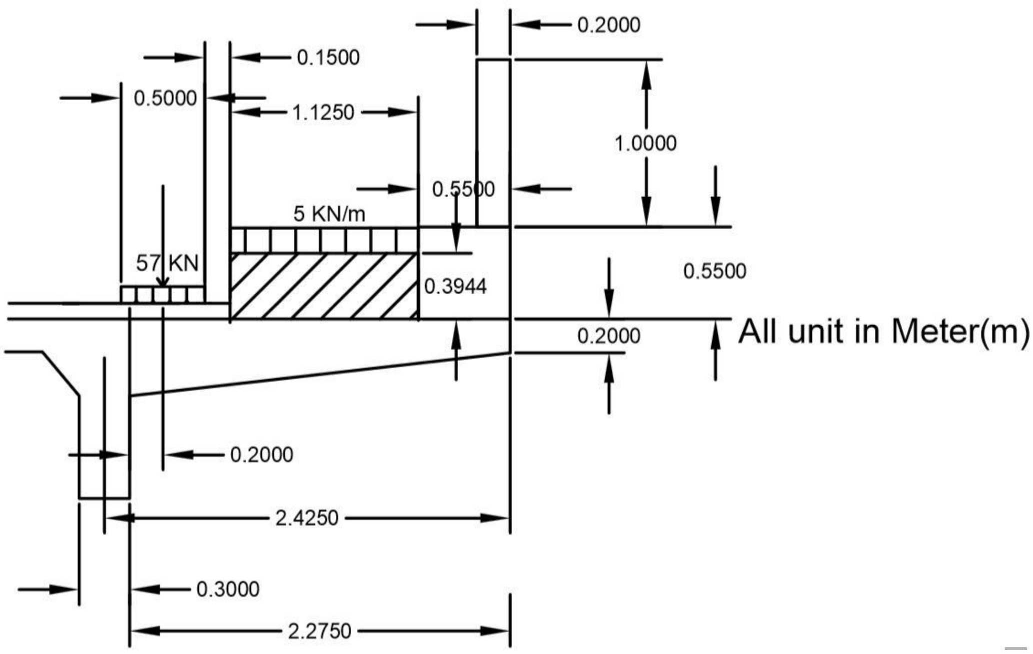
S.F = 8.5 × 3/2 + 92 × 1.05/2 × 1.25 = 73.13 KN-m

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 × 0.1) = 0.69 m

Live Load/m = 57 × 1.5/0.69

Maximum moment due to L.L = 123.9 × 0.2 + 5*1.125 * 0.763 = 29.07 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 = 29.07 + 34.75 = 63.82 KN-m

S.F = (123.9 × 0.45) + 5 * 1.125 + (7.6 + 14.8 +1.8) = 83.6 KN

Mu = 95.73 KN-m

Vu = 128.4 KN-m

$Mu/bd^2 = 95.73 \times 10^6/1000 \times 300^2 = 1.064$

Pt = 0.265%

Ast = 7.95cm^2

Provide ϕ12@ 100 c/c main

Provide ϕ 10 @ 150 c/c dist.

Longitudinal Girders (Intermediate Girders):-

B.M due to dead load (Intermediate Girder/m length)

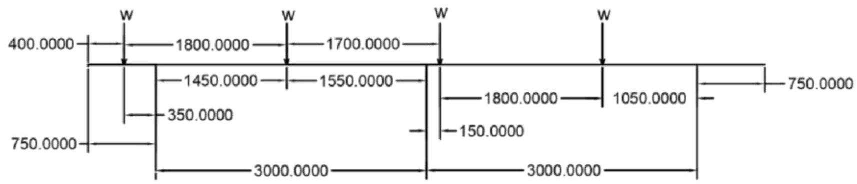
Sr No.	Item	Details	Weight (KN)
1. 2. 3. 4.	Wearing Coat Deck Slab Tub Cross Beams	3.0 × 0.1 × 22 3.0 × 0.25 × 25 0.4 × 2.0 × 25 (3.0 × 2.0 × 25 × 0.5)/41	66 18.75 20 2.57(say) = 47.92 KN/m ≈ 50 KN/m

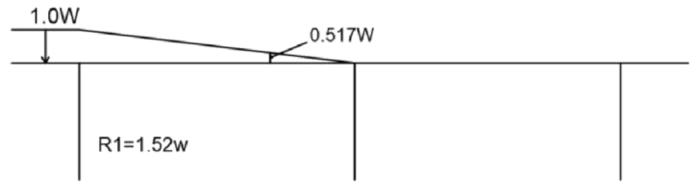
Maximum B.M due to DL = $50 \times 41^2/8 = 10506$ KN-m

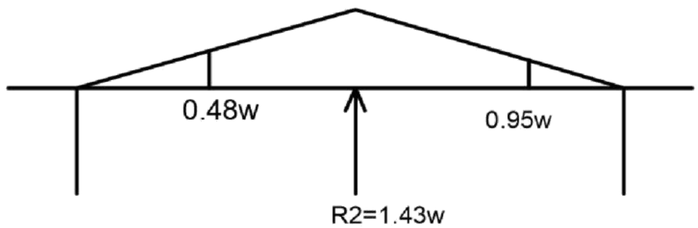
Maximum S.F due to DL = 50 × 41/2 = 1025 KN

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 Cub	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.	Cross Beam		1.29 (say)
			= 41.5 KN/m ≈ 42KN/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

Seismic analysis:

T= 2.0√D/1000F

D= DL+ 0.2LL =3075 + 0.2*(365*3) = 3294 kN

Here F=D*6EI/L^3

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

T = 2.0√3294/1000*1623 = 0.9 sec

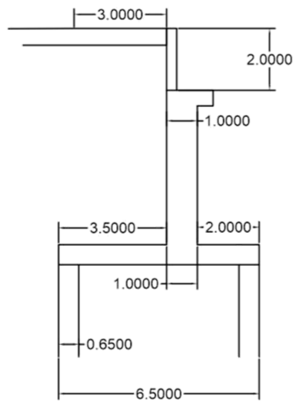
Sa/g = 1.1

Ah = Z/2 * 2 *I *Sa/g =0.24/2*(1.2*1.1)= 0.16

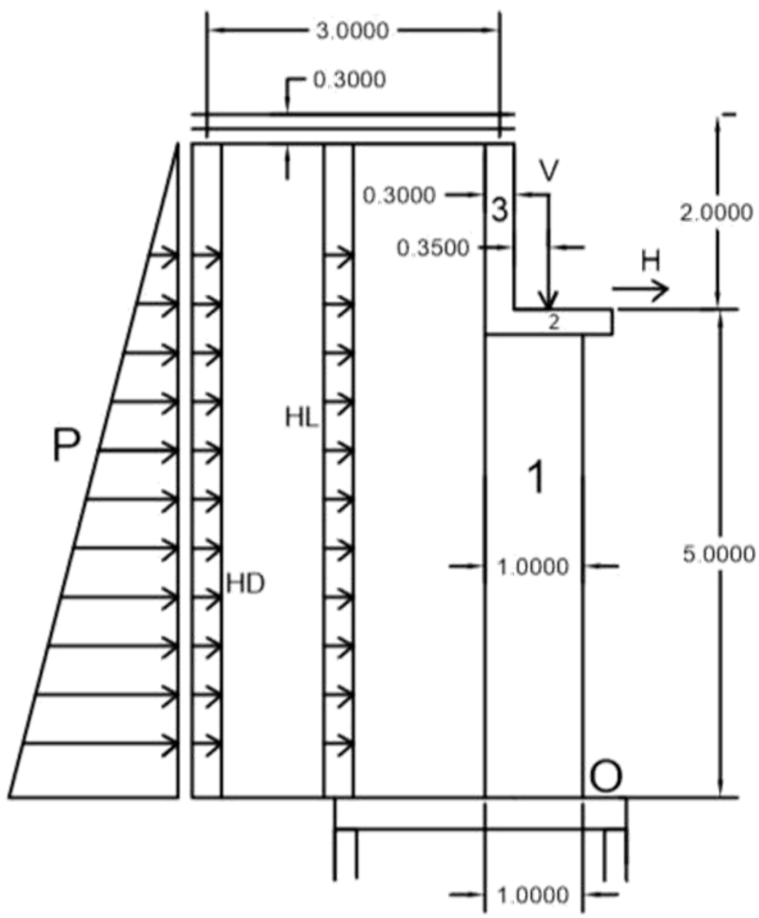
H = 0.16 * 1244 = 199 kN

M = 199 * 5 = 995 kN

Total moment = 995 + 869.3 = 1865 kN m



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	1025 * 3/ 7.5 =410	--	0.15	61.5
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*3/7.5 =146	--	0.15	219
7.	Horizontal Bending moment	---	15	5.71	86
	Total	769	170		869.3 kNm

Total vertical load at base = 769 * 7.5 = 5768 KN

Total horizontal load at base = 170 * 7.5 = 1275 kN

Total bending moment at base = 869 * 7.5 = 6518 KNm

Design of Abutment :-

1.5 (DL+LL):

M= 869.3 KN- m

Mu =1304 KN-m

V = 170 KN

Vu = 255 KN

$Mu/bd^2 = 1304 \times 10^6/(1000\times950^2) = 1.45$

Pt = 0.368%

1.2 (DL+LL+EQ):

M=1865/7.5 = 248.67 KN- m

Mu =373 KN-m

V = 170 +448/7.5 = 230 KN

Vu = 276 KN

$Mu/bd^2 = 373 \times 10^6/(1000\times950^2) = 0.41$

Ast = 3496 mm^2

$\tau u = 276 \times 10^3/1000 \times 950 = 0.29$ N/ mm^2

$\tau c = 0.36$ N/mm^2 **SAFE**

Provide 20Ø @ 80 c/c main steel on Earth force

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

Provide 12Ø @ 100 c/c Distribution steel

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)

M= (3843-1190)×7.5 = 19898 KN-m

V = 1098×7.5 = 8235 KN

H = 289× 7.5 = 2168 KN

DESIGN OF WELL

Min thickness of stiening = 500 mm

Thickness = h= Kd√L =0.030 ×6.5 ×√13 =0.703 m (Provide 750mm)

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%)

=.12/100 × π/4 × 23.78 =.023 m^2 = 230 cm^2

Provide 12 ϕbars @ 100 c/c on each face vertically

Horizontal reinforcement (0.2%)

Provide 12Ø @100c/c on each face

Bottom Plug

Thickness of bottom plug is

$t^2 = 1.18 \times r^2 q / fc = 1.18 \times 3.25^2 \times 400 / 7000 = .71$ m say 800 mm

Check For Section adopted

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

X = √(2FH/–Ka)γb(Kpβ

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 $x^2 = 2 * 2 * 1275/(9.5(5-0.3)6.5) = 17.57$ X = 4.19m

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 = 0.012 × 27226 = 327 KN-m

Mmax = 327 + 2/3 × 1275 × 4.19 = 3888 KN-m

MOI = $\pi/64 \times - 5(.2^4)6+(.65^4.5*6.5^3/12 - 6.5*5.2^3/12) = 124.32\ m^4$

Max Stress in steining

σmax = 33058 / 23.78+(3888/124.32 × 3.25)

1390±103 KN/m² = 1492 KN / m² =1.5 N/mm²< 6.0 N/ mm² (M25)

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

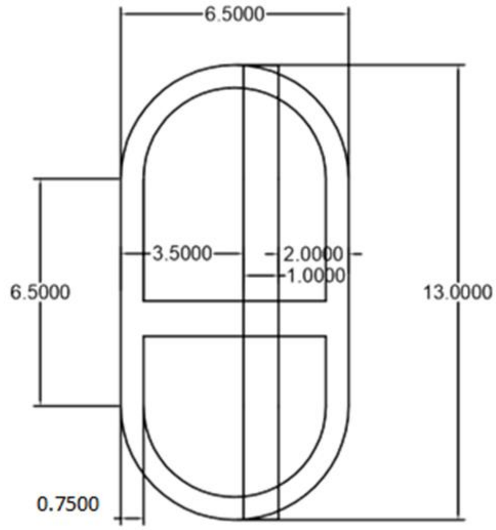
Upward Pressure = μP ;

$P = \gamma(Kp - Ka)LD^2/6$

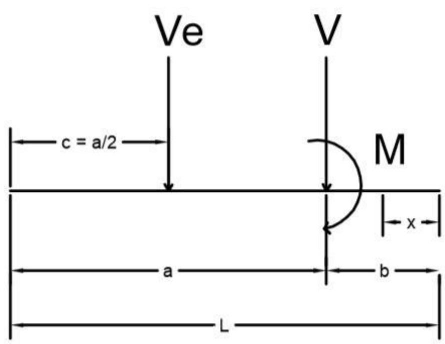
P= 9.5(5-0.3) 13*5.78² /6 =3232 kN

Total vertical load = (33058-3232)= 29826 KN

Bearing pressure = 29826/75.43 = 395.4 KN/m²



Design of well cap



L = 5.85 m
b = 1.54 m
a = 4.31 m
c = 2.16 m

(At x = b)

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

M = 3904 × 2.16 × 1.54/5.85 + 6518 × 1.54/5.85 + 5768 × 1.54/5.85 = 2220+1716+1518 = 5454 KM-m

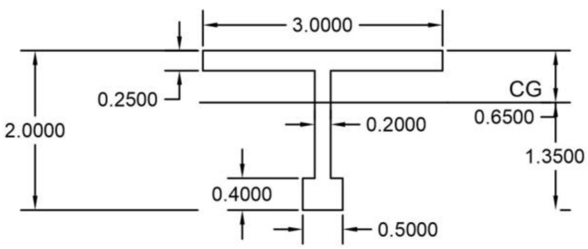
S.F = 3904 × 2.16/5.85 + 6518/5.85 + 5768 × 4.31/5.85 = 6805 KN M/Width = 5454/13 = 420 KN-m , Mu = 630 KN-m/m

S.F/Width = 6805/13 = 523 KN , Vu = 785 KN/m Tu = 785 × 10^3/1000×950 = 0.83 M/mm²

Mu/bd^2 = 630 × 10 /1000×950^2,pt=.197% = 0.698

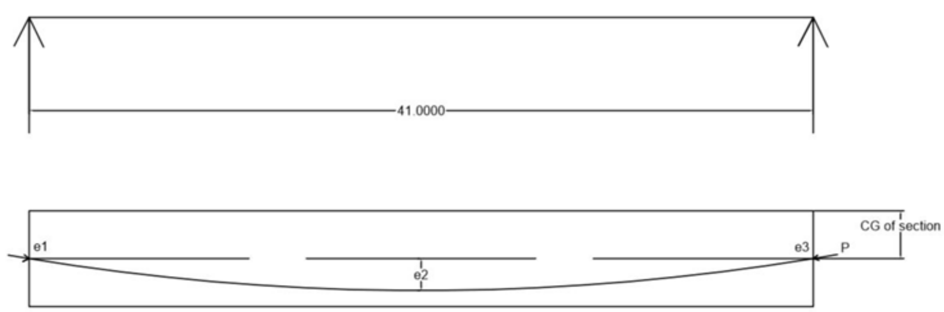
Ast = 18.72 cm²/m , provide = 16ϕ@ 100 c/c bathway at bottom Provide 12 ϕ@100 c/c bathway at top.

Analysis of Girder with Staad Pro:-



All units in meter(m)

P= 12000 kN , e1 =e3 = 0 ,e2 = 1.00 m



P = 12000 KN, e1 = e3 = 0, e2 = 1.0 m

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 1000 mm.

Post stressing force required = 12000 kN

Post stressing force at Jack Level = 12000x1.1 = 13200 kN

Provide 3 cables

Post stressing force in each cable = 4400 kN < 5366 kN

Safe

Base Pressure Calculations

Moment at base of well = 53.74 * 18=3582kNm

Total Moment = 3888 +3582 = 7470 kNm

Total vertical Load when half well is empty =29826-4341=25485kN

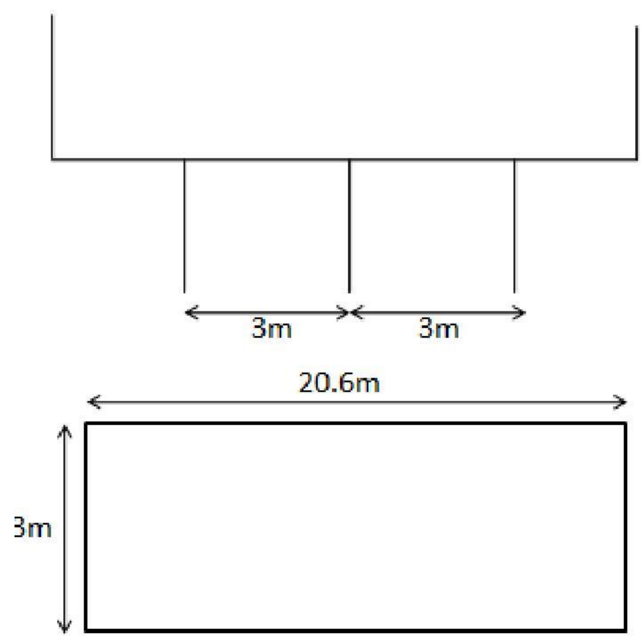
MOI = л/64 * 6.5^4+6.5*6.5^3/12 = 237.4 m^4

Beam pressure with BG = 25485/75.43 +7470*3.25 /237.4 = 440 kN/m^2 < 400* 1.5 kN/m^2 Beam pressure

without BG = 25485/75.43 +3888*3.25/237.4 = 391.1 kN/m^2 > 400 kN/m^2

Safe

Design Cross Beam

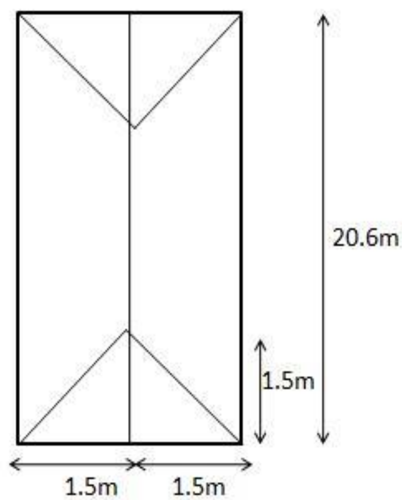


Given

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

Step1:- Dead Load:

Spacing of Main girder / Beam	=	3	m
Weight of rib of x- beam	=	1.4 x 0.4 x 25	
	=	14	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

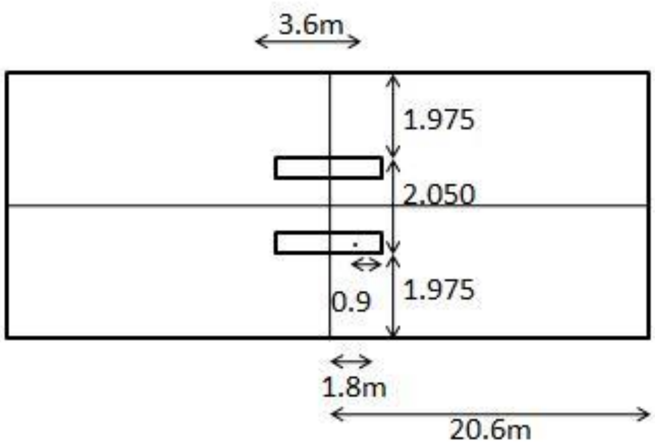
= 12.68 kN/m

Total dead load per meter run = 14+38.025 = 26.7 kN/m
This load is assumed uniformly distributed along
This cross – gird
The reaction on each longitudinal girder

= 26.7*2*3/3

= 53.4 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

= 53.4*1.975-(26.675(1.975/2)^2)

= 80 kN-m

Total Bending Moment = 507+80

= 587 kN-m

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

Impact

= 257 kN

Dead Load shear = 53.35 kN

Total shear for depth = 53.35+257

= 310.4 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 = 310.35*1000/400*1597.5

= 0.486 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

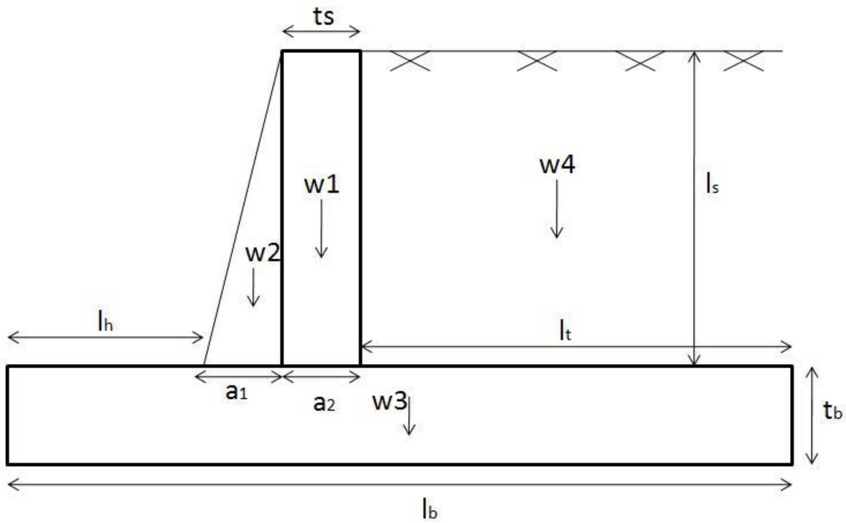
Minimum shear reinforcement = 226/400*.0015

= 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 Return Wall



Given

ϕ =		30 ˚
γ=		19.5 kN/m^3
h =		5 m
l_t	=	2.5 m
l_h	=	0.5 m
a1	=	0.4 m
a2	=	0.25 m
ts	=	0.65 m
tb	=	0.9 m
γ_c	=	25 kN
Live load	=	75 kN
fck	=	30
fy	=	415

Step1:-

K_a = (1-Sinϕ)/(1+Sinϕ)

Sinϕ= 0.5

K_a = 0.33

b = 3.65 m

Step2:-

S.No.	Description	Vertical load	Horizonal load	Lever Arm	Clockwise moment	clockwise moment
1	Steam (Rectanglar portio =	a1*h*ɣc50		0.95	47.5	
2	Steam (Triangular portion =	0.5*h 15.625		0.667	10.422	
3	Base slab =	b*tb*ɣc82.125		1.825	149.878	
4	Earth fill =	h*lt*ɣ243.75		2.4	585	
5	Live load =	75 75		2.4	180	
6	Earthfill Horizonal =		81.25	1.667		135.44
7	Live load Horizonal =		80	2.5		200
	Total	466.5	161.25		972.8	335.44

stem thickness at base (d) required = $\frac{1.5\times335.42\times10^{6}}{30\times1000\times0.136}$

= 351.2 mm

provided (d) = 590 mm safe

b = 1000 mm

stem thickness at base(d) = 590 mm

R = 1.445

% of steel = $\frac{fck}{2\times fy}\times\left[1-\frac{\sqrt{1-4.6\times R}}{fck}\right]$

= 0.004255 %

Ast requried = 2510.45 mm2

Check For shear at base of stem

Zv = 1.5*V/b*d

= 0.41

Z v< Zc Safe .

Design of Parapet:-

Horizontal load = 150 kg/m2

Width of wall considered = 1 m

B.M. = 0.5*150*1

6

1.5×0. ×10

= 75 kg-m

[redacted]

=30×1000.75×0KN.136-m

M.O.R. = 0.136*fck*b*stem thickness at base(d)^2

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.