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Testing & Consultancy Cell

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HYDRAULIC CALCULATION

Introduction: The Ansal Buildwell group is developing an integrated township of 27 acres named as Florence City at Pathankot (Punjab) near Abrol Nagar posh area. Ansal site is located along Khadi Khad. A flexible pavement is laid along the left side of Khad. The average height of road from the avg bed level is about 2.5 m. The side of khad is not defined and the height from average bed level varies from 1m to 2m. It is noted the discharge 16025 cusec d/s and 12000cused u/s could not be pass through the existing cross section of khad. At present while calculating the width of khad so that Max. height of water could not raise more than 2.5m, a discharge of 16025 cusec is taken. The bridge proposed is of single span and the existing width is not altered at any point. Outcome from calculation is tabulated as below. It is noted that as width of khad is not altered at any point, the effect at u/s and d/s is not considered.

Description	Value
Average bed Level	**320.69 Mtrs**
Max. height of water surface	**2.5 Mtrs**
HSL	**323.19 Mtrs**
Bed width	**39.8 Mtrs** upto Drang Khad outfall in Khadi Kahd
Length of protection work at u/s	**300' u/s** upto Drang Khad outfall in Khadi Kahd and 150' beyond this point
Length of protection work at u/s	**150'**

1.) At 300 meter u/s of proposed (incomplete) bridge at conflux of khadi khad and canal by P.W.D. :-

Data taken from PWD/ Irrigation Deptt.

1.) Bed Width of KhadiKhad	= 35 Meters
2.) H.F.L.	=321.31 Meters
3.) Average bed level	= 319.595 Meters
4.) Average Depth	= 1.715 Meters
5.) Bed Slope	= 1 IN 359

6.) Discharge(in Khadi Khad) = 10894 Cusecs

(This discharge is taken at u/s of PWD proposed Bridge, i.e. it is at d/s of proposed Bridge site by Ansal Group. Hence this includes all discharge from Kaddi Khad, Drang Khad and discharge from whole of its catchment area)

2.) AT SITE OF PURPOSED BRIDGE : -

Data from field Survey

1.)Available BedWidth(clear waterway) = 39.8 Meters

Total width available = 43.00m)

2.) Average Bed Level = (1053.14 + 1050.67 + 1049.67 + 1050.70 + 1053.82 + 1054.82) /6

= 1052.136 Feet

= 320.69 Mtrs

3.) Available Depth of Khadi Khad = 2.5 Meters (from right bank)

CALCULATION OF H.F.L. AT PURPOSED BRIDGE SITE :-

At 300 Meters u/s of P.W.D. Bridge in KhadiKhad Discharge (Q) = 16025 Cusecs

= 453.8 Cumecs

Bed Width = 35 m

Discharge intensity (q_1) = 453.8/35

= 12.965 cumecs per meter width

Total Energy at this section (E_1) $= y_1 + (q_1{}^2 \div (2 \times g \times Y_1{}^2))$

= 4.627

At site of purposed Bridge Discharge (Q_2) = 16025 Cusecs

= 453.8 Cumecs

Bed width = 39.8 Mtrs

Discharge intensity (q_2) = 453.8/38.9

= 11.401 Cumecs per meter width

Energy (E_2) $= Y_2 + ({q_2}^2 \div (2 \times g \times {Y_2}^2))$

E_1-H_F= E_2

Y_2 = 2.1 Mtrs< 2.5 Mtrs (available depth)

Thus , H.F.L at the proposed site of bridge. = Avg. Bed Level+ Depth of water

= 320.69 +2.1

= 322.71 Mtrs

CALCULATION OF MAXIMUM DISCHARGE POSSIBLE AT PURPOSED BRIDGE SITE:-

Available Depth = 2.5 Mtrs

Available Bed width(clear waterway) =39.8 Mtrs

Area of cross-section (A) = 39.8X2.5 (let Rectangular Section)

= 99.8Square Mtrs

Wetted Perimeter (P) = 39.8 + 2.5 + 2.5

= 44.8 Mtrs

Hydraulic Mean Depth (R) = A/P

= 99.8/44.8

=2.221……………………………. (a)

Bed Slope (S) $=4.78 \times 10^{-3}$ (Average slope from proposed Bridge site to 1000' d/s)

Co-efficient of Rugosity(n) = 0.025

Velocity (V) $=(R^{(2/3)} \times \sqrt{S}) \div n$

= 4.7046 Mtrs/Sec. …………………………………. (b)

Discharge $= A \times V$

= 99.5X74.7076

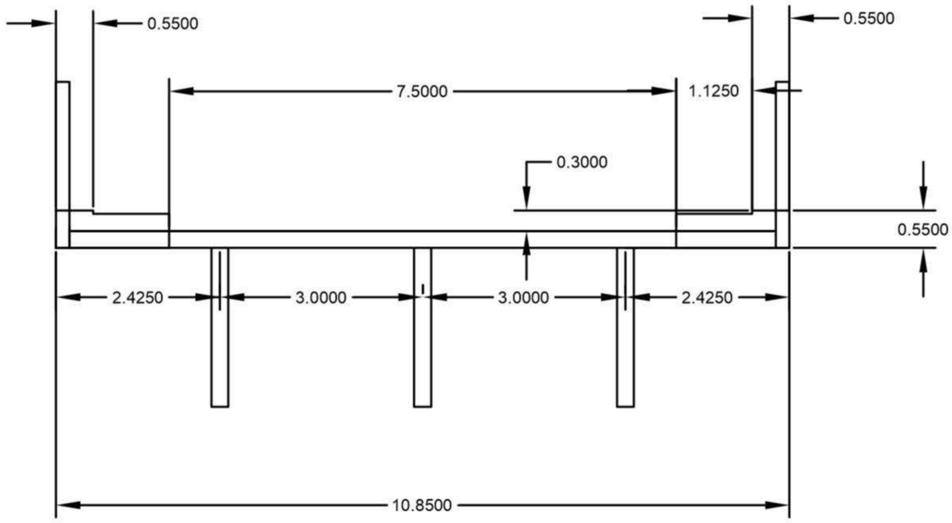
= 468.41 Cumecs

=16529 Cusecs > 16025Cusec calculated at d/ s of proposed site

Therefore if max discharge at d/s of proposed site is taken (As given by department at 300 u/s of proposed bridge site of department at khadi khad and canal), HFL calculated at bridge site (Proposed by Ansal Group) is 322.71 m i.e. depth required at this section is 2.1 m while 2.5 m depth is available . If the HFL is calculated based on 2.5m depth, **HFL will be 323.19 m** hence it is safe. It is also calculated that a max of **16529** cusecs discharge may pass easily under bridge of 39.8 m wide which is sufficiently more than **16025** cusecs (observed by PWD/ irrigation department)

Prashant Garg

Structural Design of Bridge Khadi Khad, Pathankot



All unit in meter(m)

DECK SLAB

Thickness of slab = 0.25

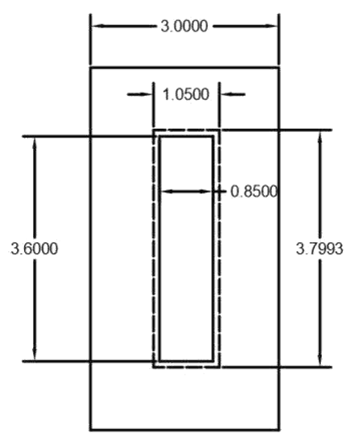
Wearing Coat = 0.1 m

Grade of Concrete = M30

Dead Load = 6.25 KN/ m²

DL of Wearing Coat = 2.2 KN/ m²

Total DL = 8.5 KN/ m²



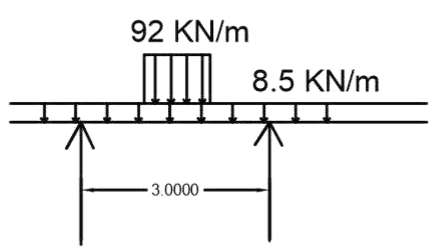
Class AA Tracked Vehicle

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

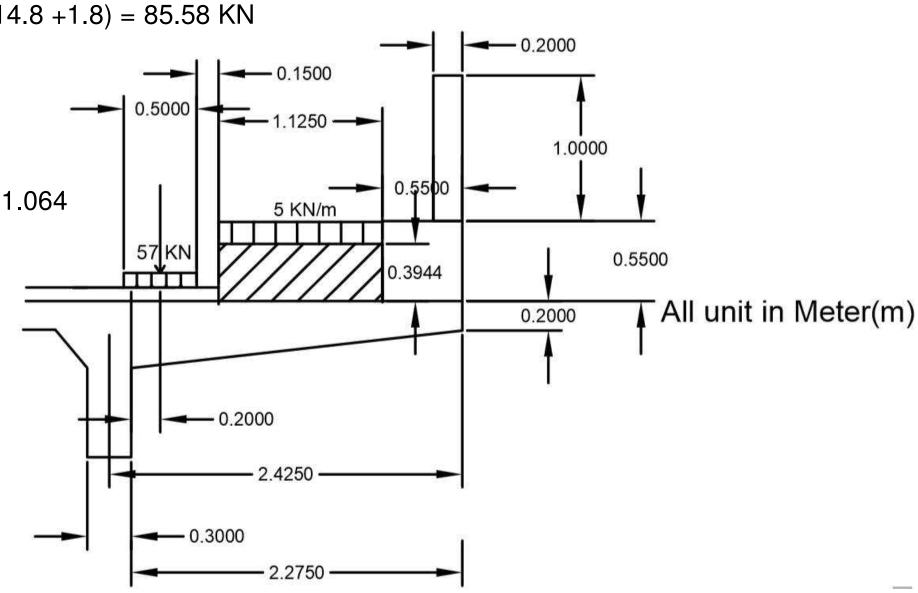
$Mu/bd^2 = 96.5 \times 10^6/1000 \times 300^2 = 1.064$

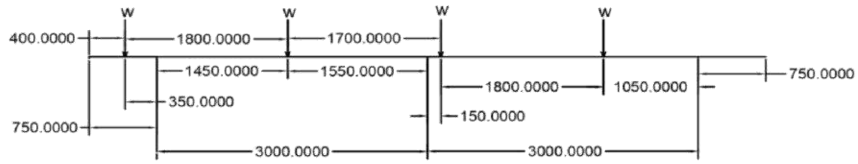
Pt = 0.265%

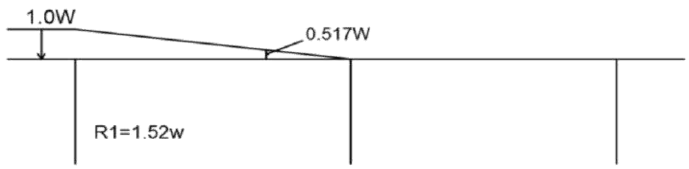
Ast = $7.95 cm^2$

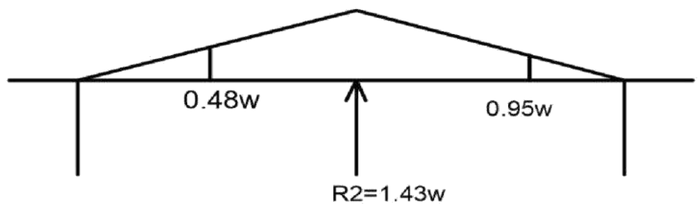
Provide ϕ12@ 100 c/c main

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:-

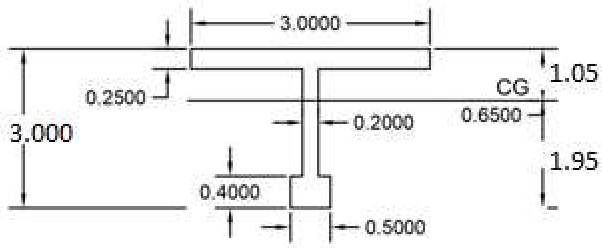
Sr No.	Item	Details	Weight (KN)
1.	Wearing Coat	0.75 × 0.1 × 22	4.96
2.	Deck Slab	0.263 × 2.425 × 25	15.94
3.	End beam	0.55 × 0.55 × 25	7.56
4.	Parapet	0.2 × 1 × 25	5
5.	Front Path	0.3 × 1.125 × 20	6.75
6.	Self weight	0.4 × 3.0× 25	30
7.	Cross Beam		1.29 (say)
			= 71.5 KN/m ≈ 75KN/m

Live Load Calculations:-

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

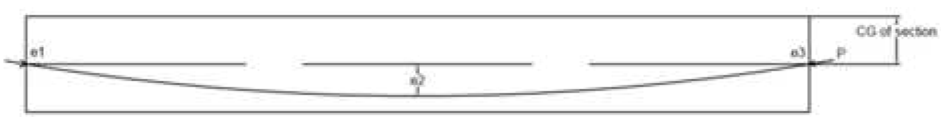
Max. Wheel Load(W) = Axle Load/2 × 1.1 × 1.52 = Axle Load × 0.836

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

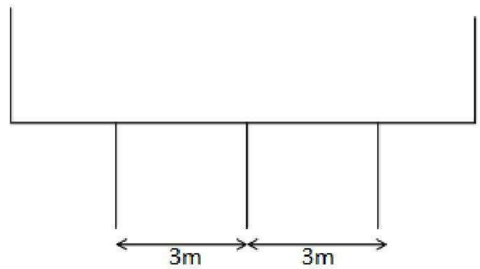
Post stressing force at Jack Level = 11000x1.1 = 12100 kN

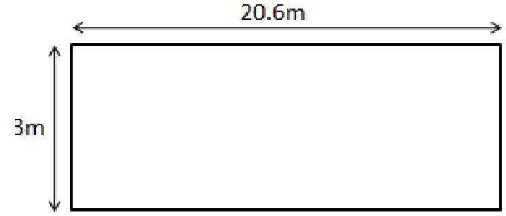
Provide 3 cables

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

Safe

Design Cross Beam



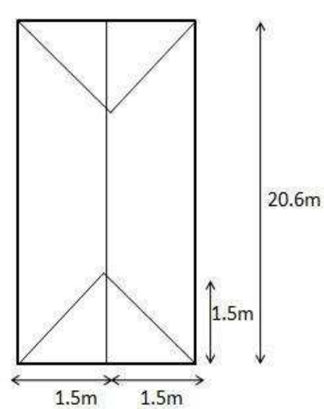


Given

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

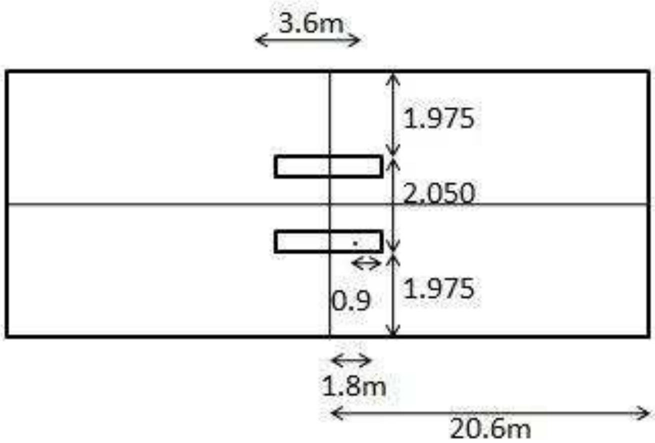
Total dead load per meter run = 24+38.025 = 36.7 kN/m
This load is assumed uniformly distributed along
This cross – gird
The reaction on each longitudinal girder

= 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

$Mu/bd^2 = 1035 \times 10^6/(1000 \times 950^2) = 1.15$

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

$Mu/bd^2 = 1688 \times 10^6/(1000 \times 950^2) = 1.87$

Pt= 0.50% Ast = 4750 mm^2

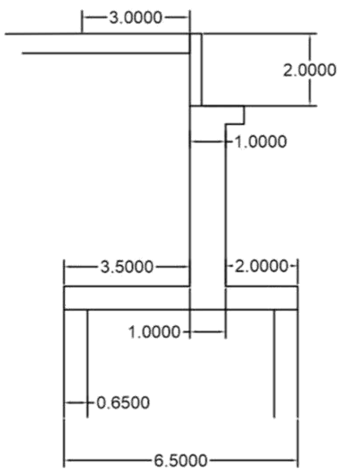
$\tau u = 381.3 \times 10^3/1000 \times 950 = 0.40$ N/ mm^2

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

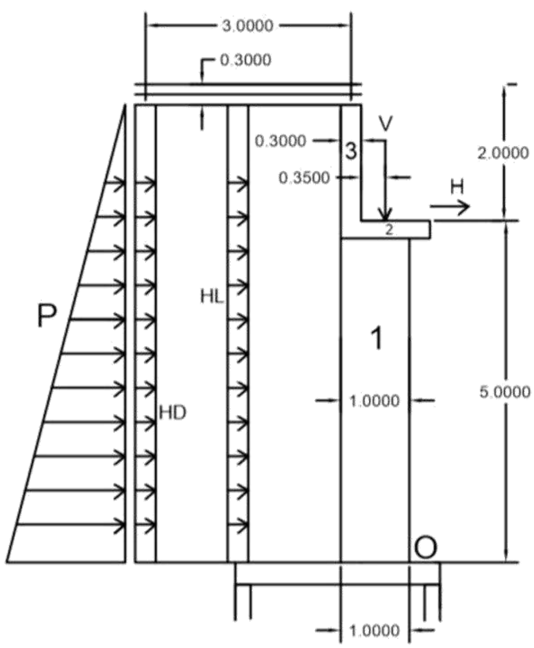
Provide 25Ø @ 125 c/c main steel on Earth force

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

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

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

Check For Section adopted

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

$X = \sqrt{(2FH/(\gamma(K_p - K_a)B)}$

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

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

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

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 ;

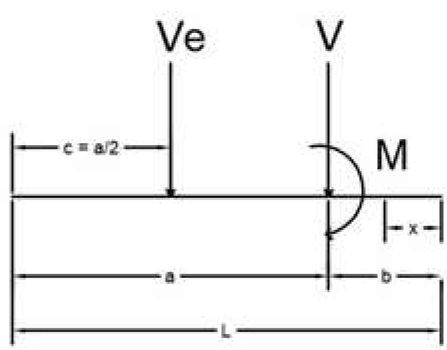
$P = \gamma(Kp-Ka)LD^2/6$

$P= 9.5(5-0.3)\ 15.78^2 /6 =3729$ 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/mm^2

Mu/bd^2 = 2867 × 10^6 /1000×1450^2 =1.32
Pt=0.33%

Ast = 4950 mm^2/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/m²

Surcharge =80 kN/m²

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 mm²

$\tau u = 290 \times 10^3/1000 \times 625 = 0.45$ N/ mm²

$\tau c = 0.48$ N/mm² **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

Design of Bearing Pad

Given

Max. Dead Load	=	1850	kN
f_{ck}	=	30	
Thickness	=	75	mm
Live load	=	365	
	=	365	kN
Horizontal force due to live load	=	80	kN
Assumed Size of bearing pad			
Effective Breadth of pad(bp)	=	550	mm
Effective Length of pad(Lp)	=	950	mm
Side cover(Sc)	=	6	mm
Thickness of steel	=	10	mm

Step 1-

Thickness should be between breadth of pad(bp)/10 to Length of pad(Lp)/5

55 to 110

O.K

Step 2-

Live load	=	400	kN
Loaded area	=	(bp*Lp)-(2(bp+Lp)*Sc)	
		5E+05	mm^2
Total load (Nmax)	=	DL+LL	
	=	1390	kN
Approx.	~	1400	kN
Nmin	=	1025	kN
A1	=	4	
A2	=	2	
A1/A2	=	2	

Step 3- Grade Provided M30 :-

Allowable contact pressure = $0.25 \times fck \times \sqrt{\frac{A1}{A2}}$

		10.61	Mpa
Effective area of bearing required	=	1400*1000/10.61	
	=	13.2	mm^2
σ_m	=	total load/loaded area	
	=	2.775	Mpa

Step 4- Thickness of individual Elastomer layer

hi	=	15	mm
No.	=	5	
Thickness of steel Laminates	=	10	mm
Overall thickness of bearing	=	75	mm
Side cover	=	6	mm
Total thickness of elastomer(t)	=	55	mm
Shear modules assumed , d	=	1	N/mm^2
Shear strain due to creep, shrinkage , temprature(L)	=	5E-04	
From temp. sheet(K)	=	41000	
Shear strain per bearing due to creep, shrinkage ,temprature	=	(L*K)/2t	

= 0.186

Shear strain due to longitudinal force = 80*1000/504500

0.159

Shear strain due to translation = B/loaded area

= 0.345 Safe

Step 5- Calculation of rotation,

$\sigma_{,min}$ = 0.5*σm*hi/b*s^2

Effective Breadth of pad(bp) N = 550-12

= 538 mm

Effective Length of pad(Lp) O = 950-12

= 938 mm

s = 15

(I) Shape factor (s) = Loaded area/(2(N+O)h_i)

= 11.39 safe

(ii) Assume, σ_m, max. = 10 MPa

αb_i , max. = 0.5*σm*hi/b*s^2

= 0.001 radians

P = 2.973

β = P/10

= 0.297 MPa

Permissible rotation = β*Effective Breadth of pad(bp) N*αbi , max.

= 0.002 MPa

Step 6- Friction

Shear strain(Z) = 0.345 MPa

Check:-

= 0.2+0.1*σ_m

= 0.478 safe

where, σ_m = 2.775

Check:- 2MPa<σm<10MPa satisified

Total Shear Stress

Step 7- Shear stress due to compression(X) = (1.5*σm)/s

= 0.365 MPa

Shear Stess due to Horizonal deformation(Y) = 0.5*b/hi^2*αbi

= 0.688 MPa

Shear Stess due to Horizonal rotation = X+Y+Z

= 1.398 MPa safe

Grit Wall analysis

Input data

Material of blocks - filling

Number	Name	γ [kN/m ^{3}]	φ [°]	c [kPa]
1	Rubble Masonry	24.00	45.00	0.00

Material of blocks - mesh

Number	Name	Strength overh. R_t [kN/m]	Spacing of vert. meshes b [m]	Bear.cap. of front joint R_s [kN/m]
1	Rubble Masonry	0.00	35.00	0.00

Geometry of structure

Number	Width b [m]	Height h [m]	Offset a [m]	Material
14	0.30	0.82	0.00	Rubble Masonry
13	0.30	1.20	0.00	Rubble Masonry
12	0.30	1.20	0.00	Rubble Masonry
11	0.30	1.20	0.00	Rubble Masonry
10	0.30	1.20	0.00	Rubble Masonry
9	0.30	1.20	0.00	Rubble Masonry
8	0.30	1.20	0.00	Rubble Masonry
7	0.30	1.20	0.00	Rubble Masonry
6	0.30	1.20	0.10	Rubble Masonry
5	0.40	1.20	0.20	Rubble Masonry
4	0.60	1.20	0.20	Rubble Masonry
3	0.80	1.20	0.20	Rubble Masonry
2	1.00	1.20	1.00	Rubble Masonry
1	2.00	1.20	-	Rubble Masonry

Gabion slope = 45.00 °
Overall height = 10.41 m
Overall wall volume = 8.89 m^3/m

Soil parameters

Soil Sandy
Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 10.00 °
Soil : cohesionless
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Geological profile and assigned soils

Number	Layer [m]	Assigned soil
1	15.00	Soil Sandy

Terrain profile

Terrain behind the structure is flat.

Input surface surcharges

Number	Surcharge		Action	Mag.1	Mag.2	Ord.x	Length	Depth
	new	change		[kN/m ^{2}]	[kN/m ^{2}]	x [m]	l [m]	z [m]
1	YES		permanent	5.00				on terrain

Resistance on front face of the structure

Resistance on front face of the structure: passive
Soil on front face of the structure - Soil Sandy
Angle of friction struc.-soil δ = 0.00 °
Soil thickness in front of structure h = 1.10 m

Terrain in front of structure is flat.

Global settings

Active earth pressure calculation - Coulomb
Passive earth pressure calculation - Coulomb

Settings of the stage of construction

Analysis carried out according to classical theory (safety factor)

Safety factor for slip = 1.50
Safety factor for overturning = 2.00
Factor of safety for bearing capacity = 1.00
Safety factor for net stress = 1.00

Verification No. 1

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. Z [m]	F_{vert} [kN/m]	App.Pt. X [m]	Design coefficient
Weight - wall	0.00	-2.67	213.26	4.83	1.000
FF resistance	-17.51	-0.37	17.51	2.06	1.000
Active pressure	56.35	-2.46	-39.46	5.28	1.000
Surch.1 - surface	2.55	-4.39	-1.79	7.22	1.000

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 843.79 kNm/m
Overturning moment M_{ovr} = 143.20 kNm/m

Safety factor = 5.89 > 2.00

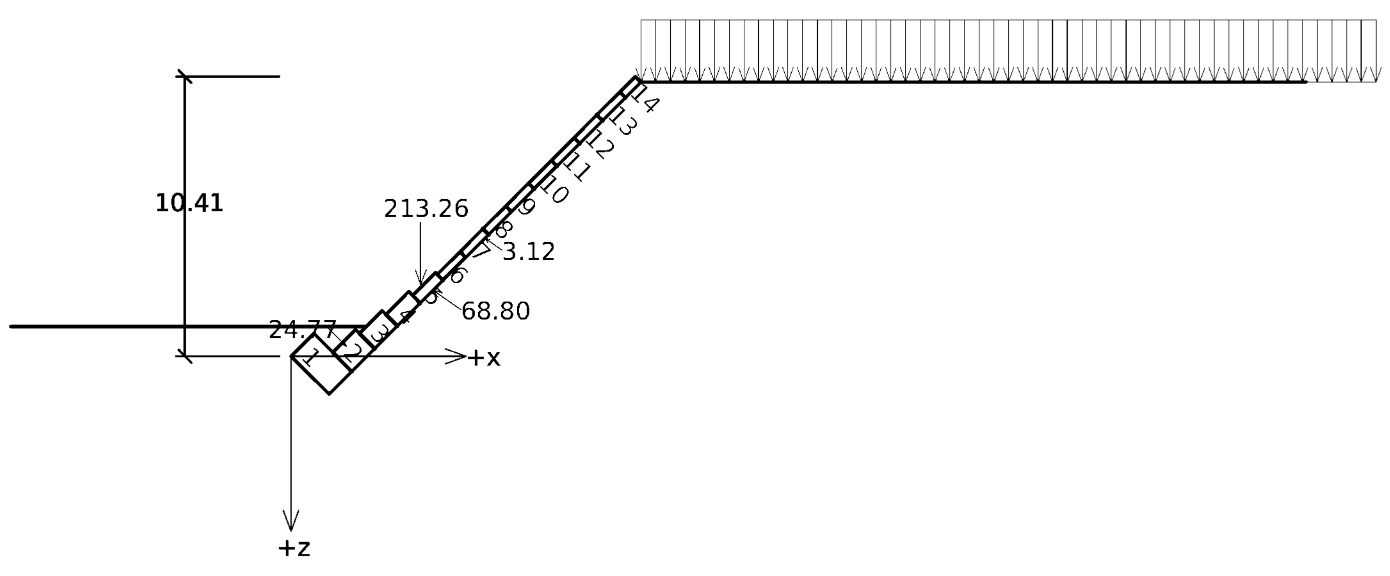
Wall for overturning is SATISFACTORY

Forces acting at the centre of footing bottom

Overall moment M = -537.30 kNm/m
Normal force N = 163.29 kN/m
Shear force Q = -86.19 kN/m

Overall check - WALL is SATISFACTORY

Name : Geometry	Stage : 1; Analysis : 1



Bearing capacity of foundation soil

Forces acting at the centre of the footing bottom

Number	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [m]	Stress [kPa]
1	-537.30	163.29	-86.19	0.00	81.64

Bearing capacity of foundation soil check

Eccentricity verification
Max. eccentricity of normal force e = 0.0 mm
Maximum allowable eccentricity e_{alw} = 660.0 mm

Eccentricity of the normal force is SATISFACTORY

Footing bottom bearing capacity verification
Max. stress at footing bottom σ = 81.64 kPa
Bearing capacity of foundation soil R_d = 180.00 kPa

Safety factor = 2.20 > 1.00
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Slope stability analysis

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	-10.21	[m]	Angles :	α_1 =	-35.28	[°]
	z =	2.27	[m]		α_2 =	80.61	[°]
Radius :	R =	13.94	[m]				
The slip surface after optimization.							

Slope stability verification (Bishop)

Sum of active forces :	F_a =	675.03	kN/m
Sum of passive forces :	F_p =	1028.21	kN/m
Sliding moment :	M_a =	9404.34	kNm/m
Resisting moment :	M_p =	14324.83	kNm/m

Factor of safety = 1.52 > 1.50

Slope stability ACCEPTABLE

GURU NANAK DEV ENGINEERING COLLEGE, LUDHIANA
Accredited by NBA (AICTE), New Delhi (ISO 9001:2000 Certified)
Testing & Consultancy Cell

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Environmental Engg.	*Prof. Puneet Pal Singh, M.E*

SOIL INVESTIGATION REPORT

1.	**Date of Testing**	**:**	*11.06.2015 to 13.06.2015*
2.	**Type of Structure**	**:**	*Bridge*
3.	**Site location**	**:**	*Latitude : 32.28413 Longitude : 75.63406*
4.	**Map**	**:**	
5.	**Tested in Presence of**	**:**	*S. Gurmeet Singh, AGM, Ansal City*
6.	**Report Submitted to**	**:**	*AGM* *Ansal City* *Pathankot*
7.	**Report Prepared by**	**:**	*Dr. J. N. Jha* *Dr. Kulbir Singh Gill* *Dr. B. S. Walia*

Construction of Bridge to Apoch Ansal City, Near Abrol Nagar, Pathankot

Introduction

The soil investigation for the proposed **Construction of Bridge to Apoch Ansal City, Near Abrol Nagar, Pathankot** had been taken up on request of **AGM, Ansal City, Pathankot.** The field soil investigation as per requirements was carried out on **11.06.2015 to 13.06.2015** by testing team of this institution in the presence of **S. Gurmeet Singh, AGM, Ansal City** of the concerned department.

The purpose of this soil investigation was to determine the nature of the subsoil stratum and the safe net allowable bearing capacity of the soil.

Field Soil Investigation

Two bore holes were tested in the field Standard Penetration Test (S.P.T) was carried out at the proposed site as per I.S. Code 2131-1981 in the soil deposits at the foundation level and at an interval of 1.5 m or at the location where change of soil strata takes place during field testing. The samples of the soil both disturbed and tube samples were collected at different depths and were properly sealed in air-tight plastic bags after labelling them carefully to maintain the natural moisture content.

Laboratory Testing

The various samples (disturbed and tube) collected during field soil investigation were tested in the laboratory (as per Standard Methods) for finding.

(i) Grain size analysis and wet analysis

(ii) Atterberg's limits

(iii) Field moisture content

(iv) Bulk density

(v) Direct/ triaxial shear/Unconfined compression tests

Safe Bearing Capacity

As per I.S. Code 6403-1981, the least of the following shall be taken as safe net allowable bearing capacity of the soil.

(i) The safe net allowable bearing capacity from shear considerations is obtained by dividing net ultimate bearing capacity by a suitable factor of safety.

(ii) The safe net allowable bearing pressure that can be imposed on the base of the foundation without the settlement exceeding a permissible value is calculated either from settlement analysis or from the Standard Penetration Test Values (N) whichever is applicable depending upon the nature of sub soil strata.

Water Table

The underground (i.e. sub-soil) water was encountered at a depth 4.5 m at the time of field soil investigation.

..........2/-

CALCULATION OF SILT FACTOR

The silt factor was found from the average size of the bed particles for 10.0 m depth below the bed level of the drain.

SIEVE SIZE IN mm I	AVERAGE SIZE OF SIEVE OPENING IN mm II	PERCENTAGE MATERIAL RETAINED III	PRODUCT (II xIII)
19 -10	14.50	08	116.0
10 -4.75	7.37	10.5	77.38
4.75 -2.36	3.55	12	42.60
2.36 -1.180	1.77	12.5	22.12
1.180-0.600	0.8900	10	8.90
0.600-0.425	0.5125	9.5	4.87
0.425-0.300	0.3625	10	5.44
0.300-0.150	0.2250	15	4.50
0.150-0.075	0.1125	10	1.12
0.075	0.0375	2.5	0.090
		(II xIII) =	283.02

The average of bed particle size = m = 283.02/100 = 2.83 mm

Silt factor = f= $1.76\sqrt{m}$ = $1.76\sqrt{2.83}$ = 2.96

Calculation of Depth of Foundation

The hydraulic data used in these calculations have been supplied by the department.

Discharge = Q = 16025 cusec = 432.67 cumec.

Bed width of the drain = B = 39.8 m

Discharge per unit width = q = $\frac{Q}{B} = \frac{432.67}{39.8}$ = 10.87 cum/s

Normal depth of scour = R = 1.35 $\left[\frac{(10.87)^2}{2.96}\right]^{1/3}$ = 4.56 m

Maximum depth of scour = 2R = 2 x4.56 = 9.12 m

Depth of foundation from full supply level = 4/3 x9.12 = 12.13 m

Full supply depth = y = 2.5 m

Depth of foundation from bed level of the drain = 12.13 -2.5 = 9.63 m, Say = 10.0 m.

Proposed Substructure

The substructure i.e. foundation of the proposed Bridge is taken in the form of well foundation to be laid at a depth of 13.0 m (As desered by designer) below bed level of the drain. The least soil properties have been taken for calculating the bearing capacity of soil for the following types of foundation.

…........3/-

Well Foundation

Depth of well foundation below the bed level of the drain, D_f = 13.0 m (As desered by designer)

Size of well foundation = 13.0 m x6.5 m

Length of well foundation, L = 13.0 m

Width of wellfoundation, B = 6.5 m

The data obtained from the field soil investigation and the results of the laboratory tests have been used in the preparation of this soil investigation report.

Bearing Capacity Calculations

(A) Bearing Capacity Based on Shear Considerations

Refer I.S. Code - 6403-1981

Well Foundation

Depth of well foundation below the bed level of the drain, D_f = 13.0 m (As desered by designer)

Width of well foundation = B = 6.5 m

The soil properties at the foundation level i.e. at 13.0 m below the bed level are:

γ = 19.5 kN/m^3, c = 0.0 kN/m^2

ϕ = 30^0 , ϕ' = 21.10^0

Bearing Capacity factors are:

Nc' = 16.60, Nq' = 7.34 and Nγ ' = 6.60

Shape factors are:

Sc = Sq = 1.10 Sγ = 0.80

Depth factors are:

dc = 1.53 , dq = dγ = 1.27

Water table correction factor, w' = 0.5 (submerged case)

Ultimate net bearing capacity, q_u' = 0.67 x0.0 x16.60 x1.10 x1.53 +19.5 x13.0 x6.34x1.10 x1.27 +0.5 x19.5 x6.5 x6.60 x1.10 x1.27 x0.5 = 2245.24 +212.48 = 2457.73 kN/m^2

Safe net allowable bearing capacity = q_u'/2.5 = 2457.73/2.5 = 983.09 kN/m^2 . ..... (a)

(B) Bearing Capacity Based on Standard Penetration Test Value(N)

Refer I.S. Code -6403, 1981

S.No.	Depth (m)	Overburden pressure (kN/m^2)	Correction factor	Observed value of N	Corrected value of N
1	13.0	192.65	0.78	36	28.08
2	15.0	206.90	0.76	38	28.88

3	16.5	221.15	0.74	39	28.86
4	18.0	235.40	0.72	41	29.80
5	19.5	249.65	0.695	43	29.88

...........4/-

Depth of well foundation below the bed level of the drain, D_f = 13.0 m

Width of well foundation, B = 6.5 m

Safe net allowable bearing pressure for

B = 6.5 m, N = 29.04, S = 0.06 m & w' = 0.5] = 295.94 kN/m^2 ....(a)

Taking least of (a) & (b), the safe net allowable bearing capacity = 295.94 kN/m^2

The safe gross allowable bearing capacity for well foundation 13.0 m x6.5 m size at depth of 13.0 m below the bed level of the drain is 427.94 kN/m^2.

REMARKS

(i) The bore hole log showing the nature of sub-soil stratum along with standard penetration test values(N) at different depths & laboratory test results is attached.

(ii) The safe **Net** allowable bearing capacity for well foundation of size 13.0 m x6.5 m at depth of 13.0 m below the bed level of the drain is 295.94 kN/m^2.

(iii) The safe **Gross** allowable bearing capacity for well foundation of size 13.0 m x6.5 m at depth of 13.0 below the bed level of the drain is 427.94 kN/m^2.

(iv) The value of silt factor is 2.96 upto a depth of 10.0 m below bed level of the drain.

(v) The sub-soil water table was encountered at a depth 4.5 m at the time of field soil investigation.

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GURU NANAK DEV ENGINEERING COLLEGE, LUDHIANA

Testing & Consultancy Cell

Project- **Construction of Bridge to Apoch Ansal City, Near Abrol Nagar, Pathankot** Date of Commencement:-
Bore Hole Log. **I (Towards Ansal City Side)** Date of Completion :-
Type of Boring:- **Manual** Ground Wat

Depth (m)	Type of Soil	Bore Hole Log	L.L. %	P.I. %	Bulk Density (kN/m^3)	W %	Grain Size Distribution				C (kN/m^2)	Ø	'N' Value	Grap Repr of 'N
							% Grav.	% Sand	% Silt	% Clay				
3.0 4.5 6.0 7.5 9.0	Bed Level Sand with Gravels (GP)		-	-	21.8	5.8	37	58	05	-	0.0	33^0	Refusal	

10.5 12.0 13.5 15.0 16.5 18.0 19.5		Sand (SP)		-	-	19.5	11.8	-	89	11	-	0.0	30^0	30 36 38 39 41 43	**Refu** 19.5 18 16.5 15 13.5 12

GURU NANAK DEV ENGINEERING COLLEGE, LUDHIANA

Testing & Consultancy Cell

Project- **Construction of Bridge to Apoch Ansal City, Near Abrol Nagar, Pathankot** Date of C

Bore Hole Log. **II** Date of (

Type of Boring:- **Manual** Ground

Depth (m)	Type of Soil	Bore Hole Log	L.L. %	P.I. %	Bulk Density (kN/m^3)	W %	Grain Size Distribution				C (kN/m^2)	Ø	'N' Valu
							% Grav.	% Sand	% Silt	% Clay			
1.0	Bed Level Sand with Gravels (GP)		-	-	22.1	6.0	35	61	04	-	0.0	33^0	Refu l
3.0													
4.5													
6.0													

7.5	Sand (SP)		-	-	19.8	12.1	-	91	09	-	0.0	31^0	
9.0													32
10.5													37
12.0													40
13.5													41
15.0													42
16.5													44
18.0													
19.5													