Design Philosophy:-

The design of submersible Causeway is carried out as per the procedure out lined below:-

Step1:-

The design discharge was fixed after arriving discharge based on the following methods:-

a.Discharge of the **stream** is arrived using area-velocity method and catchment area method.Further the discharge from the surplus wier of the tank is also taken into account,while finalising the design discharge.The surplus wier is treated as broad-crested wier and height of fall is locally enquired.The discharge is arrived using broad crested wier formula.

Step2:-

a.Hydraulic particulars like **HFL**,**OFL** are fixed as per the local enquiry.

b.It is proposed to design the structure as vented submersible causeway.RTL of the causeway is kept below the HFL,so that the obstruction to flow is less than 70%, when the flow is at RTL.Further,when the flow is at HFL,the obstruction to flow is kept below 30%.All the above ventway calculations are done as per IRC SP:82--2008.

c.After finalisation of design discharge,RTL and ventway calculations,afflux calculations are carried out.

d.Normal scour depth with reference to HFL was calculated using Lacey's equations

e.After arriving at the Maximum scour depth,bottom level of the foundation was fixed below the maximum scour depth

Step3:-

After arriving at **RTL**,**bottom of foundation level** and required ventway,the dimensions of the bridge are finalised.

The structural components are desined in the following manner:-

a.As per the recommendations of IRC 6:2000,IRC class A live load required for bridges and culverts of medium importance is selected.

b.The effect of drag and lift is considered on the causeway as per IRC-SP:82--2008. Additional live load due to silt is considered on the deck slab as per IRC SP:82--2008.

c.Load combinations and remaining loads are selected as per IRC 6:2000

d.Stainless steel anchor bars and VRCC thrust blocks are proposed as per IRC SP:82--2007 to safeguard against lift and drag forces respectively.

e.Based on the soil test reports,indivdual foundations are proposed for an SBC of 15t/m^2.

f.The structural components like Abutments,piers,face walls,strip foundation are designed as per the guide lines given in relevent IRC codes.

g.The deck slab is proposed as per the drawings given in Plate No.7.09 of **IRC:SP20-2002(Rural roads manual)**

h.The dirt wall is proposed as per the drawings given in **Plate No.7.25 of IRC:SP20-2002(Rural roads manual)**

Design of Abutments for causeway

I)Design Parameters:-

Clear Right Span	=	6.00m
Deck slab length	=	6.800m
Width of the carriage way	=	6.00m
Thickness of deck slab as per IRC SP 20	=	0.480m
Thickness of wearing coat	=	0.075m
Height of guard stones	=	0.750m
Thickness of dirt wall	=	0.30m
Sectional area of dirt wall	=	0.370sqm
Thickness of strip footing	=	0.45m
Height of abutments	=	1.200m
(As per hydralic calculations)		
Top width of abutments	=	0.750m
Bottom width of abutments	=	1.05m
Sectional area of abutment section	=	1.080sqm
Bank side batter of abutment	=	0.000m
Stream side batter of abutment	=	0.300m
Width of 1st footing	=	1.35m
Thickness of 1st footing	=	0.30m
Canal side offset of 1st footing wrt abutment	=	0.15m
Bank side offset of 1st footing wrt abutment	=	0.15m
Width of 2nd footing	=	1.50m
Thickness of 2nd footing	=	0.30m
Canal side offset of 2nd footing wrt abutment	=	0.30m
Bank side offset of 2nd footing wrt abutment	=	0.15m
Width of 3rd footing	=	1.65m
Thickness of 3rd footing	=	0.30m
Canal side offset of 3rd footing wrt abutment	=	0.45m
Bank side offset of 3rd footing wrt abutment	=	0.15m
Width of VRCC strip footing	=	1.95m
Thickness of VRCC strip footing **(d_3)**	=	0.45m
Canal side offset of RCC strip footing wrt abutment **(s_5)**	=	0.60m
Bank side offset of RCC strip footing wrt abutment **(s_6)**	=	0.30m
Offset of top footing along width	=	0.00m
Offset of 2nd footing along width	=	0.00m
Offset of 3rd footing along width	=	0.00m
Offset of RCC strip footing along width **(w_1)**	=	0.15m

Type of bearings	=	No bearings proposed
Unit weight of RCC **(y_{rc})**	=	25KN/cum
Unit weight of PCC **(y_{pc})**	=	24KN/cum
Density of back fill soil behind abutments **(y)**	=	18KN/Cum
Unit weight of water **(y_w)**	=	10KN/Cum
Angle of shearing resistance of back fill material**(Q)**	=	30
Angle of face of wall supporting earth with horizontal(In degrees)(in clock wise direction)**(a)**	=	**90**
Slope of back fill **(b)**	=	0
Angle of wall friction **(q)**	=	15
Height of surcharge considered **(h_3)**	=	1.20m
Road crest level **(RTL)**	=	5.645m
Low bed level **(LBL)**	=	3.965m
High flood Level **(HFL)**	=	6.235m
Bottom of foundation level **(BFL)**	=	2.315m
Safe Bearing Capacity of the soil **(SBC)**	=	15.00t/sqm
Compressive strength of concrete for PCC **(f_{ck})**	=	20.00N/sqmm
Compressive strength of concrete for VRCC **(f_{ck})**	=	25.00N/sqmm
Yield strength of steel **(f_y)**	=	415.00N/sqmm
Cover to reinforcement	=	50.00mm

II)General loading pattern:-

As per IRC:6---2000,the following loadings are to be considered on the submersible bridge or slab culvert:-

1.Dead load
2.Live load
3.Impact load
4.Wind load
5.Water current
6.Tractive,braking effort of vehicles&frictional resistance of bearings
7.Buoyancy
8.Earth pressure
9.Seismic force
10.Water pressure force

Apart from the above forces,the following pressures are to be considered as per clause 7.11.2.2 of IRC SP:82---2007:-

(a) Pressure due to static head due to afflux on upstream side and trough of standing wave on down stream side:

(b) Pressure due to velocity head

(c) Pressure due to eddies

(d) Pressure due to friction of water against piers and bottom of slab

(e) Force due to uplift under superstructure

As per the clause 7.11.3.4 of IRC:SP82--2007,Additional load of **150 mm** thick silt with density equal to **15 kN/m^3** spread over the entire soffit(in case of box girders) and deck slabs of all types of super structure should also be considered:

As per clause 202.3 of IRC 6:2000,the increase in permissible stresses is not permissible for the above loading combination.

III)Loading on the submersible bridge for design of abutments:-

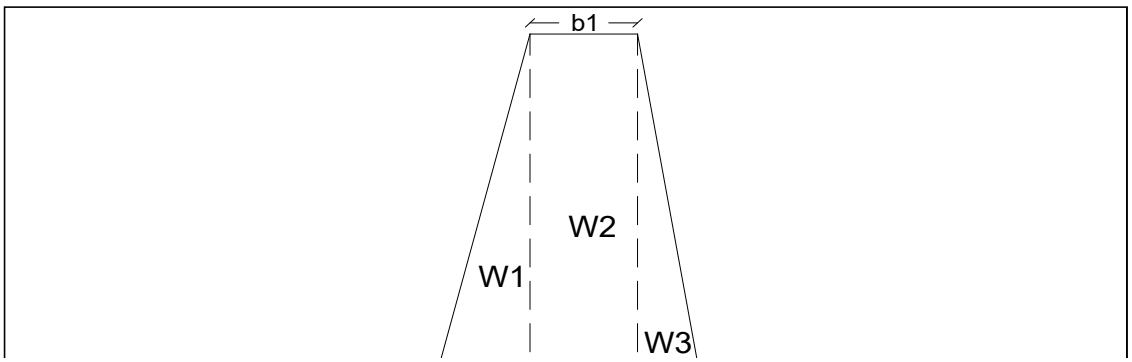
1.Dead Load:-

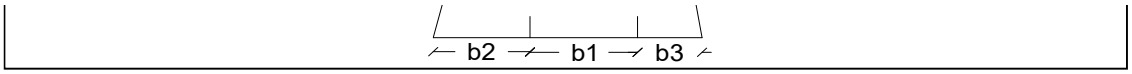
i)Self wieght of the deck slab =	244.80KN
ii)Self wieght of dirtwall over abutment =	55.50KN
iii)Self weight of wearing coat =	38.25KN
	338.55KN

There is no need to consider snow load as per the climatic conditions

Self wieght of the abutments upto bottom most footing based on the preliminary section assumed:-

iv)Self wieght of the abutment section =	155.52KN
v)Self wieght of top footing =	58.32KN
vi)Self wieght of 2nd footing =	64.80KN
vii)Self wieght of 3rd footing =	71.28KN
viii)Self wieght of 4th footing =	0.00KN
	349.92KN





ix)Calculation of eccentricity of self weight of abutment w.r.t base of abutment

S.No	Description	Load in KN	Distance of centroid of load from toe of abutment	Moment
1	Back batter(W1)	0	1.05	0
2	Centre portion(W2)	129.6	0.675	87.48
3	Front batter(W3)	25.92	0.2	5.18
		155.52		**92.66**

Location of resultant from toe of abutment = 0.60m

Eccentricity wrt centre of base of abutment = 0.075m

x)Calculation of eccentricity of self weight of abutment&1st footing w.r.t bottom of 1st footing

S.No	Description	Load in KN	Distance of centroid of load from toe of 1st footing	Moment
1	Back batter	0	1.2	0
2	Centre portion	129.6	0.825	106.92
3	Front batter	25.92	0.35	9.07
4	1st footing	58.32	0.675	39.37
		213.84		**155.36**

Location of resultant from toe of abutment = 0.73m

Eccentricity wrt centre of 1st footing= 0.055m

xi)Calculation of eccentricity of self weight of abutment,1st&2nd footings w.r.t bottom of 2nd footing

S.No	Description	Load in KN	Distance of centroid of load from toe of 2nd footing	Moment
1	Back batter	0	1.35	0
2	Centre portion	129.6	0.975	126.36
3	Front batter	25.92	0.5	12.96
4	1st footing	58.32	0.83	48.11
5	2nd footing	64.8	0.75	48.6
		278.64		**236.03**

Location of resultant from toe of abutment = 0.85m

Eccentricity = 0.100m

xii)Calculation of eccentricity of self weight of abutment,1st&2nd footings w.r.t bottom of 2nd footing

S.No	Description	Load in KN	Distance of centroid of load from toe of 3rd footing	Moment
1	Back batter	0	1.35	0
2	Centre portion	129.6	0.975	126.36
3	Front batter	25.92	0.5	12.96
4	1st footing	58.32	0.83	48.11
5	2nd footing	64.8	0.75	48.6
6	3rd footing	71.28	0.83	58.81
		349.92		**294.84**

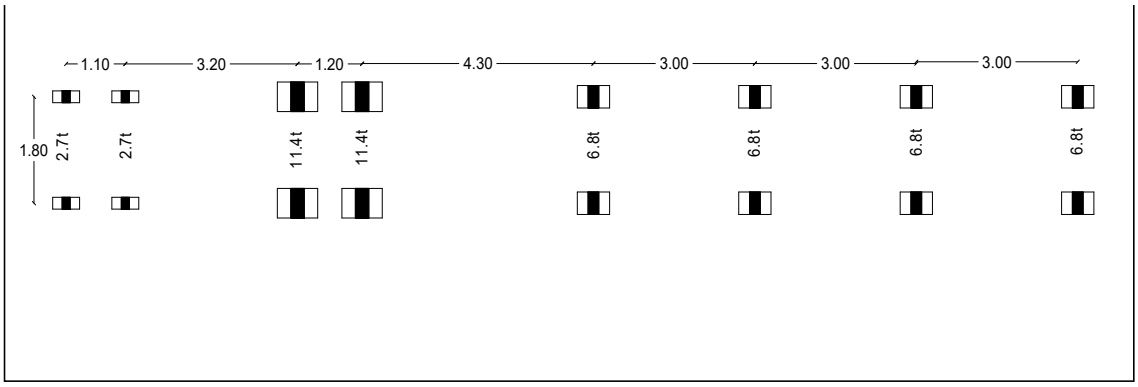
Location of resultant from toe of abutment = 0.84m

Eccentricity = 0.015m

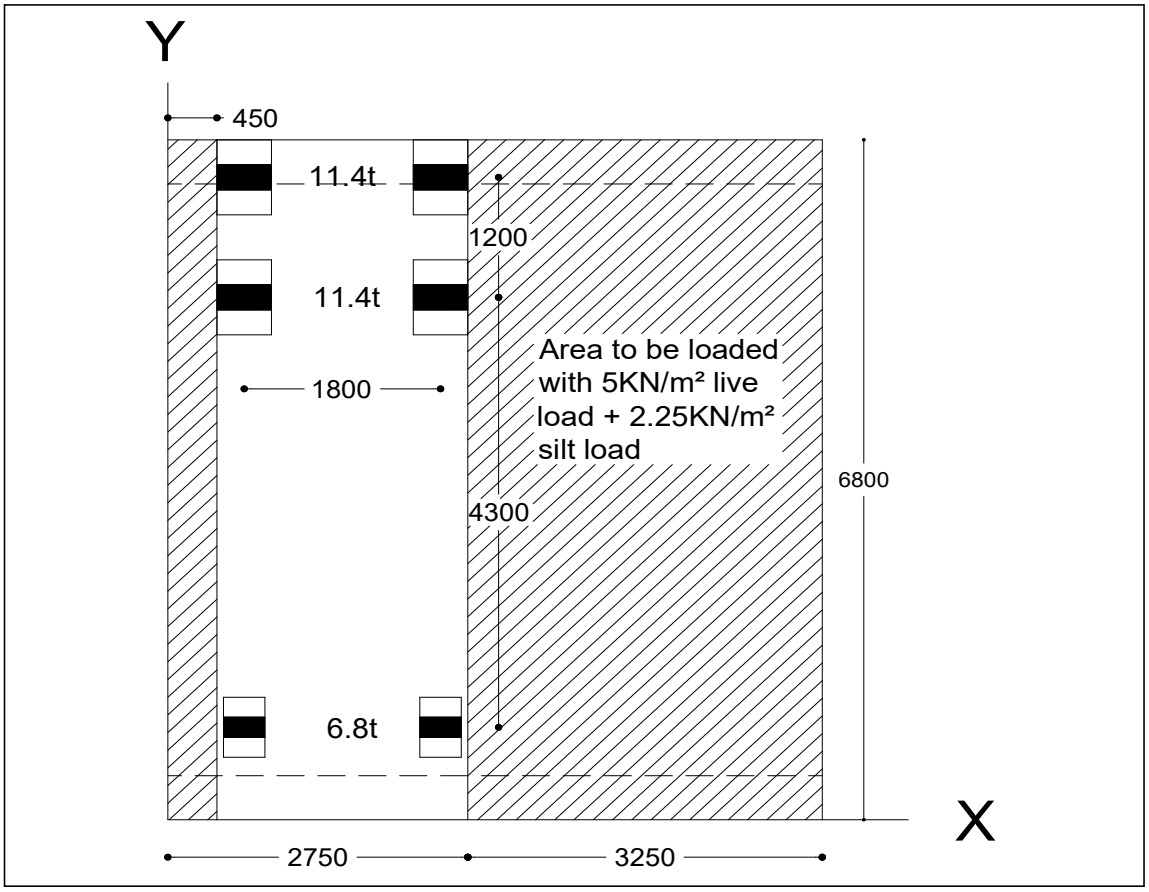
2.Live Load:-

As per clause 201.1 of IRC:6--2000,the bridges and culverts of medium importance are to be designed for **IRC Class A** loading.

GENERAL IRC Class-A loading Pattern


1.10
3.20
1.20
4.30
3.00
3.00
3.00
1.80
2.7t
2.7t
11.4t
11.4t
6.8t
6.8t
6.8t
6.8t

The IRC Class A loading as per **the drawing** is severe and the same is to be considered as per clauses 207.1.3&207.4



The ground contact area of wheels for the above placement,each axle wise is given below:-

Axle load (Tonnes)	Ground Contact Area B(mm)	W(mm)
11.4	250	500
6.8	200	380
2.7	150	200

Assuming 0.3m allowance for guide posts and the clear distance of vehicle from the edge of guide post being 0.15m as per clause 207.1,the value of 'f' shown in the figure will be 0.45m

Hence,the width of area to be loaded with 7.25KN/m2 on left side is **(f)** =	0.45m
Similarly,the area to be loaded on right side **(k)** =	3.25m
	3.70m

The total live load on the deck slab composes the following components:-

1.Wheel loads----Point loads	296.00KN
2.Live load in remaing portion(Left side)----UDL	22.185KN
2.Live load in remaing portion(Right side)----UDL	160.225KN
	478.41KN

Resultant live load:-

Eccentricity of live load w.r.t y-direction(Along the direction of travel of vehicles)

Taking moments of all the forces w.r.t y-axis

S.No	Wheel Load/UDL in KN	Distance from Y-axis	Moment
1	57	0.70m	39.90KNm
2	57	0.70m	39.90KNm
3	57	2.50m	142.50KNm
4	57	2.50m	142.50KNm
5	34	0.64m	21.76KNm
6	34	2.44m	82.96KNm
7	22.185	0.225m	4.99KNm
8	160.225	4.375m	700.98KNm
	478.410		**1175.50KNm**

Distance of centroid of forces from y-axis

= 2.457m

Eccentricity = 0.543m

Eccentricity of live load w.r.t x-direction(At right angle to the travel of vehicles)

Taking moments of all the forces w.r.t x-axis

S.No	Load in KN	Distance from X-axis	Moment
1	34	0.925m	31.45KNm
2	34	0.925m	31.45KNm

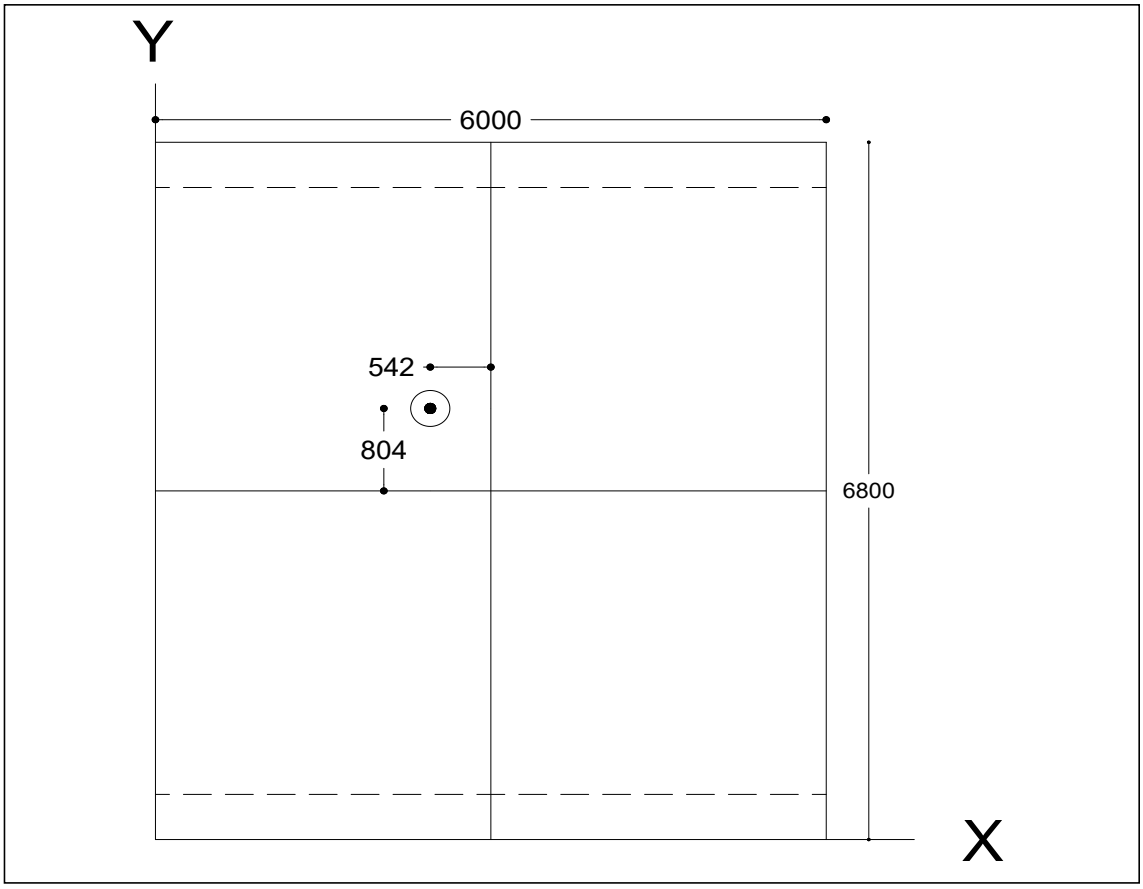
5	57	5.225m	297.83KNm
6	57	5.225m	297.83KNm
7	57	6.425m	366.23KNm
8	57	6.425m	366.23KNm
9	22.19KN	3.400m	75.43KNm
10	160.23KN	3.400m	544.77KNm
	478.41		**2011.19KN**

Distance of centroid of forces from x-axis

= 4.204m

Eccentricity = 0.804m

Location of resultant is as shown below:-



Calculation of reactions on abutments:-

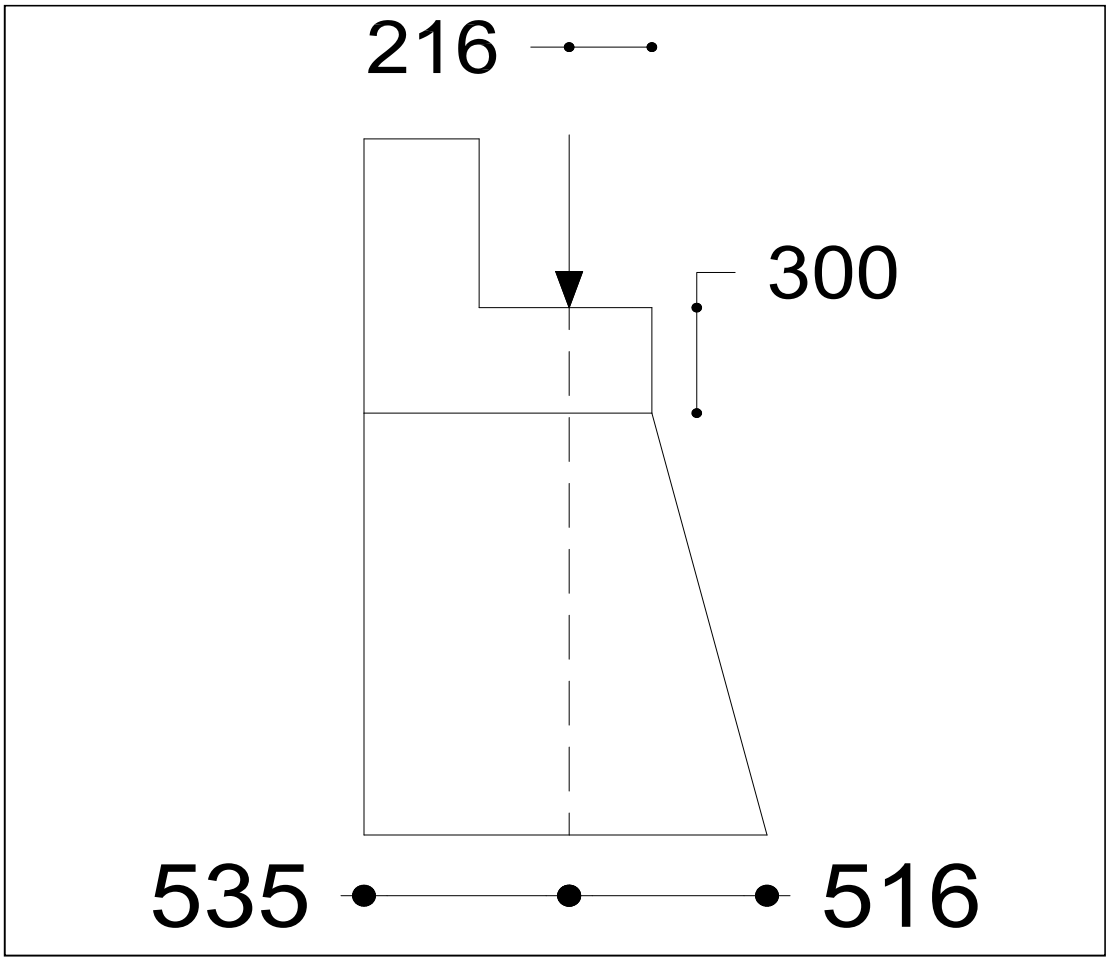
Reaction due to loads R_a = 182.64KN

Reaction due to point loads = R_b = 295.77KN

Hence,the critical reaction is Ra = **295.77KN**

The corrected reaction = **295.77KN**

Assuming that the live load reaction acts at the centre of the contact area on the abutment,



The eccentricty of the line of action of live load = 0.01m

3.Impact of vehicles:-

As per Clause 211 of IRC:6--2000,impact allowance shall be made by an increment of live load by a factor 4.5/(6+L)

Hence,the factor is **0.352**

Further as per clause 211.7 of IRC:6--2000,the above impact factor shall be only

50% for calculation of pressure on piers and abutments just below the level of bed block.There is no need to increase the live load below 3m depth.

As such,the impact allowance for the top 3m of abutments will be **0.176**

For the remaining portion,impact need not be considered.

4.Wind load:-

The deck system is located at height of (RTL-LBL) **1.68m**

The Wind pressure acting on deck system located at that height is considered for design.

As per clause 212.3 and from Table .4 of IRC:6---2000,the wind pressure at that hieght is=

59.48 Kg/m^2.

Height of the deck system = 1.755

Breadth of the deck system = 7.4

The effective area exposed to wind force =HeightxBreadth =

Hence,the wind force acting at centroid of the deck system = **3.86KN**
(Taking 50% perforations)

Further as per clause 212.4 of IRC:6---2000 ,300 Kg/m wind force is considered to be acting at a hieght of 1.5m from road surface on live load vehicle.

Hence,the wind force acting at 1.5m above the road surface = **18.00KN**

The location of the wind force from the top of RCC strip footing = **4.16m**

5.Water current force:-

a)Water current force on deck slab:-

Velocity of stream at top,when the flow approaches the top of deck slab = $\sqrt{2} \times V_{mean}$ = 3.65m/sec

$P = 52KV^2$ = **201.24 Kg/m^2.**

(where the value of 'K' is 1.5)

Force acting on centroid of deck slab = **3.80KN**

Point of action of water current force from the top of RCC strip footing = **3.09m**

b)Water current force on abutment:-

Water pressure is considered on square ended abutments as per clause 213.2 of IRC:6---2000 is

For the purpose of calculation of exposed area to water current force,only 1.0m width of abutment is considered for full hieght upto HFL

Hence,the water current force = **3.38KN**

Point of action of water current force from the top of RCC strip footing = **2.88m**

6.Tractive,braking effort of vehicles&frictional resistance of bearings:-

The breaking effect of vehicles shall be 20% of live load acting in longitudinal direction at 1.2m above road surface as per the clause 214.2 of IRC:6--2000.

As no bearings are assumed in the present case,50% of the above longitudinal force can be assumed to be transmitted to the supports of simply supported spans resting on stiff foundation with no bearings as per clause 214.5.1.3 of IRC:6---2000

Hence,the longitudinal force due to braking,tractive or frictional resistance of bearings transferred to abutments is

47.84KN

The location of the tractive force from the top of RCC strip footing = **3.86m**

7.Buoyancy :-

As per clause 216.4 of IRC:6---2000,for abutments or piers of shallow depth,the dead weight of the abutment shall be reduced by wieght of equal volume of water upto HFL.

The above reduction in self wieght will be considered assuming that the back fill behind the abutment is scoured.

For the preliminary section assumed,the volume of abutment section is

i)Volume of abutment section = 6.48Cum

ii)Volume of top footing = 2.43Cum

iii)Volume of 2nd footing = 2.70Cum

iv)Volume of 3rd footing = 2.97Cum

v)Volume of 4th footing = 0.00Cum

	14.58Cum

Reduction in self wieght = **145.80KN**

8.Earth pressure :-

As per clause 217.1 of IRC:6---2000,the abutments are to be designed for a surcharge equivalent to a back fill of hieght 1.20m behind the abutment.

The coefficient of active earth pressure exerted by the cohesion less back fill on the abutment as per the Coulomb's theory is given by

$$K_a = \left[\frac{\mathrm{Sin}(a+Q)}{\mathrm{sina}\left[\sqrt{\mathrm{sin}(a-q)} + \sqrt{\frac{\mathrm{sin}(Q+q)\mathrm{sin}(Q-b)}{\mathrm{sin}(a+b)}}\right]} \right]^{'2}$$

Sin(a+Q) =	SIN[3.14*(76.06+30)/180] =	0.961
Sin(a-q) =	SIN[3.14*(76.06-15)/180] =	0.875
Sina =	SIN[3.14*(76.06)/180] =	0.97
Sin(Q+q) =	SIN[3.14*(30+15)/180] =	0.707
Sin(Q-b) =	SIN[3.14*(30-0)/180] =	0.5
Sin(a+b) =	SIN[3.14*(76.06+0)/180] =	0.97

From the above expression,

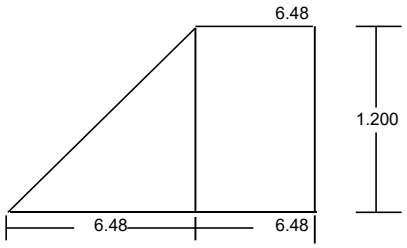
K_a = 0.3

The hieght of abutment above GL,as per the preliminary section assumed = 1.200m

Hence,maximum pressure at the base of the wall Pa = 6.48KN/sqm

The pressure distribution along the height of the wall is as given below:-

Surcharge load = 6.48 KN/sqm



Area of the rectangular portion =	7.78
Area of the triangular portion =	3.89
	11.67

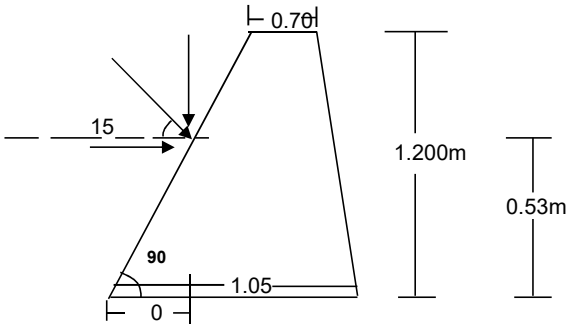
Taking moments of the areas about the toe of the wall

S.No	Description	Area	Lever arm	Moment

1	Rectangular	7.78	0.6	4.668
2	Triangular	3.89	0.4	1.556
		11.67		**6.224**

Height from the bottom of the wall = 0.53m

The active Earth pressure acts on the abutment as shown below:-



Total earth pressure acting on the abutment P = 69.98KN

Horizontal component of the earth pressure P_h = 67.60KN

Vertical component of the earth pressure P_v = 18.10KN

Eccentricity of vertical component of earth pressure = 0.53m

9.Siesmic force :-

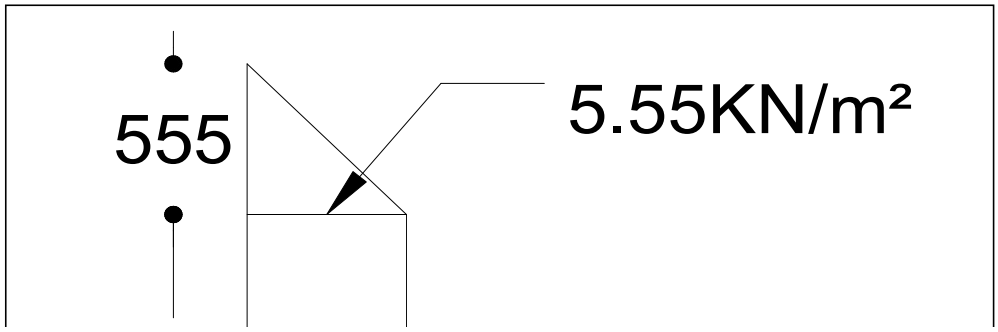
As per clause 222.1 of IRC:6---2000,the bridges in siesmic zones I and II need not be designed for siesmic forces.The location of the slab culvert is in Zone-I.Hence,there is no need to design the bridge for siesmic forces.

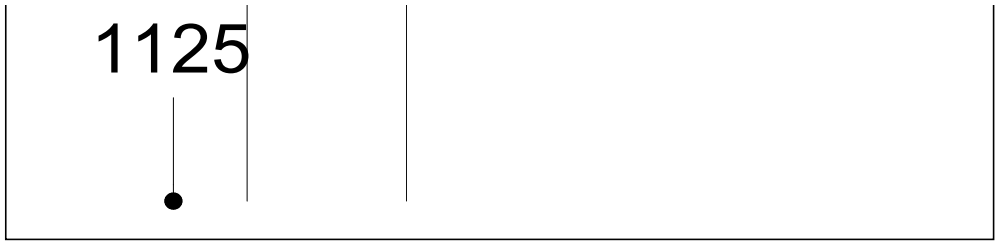
10.Water pressure force:-

As per clause 7.11.2.2(b) of IRC SP82:2007,the pressure due to static head will be zero at the surface of water and will increase linearly to P = wh at depth 'h' from the surface, below which it will be constant as indicated in the sketch below :-

Where, w = unit weight of water

h = afflux or depth of superstructure (including wearing coat) whichever is more.





Total horizontal water pressure force = **11.48KN**

The above pressure acts at height of 0.42H = **0.71m**

11.Pressure due to eddies :-

Pressure due to eddies = $\frac{w (V_v-V)^2}{2g}$

Where,
V_v = velocity of flow through the vents,
V = velocity of approach
(w = unit weight of water; g= Acceleration due to gravity)

Pressure force due to eddies = **0.007KN**

which is negligible.Hence it need not be considered

12. Pressure due to friction of water against piers and bottom of slab :-

Pressure due to friction =f x ρ x $(Cx V_v)^2$

Where,
f = friction coefficient = 1
ρ = mass density of water (w/g)
V_v = velocity of flow through the vents (m/sec)
C = value of constant generally taken as10%

i)Force due to friction on Deck slab:-

Frictional force on bottom and top of deck slab = **4.96KN**

The location of the frictional force from the top of RCC strip footing = **3.09m**

ii)Force due to friction on abutment:-

Frictional force on the canal side face of abutment = **0.50KN**

The location of the frictional force from the top of RCC strip footing = **1.50m**

13. Force due to uplift under superstructure :-

This force acts vertically upwards and is given by

Uplift force = wh x A_{sp}

Where,
A_{sp} area of the superstructure in plan

h = the uplift head under the deckslab which may be taken as higher of the following two values: (i) Afllux (ii) Thickness of superstructure including wearing coat-head loss due to increase in velocity through vents (V_v) Head loss due to increase in velocity through the vents is calculated by following expression

$$h_1 = \frac{V_v^2 - V^2}{2g}$$

Where,
V_v =velocity of flow through the vents
V = velocity of approach

Afflux =	0.131m
Head loss due to increase in velocity =	0.012m
Hence,up lift head =	0.543m
Hence uplift force on the deck slab =	**195.48KN**

IV)Check for stresses for abutments&footings:-

a)Load Envelope-I:-(The Canal is dry,back fill scoured with live load on span)

i)On top of RCC Strip footing

The following co-ordinates are assumed:-

a)x-Direction-----At right angle to the movement of vehicles

b)y-Direction-----In the direction of movement of vehicles

Vertical forces acting on the abutment **(P)** composes of the following components

S.No	Type of load	Intensity in KN	Eccentricty about x-axis(m)	Eccentricty about y-axis(m)
1	Reaction due to dead load from super structure	338.55KN	0.00	0.00
2	Self wieght of abutment&footings	349.92KN	0.015	0.000
3	Reaction due to live load with impact factor---(Wheel loads+UDL)	347.83KN	-0.01	0.543
4	Impact load	52.06	-0.01	0.543
		1088.35		

Horizontal forces acting/transferred on the abutment **(H)** composes of the following components

S.No	Type of load	Intensity in KN	Direction x or y	Location(Ht.from the section considered).(m)
1	Wind load	18.00KN	x-Direction	4.16
2	Tractive,Braking&Frictional resistance of bearings	47.84KN	y-Direction	3.86
3	Water current force	3.38KN	x-Direction	2.88

Check for stresses:-

About x-axis:-

Breadth of 3rd footing b = 6.00m

Depth of 3rd footing d = 1.65m

Area of the footing = A = 9.9 m^2

Section modulus of bottom footing about x-axis --Zx = $(1/6)bd^2$ = 2.72 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is $5N/mm^2$

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is $-2.8N/mm^2$

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at heel P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	34.2
2	Self wieght of abutment&footings	349.92KN	0.02	35.88
3	Reaction due to live load with impact factor	347.83KN	-0.01	34.78
4	Impact load	52.06KN	-0.01	0
	Horizontal loads:- (Stress = M/Z)			
5	Tractive,Braking&Frictional resistance of bearings (Stress = -31.36*4.93/6.38)	47.84KN	3.86	-67.83
				37.03

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at toe P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	34.2
2	Self wieght of abutment&footings	349.92KN	-0.02	34.82
3	Reaction due to live load with impact factor	347.83KN	0.01	35.49
4	Impact load	52.06KN	-0.01	0
	Horizontal loads:- (Stress = M/Z)			
5	Tractive,Braking&Frictional resistance of bearings	47.84KN	3.86	67.83
				172.34

Stress at heel = P/A(1+6e/b)+M/Z = 37.03 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at toe = P/A(1+6e/b)+M/Z = 172.34 KN/Sqm<5000KN/sqm

Hence safe.

About y-axis:-

Breadth of 3rd footing b = 1.65m

Depth of 3rd footing d = 6.00m

Area of the footing = A = 9.9 m^2

Section modulus of bottom footing about y-axis--Zy = $(1/6)bd^2$ = 9.90 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is $5N/mm^2$

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is $-2.8N/mm^2$

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at upstream edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	34.2
2	Self wieght of abutment&footings	349.92KN	0.00	35.35
3	Reaction due to live load with impact factor	347.83KN	-0.543	-34.24
4	Impact load	52.06KN	0.54	15.64
	Horizontal loads:- (Stress = M/Z)			
5	Wind load	18.00KN	4.16	-7.56
6	Water current force	3.38KN	2.88	-0.98
				42.41

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at D/S edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	34.2
2	Self wieght of abutment&footings	349.92KN	0.00	35.35
3	Reaction due to live load with impact factor	347.83KN	0.543	104.51
4	Impact load	52.06KN	0.54	15.64
	Horizontal loads:- (Stress = M/Z)			
5	Wind load	18.00KN	4.16	7.56
6	Water current force	3.38KN	2.88	0.98
				198.24

Stress at up stream side edge = P/A(1+6e/b)+M/Z = 42.41 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at down stream side edge = P/A(1+6e/b)+M/Z = 198.24 KN/Sqm<5000KN/sqm

Hence safe.

ii)On top of 3rd footing

The following co-ordinates are assumed:-

a)x-Direction-----At right angle to the movement of vehicles

b)y-Direction-----In the direction of movement of vehicles

Vertical load acting on the abutment **(P)** composes of the following components

S.No	Type of load	Intensity in KN	Eccentricty about x-axis(m)	Eccentricty about y-axis(m)
1	Reaction due to dead load from super structure	338.55KN	0.00	0.00
2	Self wieght of abutment&footings	278.64KN	0.100	0.000
3	Reaction due to live load with impact factor	347.83KN	-0.01	0.543
4	Impact load	52.06	-0.01	0.543

Horizontal load acting/transferred on the abutment **(H)** composes of the following components

S.No	Type of load	Intensity in KN	Direction x or y	Location(Ht.from the section considered).(m)
1	Wind load	18.00KN	x-Direction	3.86
2	Tractive,Braking&Frictional resistance of bearings	47.84KN	y-Direction	3.56
3	Water current force	3.38KN	x-Direction	2.58

Check for stresses:-

About x-axis:-

Breadth of 2nd footing b = 6.00m
Depth of 2nd footing d = 1.50m
Area of the footing = A = 9 m^2

Section modulus of Ist footing about x-axis--Zx = $(1/6)bd^2$ = 2.25 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is 5N/mm^2

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is -2.8N/mm^2

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at heel P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	37.62
2	Self wieght of abutment&footings	278.64KN	0.10	34.06
3	Reaction due to live load with impact factor	347.83KN	-0.01	38.26
4	Impact load	52.06KN	-0.01	0
	Horizontal loads:- (Stress = M/Z)			
5	Tractive,Braking&Frictional resistance of bearings	47.84KN	3.56	-75.7
				34.24

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at toe P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	37.62

2	Self wieght of abutment&footings	278.64KN	-0.10	27.86
3	Reaction due to live load with impact factor	347.83KN	0.01	39.03
4	Impact load	52.06KN	-0.01	0
	Horizontal loads:- (Stress = M/Z)			
5	Tractive,Braking&Frictional resistance of bearings	47.84KN	3.56	75.7
				180.21

Stress at heel = P/A(1+6e/b)+M/Z = 34.23 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at toe = P/A(1+6e/b)+M/Z = 180.21 KN/Sqm<5000KN/sqm

Hence safe.

About y-axis:-

Breadth of 1st footing b = 1.50m
Depth of 1st footing d = 6.00m
Area of the footing = A = 9 m^2

Section modulus of Ist footing about y-axis--Zy = $(1/6)bd^2$ = 9.00 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is $5N/mm^2$

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is $-2.8N/mm^2$

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at upstream edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	37.62
2	Self wieght of abutment&footings	278.64KN	0.00	30.96
3	Reaction due to live load with impact factor	347.83KN	-0.543	-45.29
4	Impact load	52.06KN	0.54	18.35
	Horizontal loads:- (Stress = M/Z)			
5	Wind load	18.00KN	3.86	-7.72
6	Water current force	3.38KN	2.58	-0.97
				32.95

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at D/S edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	37.62
2	Self wieght of abutment&footings	278.64KN	0.00	30.96
3	Reaction due to live load with impact factor	347.83KN	0.543	122.59
4	Impact load	52.06KN	0.54	18.35
	Horizontal loads:- (Stress = M/Z)			
5	Wind load	18.00KN	3.86	7.72
6	Water current force	3.38KN	2.58	0.97
				218.21

Stress at up stream side edge = P/A(1+6e/b)+M/Z = 32.95 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at down stream side edge = P/A(1+6e/b)+M/Z = 218.21 KN/Sqm<5000KN/sqm

Hence safe.

i)On top of 2nd footing

The following co-ordinates are assumed:-

a)x-Direction-----At right angle to the movement of vehicles

b)y-Direction-----In the direction of movement of vehicles

Vertical load acting on the abutment **(P)** composes of the following components

S.No	Type of load	Intensity in KN	Eccentricty about x-axis(m)	Eccentricty about y-axis(m)
1	Reaction due to dead load from super structure	338.55KN	0.00	0.00
2	Self wieght of abutment&cut waters	213.84KN	0.055	0.000
3	Reaction due to live load with impact factor	347.83KN	-0.01	0.543
4	Impact load	52.06	-0.01	0.543

Horizontal load acting/transferred on the abutment **(H)** composes of the following components

S.No	Type of load	Intensity in KN	Direction x or y	Location(Ht.from the section considered).(m)
1	Wind load	18.00KN	x-Direction	3.56
2	Tractive,Braking&Frictional resistance of bearings	47.84KN	y-Direction	3.26
3	Water current force	3.38KN	x-Direction	2.28

Check for stresses:-

About x-axis:-

Breadth of 1st footing b = 6.00m
Depth of 1st footing d = 1.35m
Area of the footing = A = 8.1 m^2

Section modulus of base of abutment about x-axis--Zx = $(1/6)bd^2$ = 1.82 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is $5N/mm^2$

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is -2.8N/mm^2

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at heel P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	41.8
2	Self wieght of abutment&footings	213.84KN	0.06	27.48
3	Reaction due to live load with impact factor	347.83KN	-0.01	42.51
4	Impact load	52.06KN	-0.01	0
	Horizontal loads:- (Stress = M/Z)			
5	Tractive,Braking&Frictional resistance of bearings	47.84KN	3.26	-85.58
				26.21

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at toe P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	41.8
2	Self wieght of abutment&footings	213.84KN	-0.06	24.95
3	Reaction due to live load with impact factor	347.83KN	0.01	43.37
4	Impact load	52.06KN	-0.01	0
	Horizontal loads:- (Stress = M/Z)			
5	Tractive,Braking&Frictional resistance of bearings	47.84KN	3.26	85.58
				195.7

Stress at heel = P/A(1+6e/b)+M/Z = 26.21 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at toe = P/A(1+6e/b)+M/Z = 195.7 KN/Sqm<5000KN/sqm

Hence safe.

About y-axis:-

Breadth of 1st footing b = 1.35m
Depth of 1st footing d = 6.00m
Area of the footing = A = 8.1 m^2

Section modulus of base of abutment about y-axis--Zy = $(1/6)bd^2$ = 8.10 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is 5N/mm^2

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is -2.8N/mm^2

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at upstream edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	41.8
2	Self wieght of abutment&footings	213.84KN	0.00	26.4
3	Reaction due to live load with impact factor	347.83KN	-0.543	-60.69
4	Impact load	52.06KN	0.54	21.94
	Horizontal loads:- (Stress = M/Z)			
5	Wind load	18.00KN	3.56	-7.91
6	Water current force	3.38KN	2.28	-0.95
				20.59

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at D/S edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	41.8
2	Self wieght of abutment&footings	213.84KN	0.00	26.4
3	Reaction due to live load with impact factor	347.83KN	0.543	146.57
4	Impact load	52.06KN	0.54	21.94
	Horizontal loads:- (Stress = M/Z)			
5	Wind load	18.00KN	3.56	7.91
6	Water current force	3.38KN	2.28	0.95
				245.57

Stress at up stream side edge of abutment = P/A(1+6e/b)+M/Z = 20.59 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at down stream side edge of abutment = P/A(1+6e/b)+M/Z = 245.57 KN/Sqm<5000KN/sqm

Hence safe.

i)On top of 1st footing

The following co-ordinates are assumed:-

a)x-Direction-----At right angle to the movement of vehicles
b)y-Direction-----In the direction of movement of vehicles

Vertical load acting on the abutment **(P)** composes of the following components

S.No	Type of load	Intensity in KN	Eccentricty about x-axis(m)	Eccentricty about y-axis(m)
1	Reaction due to dead load from super structure	338.55KN	0.00	0.00
2	Self wieght of abutment&footings	155.52KN	0.075	0.000
3	Reaction due to live load with impact factor	347.83KN	-0.01	0.543
4	Impact load	52.06	-0.01	0.543

Horizontal load acting/transferred on the abutment **(H)** composes of the following components

S.No	Type of load	Intensity in KN	Direction x or y	Location(Ht.from the section considered).(m)
1	Wind load	18.00KN	x-Direction	3.56
2	Tractive,Braking&Frictional resistance of bearings	47.84KN	y-Direction	2.96
3	Water current force	3.38KN	x-Direction	2.28

Check for stresses:-

About x-axis:-

Breadth of abutment b = 6.00m
Depth of abutment d = 1.05m
Area of the footing = A = 6.3 m^2

Section modulus of base of abutment about x-axis--Zx = $(1/6)bd^2$ = 1.10 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is $5N/mm^2$

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is $-2.8N/mm^2$

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at heel P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	53.74
2	Self wieght of abutment&footings	155.52KN	0.08	26.45
3	Reaction due to live load with impact factor	347.83KN	-0.01	54.66
4	Impact load	52.06KN	-0.01	0
	Horizontal loads:- (Stress = M/Z)			
5	Tractive,Braking&Frictional resistance of bearings	47.84KN	2.96	-128.44
				6.41

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at toe P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	53.74
2	Self wieght of abutment&footings	155.52KN	-0.08	22.83
3	Reaction due to live load with impact factor	347.83KN	0.01	55.76
4	Impact load	52.06KN	-0.01	0
	Horizontal loads:- (Stress = M/Z)			
5	Tractive,Braking&Frictional resistance of bearings	47.84KN	2.96	128.44
				260.77

Stress at heel = P/A(1+6e/b)+M/Z = 6.41 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at toe = P/A(1+6e/b)+M/Z = 260.77 KN/Sqm<5000KN/sqm

Hence safe.

About y-axis:-

Breadth of abutment b = 1.05m
Depth of abutment d = 6.00m
Area of the footing = A = 6.3 m^2

Section modulus of base of abutment about y-axis--Zy = $(1/6)bd^2$ = 6.30 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is $5N/mm^2$

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is $-2.8N/mm^2$

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at upstream edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	53.74
2	Self wieght of abutment&footings	155.52KN	0.00	24.69
3	Reaction due to live load with impact factor	347.83KN	-0.543	25.23
4	Impact load	52.06KN	0.54	33.9
	Horizontal loads:- (Stress = M/Z)			
5	Wind load	18.00KN	3.56	-10.17
6	Water current force	3.38KN	2.28	-1.22
				126.17

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at D/S edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	53.74
2	Self wieght of abutment&footings	155.52KN	0.00	24.69
3	Reaction due to live load with impact factor	347.83KN	0.543	226.52
4	Impact load	52.06KN	0.54	33.9
	Horizontal loads:- (Stress = M/Z)			
5	Wind load	18.00KN	3.56	10.17
6	Water current force	3.38KN	2.28	1.22
				350.24

Stress at up stream side edge of abutment = P/A(1+6e/b)+M/Z = 126.17 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at down stream side edge of abutment = P/A(1+6e/b)+M/Z = 350.24 KN/Sqm<5000KN/sqm

Hence safe.

b)Load Envelope-II:-(The Canal is full,back fill intact with no live load on span)

i)On top of RCC Strip footing

The following co-ordinates are assumed:-

a)x-Direction-----At right angle to the movement of vehicles

b)y-Direction-----In the direction of movement of vehicles

Vertical load acting on the abutment **(P)** composes of the following components

S.No	Type of load	Intensity in KN	Eccentricty about x-axis(m)	Eccentricty about y-axis(m)
1	Reaction due to dead load from super structure	338.55KN		
	Deduct uplift pressure	-195.48KN		
	Net reaction due to dead load from super structure	**143.07KN**	0.00	0.00
	Self wieght of abutment&cut waters	349.92KN		
	Reduction in self weight due to buoyancy	-145.80KN		
2	Net self weight	**204.12KN**	0.015	0.000
3	Vertical component of earth pressure	18.10KN	0.525	0.000

Horizontal load acting/transferred on the abutment **(H)** composes of the following components

S.No	Type of load	Intensity in KN	Direction x or y	Location(Ht.from the section considered).(m)
1	Wind load	18.00KN	x-Direction	4.16
2	Tractive,Braking&Frictional resistance of bearings	0.00KN	y-Direction	0.00
3	Water current force on deck slab	3.80KN	x-Direction	3.09
4	Water current force on abutment	3.38KN	x-Direction	2.88
5	Frictional force due to water on deck slab	4.96KN	x-Direction	3.09
6	Frictional force due to water on abutment	0.50KN	x-Direction	1.50
7	Horizontal load due to earth pressure	67.60KN	y-Direction	1.43
8	Water pressure force	11.48KN	y-Direction	1.61

Check for stresses:-

About x-axis:-

Breadth of bottom footing b = 6.00m
Depth of bottom footing d = 1.65m
Area of the footing = A = 9.9 m^2

Section modulus of bottom footing about x-axis --Zx = $(1/6)bd^2$ = 2.72 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is $5N/mm^2$

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is $-2.8N/mm^2$

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at heel P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	14.45
2	Net self wieght of abutment&footings	204.12KN	0.015	20.93
3	Vertical component of Earth pressure	18.10KN	0.53	2.79
	Horizontal loads:- (Stress = M/Z)			
4	Horizontal load due to earth pressure	67.60KN	1.43	-35.59
5	Water pressure force	11.48KN	1.61	6.8
				9.35

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at toe P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	14.45
2	Net self wieght of abutment&footings	204.12KN	-0.02	20.31
3	Vertical component of Earth pressure	18.10KN	-0.53	0.87
	Horizontal loads:- (Stress = M/Z)			
4	Horizontal load due to earth pressure	67.60KN	1.43	35.59
5	Water pressure force	11.48KN	1.61	-6.8
				64.45

Stress at heel = P/A(1+6e/b)+M/Z = 9.35 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at toe = P/A(1+6e/b)+M/Z = 64.45 KN/Sqm<5000KN/sqm

Hence safe.

About y-axis:-

Breadth of bottom footing b = 1.65m
Depth of bottom footing d = 6.00m
Area of the footing = A = 9.9 m^2

Section modulus of bottom footing about y-axis --Zy = $(1/6)bd^2$ = 9.90 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is 5N/mm^2

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is -2.8N/mm^2

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at U/S Edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	14.45

2	Net self wieght of abutment&footings	204.12KN	0.00	20.62
3	Vertical component of Earth pressure	18.10KN	0.00	1.83
	Horizontal loads:- (Stress = M/Z)			
4	Wind load	18.00KN	4.16	-7.56
5	Water current force on abutment	3.38KN	2.88	-1.0
6	Water current force on deck slab	3.80KN	3.09	-1.2
7	Frictional force due to water on deck slab	4.96KN	3.09	-1.6
8	Frictional force due to water on abutment	0.50KN	1.50	-0.1
				25.54

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at D/S edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	14.45
2	Net self wieght of abutment&footings	204.12KN	0.00	20.62
3	Vertical component of Earth pressure	18.10KN	0.00	1.83
	Horizontal loads:- (Stress = M/Z)			
4	Wind load	18.00KN	4.16	7.56
5	Water current force on abutment	3.38KN	2.88	1.0
6	Water current force on deck slab	3.80KN	3.09	1.2
7	Frictional force due to water on deck slab	4.96KN	3.09	1.6
8	Frictional force due to water on abutment	0.50KN	1.50	0.1
				48.26

Stress at up stream side edge of abutment = P/A(1+6e/b)+M/Z = 25.54 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at down stream side edge of abutment = P/A(1+6e/b)+M/Z = 48.26 KN/Sqm<5000KN/sqm

Hence safe.

ii)On top of 3rd footing

The following co-ordinates are assumed:-

a)x-Direction-----At right angle to the movement of vehicles

b)y-Direction-----In the direction of movement of vehicles

Vertical load acting on the abutment **(P)** composes of the following components

S.No	Type of load	Intensity in KN	Eccentricty about x-axis(m)	Eccentricty about y-axis(m)
1	Reaction due to dead load from super structure	338.55KN		
	Deduct uplift pressure	-195.48KN		
	Net reaction due to dead load from super structure	**143.07KN**	0.00	0.00
	Self wieght of abutment&footings	278.64KN		
	Reduction in self weight due to buoyancy	-116.10KN		
2	Net self weight	**162.54KN**	0.100	0.000
3	Vertical component of earth pressure	18.10KN	0.525	0.000

Horizontal load acting/transferred on the abutment **(H)** composes of the following components

S.No	Type of load	Intensity in KN	Direction x or y	Location(Ht.from the section considered).(m)
1	Wind load	18.00KN	x-Direction	3.86
2	Tractive,Braking&Frictional resistance of bearings	0.00KN	y-Direction	0.00
3	Water current force on deck slab	3.80KN	x-Direction	2.79
4	Water current force on abutment	3.38KN	x-Direction	2.58
5	Frictional force due to water on deck slab	4.96KN	x-Direction	2.79
6	Frictional force due to water on abutment	0.50KN	x-Direction	1.20
7	Horizontal load due to earth pressure	67.60KN	y-Direction	1.13
8	Water pressure force	11.48KN	y-Direction	1.31

Check for stresses:-

About x-axis:-

Breadth of 2nd footing b = 6.00m
Depth of 2nd footing d = 1.50m
Area of the footing = A = 9 m^2

Section modulus of bottom footing about x-axis --Zx = $(1/6)bd^2$ = 2.25 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is 5N/mm^2

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is -2.8N/mm^2

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at heel P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	15.9
2	Net self wieght of abutment&footings	162.54KN	0.10	19.87
3	Vertical component of Earth pressure	18.10KN	0.53	3.07
	Horizontal loads:- (Stress = M/Z)			
4	Horizontal load due to earth pressure	67.60KN	1.13	-34.05
5	Water pressure force	11.48KN	1.31	6.7
				11.45

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at toe P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	15.9
2	Net self wieght of abutment&footings	162.54KN	-0.10	16.25
3	Vertical component of Earth pressure	18.10KN	-0.53	0.96
	Horizontal loads:- (Stress = M/Z)			
4	Horizontal load due to earth pressure	67.60KN	1.13	34.05
5	Water pressure force	11.48KN	1.31	-6.7

	60.5

Stress at heel = P/A(1+6e/b)+M/Z = 11.45 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at toe = P/A(1+6e/b)+M/Z = 60.5 KN/Sqm<5000KN/sqm

Hence safe.

About y-axis:-

Breadth of 1st footing b = 1.50m
Depth of 1st footing d = 6.00m
Area of the footing = A = 9 m^2

Section modulus of bottom footing about y-axis --Zy = $(1/6)bd^2$ = 9.00 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is $5N/mm^2$

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is $-2.8N/mm^2$

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at U/S Edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	15.9
2	Net self wieght of abutment&footings	162.54KN	0.00	18.06
3	Vertical component of Earth pressure	18.10KN	0.00	2.01
	Horizontal loads:- (Stress = M/Z)			
4	Wind load	18.00KN	3.86	-7.72
5	Water current force on deck slab	3.80KN	2.79	-1.2
6	Water current force on abutment	3.38KN	2.58	-1.0
7	Frictional force due to water on deck slab	4.96KN	2.79	-1.5
8	Frictional force due to water on abutment	0.50KN	1.20	-0.1
				24.49

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at D/S edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	15.9
2	Net self wieght of abutment&footings	162.54KN	0.00	18.06
3	Vertical component of Earth pressure	18.10KN	0.00	2.01
	Horizontal loads:- (Stress = M/Z)			
4	Wind load	18.00KN	3.86	7.72
5	Water current force on deck slab	3.80KN	2.79	1.2
6	Water current force on abutment	3.38KN	2.58	1.0
7	Frictional force due to water on deck slab	4.96KN	2.79	1.5
8	Frictional force due to water on abutment	0.50KN	1.20	0.1
				47.45

Stress at up stream side edge of abutment = P/A(1+6e/b)+M/Z = 24.49 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at down stream side edge of abutment = P/A(1+6e/b)+M/Z = 47.45 KN/Sqm<5000KN/sqm

Hence safe.

iii)On top of 2nd footing

The following co-ordinates are assumed:-

a)x-Direction-----At right angle to the movement of vehicles

b)y-Direction-----In the direction of movement of vehicles

Vertical load acting on the abutment **(P)** composes of the following components

S.No	Type of load	Intensity in KN	Eccentricty about x-axis(m)	Eccentricty about y-axis(m)
1	Reaction due to dead load from super structure	338.55KN		
	Deduct uplift pressure	-195.48KN		
	Net reaction due to dead load from super structure	**143.07KN**	0.00	0.00
	Self wieght of abutment&cut waters	213.84KN		
	Reduction in self weight due to buoyancy	-89.10KN		
2	Net self weight	**124.74KN**	0.055	0.000
3	Vertical component of earth pressure	18.10KN	0.525	0.000

Horizontal load acting/transferred on the abutment **(H)** composes of the following components

S.No	Type of load	Intensity in KN	Direction x or y	Location(Ht.from the section considered).(m)
1	Wind load	18.00KN	x-Direction	3.56
2	Tractive,Braking&Frictional resistance of bearings	0.00KN	y-Direction	0.00
3	Water current force on deck slab	3.80KN	x-Direction	2.49
4	Water current force on abutment	3.38KN	x-Direction	2.28
5	Frictional force due to water on deck slab	4.96KN	x-Direction	2.49
6	Frictional force due to water on abutment	0.50KN	x-Direction	0.90
7	Horizontal load due to earth pressure	67.60KN	y-Direction	0.83
8	Water pressure force	11.48KN	y-Direction	1.01

Check for stresses:-

About x-axis:-

Breadth of 1st footing b = 6.00m
Depth of 1st footing d = 1.35m

Area of the footing = A = 8.1 m^2

Section modulus of bottom footing about x-axis --Zx = $(1/6)bd^2$ = 1.82 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is 5N/mm^2

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is -2.8N/mm^2

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at heel P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	17.66
2	Net self wieght of abutment&footings	124.74KN	0.06	16.25
3	Vertical component of Earth pressure	18.10KN	0.53	3.41
	Horizontal loads:- (Stress = M/Z)			
4	Horizontal load due to earth pressure	67.60KN	0.83	-30.91
5	Water pressure force	11.48KN	1.01	6.3
				12.74

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at toe P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	17.66
2	Net self wieght of abutment&footings	124.74KN	-0.06	14.55
3	Vertical component of Earth pressure	18.10KN	-0.53	1.06
	Horizontal loads:- (Stress = M/Z)			
4	Horizontal load due to earth pressure	67.60KN	0.83	30.91
5	Water pressure force	11.48KN	1.01	-6.3
				57.85

Stress at heel = P/A(1+6e/b)+M/Z = 12.74 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at toe = P/A(1+6e/b)+M/Z = 57.85 KN/Sqm<5000KN/sqm

Hence safe.

About y-axis:-

Breadth of 1st footing b = 1.35m
Depth of 1st footing d = 6.00m
Area of the footing = A = 8.1 m^2

Section modulus of bottom footing about y-axis --Zy = $(1/6)bd^2$ = 8.10 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is 5N/mm^2

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is -2.8N/mm^2

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at U/S Edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	17.66
2	Net self wieght of abutment&footings	124.74KN	0.00	15.4
3	Vertical component of Earth pressure	18.10KN	0.00	2.23
	Horizontal loads:- (Stress = M/Z)			
4	Wind load	18.00KN	3.56	-7.91
5	Water current force on deck slab	3.80KN	2.49	-1.2
6	Water current force on abutment	3.38KN	2.28	-1.0
7	Frictional force due to water on deck slab	4.96KN	2.49	-1.5
8	Frictional force due to water on abutment	0.50KN	0.90	-0.1
				23.68

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at D/S edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	17.66
2	Net self wieght of abutment&footings	124.74KN	0.00	15.4
3	Vertical component of Earth pressure	18.10KN	0.00	2.23
	Horizontal loads:- (Stress = M/Z)			
4	Wind load	18.00KN	3.56	7.91
5	Water current force on deck slab	3.80KN	2.49	1.2
6	Water current force on abutment	3.38KN	2.28	1.0
7	Frictional force due to water on deck slab	4.96KN	2.49	1.5
8	Frictional force due to water on abutment	0.50KN	0.90	0.1
				46.9

Stress at up stream side edge of abutment = P/A(1+6e/b)+M/Z = 23.68 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at down stream side edge of abutment = P/A(1+6e/b)+M/Z = 46.9 KN/Sqm<5000KN/sqm

Hence safe.

iii)On top of 1st footing

The following co-ordinates are assumed:-

a)x-Direction-----At right angle to the movement of vehicles
b)y-Direction-----In the direction of movement of vehicles

Vertical load acting on the abutment **(P)** composes of the following components

S.No	Type of load	Intensity in KN	Eccentricty about x-axis(m)	Eccentricty about y-axis(m)
1	Reaction due to dead load from super structure	338.55KN		
	Deduct uplift pressure	-195.48KN		

	Net reaction due to dead load from super structure	**143.07KN**	0.00	0.00
	Self wieght of abutment&cut waters	213.84KN		
	Reduction in self weight due to buoyancy	-89.10KN		
2	Net self weight	**124.74KN**	0.055	0.000
3	Vertical component of earth pressure	18.10KN	0.525	0.000

Horizontal load acting/transferred on the abutment **(H)** composes of the following components

S.No	Type of load	Intensity in KN	Direction x or y	Location(Ht.from the section considered).(m)
1	Wind load	18.00KN	x-Direction	3.26
2	Tractive,Braking&Frictional resistance of bearings	0.00KN	y-Direction	0.00
3	Water current force on deck slab	3.80KN	x-Direction	2.19
4	Water current force on abutment	3.38KN	x-Direction	1.98
5	Frictional force due to water on deck slab	4.96KN	x-Direction	2.19
6	Frictional force due to water on abutment	0.50KN	x-Direction	0.60
7	Horizontal load due to earth pressure	67.60KN	y-Direction	0.53
8	Water pressure force	11.48KN	y-Direction	0.71

Check for stresses:-

About x-axis:-

Breadth of abutment b = 6.00m
Depth of abutment d = 1.05m
Area of the footing = A = 6.3 m^2

Section modulus of bottom footing about x-axis --Zx = $(1/6)bd^2$ = 1.10 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is $5N/mm^2$

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is $-2.8N/mm^2$

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at heel P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	22.71
2	Net self wieght of abutment&footings	124.74KN	0.06	20.89
3	Vertical component of Earth pressure	18.10KN	0.53	4.38
	Horizontal loads:- (Stress = M/Z)			
4	Horizontal load due to earth pressure	67.60KN	0.53	-32.7
5	Water pressure force	11.48KN	0.71	7.4
				22.63

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at toe P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	22.71
2	Net self wieght of abutment&footings	124.74KN	-0.06	18.71
3	Vertical component of Earth pressure	18.10KN	-0.53	1.36
	Horizontal loads:- (Stress = M/Z)			
4	Horizontal load due to earth pressure	67.60KN	0.53	32.7

5	Water pressure force		11.48KN	0.71	-7.4
					68.13

Stress at heel = P/A(1+6e/b)+M/Z = 22.63 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at toe = P/A(1+6e/b)+M/Z = 68.13 KN/Sqm<5000KN/sqm

Hence safe.

About y-axis:-

Breadth of abutment b = 1.05m
Depth of abutment d = 6.00m
Area of the footing = A = 6.3 m^2

Section modulus of bottom footing about y-axis --Zy = $(1/6)bd^2$ = 6.30 m^3

For M20 grade of concrete permissible compressive stress in direct compreession is $5N/mm^2$

i.e, **5000KN/sqm**

For M20 grade of concrete permissible tensile stress in bending tension is $-2.8N/mm^2$

i.e, **-2800KN/sqm**

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at U/S Edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	22.71
2	Net self wieght of abutment&footings	124.74KN	0.00	19.8
3	Vertical component of Earth pressure	18.10KN	0.00	2.87
	Horizontal loads:- (Stress = M/Z)			
4	Wind load	18.00KN	3.26	-9.31
5	Water current force on deck slab	3.80KN	2.19	-1.3
6	Water current force on abutment	3.38KN	1.98	-1.1
7	Frictional force due to water on deck slab	4.96KN	2.19	-1.7
8	Frictional force due to water on abutment	0.50KN	0.60	-0.1
				31.92

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at D/S edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	143.07KN	0.00	22.71
2	Net self wieght of abutment&footings	124.74KN	0.00	19.8
3	Vertical component of Earth pressure	18.10KN	0.00	2.87
	Horizontal loads:- (Stress = M/Z)			
4	Wind load	18.00KN	3.26	9.31
5	Water current force on deck slab	3.80KN	2.19	1.3
6	Water current force on abutment	3.38KN	1.98	1.1
7	Frictional force due to water on deck slab	4.96KN	2.19	1.7
8	Frictional force due to water on abutment	0.50KN	0.60	0.1
				58.84

Stress at up stream side edge of abutment = P/A(1+6e/b)+M/Z = 31.92 KN/Sqm>-2800KN/sqm.

Hence safe.

Stress at down stream side edge of abutment = P/A(1+6e/b)+M/Z = 58.84 KN/Sqm<5000KN/sqm

Hence safe.

V)Check for stability of abutments:-

a)Load Envelope-III:-(The Canal is dry,back fill intact with live load on span)

The following co-ordinates are assumed:-

a)x-Direction-----At right angle to the movement of vehicles

b)y-Direction-----In the direction of movement of vehicles

Vertical load acting on the abutment **(P)** composes of the following components

S.No	Type of load	Intensity in KN	Eccentricty about x-axis(m)	Eccentricty about y-axis(m)
1	Reaction due to dead load from super structure	338.55KN	0.00	0.00
2	Self wieght of abutments	155.52KN	0.075	0.000
3	Reaction due to live load with impact factor	399.88KN	-0.01	0.543
4	Vertical component of Active Earth pressure	18.10KN	0.525	0.00
		912.05KN		

Horizontal load acting/transferred on the abutment **(H)** composes of the following components

S.No	Type of load	Intensity in KN	Direction x or y	Location(Ht.from the section considered).(m)
1	Wind load	18.00KN	x-Direction	3.26
2	Tractive,Braking&Frictional resistance of bearings	47.84KN	y-Direction	2.96
3	Horizontal Active Earth pressure force	67.60KN	y-Direction	0.53
		133.44KN		

Check for stability against over turning:-

Taking moments of all the overturning forces about toe of the abutment wrt x-axis,

Moment due to tractive,braking&frictional resistance of bearings = 141.61Kn-m

Moment due to active earth pressure force = 36.05Kn-m

Total overturning moment = **177.66Kn-m**

Taking moments of all the restoring forces about toe of the abutment wrt x-axis,,

Moment due to dead load reaction from super structure = 177.74Kn-m

Moment due to self weight of abutment = 93.31Kn-m

Moment due to live load reaction on abutment = 205.94Kn-m

Moment due to vertical component of active earth pressure = 19.01Kn-m

Total Restoring moment = **496.00Kn-m**

Factor of safety = 2.79181252 > 2.0 Hence safe
(As per clause 706.3.4 of IRC:78-2000)

Check for stability against sliding:-

Total vertical load acting on the base of the abutment V_b = 912.05KN

Total sliding force,ie,horizontal load on the abutment H_b = 133.44KN

Coefficient of friction between concrete surfaces = 0.80

Factor of safety against sliding F_s = 5.46799594 > 1.5 Hence safe
(As per clause 706.3.4 of IRC:78-2000)

b)Load Envelope-II:-(The Canal is full,back fill intact with no live load on span)

The following co-ordinates are assumed:-

a)x-Direction-----At right angle to the movement of vehicles

b)y-Direction-----In the direction of movement of vehicles

Vertical load acting on the abutment **(P)** composes of the following components

S.No	Type of load	Intensity in KN	Eccentricty about x-axis(m)	Eccentricty about y-axis(m)
1	Reaction due to dead load from super structure	338.55KN		
	Deduct uplift pressure	-195.48KN		
	Net reaction due to dead load from super structure	**143.07KN**	0.00	0.00
	Self wieght of abutments	155.52KN		
	Reduction in self weight due to buoyancy	-64.80KN		
2	Net self wieght	**90.72KN**	0.075	0.000
3	Vertical component of Active Earth pressure	18.10	0.525	0.00

Horizontal load acting/transferred on the abutment **(H)** composes of the following components

S.No	Type of load	Intensity in KN	Direction x or y	Location(Ht.from the section considered).(m)
1	Wind load	18.00KN	x-Direction	3.26
2	Tractive,Braking&Frictional resistance of bearings	0.00KN	y-Direction	0.00
3	Active Earth pressure force	67.60KN	y-Direction	0.53
4	Force due to water pressure	11.48KN	y-Direction	0.71

Check for stability against over turning:-

Taking moments of all the overturning forces about toe of the abutment wrt x-axis,

Moment due to tractive,braking&frictional resistance of bearings = 0.00Kn-m

Moment due to active earth pressure force = 36.05Kn-m

Total overturning moment = **36.05Kn-m**

Taking moments of all the restoring forces about toe of the abutment wrt x-axis,

Moment due to dead load reaction from super structure = 75.11

Moment due to self weight of abutment = 54.43Kn-m

Moment due to water pressure force on the abutment = 8.10Kn-m

Moment due to vertical component of active earth pressure = 19.01Kn-m

Total Restoring moment = **156.65Kn-m**

Factor of safety = 4.34515347 > 2.0 Hence safe
(As per clause 706.3.4 of IRC:78-2000)

Check for stability against sliding:-

Total vertical load acting on the base of the abutment V_b = 251.89KN

Total sliding force,ie,horizontal load on the abutment H_b = 67.60KN

Coefficient of friction between concrete surfaces = 0.80

Factor of safety against sliding F_s = 2.98107738 > 1.5 Hence safe
(As per clause 706.3.4 of IRC:78-2000)

VI)Design of Strip footing:-

a)Load Envelope-III:-(The Canal is dry,back fill intact with live load on span)

i)At the bottom of RCC strip footing

The following co-ordinates are assumed:-

a)x-Direction-----At right angle to the movement of vehicles

b)y-Direction-----In the direction of movement of vehicles

Vertical load acting on the abutment **(P)** composes of the following components

S.No	Type of load	Intensity in KN	Eccentricty about x-axis(m)	Eccentricty about y-axis(m)
1	Reaction due to dead load from super structure	338.55KN	0.00	0.00
2	Self weight of abutment&footings	349.92KN	0.015	0.000
3	Self weight of RCC strip footing	138.21KN	0.00	0.00
4	Reaction due to live load with impact factor	295.77KN	0.00	0.543
4	Vertical component of earth pressure	18.10KN	0.525	0.000

Horizontal load acting/transferred on the abutment **(H)** composes of the following components

S.No	Type of load	Intensity in KN	Direction x or y	Location(Ht.from the section considered).(m)
1	Wind load	18.00KN	x-Direction	4.46
2	Tractive,Braking&Frictional resistance of bearings	47.84KN	y-Direction	4.16
3	Horizontal load due to earth pressure	67.60KN	y-Direction	1.73

Safe bearing capacity SBC of the soil = 15.00t/sqm

Check for stresses:-

About x-axis:-

Breadth of footing b = 6.30m

Depth of footing d = 1.95m

Area of the footing = A = 12.285 m^2

Section modulus of bottom footing about x-axis --Zx = $(1/6)bd^2$ = 3.99 m^3

For RCC Strip footing permissible bearing pressure is 1.5xSBC = **225KN/sqm**

No tension is allowed on soil as per clause 706.3.3.1 of IRC 78:2000

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at heel P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	27.56
2	Self wieght of abutment&footings	349.92KN	0.02	28.89
3	Self weight of RCC strip footing	138.21KN	0.00	11.25
4	Reaction due to live load with impact factor	295.77KN	0.00	24.08

5	Vertical component of Earth pressure	18.10KN	0.53	2.21
	Horizontal loads:- (Stress = M/Z)			
1	Wind load	18.00KN	0.00	0
2	Tractive,Braking&Frictional resistance of bearings	47.84KN	4.16	-49.9
3	Horizontal load due to earth pressure	67.60KN	1.73	-29.4
				14.79

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at toe P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	27.56
2	Self wieght of abutment&footings	349.92KN	-0.02	28.08
3	Self weight of RCC strip footing	138.21KN	0.00	11.25
4	Reaction due to live load with impact factor	295.77KN	0.00	24.08
5	Vertical component of Earth pressure	18.10KN	-0.53	0.74
	Horizontal loads:- (Stress = M/Z)			
1	Wind load	18.00KN	0.00	0
2	Tractive,Braking&Frictional resistance of bearings	47.84KN	4.16	49.85
3	Horizontal load due to earth pressure	67.60KN	1.73	29.35
				170.91

Stress at heel = P/A(1+6e/b)+M/Z = 14.79 KN/Sqm>0

Hence safe.

Stress at toe = P/A(1+6e/b)+M/Z = 170.91 KN/Sqm<225KN/sqm

Hence safe.

About y-axis:-

Breadth of footing b = 1.95m
Depth of footing d = 6.30m
Area of the footing = A = 12.285 m^2

Section modulus of bottom footing about y-axis --Zy = $(1/6)bd^2$ = 12.90 m^3

For RCC Strip footing permissible bearing pressure is 1.5xSBC = **225KN/sqm**

No tension is allowed on soil as per clause 706.3.3.1 of IRC 78:2000

S.No	Type of load	Intensity in KN (P)	Eccentricity/Lever arm	Stress at U/S edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	27.56
2	Self wieght of abutment&footings	349.92KN	0.00	28.48
3	Self weight of RCC strip footing	138.21KN	0.00	11.25
4	Reaction due to live load with impact factor	295.77KN	-0.543	-16.15
5	Vertical component of Earth pressure	18.10KN	0.00	1.47
	Horizontal loads:- (Stress = M/Z)			
1	Wind load	18.00KN	4.46	-6.22
2	Tractive,Braking&Frictional resistance of bearings	47.84KN	0.00	0.0
3	Horizontal load due to earth pressure	67.60KN	0.00	0.0
				46.39

S.No	Type of load	Intensity in KN (P)	Eccentricity	Stress at D/S edge P/A(1+6e/b)
	Vertical loads:-(Stress = P/A(1+6e/b)			
1	Reaction due to dead load from super structure	338.55KN	0.00	27.56
2	Self wieght of abutment&footings	349.92KN	0.00	28.48
3	Self weight of RCC strip footing	138.21KN	0.00	11.25
4	Reaction due to live load with impact factor	295.77KN	0.543	64.3
5	Vertical component of Earth pressure	18.10KN	0.00	1.47
	Horizontal loads:- (Stress = M/Z)			
1	Wind load	18.00KN	4.46	6.22
2	Tractive,Braking&Frictional resistance of bearings	47.84KN	0.00	0
3	Horizontal load due to earth pressure	67.60KN	0.00	0
				139.28

Stress at up stream side edge of abutment = P/A(1+6e/b)+M/Z = 46.39 KN/Sqm>0

Hence safe.

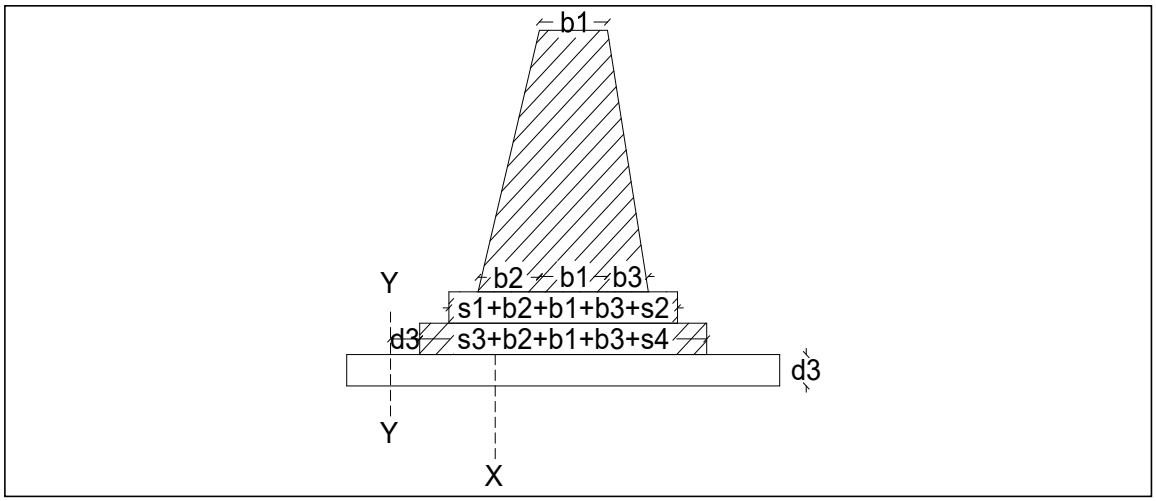
Stress at down stream side edge of abutment = P/A(1+6e/b)+M/Z = 139.29 KN/Sqm<225KN/sqm

Hence safe.

The footing has to be designed as strip footing supporting the masonry structure

The net bearing pressure on the toe of footing = 159.66 KN/Sqm
(Excluding self weight of footing)

The footing needs to be designed for 1.5 times the above net bearing pressure 239.49 KN/Sqm



The UDL on the footing for unit width = 239.49 KN/m

The critical section for bending is at a distance of 1/4xwidth of bottom footing from the centre,ie,at section X--X

Hence,the length of cantilever portion to be considered for design =

0.83m

Hence,the critical bending moment = $(1/2)Wl^2$ = **82.49KN-m**

Effective depth required d = $\sqrt{M_u/0.133f_{ck}b}$ = 157.51mm

The over all depth required(Assuming 16mm dia bars) = 215.51mm

However provide overall depth of = **450.00mm**

Hence,effective depth = 392.00mm

Bottom steel:-

M_u/bd^2 = 0.537

From table 3 of SP 16,percentage of steel required = 0.156

Area of steel required = 611.52sqmm

Hence provide 12mm dia bars at 125mm c/c along width,the area of reinforcement comes to

904.32sqmm

Distribution steel:-

Provide distribution reinforcement of 0.15% of cross sectional area of footing

Hence,the distribution reinforcement required = 675.00sqmm

Adopting 12mm dia bars,the spacing required = 167.00mm

However provide 12mm dia bars at 150mm c/c spacing,as distribution reinforcement

Check for one way shear:-

The critical section for beam shear is at distance of 'd' from the face of the column,ie,at Y-Y

Hence,the factored design shear force V_{Fd} = 35.92KN

Nominal shear stress T_v = ⟶ 0.1N/sqmm <2.8 N/sqmm
(As per Table 20 of 1S 456)

Hence,the section is safe from shear point of view

Assumed percentage area of the steel reinforcement = 0.23%

The design shear strength of concrete for the above steel percentage from Table 19 of IS 456 is

0.35 Hence V_{uc} = 137.20KN

⟶ 0.35>0.1

Hence,the depth provided is safe from beam shear point of view

The check for two way shear is not necessary in the present context.