DESIGN OF SUBMERSIBLE BRIDGE

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

Hydraulic Calculation

Computation of Discharge

1 Flood calculation by Area Velocity Method (As per Article- 5 of IRC SP-13)

Q =	A x V			Where	
A =	440.83	m2		A =	Cross sectional area in m^2
P =	117.02	m		P =	Perimeter calculated in m
S =	1	IN	926	S =	Slope as per drain LS taken at Proposal site
n =	0.033			n =	Rugosity coefficient (As per IRC SP-13)
V =	$I/nx\,(A/P)^{2/3}\ x(S)^{1/2}$			V =	Velocity in m/sec.
=	2.42	m/sec.			
Q =	1066.80	Cumecs			

Linear Water Way Calculation

Regime Surface width of the stream is given by :- L = 4.8 (Q)1/2

= 156.78 m

Looking to the built up Urban area constraints adopt 12 Spans of 8 M each.

This will cause contraction and afflux. Calculation is done for the same to fix deck level.

Effective linear water way proposed = 11 x 8 = 88 M

Total 88 M

Scour Depth Calculation

(As per clause no. 703.2.2.1 of IRC : 78.1983)

$dsm = 1.34x\,(Db^2\ /Ksf)^{1/3}$

Where

Db = The discharge in Cumecs per meter width

Ksf = the silt factor

= 1.5

Effective linear waterway = Width of waterway - Obstructed width of piper

= 94.80 - (10 x 1.2)

= 82.80 m

Db = 1066.80 / 82.80

= 12.89 Cumecs per metre width

dsm = 6.44 m

As per Clause No. 703-2-3-1 of IRC 78-1983 considering Scour at the pier two times of calculated scour depth below the highest flood level. But hard rock is available in foundation so the foundation will be anchored in the rock as per IRC guidelines.

Afflux Calculation

As per IS: 7784 (Part -I) 1975

Molesworth Formula for Afflux

Afflux h = $((V^2/17.85) + 0.0152) x (A^2/a^2 - 1)$

Where,

h	=	afflux in m,
v	=	Velocity in the unobstructed stream in m/s,
A	=	the unobstructed sectional area of the river in m^2
a	=	the obstructed sectional area of the river at the cross drainage work in m^2.

As per Annexure- 1

Unobstructed Area of Flow after Bridge Construction = 94.800 x 3.78 = 358.48 m^2

A = 440.83 m^2

V = 2.42 m/sec.

Computation of Area obstructed by Deck Slab

HFL :	99.500	m
Top Level of Deck slab :	99.950	m
Thickness of Slab and Wearing Coat	0.830	m
Length Of Slab	94.800	m
Height of Obstruction	0.830	m
Area obstructed by deck slab	94.800 x 0.83	
=	78.68	m^2

Computation of Area obstructed by Piers

HFL :	99.500	m
Soffit of Deck slab :	99.120	m
Average river bed level =	96.169	m
Nos. of pier =	10	
Height of Obstruction	99.500 - 96.169 = 3.331	m
Area obstructed by one pier : =	1.2 x 3.33	
=	3.998	m^2
For 10 Nos. of piers =	10 x 3.998	
A1 =	39.98	m^2

Computation of Area obstructed by Abutments

Average ground level =	96.169	m
Height of Obstruction	99.500 = 96.169 = 3.331	m
Area obstructed by one Abutment : A2 =	(0.40+0.75)/2 x 3.33	
=	1.92	m^2
For two Abutments =	2 x 1.92	
=	3.83	m^2

Total area of obstruction due to slab,
piers and abutments A = A0 +A1 + A2

= 78.68 + 39.98 + 3.83

= 122.50 m^2

Actual Area of flow a =		*440.825*	*-*		*122.50*	
	=			*318.33*	*m^2*	
Afflux h =		*0.32*	*m*			
Afflux flood level =		*99.500*	*+*		*0.32 =*	*99.820 m*
Obstructed Velocity	*V*		*=*		*Q/a -*	
Obstructed Velocity	*=*			*1066.8*	*/*	*318.33*
	=			*3.36*	*m/sec*	
However we consider design velocity		*3.36*	*m/sec.*			
Afflux flood level	*=*			**99.820**	**M**	
Top of deck slab	*=*			**99.950**	**M**	

This is well above the Afflux flood level.

Though it is not a high level bridge; there shall be no hindrance to traffic during high floods.

Hence OK.

DETERMINATION OF VELOCITY AT PROPOSED SUBMERSIBLE BRIDGE

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

AS PER UP-STREAM SECTION

HIGHEST FLOOD LEVEL 99.500 M

CHAINAGE	G.L.	DEPTH OF FLOW IN M	LENGTH OF FLOW	AVERAGE DEPTH OF FLOW	CROSS SECTIONAL AREA OF FLOW	WETTED PERIMETER
0	99.350	0.15	0.00	0.00	0.00	0.00
5	98.080	1.42	5.00	0.79	3.93	5.16
10	94.390	5.11	5.00	3.27	16.33	6.21
20	93.840	5.66	10.00	5.39	53.85	10.02
30	92.690	6.81	10.00	6.24	62.35	10.07
40	93.590	5.91	10.00	6.36	63.60	10.04
50	94.020	5.48	10.00	5.70	56.95	10.01
60	94.620	4.88	10.00	5.18	51.80	10.02
70	94.340	5.16	10.00	5.02	50.20	10.00
80	95.580	3.92	10.00	4.54	45.40	10.08
90	97.610	1.89	10.00	2.91	29.05	10.20
95	98.980	0.52	5.00	1.21	6.02	5.18
100	99.490	0.01	5.00	0.27	1.33	5.03
105	99.780	0.00	5.00	0.01	0.03	5.00
110	100.120	0.00	5.00	0.00	0.00	5.00
115	100.573	0.00	5.00	0.00	0.00	5.00
	96.17	TOTAL	115.00		440.83	117.02

A		440.83	SQM
P		117.02	M
R		3.77	M
N		0.033	
S	1 IN	926	

CHAINAGE	G.L.	DEPTH OF FLOW IN M	LENGTH OF FLOW	AVERAGE DEPTH OF FLOW	CROSS SECTIONAL AREA OF FLOW	WETTED PERIMETER

V	2.41	M/SEC
Q	1062.82	CUMECS

The design engineer visually observed the river to ascertain the Roughness Coefficient n for the Manning's formula. Upon visual inspection of the river in the vicinity of the proposed bridge site it was found that the River bed surface is good with clean straight banks, no rifts or deep pools however containing some weeds and stones. Roughness Coefficient pertaining to these characteristics is 0.033

Design Discharge = 1062.82 CUMECS

Critical Levels		
Road top level (RTL)	*99.950*	*M*
Average Ground Level(AGL)	*96.169*	*M*
Average Height Of Bridge	*3.780*	*M*
Lowest Nala Bed level (NBL)	*92.690*	*M*
Ordinary flood level (OFL)	*97.369*	*M*
Foundation level (FL)	*89.690*	*M*
Ht. of bridge h= (RTL-NBL)	*7.260*	*M*
Ht. of bridge H=(RTL-FL)	*10.260*	*M*

**** Needs Rational Evaluation w.r.t. afflux.**

**** Average of GL for points lying below HFL.**

ANCHORAGE OF DECK SLAB TO SUBSTRUCTURE

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

In the case of a submersible bridge, the deck slab is near the plane of maximum velocity. To counteract the sliding action due to velocity of flow, loss of weight of slab due to buoyancy, the tilting forces due to eddies and currents and the disturbing forces due to debris or trees floating down the stream , it is necessary to anchor the deck slab to the substructure.

One possible solution to this anchorage is as shown in detailed drawing. The aim in this anchorage is to secure the deck slab to piers or abutments against uplift or lateral thrust and at the same time allow lateral movement due to expansion and contraction due to temperature effects the arrangement will be evident from the sketch given in the detailed drawing.

Check Against Uplift

The uplift force shall be maximum when the flow level is Just at near deck level. *THIS WILL BE IN CASE OF AFFLUX FLOOD LEVEL* 99.82 M

Total Height	=	0.32 M				
Maximum Uplift Pressure	=	0.32 x	10 =	3.2 kN/Sqm		
Area of Slab under effect of buoyancy	=	8.80 x	12 =	105.6 Sqm		
Uplift Force on Slab	=	105.6 x	3.2 =	337.92 kN		
Self Weight of Slab	=	8.80 x	12 x	0.75 x	24.00 =	1900.80 kN
Self Weight of Wearing Coat	=	8.80 x	12 x	0.075 x	24.00 =	190.08 kN
Footpath	=	2X10.8 x	1.50 x	0.50 x	0.00 =	0.00 kN
TOTAL						**2090.88 kN**
Net Uplift Pressure	=	337.92 -	2090.88 =	**-1752.96** kN		
				< 0 Hence Ok.		

Check Against Sliding

Refer Stability Check of Pier

WATER CURRENT IN TRANSVERSE DIRECTION (ACROSS THE BRIDGE)

As per IRC- II (6-1966) clause 213.5 For V= 3.36 m/sec Maximum velocity being 1.414 x mean velocity (1.414= Root of 2)

Obstructed Velocity = V Cos 20 0	=	3.36 x	Cos 20 0	
	=	3.16		
2v2	=	19.94		
The soffit of the deck is at HFL	=	99.50 M	The afflux Flood Level is	99.82 M

DRAG FORCE ON DECK SLAB DUE TO AFFLUX

Area Obstructed	=	8.80 x	0.320 =	2.82 Sqm			
Drag Force on Slab	=	52.00 x	k x	v^2 x	Area Obstructed		
	=	52.00 x	1.50 x	19.94 x	2.82 / 100	=	**43.80** kN

Dia of Anchor Bars		32 mm					
Permissible Shear Stress		190 N/mm^2					
Shear Force Resisted by one Anchor Bar	=	(0.785 x	32^2	/4)x	190 / 1000	=	38.19 kN
Number Of Bars Provided Per slab		18 Nos.					
Total Shear Resisted	=	18 x	38.19 =	687.42 kN			
FACTOR OF SAFETY	=	687.42 /	43.79892 =	15.7			
				> 2.00 Hence OK			

CROSS SECTION OF RIVER DOWN-STREAM

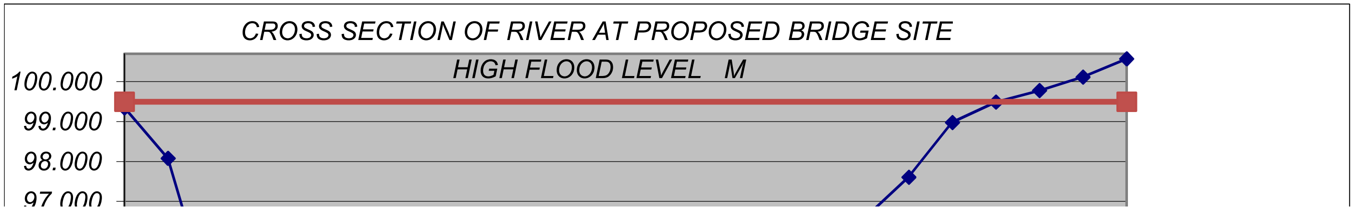
Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

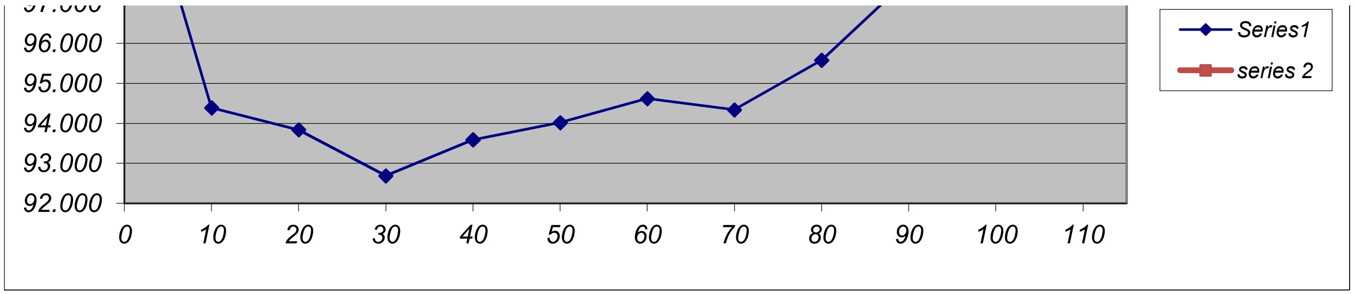
CROSS SECTION OF RIVER AT PROPOSED BRIDGE SITE

HIGHEST FLOOD LEVEL 99.500 M

Chainage in M (u/s or d/s)	RL in M	DEPTH OF FLOW IN M	LENGTH OF FLOW	AVERAGE DEPTH OF FLOW	CROSS SECTIONAL AREA OF FLOW	WETTED PERIMETER
0	99.350	0.15	0.00	0.00	0.00	0.00
5	98.080	1.42	5.00	0.79	3.93	5.16
10	94.390	5.11	5.00	3.27	16.33	6.21
20	93.840	5.66	10.00	5.39	53.85	10.02
30	92.690	6.81	10.00	6.24	62.35	10.07
40	93.590	5.91	10.00	6.36	63.60	10.04
50	94.020	5.48	10.00	5.70	56.95	10.01
60	94.620	4.88	10.00	5.18	51.80	10.02
70	94.340	5.16	10.00	5.02	50.20	10.00
80	95.580	3.92	10.00	4.54	45.40	10.08
90	97.610	1.89	10.00	2.91	29.05	10.20
95	98.980	0.52	5.00	1.21	6.02	5.18
100	99.490	0.01	5.00	0.27	1.33	5.03
105	99.780	0.00	5.00	0.01	0.03	5.00
110	100.120	0.00	5.00	0.00	0.00	5.00
115	100.573	0.00	5.00	0.00	0.00	5.00
		TOTAL	115.00		440.83	117.02

0.00	99.50
115.00	99.50




96.000
95.000
94.000
93.000
92.000
0
10
20
30
40
50
60
70
80
90
100
110
Series1
series 2

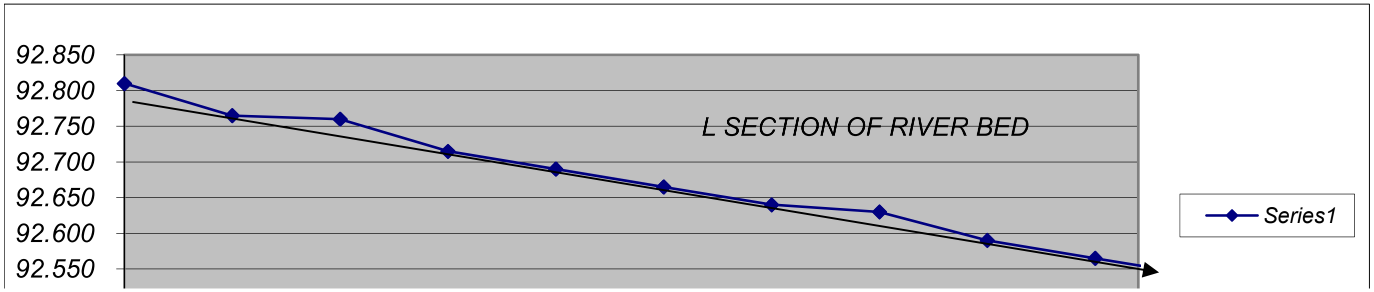
DETERMINATION OF BED SLOPE OF THE RIVER

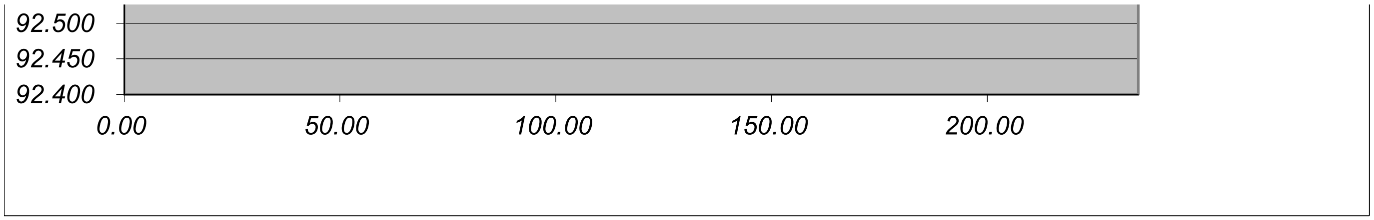
Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

Chainage in M (u/s or d/s)	RL in M
0.00	92.810
25.00	92.765
50.00	92.760
75.00	92.715
100.00	92.690
125.00	92.665
150.00	92.640
175.00	92.630
200.00	92.590
225.00	92.565
250.00	92.540

Reference Poits	
Ch	RL
0.00	92.810
250.00	92.540

DISTANCE	250	M	
FALL	0.27	M	
SLOPE	1	IN	926




92.500
92.450
92.400
0.00
50.00
100.00
150.00
200.00

DESIGN OF PIER AND CHECK FOR STABILITY- SUBMERSIBLE BRIDGE

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

DESIGN DATA

No.	Item		Value	Unit	
1	RIGHT EFFECTIVE SPAN	=	7.60	M	
2	SPAN C/C OF PIERS	=	8.80	M	
3	OVERALL WIDTH OF PIER CAP	=	8.40	M	
4	H.F.L.	=	99.50	M	
5	BUOYANCY				
6	AT FOOTING LEVEL	=	100.00	%	
7	AT PIER LEVEL	=	100.00	%	
8	AQUEDUCT FALLS UNDER ZONE-II SO SEISMIC CASE IS NOT GOVERNING HERE.				
9	FLOOD DISCHARGE	=	**1062.82**	**CUMECS**	
10	RIVER BED SLOPE	=	1	IN	926
11	DESIGN VELOCITY	=	2.41	m/sec	
12	BED LEVEL OF THE HEIGHEST PIER	=	92.69	M	
13	SAFE BEARING CAPACITY	=	**20.00**	**t/m2**	**200.00** kN/m^2
14	TOP LEVEL OF FOUNDING ROCK	=	89.69	M	
15	EMBEDMENT OF PIER IN HARD ROCK	=	1.50	M	
16	FOUNDATION LEVEL OF THE HIGHEST PIER	=	88.190	M	
17	DECK LEVEL OF THE BRIDGE	=	99.950	M	
18	TOP LEVEL OF THE PIER CAP	=	99.125	M	
19	LEVEL DIFFERENCE OF PIER CAP TOP AND FOUNDING LEVEL	=	10.94	M	

CHECKING STABILITY OF PIER AT R.L.88.19 M FOOTING LEVEL

A DEAD LOAD CALCULATION

SUPER STRUCTURE

Self Weight of Slab =	8.80 x	8.40 x	0.75 x	24.00 =	1330.56 kN		
Self Weight of Wearing Coat =	8.80 x	8.40 x	0.075 x	24.00 =	133.06 kN		
TOTAL					**1463.62 kN**		

SUB STRUCTURE

Pier Cap

Pier Cap =	1.50 x	8.40 x	0.60 x	24.00		=	181.440 kN
Flared Portion Sides =	0.50 x	0.15 x	0.60 x	8.40 x	2.00 x	24.00 =	18.144 kN
=	0.50 x	0.15 x	0.60 x	3.14 x	1.20 x	24.00 =	4.069 kN
Flared Portion u/s & d/s Sides =	0.60 x	0.60 x	1.50 x	24.00		=	12.960 kN
=	3.14 /	4.00 x	1.20 x	1.20 x	0.60 x	24.00 =	16.278 kN
TOTAL							**232.891 kN**

Pier

Flared Portion Top =	**0.50** x	0.15 x	0.60 x	8.40 x	**2** x	24.00 =	18.144 kN
=	**0.50** x	0.15 x	0.60 x	**3.14** x	1.20 x	24.00 =	4.069 kN
Pier Rectangular portion =	1.20 x	7.50 x	8.09 x	24.00		=	1746.360 kN
Pier Curved portion =	**3.14** /	4 x	1.20 x	1.20 x	8.09 x	24.00 =	219.343 kN
Flared Portion bottom =	0.50 x	0.60 x	0.30 x	24.00		=	2.160 kN
=	**3.14** /	4 x	1.20 x	1.20 x	0.60 x	24.00 =	16.278 kN
TOTAL							**2011.780 kN**
Weight of Pier Above H.F.L. =							**0.000 kN**
Weight of Pier Below H.F.L. =	2011.78 -	0.00				=	**2011.780 kN**
Weight of Sub Structure with 15% Buoyancy =	0.00 + (	2011.78 x	22.50 /	24.00)		=	**1886.044 kN**
Footing	**SIZE 12.00**	**M x 3.80**	**M x**	**1.00 M**			
Weight without Buoyancy =	12.00 x	3.80 x	1.00 x	24.00		=	1094.400 kN
Weight with 100% Buoyancy =	12.00 x	3.80 x	1.00 x	**14.00**		=	638.400 kN

Total Weight of Substructure Without Buoyancy

= 232.89 + 2011.78 + 1094.40 = **3339.071 kN**

Total Weight of Substructure With Buoyancy

= 232.89 + 1886.04 + 638.40 = **2757.335 kN**

B LIVE LOAD CALCULATION

Maximum Reaction due Live Load including Impact

= 788.27 x 1.00 = **788.27** **kN**

Refer Live load Computation sheet showing maximum reaction

= 78.83 T which is = 788.27 kN

Haunch	0.60	M
PCC Offset	0.20	M
Length Variant	1.00	M
Width Variai	0.50	M

TOTAL LONGITUDINAL MOMENT DUE TO LIVE LOAD & BREAKING FORCE

Maximum Longitudinal moment due to Live Load including Impact and Breaking Force

= 122.13 x 2.00 = **244.25** **kN-m**

Refer Live load Computation sheet showing maximum reaction = 12.21 T- m which is = 122.13 kN-m

153.89	Stress
66.34	

TOTAL TRANSVERSE MOMENT DUE TO LIVE LOAD & BREAKING FORCE

Maximum Transverse moment due to Live Load including Impact and Breaking Force

= 1123.94 x 2.00 = **2247.88** **kN-m**

Refer Live load Computation sheet showing maximum reaction = 112.39 T- m which is = 1123.94 kN-m

C LOADS DUE TO WATER CURRENT

WATER CURRENT IN LONGITUDINAL DIRECTION (ALONG THE BRIDGE)

As per IRC- II (6-1966) clause 213.5 For V= 2.41 m/sec

Since the bridge is at Zero Degrees skew from the direction of current as per IRC- II (6-1966) clause 213.5 it should be designed for (20+0) =20 Degrees or (20-0) = 20 Degrees whichever gives higher quantum of water current forces.

Obstructed Velocity = V Sin 20 ^{0} = **2.41 x** **Sin 20 ^{0}**

= 0.82
$2v^2$ = 1.36
Total SUBMERGED Height = 9.81 M 1.36 1.22 1.21 0.00

#NAME?

$2v^2$ = (1.36 + 1.22) /2 = 1.29
Area Obstructed = 12.00 x 0.00 = 0.00 Sqm

Force on Pier = 52.00 x k x v^2 x Area Obstructed
= 52.00 x 1.50 x 1.29 x 0.00 / 100 = **0.00 kN** at R.L. 99.535 M
Moment @ R. L. 89.79 M = 0.00 x 9.75 = **0.00 kN-m**
Moment @ R. L. 89.19 M = 0.00 x 10.35 = **0.00 kN-m**
Moment @ R. L. 88.19 M = 0.00 x 11.35 = **0.00 kN-m**

#NAME?

$2v^2$ = (1.22 + 1.21) /2 = 1.21
Area Obstructed = 12.00 x 0.60 = 7.20 Sqm

Force on Pier = 52.00 x k x v^2 x Area Obstructed
= 52.00 x 1.50 x 1.21 x 7.20 / 100 = **6.82 kN** at R.L. 93.658 M
Moment @ R. L. 89.79 M = 6.82 x 3.87 = **26.39 kN-m**
Moment @ R. L. 89.19 M = 6.82 x 4.47 = **30.48 kN-m**
Moment @ R. L. 88.19 M = 6.82 x 5.47 = **37.31 kN-m**

#NAME?

$2v^2$ = (1.21 + 0.00) /2 = 0.60
Area Obstructed = 7.33 x 8.70 = 63.81 Sqm

Force on Pier = 52.00 x k x v^2 x Area Obstructed
= 52.00 x 1.50 x 0.60 x 63.81 / 100 = **30.02 kN** at R.L. 93.358 M
Moment @ R. L. 89.79 M = 30.02 x 3.57 = **107.10 kN-m**
Moment @ R. L. 89.19 M = 30.02 x 4.17 = **125.11 kN-m**
Moment @ R. L. 88.19 M = 30.02 x 5.17 = **155.14 kN-m**

TOTAL LONGITUDINAL MOMENT DUE TO WATER CURRENT
Moment @ R. L. 89.79 M = 0.00 + 26.39 + 107.10 = **133.49 kN-m**
Moment @ R. L. 89.19 M = 0.00 + 30.48 + 125.11 = **155.60 kN-m**
Moment @ R. L. 88.19 M = 0.00 + 37.31 + 155.14 = **192.44 kN-m**

WATER CURRENT IN TRANSVERSE DIRECTION (ACROSS THE BRIDGE)
As per IRC- II (6-1966) clause 213.5 For V= 2.41 m/sec Maximum velocity being 1.414 x mean velocity (1.414= Root of 2)
Obstructed Velocity = V Cos 20 0 = **2.41 x Cos 20 0**
= 2.27
2v2 = 10.27
Total Height = 9.81 M 10.27 9.25 9.12 0.00

#NAME?

$2v^2$ = (10.27 + 9.25) /2 = 9.76
Area Obstructed = 8.80 x 0.000 = 0.00 Sqm

Force = 52.00 x k x v^2 x Area Obstructed
= 52.00 x 1.50 x 9.76 x 0.00 / 100 = **0.00 kN** at R.L. 99.535 M
Moment @ R. L. 89.79 M = 0.00 x 9.75 = **0.00 kN-m**
Moment @ R. L. 89.19 M = 0.00 x 10.35 = **0.00 kN-m**
Moment @ R. L. 88.19 M = 0.00 x 11.35 = **0.00 kN-m**

#NAME?

$2v^2$ = (9.25 + 9.12) /2 = 9.18
Area Obstructed = 1.50 x 0.60 = 0.90 Sqm

Force on Pier = 52.00 x k x v^2 x Area Obstructed
= 52.00 x 1.50 x 9.18 x 0.90 / 100 = **6.45 kN** at R.L. 93.658 M
Moment @ R. L. 89.79 M = 6.82 x 3.87 = **26.39 kN-m**
Moment @ R. L. 89.19 M = 6.82 x 4.47 = **30.48 kN-m**
Moment @ R. L. 88.19 M = 6.82 x 5.47 = **37.31 kN-m**

#NAME?

$2v^2$ = (9.12 + 0.00) /2 = 4.56
Area Obstructed = 7.33 x 1.20 = 8.80 Sqm

Force on Pier = 52.00 x k x v^2 x Area Obstructed
= 52.00 x 1.50 x 4.56 x 8.80 / 100 = **31.29 kN** at R.L. 93.358 M
Moment @ R. L. 89.79 M = 30.02 x 3.57 = **107.10 kN-m**
Moment @ R. L. 89.19 M = 30.02 x 4.17 = **125.11 kN-m**
Moment @ R. L. 88.19 M = 30.02 x 5.17 = **155.14 kN-m**

TOTAL TRANSVERSE MOMENT DUE TO WATER CURRENT
Moment @ R. L. 89.79 M = 0.00 + 26.39 = + 107.10 **133.49 kN-m**
Moment @ R. L. 89.19 M = 0.00 + 30.48 = + 125.11 **155.60 kN-m**
Moment @ R. L. 88.19 M = 0.00 + 37.31 = + 155.14 **192.44 kN-m**

D SEISMIC CONDITION
According to clause 222.1 of IRC : 6- 1966 the Aqueduct is situated in the standard Zone- II ; therefore the aqueduct need not to be designed for Seismic Forces.

E WIND FORCE
Slab
Area = 11.10 x 0.98 = 10.82 Sqm
height of C.G. above Bed level = 99.54 - 92.69 = 6.85 m
According to Clause 212.3 IRC -6 -1966 Wind pressure = 90.06 Kg/Sqm = 0.90 kN/Sqm
Wind Force = 10.82 x 0.90 = **9.75 kN**
Moment @ R. L. 89.79 M = 9.75 x 9.75 = **94.98 kN-m**
Moment @ R. L. 89.19 M = 9.75 x 10.35 = **100.83 kN-m**
Moment @ R. L. 88.19 M = 9.75 x 11.35 = **110.58 kN-m**
Pier Cap
Area A1 = 1.50 x 0.60 = 0.90 Sqm
Area A2 = 1.35 x 0.60 = 0.81 Sqm

								Total	1.71 Sqm
¥ = (	0.90 x	0.90)+ (		0.81 x	0.30) /			1.71	0.62 M

height of C.G. above Bed level = 93.66 - 92.69 = 0.97 m
According to Clause 212.3 IRC -6 -1966 Wind pressure = 77.13 Kg/Sqm = 0.77 kN/Sqm
Wind Force = 1.71 x 0.77 = **1.32 kN**
Moment @ R. L. 89.79 M = 1.32 x 3.87 = **5.10 kN-m**
Moment @ R. L. 89.19 M = 1.32 x 4.47 = **5.89 kN-m**
Moment @ R. L. 88.19 M = 1.32 x 5.47 = **7.21 kN-m**

(I) **Pier from R.L. 99.125 to 92.69 M**

Area = 1.20 x 6.44 = 7.72 Sqm
height of C.G. above Bed level = 95.91 - 92.69 = 3.22 m
According to Clause 212.3 IRC -6 -1966 Wind pressure = 82.08 Kg/Sqm = 0.82 kN/Sqm
Wind Force = 7.72 x 0.82 = **6.34 kN**
Moment @ R. L. 89.79 M = 6.34 x 6.12 = **38.77 kN-m**
Moment @ R. L. 89.19 M = 1.32 x 6.72 = **8.86 kN-m**
Moment @ R. L. 88.19 M = 1.32 x 7.72 = **10.18 kN-m**

TOTAL TRANSVERSE MOMENT DUE TO WIND FORCE

Moment @ R. L. 89.79 M = 94.98 + 5.10 + 38.77 + = 138.86 **kN-m**
Moment @ R. L. 89.19 M = 100.83 + 5.89 + 8.86 + = 115.58 **kN-m**
Moment @ R. L. 88.19 M = 110.58 + 7.21 + 10.18 + = 127.97 **kN-m**

BASE PRESSURE CALCULATION

CASE- 1 FOR SERVICE CONDITION AT R. L.88.19 M

VERTICAL LOADS

DEAD LOAD CALCULATION

SUPER STRUCTURE = **1463.62 kN**
SUB STRUCTURE = **3339.07 kN** **Without Buoyancy**
SUB STRUCTURE = **2757.33 kN** **With Buoyancy**
LIVE LOAD = **788.27 kN**
Total Load without Buoyancy = **5590.95 kN**
Total Load with Buoyancy = **5009.22 kN**
Total LONGITUDINAL MOMENT = **192.44 + 244.25 = 436.69 kN-m**
Total TRANSVERSE MOMENT = **192.44 + 2247.88 = 2440.32 kN-m**

C.S.A. = 12.00 x 3.80 = 45.60 m^2
I_{xx} = 1/6x 12.00 x 3.80 ^{2} = 28.88 m^3
I_{yy} = 1/6x 12.00 ^{2} x 3.80 = 91.20 m^3

STRESS with Buoyancy = (5009.22 / 45.60)+ / - (436.69 / 28.88)+ / - (2440.32 / 91.20)
= 109.85 + / - 15.12 + / - 26.76
P_{max} = 109.85 + 15.12 + 26.76
= **151.73** **kN/m²**
< 250 kN/m2 Hence O.K.
P_{min} = 109.85 - 15.12 - 26.76
= **67.97** **kN/m²**
> 0 Hence O.K.

STRESS without Buoyancy = (5590.95 / 45.60)+ / - (436.69 / 28.88)+ / - (2440.32 / 91.20)
= 122.61 + / - 15.12 + / - 26.76
P_{max} = 122.61 + 15.12 + 26.76
= **152.49** **kN/m²**
< 250 kN/m2 Hence O.K.
P_{min} = 122.61 - 15.12 - 26.76
= **80.73** **kN/m²**
> 0 Hence O.K.

CASE- 2 FOR IDLE CONDITION AT R. L.88.19 M **(WHEN THERE IS NO LIVE LOAD)**

SUPER STRUCTURE = **1463.62 kN** **A CHECK OF STABILITY DUE TO BUOYANCY EFFECT**
SUB STRUCTURE = **3339.07 kN** **Without Buoyancy**
SUB STRUCTURE = **2757.33 kN** **With Buoyancy**
LIVE LOAD = **0.00 kN**
Total Load without Buoyancy = **4802.69 kN**
Total Load with Buoyancy = **4220.95 kN**

STRESS with Buoyancy = (4220.95 / 45.60)+ / - (192.44 / 28.88)+ / - (192.44 / 91.20)
= 92.56 + / - 6.66 + / - 2.11
P_{max} = 92.56 + 6.66 + 2.11
= **101.34** **kN/m²**
< 250 kN/m2 Hence O.K.
P_{min} = 92.56 - 6.66 - 2.11
= **83.79** **kN/m²**
> 0 Hence O.K.

STRESS without Buoyancy = (4802.69 / 45.60)+ / - (192.44 / 28.88)+ / - (192.44 / 91.20)
= 105.32 + / - 6.66 + / - 2.11
P_{max} = 105.32 + 6.66 + 2.11
= **114.10** **kN/m²**
< 250 kN/m2 Hence O.K.
P_{min} = 105.32 - 6.66 - 2.11
= **96.55** **kN/m²**
> 0 Hence O.K.

CASE- 3 FOR WIND FORCE AT SERVICE CONDITION AT R. L.88.19 M

SUPER STRUCTURE = **1463.62 kN**
SUB STRUCTURE = **3339.07 kN** **Without Buoyancy**
SUB STRUCTURE = **2757.33 kN** **With Buoyancy**
LIVE LOAD = **788.27 kN**
Total Load without Buoyancy = **5590.95 kN**
Total Load with Buoyancy = **5009.22 kN**
Total LONGITUDINAL MOMENT = **192.44 + 244.25 = 436.69 kN-m**
Total TRANSVERSE MOMENT = **192.44 + 127.97 + 2247.88 = 2568.29 kN-m**

STRESS with Buoyancy = (5009.22 / 45.60)+ / - (436.69 / 28.88)+ / - (2568.29 / 91.20)
= 109.85 + / - 15.12 + / - 28.16
P_{max} = 109.85 + 15.12 + 28.16

= **153.13** kN/m²
< 250 kN/m2 Hence O.K.
P_{min} = 109.85 - 15.12 - 28.16
= **66.57** kN/m²
> 0 Hence O.K.

STRESS without Buoyancy = (5590.95 / 45.60)+ / - (436.69 / 28.88)+ / - (2568.29 / 91.20)
= 122.61 + / - 15.12 + / - 28.16
P_{max} = 122.61 + 15.12 + 28.16
= **153.89** kN/m²
< 250 kN/m2 Hence O.K.
P_{min} = 122.61 - 15.12 - 28.16
= **79.33** kN/m²
> 0 Hence O.K.

CASE- 4 FOR WIND FORCE AT IDLE CONDITION AT R. L.88.19 M **[NO LIVE LOAD]**

SUPER STRUCTURE	=	**1463.62 kN**	
SUB STRUCTURE	=	**3339.07 kN**	**Without Buoyancy**
SUB STRUCTURE	=	**2757.33 kN**	**With Buoyancy**
LIVE LOAD	=	**0.00 kN**	
Total Load without Buoyancy	=	**4802.69 kN**	
Total Load with Buoyancy	=	**4220.95 kN**	
Total LONGITUDINAL MOMENT	=	*192.44* **kN-m**	
Total TRANSVERSE MOMENT	=	**192.44 +**	**127.97 = 320.41 kN-m**

STRESS with Buoyancy = (4220.95 / 45.60)+ / - (192.44 / 28.88)+ / - (320.41 / 91.20)
= 92.56 + / - 6.66 + / - 3.51
P_{max} = 92.56 + 6.66 + 3.51
= **102.74** kN/m²
< 250 kN/m2 Hence O.K.
P_{min} = 92.56 - 6.66 - 3.51
= **82.39** kN/m²
> 0 Hence O.K.
P_3 = 92.56 + 6.66 - 3.51
= **95.71** kN/m²
< 250 kN/m2 Hence O.K.
P_4 = 92.56 - 6.66 + 3.51
= **89.41** kN/m²
> 0 Hence O.K.

95.71	89.41
82.39	102.74

Stress Diagram

STRESS without Buoyancy = (4802.69 / 45.60)+ / - (192.44 / 28.88)+ / - (320.41 / 91.20)
= 105.32 + / - 6.66 + / - 3.51
P_{max} = 105.32 + 6.66 + 3.51
= **115.50** kN/m²
< 250 kN/m2 Hence O.K.
P_{min} = 105.32 - 6.66 - 3.51
= **95.15** kN/m²
> 0 Hence O.K.

102.17	108.47
95.15	115.50

Stress Diagram

CASE- 5 FOR ONE SPAN DISLODGED CONDITION AT R. L.88.19 M

SUPER STRUCTURE	=	**731.81 kN**	
SUB STRUCTURE	=	**3339.07 kN**	**Without Buoyancy**
SUB STRUCTURE	=	**2757.33 kN**	**With Buoyancy**
LIVE LOAD	=	**0.00 kN**	
Total Load without Buoyancy	=	**4070.88 kN**	
Total Load with Buoyancy	=	**3489.14 kN**	
Total LONGITUDINAL MOMENT	=	**192.44 kN-m**	
Total TRANSVERSE MOMENT	=	**192.44 +**	**127.97 = 320.41 kN-m**

STRESS with Buoyancy = (3489.14 / 45.60)+ / - (192.44 / 28.88)+ / - (320.41 / 91.20)
= 76.52 + / - 6.66 + / - 3.51
P_{max} = 76.52 + 6.66 + 3.51
= **86.69** kN/m²
< 250 kN/m2 Hence O.K.
P_{min} = 76.52 - 6.66 - 3.51
= **66.34** kN/m²
P_3 = 76.52 + 6.66 - 3.51
= **79.67** kN/m²
P_4 = 76.52 - 6.66 + 3.51
= **73.37** kN/m²

73.37	79.67
66.34	86.69

Stress Diagram

STRESS without Buoyancy = (4070.88 / 45.60)+ / - (192.44 / 28.88)+ / - (0.00 / 91.20)
= 89.27 + / - 6.66 + / - 0.00
P_{max} = 89.27 + 6.66 + 0.00
= **95.94** kN/m²
P_{min} = 89.27 - 6.66 - 0.00
= **82.61** kN/m²
P_3 = 89.27 + 6.66 - 0.00
= **95.94** kN/m²
P_4 = 89.27 - 6.66 + 0.00
= **82.61** kN/m²

82.61	95.94
82.61	95.94

Stress Diagram

CASE- 6 FOR SERVICE CONDITION AT R. L.89.19 M
VERTICAL LOADS
DEAD LOAD CALCULATION

SUPER STRUCTURE	=	**1463.62 kN**	
SUB STRUCTURE	=	**2244.67 kN**	**Without Buoyancy**
SUB STRUCTURE	=	**2118.93 kN**	**With Buoyancy**
LIVE LOAD	=	**788.27 kN**	

Total Load without Buoyancy = **4496.55 kN**
Total Load with Buoyancy = **4370.82 kN**
Total LONGITUDINAL MOMENT = **133.49 + 244.25 = 377.74 kN-m**
Total TRANSVERSE MOMENT = **133.49 + 2247.88 = 2381.37 kN-m**

C.S.A. = *12.00 x 1.20 = 14.40* m^2
I_{xx} = *1/6x 12.00 x 1.20* ^{2} = *2.88* m^3
I_{yy} = *1/6x 12.00* ^{2} *x 1.20 = 28.80* m^3

STRESS with Buoyancy = (*4370.82 / 14.40)+ / - (377.74 / 2.88)+ / - (2381.37 / 28.80)*
= *303.53 + / - 131.16 + / - 82.69*
P_{max} = *303.53 + 131.16 + 82.69*
= **517.38** **kN/m²**
< 8000 kN/m² (that is 8 N/mm²) Hence O.K.
P_{min} = *303.53 - 131.16 - 82.69*
= **89.68** **kN/m²**
> (- 3600 kN/m² (that is 3.6 N/mm²) Hence O.K.

STRESS without Buoyancy = (*4496.55 / 14.40)+ / - (377.74 / 2.88)+ / - (2381.37 / 28.80)*
= *312.26 + / - 131.16 + / - 82.69*
P_{max} = *312.26 + 131.16 + 82.69*
= **526.11** **kN/m²**
< 8000 kN/m² (that is 8 N/mm²) Hence O.K.
P_{min} = *312.26 - 131.16 - 82.69*
= **98.41** **kN/m²**
> (- 3600 kN/m² (that is 3.6 N/mm²) Hence O.K.

CASE- 7 FOR IDLE CONDITION AT R. L.89.19 M

SUPER STRUCTURE = **1463.62 kN**
SUB STRUCTURE = **2244.67 kN** **Without Buoyancy**
SUB STRUCTURE = **2118.93 kN** **With Buoyancy**
LIVE LOAD = **0.00 kN**
Total Load without Buoyancy = **3708.29 kN**
Total Load with Buoyancy = **3582.55 kN**

STRESS with Buoyancy = (*3582.55 / 14.40)+ / - (133.49 / 2.88)+ / - (133.49 / 28.80)*
= *248.79 + / - 46.35 + / - 4.64*
P_{max} = *248.79 + 46.35 + 4.64*
= **299.77** **kN/m²**
< 8000 kN/m² (that is 8 N/mm²) Hence O.K.
P_{min} = *248.79 - 46.35 - 4.64*
= **197.80** **kN/m²**
> (- 3600 kN/m² (that is 3.6 N/mm²) Hence O.K.

STRESS without Buoyancy = (*3708.29 / 14.40)+ / - (133.49 / 2.88)+ / - (133.49 / 28.80)*
= *257.52 + / - 46.35 + / - 4.64*
P_{max} = *257.52 + 46.35 + 4.64*
= **308.51** **kN/m²**
< 8000 kN/m² (that is 8 N/mm²) Hence O.K.
P_{min} = *257.52 - 46.35 - 4.64*
= **206.53** **kN/m²**
> (- 3600 kN/m² (that is 3.6 N/mm²) Hence O.K.

CASE- 8 FOR WIND FORCE AT SERVICE CONDITION AT R. L.89.19 M

SUPER STRUCTURE = **1463.62 kN**
SUB STRUCTURE = **2244.67 kN** **Without Buoyancy**
SUB STRUCTURE = **2118.93 kN** **With Buoyancy**
LIVE LOAD = **788.27 kN**
Total Load without Buoyancy = **4496.55 kN**
Total Load with Buoyancy = **4370.82 kN**
Total LONGITUDINAL MOMENT = **133.49 + 244.25 = 377.74 kN-m**
Total TRANSVERSE MOMENT = **133.49 + 138.86 + 2247.88 = 2520.23 kN-m**

STRESS with Buoyancy = (*4370.82 / 14.40)+ / - (377.74 / 2.88)+ / - (2520.23 / 28.80)*
= *303.53 + / - 131.16 + / - 87.51*
P_{max} = *303.53 + 131.16 + 87.51*
= **522.20** **kN/m²**
< 8000 kN/m² (that is 8 N/mm²) Hence O.K.
P_{min} = *303.53 - 131.16 - 87.51*
= **84.86** **kN/m²**
> (- 3600 kN/m² (that is 3.6 N/mm²) Hence O.K.

STRESS without Buoyancy = (*4496.55 / 14.40)+ / - (377.74 / 2.88)+ / - (2520.23 / 28.80)*
= *312.26 + / - 131.16 + / - 87.51*
P_{max} = *312.26 + 131.16 + 87.51*
= **530.93** **kN/m²**
< 8000 kN/m² (that is 8 N/mm²) Hence O.K.
P_{min} = *312.26 - 131.16 - 87.51*
= **93.59** **kN/m²**
> (- 3600 kN/m² (that is 3.6 N/mm²) Hence O.K.

CASE- 9 FOR WIND FORCE AT IDLE CONDITION AT R. L.89.19 M

SUPER STRUCTURE = **1463.62 kN**
SUB STRUCTURE = **2244.67 kN** **Without Buoyancy**
SUB STRUCTURE = **2118.93 kN** **With Buoyancy**
LIVE LOAD = **788.27 kN**
Total Load without Buoyancy = **4496.55 kN**
Total Load with Buoyancy = **4370.82 kN**
Total LONGITUDINAL MOMENT = **133.49 kN-m**
Total TRANSVERSE MOMENT = **133.49 + 138.86 = 272.34 kN-m**

STRESS with Buoyancy = (*4370.82 / 14.40)+ / - (133.49 / 2.88)+ / - (272.34 / 28.80)*
= *303.53 + / - 46.35 + / - 9.46*
P_{max} = *303.53 + 46.35 + 9.46*
= **359.34** **kN/m²**
< 8000 kN/m² (that is 8 N/mm²) Hence O.K.
P_{min} = *303.53 - 46.35 - 9.46*

= **247.72 kN/m^2**

> (- 3600 kN/m^2 (that is 3.6 N/mm^2) Hence O.K.

STRESS without Buoyancy = (4496.55 / 14.40)+ / - (133.49 / 2.88)+ / - (272.34 / 28.80)

= 312.26 + / - 46.35 + / - 9.46

P_{max} = 312.26 + 46.35 + 9.46

= **368.07 kN/m^2**

< 8000 kN/m^2 (that is 8 N/mm^2) Hence O.K.

P_{min} = 312.26 - 46.35 - 9.46

= **256.45 kN/m^2**

> (- 3600 kN/m^2 (that is 3.6 N/mm^2) Hence O.K.

ABSTRACT OF BASE PRESSURE AND STRESSES

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

CASE- 1 FOR SERVICE CONDITION AT R. L.88.19 M	151.73	67.97	152.49	80.73		
CASE- 2 FOR IDLE CONDITION AT R. L.88.19 M	101.34	83.79	114.10	96.55		
CASE- 3 FOR WIND FORCE AT SERVICE CONDITION AT R. L.88.19 M	153.13	66.57	153.89	79.33		
CASE- 4 FOR WIND FORCE AT IDLE CONDITION AT R. L.88.19 M	102.74	82.39	95.71	89.41	115.50	95.15
CASE- 5 FOR ONE SPAN DISLODGED CONDITION AT R. L.88.19 M	86.69	66.34	79.67	73.37	89.27	82.61

Maximum 153.89 | 66.34 Minimum

CASE- 6 FOR SERVICE CONDITION AT R. L.89.19 M	517.38	89.68	526.11	98.41
CASE- 7 FOR IDLE CONDITION AT R. L.89.19 M	299.77	197.80	308.51	206.53
CASE- 8 FOR WIND FORCE AT SERVICE CONDITION AT R. L.89.19 M	522.20	84.86	530.93	93.59
CASE- 9 FOR WIND FORCE AT IDLE CONDITION AT R. L.89.19 M	359.34	247.72	368.07	256.45

Maximum 530.93 | 84.86 Minimum

REINFORCEMENT CALCULATION IN PIER IN LOWER FLARED PORTION

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

R.L. 89.19 M TO 89.79 M

FOR SERVICE CONDITION

VERTICAL LOADS									
SUPER STRUCTURE	=	1463.62 kN							
SUB STRUCTURE	=	2244.67 kN		*Without Buoyancy*					
SUB STRUCTURE	=	2118.93 kN		*With Buoyancy*					
LIVE LOAD	=	788.27 kN							
Total Load without Buoyancy	=	4496.55 kN							
Total Load with Buoyancy	=	4370.82 kN							
Total LONGITUDINAL MOMENT									
Moment @ R. L.	89.19	*M =*	377.74	*kN-m*					
Total TRANSVERSE MOMENT									
Moment @ R. L.	89.19	*M =*	2520.23	*kN-m*					
CONCRETE MIX		*M-25*							
CHARACTERISTIC STRENGTH OF REINFORCEMENT				415 N/mm2					
PERMISSIBLE STRESSES									
IN STEEL		190							
IN CONCRETE									
CHARACTERISTIC STRENGTH OF									
Concrete		*fck*	=	30 N/mm2					
Permissible Compressive Stress in									
Bending		*σcbc*	=	8 N/mm2					
Permissible Compressive Stress in Direct									
Compression		*σcc*	=	8 N/mm2					
		σct	=	3.6 N/mm2					
Ultimate Axial Load P_U	=	1.5 X	4496.55 =	6744.83 kN					
Ultimate Longitudinal Moment M_U	=	1.5 X	377.74 =	566.6145 kN-m					
Ultimate Transverse Moment M_U	=	1.5 X	2520.23 =	3780.339 kN-m					
INCREASE WHEN WIND CONDITION IS CONSIDERED				33.33 %					
Neglecting area of Cut and Ease water parts Rectangular Section considered is									
	12001	mm x	1201	mm					
	Assume cover as	75							
d^1/d	=	87.5 /	1201.2 =	0.0728					
$P_U/(f_{ck}\ b\ d)$	=	6744.83 x	1000 / (	30 x	12001 x	1201.2)			
	=	0.0156							
FOR LONGITUDINAL MOMENT									
$Mu/(f_{ck}\ b\ d^2)$	=	566.61 x	1000000 / (	30 x	12001 x	1201.2^2)			
	=	0.0011							

Refer Chart 31 & 32 of Design Aids for Reinforced concrete SP-16 the point lies below the range of applicability. Hence provide minimum percentage of steel.

The point lies below the range of applicability. Hence provide minimum percentage of steel

CRITERIA 1 FOR MINIMUM STEEL Pt = 0.8 % OF CROSS SECTION AREA OF COLUMN REQUIRED FOR COMPRESSION

Area Required due to Compression =		4370.82 x	1000 /	8	
	=	546352 mm^2			
Area of steel @ 0.8% =	0.8 x	546352 /	100		
	=	**4371** mm^2			

CRITERIA 2 FOR MINIMUM STEEL Pt = 0.3 % OF GROSS SECTION AREA OF COLUMN

Area of steel @ 0.3% =	0.3 x	12001.2 x	1201.2 /	100	
	=	**43248** mm^2			
PROVIDE STEEL AREA	=	**43248** mm^2			

NO. OF 25 MM BARS = 88 Nos.
SPACING = 290 MM
FOR TRANSVERSE MOMENT

$Mu/(f_{ck}\ b\ d^2)$ = 3780.34 x 1000000 / (30 x 12001.2 x 1201.2 ^{2})
= 0.0073

Refer Chart 31 & 32 of Design Aids for Reinforced concrete SP-16 the point lies below the range of applicability. Hence provide minimum percentage of steel.

TRANSVERSE REINFORCEMENT

Shear Force to be resisted by the pier In Accordance to IS 1893
2520.23 / 11.87 = 212.27 kN

Check for Shear

Nominal Shear Stress = 212.27 x 1000 / (12001 x 1201)
= 0.01 N/mm^2
Pt 0.30
Permissible Shear Stress = 0.40 N/mm^2 Refer table 61

Nominal Shear Reinforcement will suffice

According to IRC 21-1987 Clause 306.3
Dia of Transverse Reinforcement = 25 / 4 = 6.25 mm
Provide 12 mm dia rings
Pitch of the Transverse should be least of
a) Least lateral Dimension = 1201.2 mm
b) 12 d = 12 x 12 = 144 mm
c) 300 mm = 300 mm
d) As per IS IS 13920:1993 Cl. 7.4.6 < or = 100 mm
Provide 12 mm dia rings @ 100 mm c/c.

This spacing is in accordance to IS 13920:1993 Cl. 7.4.6

CODE OF PRACTICE FOR DUCTILE DETAILING OF REINFORCED CONCRETE STRUCTURES SUBJECTED TO SEISMIC FORCES

Check for Size of Hoop Reinforcement **Refer IS 13920:1993 Cl. 7.4.8**

Ash= 0.18 Sh (Fck/Fy)x(Ag/Ak-1)

S	=	100.00	mm	
h	=	300.00	N/mm^2	(Spacing of long. bars+ effective cover) or 300 mm whichever is less
Fck	=	30.00	N/mm^2	**Cover 75 mm to main reinforcement**
Fy	=	415.00	N/mm^2	
Ag	=	1201.20	mm^2	Considering 1 mm Wide Pier
Ak	=	1100.20	mm^2	Considering 1 mm Wide Pier Effective
Hence Ash	=	35.84	mm^2	
Ash ProvideD	=	113.04	mm^2	Which is OK

d) As per IS IS 13920:1993 Cl. 7.4.6 < or = 100 mm
Provide 12 mm dia rings @ 100 mm c/c.

This spacing is in accordance to IS 13920:1993 Cl. 7.4.6

CODE OF PRACTICE FORDUCTILE DETAILING OF REINFORCED CONCRETE STRUCTURES SUBJECTED TO SEISMIC FORCES

ABSTRACT

LONGITUDINAL REINFORCEMENT 25 MM BARS 290 MM **However Adopt spacing as 250 mm**
TRANSVERSE REINFORCEMENT 12mm dia rings @100mm c/c.

REINFORCEMENT CALCULATION IN PIER

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

R.L. 89.79 M TO 100.80 M

FOR SERVICE CONDITION

VERTICAL LOADS

SUPER STRUCTURE	=	**1463.62**	*kN*	
SUB STRUCTURE	=	**3339.07**	*kN*	*Without Buoyancy*
SUB STRUCTURE	=	**2757.33**	*kN*	*With Buoyancy*
LIVE LOAD	=	**788.27**	*kN*	
Total Load without Buoyancy	=	**5590.95**	*kN*	
Total Load with Buoyancy	=	**5009.22**	*kN*	

Total LONGITUDINAL MOMENT

Moment @ R. L. 89.79 M = 436.69 kN-m

Total TRANSVERSE MOMENT

Moment @ R. L. 89.79 M = 2440.32 kN-m

CONCRETE MIX M-25

CHARACTERISTIC STRENGTH OF REINFORCEMENT 415 N/mm2

PERMISSIBLE STRESSES

IN STEEL 190

IN CONCRETE

CHARACTERISTIC STRENGTH OF

Concrete f_{ck} = 30 N/mm2

Permissible Compressive Stress in Bending σ_{cbc} = 8 N/mm2

Permissible Compressive Stress in Direct Compression σ_{cc} = 8 N/mm2

σ_{ct} = 3.6 N/mm2

Ultimate Axial Load P_U = 1.5 X 5590.95 = 8386.43 kN

Ultimate Longitudinal Moment M_U = 1.5 X 436.69 = 655.0414 kN-m

Ultimate Transverse Moment M_U = 1.5 X 2440.32 = 3660.483 kN-m

INCREASE WHEN WIND CONDITION IS CONSIDERED 33.33 %

Neglecting area of Cut and Ease water parts Rectangular Section considered is

12000 mm x 1200 mm

Assume cover as 75

d^1/d = 87.5 / 1200 = 0.0729

$P_U/(f_{ck}\ b\ d)$ = 8386.43 x 1000 / (30 x 12000 x 1200)

= 0.0194

FOR LONGITUDINAL MOMENT

$Mu/(f_{ck}\ b\ d^2)$ = 655.04 x 1000000 / (30 x 12000 x 1200^2)

= 0.0013

Refer Chart 31 & 32 of Design Aids for Reinforced concrete SP-16 the point lies below the range of applicability. Hence provide minimum percentage of steel.

The point lies below the range of applicability. Hence provide minimum percentage of steel

CRITERIA 1 FOR MINIMUM STEEL Pt = 0.8 % OF CROSS SECTION AREA OF COLUMN REQUIRED FOR COMPRESSION

Area Required due to Compression = 5009.22 x 1000 / 8

= 626152 mm^2

Area of steel @ 0.8% = 0.8 x 626152 / 100

= **5009** mm^2

CRITERIA 2 FOR MINIMUM STEEL Pt = 0.3 % OF GROSS SECTION AREA OF COLUMN

Area of steel @ 0.3% = 0.3 x 12000 x 1200 / 100

= **43200** mm^2

PROVIDE STEEL AREA = **43200** mm^2

NO. OF 25 MM BARS = 88 Nos.

SPACING = **290** *MM*

FOR TRANSVERSE MOMENT

$Mu/(f_{ck}\ b\ d^2)$ = 3660.48 x 1000000 / (30 x 12000 x 1200^2)

= 0.0071

Refer Chart 31 & 32 of Design Aids for Reinforced concrete SP-16 the point lies below the range of applicability. Hence provide minimum percentage of steel.

TRANSVERSE REINFORCEMENT

Shear Force to be resisted by the pier In Accordance to IS 1893

2440.32 / 11.87 = 205.54 kN

Check for Shear

Nominal Shear Stress = 205.54 x 1000 / (12000 x 1200)

= 0.01 N/mm^2

Pt 0.30

Permissible Shear Stress = 0.40 N/mm^2 Refer table 61

Nominal Shear Reinforcement will suffice

According to IRC 21-1987 Clause 306.3

Dia of Transverse Reinforcement = 25 / 4 = 6.25 mm

Provide 12 mm dia rings

Pitch of the Transverse should be least of

a) Least lateral Dimension = 1200 mm

b) 12 d = 12 x 12 = 144 mm

c) 300 mm = 300 mm

d) As per IS IS 13920:1993 Cl. 7.4.6 < or = 100 mm

Provide 12 mm dia rings @ 100 mm c/c.

This spacing is in accordance to IS 13920:1993 Cl. 7.4.6

CODE OF PRACTICE FOR DUCTILE DETAILING OF REINFORCED CONCRETE STRUCTURES SUBJECTED TO SEISMIC FORCES

Check for Size of Hoop Reinforcement **Refer IS 13920:1993 Cl. 7.4.8**

Ash= 0.18 Sh (Fck/Fy)x(Ag/Ak-1)

S	=	*100.00*	*mm*	
h	=	*300.00*	*N/mm^2*	*(Spacing of long. bars+ effective cover) or 300 mm whichever is less*
Fck	=	*30.00*	*N/mm^2*	**Cover 75 mm to main reinforcement**
Fy	=	*415.00*	*N/mm^2*	
Ag	=	*1200.00*	*mm^2*	*Considering 1 mm Wide Pier*
Ak	=	*1099.00*	*mm^2*	*Considering 1 mm Wide Pier Effective*
Hence Ash	=	*35.87*	*mm^2*	
Ash ProvideD	=	*113.04*	*mm^2*	*Which is OK*

d) As per IS IS 13920:1993 Cl. 7.4.6 < or = 100 mm

Provide 12 mm dia rings @ 100 mm c/c.

This spacing is in accordance to IS 13920:1993 Cl. 7.4.6

CODE OF PRACTICE FORDUCTILE DETAILING OF REINFORCED CONCRETE STRUCTURES SUBJECTED TO SEISMIC FORCES

ABSTRACT

LONGITUDINAL REINFORCEMENT 25 MM BARS 290 MM **However Adopt spacing as 250 mm**

TRANSVERSE REINFORCEMENT 12mm dia rings @100mm c/c.

DESIGN OF PIER FOOTING SUBMERSIBLE BRIDGE

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

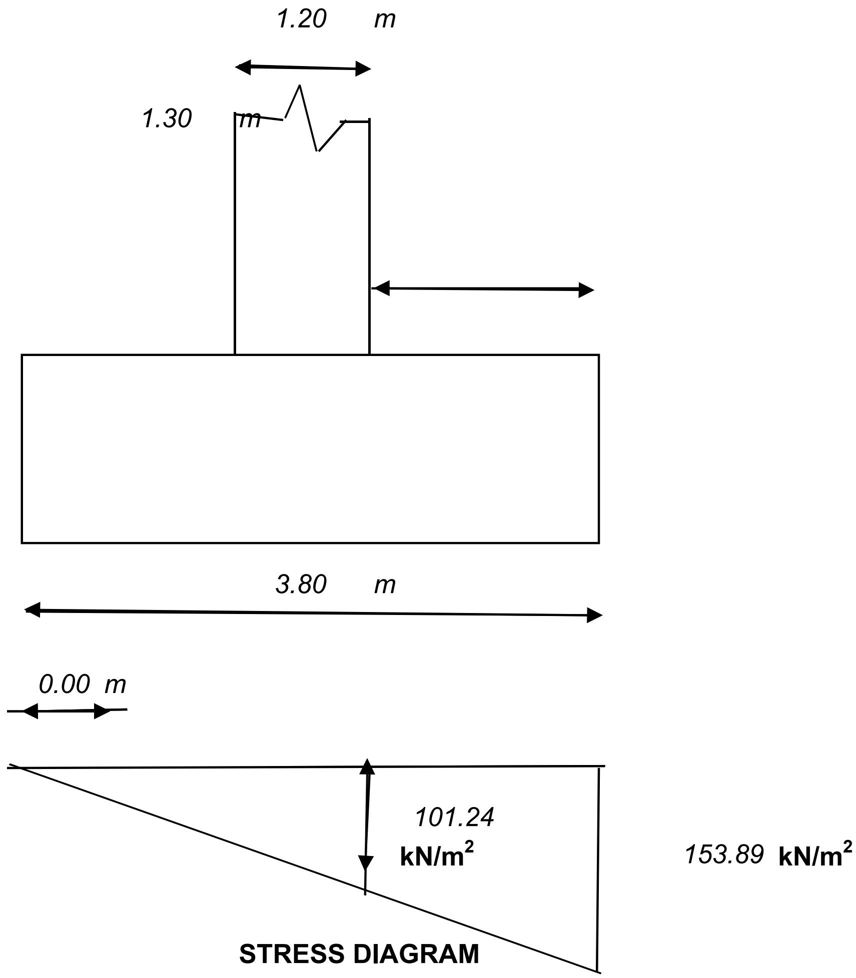
FOR WIND AT SERVICE CONDITION

Length of footing	l_f	12.00	*m*	
Width of Footing	l_b	3.80	*m*	
Width of Pier		1.20	*m*	
Vertical Load	*P*	5590.95	*kN*	
Longitudinal Moment	M_e	436.69	*kN-m*	
Transverse Moment	M_b	2568.29	*kN-m*	
Area in Tension = y x l_b		0.00	**m^2**	0.00 %
Maximum Pressure before Redistribution		153.89	**kN/m^2**	
Maximum Pressure After Redistribution = pxK		153.89	**kN/m^2**	
Maximum Stress at Edge of Pier		153.89	**kN/m^2**	
Distance From Face of Pier to the Edge		1.30	*m*	
Stress at the Edge of Pier		101.24	**kN/m^2**	
Average Stress on Cantilevered Area		127.57	**kN/m^2**	
Area of the Cantilever Portion		1.30	**m^2**	
Distance of Centroid of the Stress in Cantilever Portion		0.69	*m*	
Moment about the Face of Pier		**115.21**	**kN-m**	
CONCRETE GRADE		**M-25**		
FOR THIS GRADE σcbc		**10**	*N/mm2*	
m		**9.33**		
σst		**200**		
factor k		0.318		
j		0.894		
R		1.422		
Effective Depth Required		285	*mm*	
Adopt Total Depth		1000	*mm*	
Cover		50	*mm*	
Assume Bar Dia		25	*mm*	
Keeping A Cover Of 50 mm Effective Depth		938	*mm*	
Adopt Effective Depth		937.5	*mm*	
Steel Required Ast		687	mm^2	
Area Of One Bar		491	mm^2	
Spacing S		**714**	**mm**	

Provide Bars Of Dia And Spacing	*25 mm*	**Adopt spacing as 250 mm**
Area Of Distribution Steel		*2000 mm^2*
Dia Of Bar For Distribution Steel		*20 mm*
Area Of One Bar In Distribution Reinforcement		*314 mm^2*
Using The Bars Spacing Required		*157 mm*
Provide Bars Of Dia And Spacing	*20 mm*	*150 mm*
Provide Bars Of Dia And Spacing for Top Main Steel	*12 mm*	*150 mm*
Provide Bars Of Dia And Spacing for Top Distribution Steel	*12 mm*	*150 mm*

CHECK FOR SHEAR *(As per IRC 21-1987 Cl. 304.7)*

Critical Section is at a distance equal to effective depth from pier face		*937.5 mm*
Section of Shear from end of pier		*0.36 m*
Maximum Stress at Edge of Pier		*153.89* **kN/m^2**
Stress at the Section for Shear Check		*138.39* **kN/m^2**
Average Stress on Cantilevered Area		*146.14* **kN/m^2**
Shear Force		*52.98 kN*
V=V' + M/d tanB	*(B=0) Hence V =V'*	
Actual Shear Stress		*0.06* **N/mm^2**
Percentage Steel	*100As/bd*	*0.07*
Tc		*0.23* **N/mm^2**
k=1		
Permissble Shear Stress = k Tc		*0.23* **N/mm^2**
		< Actual Shear Stress hence Shear Reinforcement should be provided
Dia Of two Legged Stirrups		*16 mm*
Area Of One Bar In Distribution Reinforcement		*201 mm^2*
Using The Bars Spacing Required s= Asw ts d/V		*1423 mm*
Provide Bars Of Dia And Spacing	**16 mm**	**Adopt spacing as 250 mm**



STRESS DIAGRAM

DESIGN OF PIER FOOTING

LIVE LOAD CALCULATION :-

[1] CLASS AA TRACKED VEHICLE :-

(a) <u>Dispersion width along the span</u>

According to clause 305.13 IRC- 21-2000

= Length of Contact + 2 (Wearing coat + depth of Slab)

= 3.6 + 2 (0.075 + 0.775)

= 5.3 M

(b) <u>Dispersion width across the span</u>

According to clause 305.13 IRC- 21-2000

be = K x (1 - x/Le) +bw
K = A Constant having the value depending upon the ratio
(L1/Le where.
be = the effective width of the slab on which the load acts.
Le = Effective Span
x = the distance of c.g. of concentrate load from the near support
bw = The breadth of concentration area of the load i.e. Dimension of the tyre or track contact area over the road surface
Heve ,

Le = 10.00 M & L1 = 7.00 M

$$= \frac{L1}{Le} = \frac{7.00}{10.0} = 0.7$$

Value of K = 2.4

bw = 0.85 + 2 x 0.075 = 1.0 M

$$X = \frac{L}{2} = \frac{10}{2} = 5.0\ M$$

be = 2.4 x 4 (1 - 5/10) + 1

= 5.8 M

Impact factor is 13.75% as pere IRC Section-II, Clause - 211-3 (a) (i)

DISPERSION ACROSS SPAN (CLASS AA TRACKED VEHICAL

The tracked vehicle is placed at a distance of minimum clearence of 1-2 m from Kerb

Dispersion across span

= C/C distance between wheels

+ width from centre of wheel on clearence side

+ Least on other side or halp the dispersion of one wheel.

= 2.05 + 1.93 + Least of 2.715 OR 5.8/2

= 2.05 + 1.93 + 2.715

= 6.695

Impact factor = 1.1375

Total load with impact

= 70 x 1.1375

= 79.63 T

= Intensity of Load

$$= \frac{79.63}{5.30 \times 6.695} = 2.24 \quad T/M$$

Maximum Reaction

For Maximum reaction at support the Centre of gravity of the loads should be adjacent to one support should be adjacent to one support

Reaction R_A *= 2.24x 3.00 x 1.50 /10.00*

= 1.01 T

Reaction R_B *= 2.24x 3.00 -1.01*

= 5.71 T

DISPERSION ALONG SPAN (CLASS AA TRACKED VEHICLE

(a) Dispersion width along the span :-

tp = tc = 2 (tw + ts)

tp = width of dispersion parallel to span

tc = width of tyre contact area parallel to span

ts = Overall depth of slab

tw = Thickness of Wearing coat

Dispersion along the span

= 0.15 + 2 (0.075 + 0.775)

= 1.9 M

Dispersion between two wheel is overlapping hence restricted to 1-2 M

= Dispersion combined for two wheels

= C/c distance between two wheels + Longitudinal dispersion

= 1-2 + 1.9

= 3.1 M (along the span)

Impact factor = 1.1375

Total load with impact

= 70 x 1.1375

= 79.63 T

= Intensity of Load

$$= \frac{79.63}{1.90 \times 5.30} = 7.91 \quad T/M$$

Maximum Reaction

For Maximum reaction at support the Centre of gravity of the loads should be adjacent to one support should be adjacent to one support

Reaction R_A *= 7.91x 3.00 x 1.50 /10.00*

= 3.56 T

Reaction R_B *= 7.91x 3.00 -3.56*

= 20.17 T

DESIGN OF PIER CAP :-

D.L./ M Width along bridge				
DL. Of Slab =	*0.75 x*	*8.40 x.*	*2.4 =*	*15.12 T*
D.L. of Wearing coat =	*0.08 x*	*8.40 x.*	*2.4 =*	*1.51 T*
			TOTAL	*16.63 T*
D.L. of Slab & Wearing coat on half of the pier		=		
		16.63 /	*2 =*	*8.32 T*
L.L. on Pier cap including impact along bridge				
	=	*82.50 x*	*1.1375 =*	*93.84 T*
(Refer Live Load Computation)				
Dispersion width across the span for				
70 T TRACKED VEHTCLE	=	*6.695 M*		
(Refer Solid slab design page SS-16)				
Live Load u.d.l. on Pier	=	*93.84 /*	*6.695 =*	*14.02 T*
Per M width				
Total Load on Half =	*8.32 +*	*14.02*	=	*22.33 T*
of pier along bridge				*Per M width*
Effective depth of slab =90-2.5-2.5/2 =	*71.25 cm*			
Placement of the live load at effective depth from the support (taking support width 750 mm)				
Eccentricity = 71.25 -75/2	=	*33.75 cm*	=	*0.34 M*
Bending Moment along the bridge =				
	22.33 x	*0.34*		*7.54 T - M/M width*
=				
	7.54 x	*10.00 =*		**75.4 kN-M/M width**
This moment is too small hence it will not/be the governing B.M.				
Moment in pier cap		**75.40 kN-m**		
CONCRETE GRADE		**M30**		
FOR THIS GRADE σcbc		**10** *N/mm2*		
m		**9.33**		
σst		**200**		
factor k		*0.318*		
j		*0.894*		
R		*1.422*		
Effective Depth Required		*230 mm*		
Adopt Total Depth		*1200 mm*		
Cover		*50 mm*		
Assume Bar Dia		*25 mm*		
Keeping A Cover Of 50 mm Effective Depth		*1138 mm*		
Adopt Effective Depth		*1137.5 mm*		
Steel Required Ast		*371* mm^2		
Area Of One Bar		*491* mm^2		
Spacing S		*1323 mm*		
Provide Bars Of Dia And Spacing	*25 mm*	**100** *mm*	**Adopt spacing as 100 mm**	
Provide Bars Of Dia And Spacing for Top Main Stee	*25 mm*	*100 mm*		
Provide Bars Of Dia And Spacing for Bottom Stee	*16 mm*	*100 mm*		

PIER SECTION ACROSS BRIDGE

DEAD LOAD MOMENT PER METRE Width across bridge :-				
Slab D.L.	*0.975 x*	*15 x.*	*2.4 =*	*35.10 T*
D.L. of Wearing coat =	*0.075 x*	*12 x.*	*2.4 =*	*2.16 T*
			TOTAL	**37.26** *T*
D.L. of Slab & Wearing coat on half of the pier		=		
		37.26 /	*2 =*	*18.63 T/ M width*
L.L on pier		=		*64.69 T*
Dispersion width along the span for				
70 T Tracked vehical	=	*5.3 M*		
L.L. . per M width on pier =		*64.69 /*	*5.3 =*	*12.21 T/ M width*
Total D.L. + L.L. on half of Pier across	*18.63 +*	*12.21*	=	*30.84 T*

bridge per M width					Per M width
The Live Load is with clearance from the Footpath and kerb. The cantilever portion of pier cap and width of footpath is 1500 mm					
Hence There is no eccentricity.					
Bending Moment across the bridge =					
		30.84 x	0		0.00 T - M/M width
Provide Minimum steel					

Minimum Reinforcement calculation for Pier cap :-

As per clause 710.8.2, IRC- 78 - 2000, the thickness of pier cap shall be at least 200 mm However the thickness of Pier cap here is 1200 MM.

Grade of Concrete M 30

Minimum Shrinkage and Temperature reinforcement required as per Clause 305.10 IRC 21-2000 in any RC structure is 250 Sq mm per m in each direction. Allowable maximum spacing is 300 mm.

Shrinkage and Temperature reinforcement required = 250 x 1.2 = 300 mm^2

Provide 25 mm tor reiforcement @ 100 mm c/c (14 Nos.) in top along the pier cap

Provide 16 mm tor reiforcement @ 100 mm c/c (14 Nos.) in bottom along the pier cap

Area of Steel Provided at top				
= (14x 491)	=	6874 mm^2	> 300 mm^2	OK
Area of Steel Provided at bottom				
= (14x 201)	=	2814 mm^2	> 300 mm^2	OK

CHECK FOR SHEAR ALONG BRIDGE DIRECTION

V =		30.84 T			
Shear Force			308.40 kN		
V=V' + M/d tanB	(B=0) Hence V =V'				
Actual Shear Stress			0.27 **N/mm^2**		
Percentage Steel	100As/bd		0.25		
Tc			0.23 **N/mm^2**		
k=1					
Permissble Shear Stress = k Tc			0.23 **N/mm^2**		
			< Actual Shear Stress hence Shear Reinforcement should be provided		
Dia Of two Legged Stirrups			16 mm		
Area Of One Bar In Distribution Reinforcement			201 mm^2		
Using The Bars Spacing Required s= Asw ts d/V			296 mm		
Provide Bars Of Dia And Spacing		16 mm	100 mm	**Adopt spacing as 100 mm**	

HOWEVER

Provide 16 mm tor 2 legged vertical stirrups @ 100 mm centre to centre along the pier cap

Provide 16 mm tor 2 legged horizontal stirrups @ 100 mm centre to centre along the pier cap

SHEAR CHECK ACROSS BRIDGE DIRECTION

V =		20.3 T	
Shear Force			203.00 kN
V=V' + M/d tanB	(B=0) Hence V =V'		
Actual Shear Stress			0.18 **N/mm^2**
Percentage Steel	100As/bd		0.25
Tc			0.23 **N/mm^2**
k=1			
Permissble Shear Stress = k Tc			0.23 **N/mm^2**
			> Actual Shear Stress hence No Shear Reinforcement is required.

HOWEVER

Provide 16 mm tor 2 legged vertical stirrups @ 100 mm centre to centre along the pier cap

Provide 16 mm tor 2 legged horizontal stirrups @ 100 mm centre to centre along the pier cap

CALCULATION OF LIVE LOAD REACTION FOR PIER SUBSTRUCTURE
FOR SIMPLY SUPPORTED SPANS OF A TWO LANE BRIDGE STRUCTURE

Centre line of pier w.r.t. the bearings :-

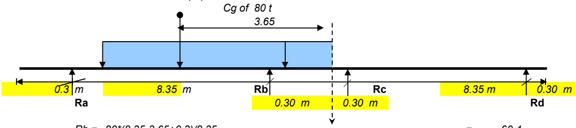
Rb	=	**0.3**	m
Rc	=	**0.3**	m

Reaction has been calculated for the following cases

1. *One lane of class 70-R(W)*
2. *One lane of class - A*
3. *Two lane of class - A*
4. *Three lane of class - A*
5. *One lane of class 70-R(W) + One lane of class - A*

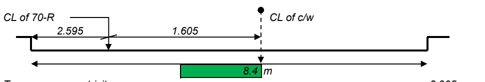
Condition A: **MAXIMUM LONGITUDINAL MOMENT CASE**

Case 1: **One lane of class 70-R(W)**



Rb = 80(8.35-3.65+0.3)/8.35*		=	60.4	t
Rc =		=	0.0	t
Ra=		=	19.6	t
Vert.Reaction=	*60.4 + 0*	=	60.4	t
Braking Force, B =	*0.2*80*	=	16.0	t
Dead load reaction on the pier , Rg		=	485.0	t
Value of " μ " =		=	0.00	
Horizontal force due to temperature, T =μ(Rg+Ra)*		=	0.0	t
Design horizontal force is higher of either (B/2+T) or (B-T)		=	16.0	t

(neglecting shear rating of elastomeric bearing in the adjacent span, which is on the conservative side)

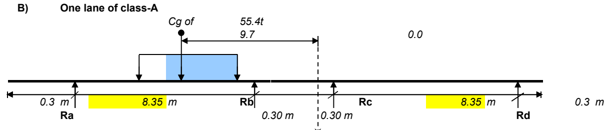


Transverse eccentricity		=	2.905	m
Transverse moment =	*2.905*(60.4 + 0)*	=	175.3	t.m
Long. moment =	*60.4*0.3-0*0.3*	=	18.1	t.m
Long. Eccentricity (for input)		=	0.300	m

span	*load*	*cg*
4.42	51	1.93
5.79	68	2.895
7.92	80	3.65
9.44	92	4.4
13.4	100	5.12

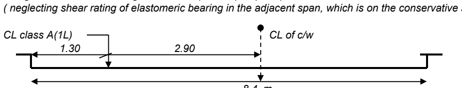
8.78

B) **One lane of class-A**



Rc = 0(8.35-0.3)/8.35*		=	0.0	t
Rb = 55.4(8.35-9.7+0.3/2)/8.35*		=	7.0	t
Ra=		=	48.4	t
Vert.Reaction =	*48.4 + 7*	=	55.4	t
Braking Force, B =	*0.2*(0+55.4)*	=	11.1	t
Dead load reaction on the pier , Rg		=	485.0	t
Value of " μ " =		=	0.00	
Horizontal force due to temperature, T =μ(Rg+Ra)*		=	0.0	t
Design horizontal force is higher of either (B/2+T) or (B-T)		=	11.1	t

(neglecting shear rating of elastomeric bearing in the adjacent span, which is on the conservative side)



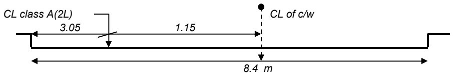
Transverse eccentricity		=	2.90	m
Transverse moment =	*2.9*55.4*	=	160.7	t.m
Long. moment =	*7*0.3-0*0.3*	=	2.1	t.m
Long. Eccentricity (for input)		=	0.038	m

SPAN	*LOAD*	*CG*
5.5	29.6	1.73
8.5	36.4	2.99
11.5	43.2	4.33
14.5	50	5.71
24	50	5.71
8.78		

Case 3 : **Two lane of class-A**

*Rc = 2*0*		=	0.0	t
*Rb = 2*7*		=	13.9	t
Ra=		=	96.9	t
Vert.Reaction =	*0 + 13.9*	=	13.9	t
Braking Force(For single lane only)		=	11.1	t
Dead load reaction on the pier , Rg		=	485.0	t
Value of " μ " =		=	0.00	
Horizontal force due to temperature, T =μ(Rg+Ra)*		=	0.0	t

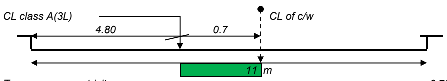
Design horizontal force is higher of either (B/2+T) or (B-T) = 11.1 t
(neglecting shear rating of elastomeric bearing in the adjacent span, which is on the conservative side)



Transverse eccentricity = 1.15 m
Transverse moment = 1.15*13.9 = 16.0 t.m
Long. moment = 13.9*0.3-0*0.3 = 4.2 t.m
Long. Eccentricity (for input) = 0.300 m

Case 4 : **Three lane of class-A**

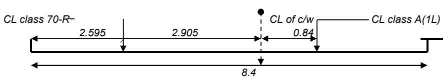
Rc = 90% of 3*0 = 0.0 t
Rb = 90% of 3*7 = 18.8 t
Ra= = 61.1 t
Vert.Reaction = 0 + 18.8 18.8
Braking Force, B = (0.2)*55.4+0.05*55.4 = 13.9 t
(5% extra taken for third lane)
Dead load reaction on the pier , Rg = 485.0 t
Value of " μ " = = 0.00
Horizontal force due to temperature, T =μ*(Rg+Ra) = 0.0 t
Design horizontal force is higher of either (B/2+T) or (B-T) = 13.9 t
(neglecting shear rating of elastomeric bearing in the adjacent span, which is on the conservative side)



Transverse eccentricity = 0.70 m
Transverse moment = 0.7*18.8 = 13.2 t.m
Long. moment = 18.8*0.3-0*0.3 = 5.6 t.m
Long. Eccentricity (for input) = 0.300 m

Case 5 : **One lane of class-70R(W)+One lane of class-A**

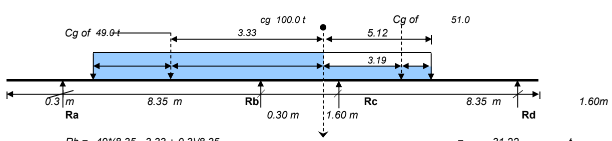
Rc = 90% of(0+0) = 0.0 t
Rb = 90% of(6.97+60.36) = 60.6 t
Ra= = 61.3 t
Braking Force = 16 + 5% of 55.4 = 18.8 t
(5% extra taken for class A)
Dead load reaction on the pier , Rg = 485.0 t
Value of " μ " = = 0.00
Horizontal force due to temperature, T =μ*(Rg+Ra) = 0.0 t
Design horizontal force is higher of either (B/2+T) or (B-T) = 18.8 t
(neglecting shear rating of elastomeric bearing in the adjacent span, which is on the conservative side)



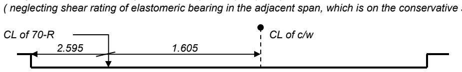
Transverse ecc.(class 70 R) = 2.905 m
Transverse ecc.(class A) = -0.84 m
Trans. moment = 0.9*(60.4*2.905-55.4*-0.84) = 115.9
Net transverse ecc. (for input) = 1.913 t.m
Long. moment = 60.6*0.3-0*0.3 = 18.2 t.m
Long. Eccentricity (for input) = 0.300 m

<u>Condition B:</u> **MAXIMUM TRANSVERSE MOMENT / REACTION CASE**

CASE 1: **ONE LANE OF CLASS 70-R(W)**



Rb = 49*(8.35 - 3.33 + 0.3)/8.35 = 31.22 t
Rc = 51*(8.35-3.19+1.6)/8.35 = 21.74 t
Ra= = 27.3 t
Vert. Reaction = 31.2 + 21.7 = 53.0 t
Braking Force, B = 0.2*100 = 20.0 t
Dead load reaction on the pier , Rg = 485.0 t
Value of " μ " = = 0.00
Horizontal force due to temperature, T =μ*(Rg+Ra) = 0.0 t
Design horizontal force is higher of either (B/2+T) or (B-T) = 20.0 t
(neglecting shear rating of elastomeric bearing in the adjacent span, which is on the conservative side)



first span

SPAN	LOAD	CG
8.28	49	3.33
5.04	58	2.18
8.95		

second span

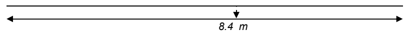
SPAN	LOAD	CG
3	80	3.65
4.52	92	4.4
8.48	100	5.12
24	100	5.12
8.95		

second span

4.4	34	3.715
5.12	51	3.19
11.55		

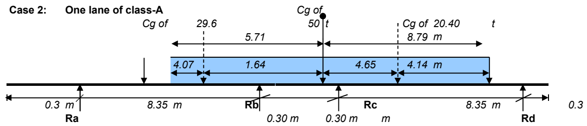
first span

3	17	0.87
4.52	29	1.75
8.48	41	2.56
24	49	3.53
8.95		



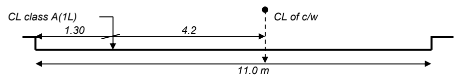
Transverse eccentricity		=	2.905	m
Transverse moment =	2.905*(31.2 + 21.7)	=	154.0	t.m
Long. moment =	31.22*0.3-21.74*0.3	=	2.8	t.m
Long. Eccentricity (for input)		=	0.054	m

Case 2: One lane of class-A



Rc = 20.4*(8.35-4.65+0.3)/8.35		=	9.77	t
Rb = 50*(8.35-1.64+0.3)/8.35		=	24.85	t
Ra=		=	4.8	t
Vert.Reaction =	9.77 + 24.85	=	34.62	t
Braking Force, B =	0.2*(50)	=	10.0	t
Dead load reaction on the pier , Rg		=	485.0	t
Value of " μ " =		=	0.00	
Horizontal force due to temperature, T =μ*(Rg+Ra)		=	0.0	t
Design horizontal force is higher of either (B/2+T) or (B-T)		=	10.0	t

(neglecting shear rating of elastomeric bearing in the adjacent span, which is on the conservative side)



Transverse eccentricity		=	4.20	m
Transverse moment =	4.2*34.6	=	145.4	t.m
Long. moment =	24.8*0.3-9.8*0.3	=	4.5	t.m
Long. Eccentricity (for input)		=	0.131	m

two span length	load	cg6.8 end	cg2.7 end
9	27.2	4.5	4.5
13.3	38.6	7.1	6.2
14.5	50	8.79	5.71
18.7	52.7	9.24	9.46
18.8	55.4	9.71	9.09
17.6	55.4	9.71	9.09

load	Span2load	cg 6.8
27.2	13.6	1.5
38.6	20.4	4.14
50	20.4	4.14
52.7	27.2	4.5
55.4	27.2	4.5

load	Span2 load	cg 6.8
55.4	27.2	4.5
52.7	27.2	4.5
50	20.4	4.14
38.6	20.4	4.14
27.2	13.6	1.5
span2	8.78	

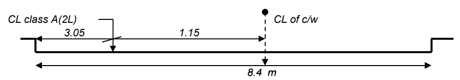
load 1	Cg 2.7 end
13.6	1.5
18.2	1.81
25.5	3.4
28.2	4.07

load 1	Cg 2.7 end
28.2	4.07
25.5	3.4
29.6	1.73
18.2	1.81

Case 3 : Two lane of class-A

Rc = 2*9.8		=	19.5	t
Rb = 2*24.8		=	49.7	t
Ra=		=	9.5	t
Vert.Reaction =	19.5 + 49.7	=	69.2	t
Braking Force(For single lane only)		=	11.1	t
Dead load reaction on the pier , Rg		=	485.0	t
Value of " μ " =		=	0.00	
Horizontal force due to temperature, T =μ*(Rg+Ra)		=	0.0	t
Design horizontal force is higher of either (B/2+T) or (B-T)		=	11.1	t

(neglecting shear rating of elastomeric bearing in the adjacent span, which is on the conservative side)

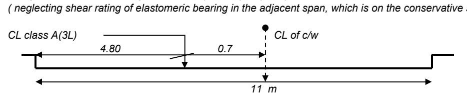


Transverse eccentricity		=	1.15	m
Transverse moment =	1.15*69.2	=	79.6	t.m
Long. moment =	49.7*0.3-19.5*0.3	=	9.0	t.m
Long. Eccentricity (for input)		=	0.131	m

Case 4 : Three lane of class-A

Rc = 90% of 3*9.8		=	26.4	t
Rb = 90% of 3*24.8		=	67.1	t
Ra=		=	12.8	t
Vert.Reaction =	26.4 + 67.1		93.5	
Braking Force, B =	(0.2)*55.4+0.05*55.4	=	13.9	t
(5% extra taken for third lane)				
Dead load reaction on the pier end , Rg		=	485.0	t
Value of " μ " =		=	0.00	
Horizontal force due to temperature, T =μ*(Rg+Ra)		=	0.0	t
Design horizontal force is higher of either (B/2+T) or (B-T)		=	13.9	t

(neglecting shear rating of elastomeric bearing in the adjacent span, which is on the conservative side)



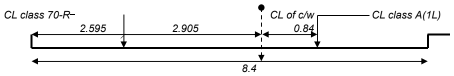
Transverse eccentricity		=	0.70	m
Transverse moment =	0.7*93.5	=	65.4	t.m
Long. moment =	67.1*0.3-26.4*0.3	=	12.2	t.m
Long. Eccentricity (for input)		=	0.131	m

Case 5 : One lane of class-70R(W)+One lane of class-A

Rc = 90% of(9.77+21.74)	=	28.4	t
Rb = 90% of(24.85+31.22)	=	50.5	t
Ra=	=	29.5	t

Braking Force =	*16 + 5% of 55.4*	=	*18.8*	*t*
(5% extra taken for class A)				
Dead load reaction on the pier , Rg		=	*485.0*	*t*
Value of " μ " =		=	*0.00*	
Horizontal force due to temperature, T =μ(Rg+Ra)*		=	*0.0*	*t*
Design horizontal force is higher of either (B/2+T) or (B-T)		=	*18.8*	*t*

(neglecting shear rating of elastomeric bearing in the adjacent span, which is on the conservative side)



Transverse ecc.(class 70 R)		=	*2.905*	*m*
Transverse ecc.(class A)		=	*-0.84*	*m*
Trans. moment =	*0.9*(60.4*2.9-0*-0.8)*	=	*112.4*	
Net transverse ecc. (for input)		=	*1.426*	*t.m*
Long. moment =	*50.5*0.3-28.4*0.3*	=	*6.6*	*t.m*
Long. Eccentricity (for input)		=	*0.084*	*m*

Summary of Loads

Max. Longitudinal Moment			Design horizontal force (t)	Transverse ecc. (m)	Longitudinal ecc. (m)
Max. vertical reaction (t)	Transverse moment (t.m)	Longitudinal moment (t.m)			
60.4	*175.3*	*18.1*	*16.0*	*2.905*	*0.300*
55.4	*160.7*	*2.1*	*11.1*	*2.900*	*0.038*
13.9	*16.0*	*4.2*	*11.1*	*0.700*	*0.300*
18.8	*13.2*	*5.6*	*13.9*	*0.700*	*0.300*
60.6	*115.9*	*18.2*	*18.8*	*1.913*	*0.300*

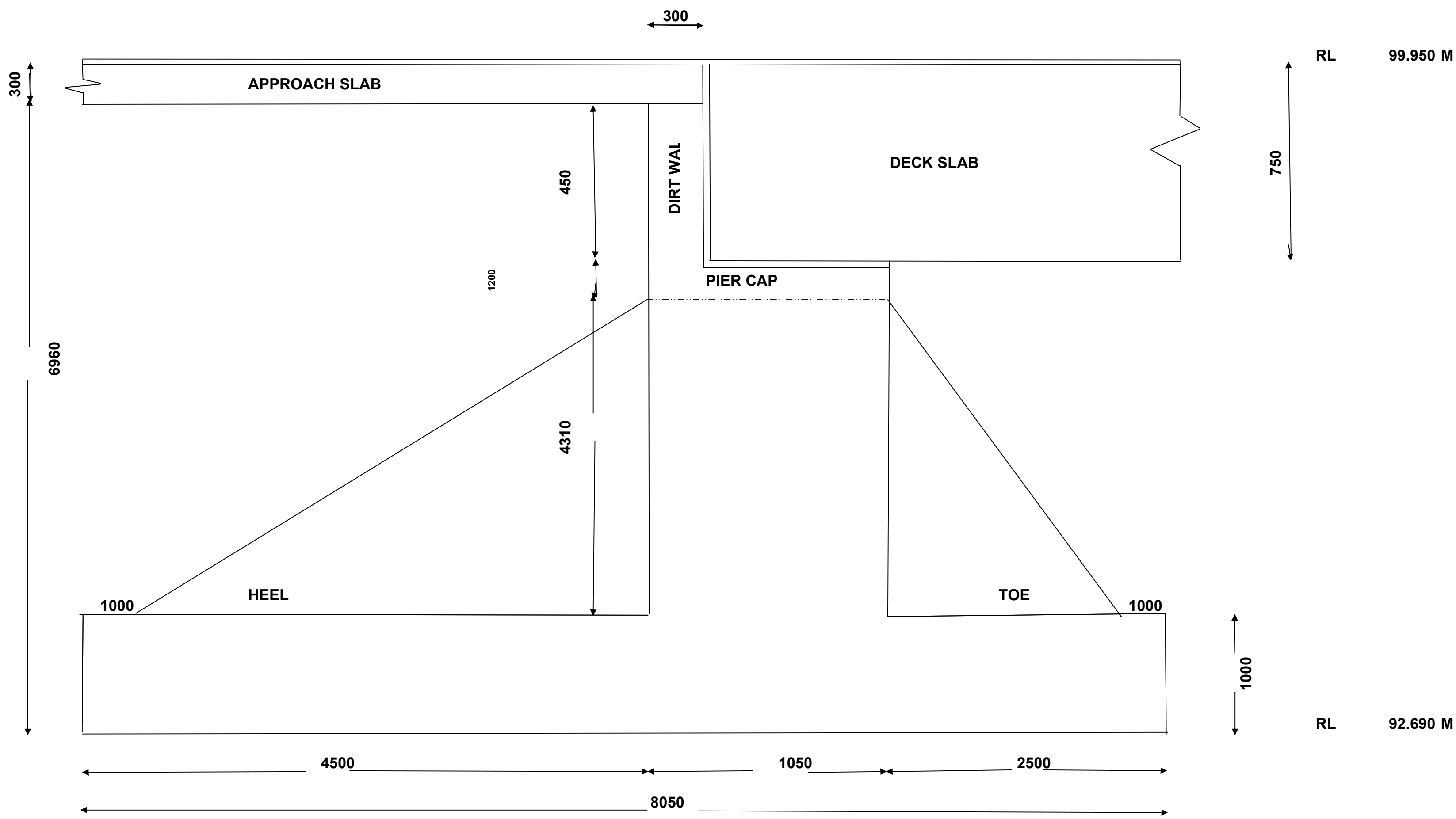
Load case	Max.Transverse Moment			Design horizontal force (t)	Transverse ecc. (m)	Longitudinal ecc. (m)
	Max. vertical reaction (t)	Transverse moment (t.m)	Longitudinal moment (t.m)			
1L class 70 - R	*53.0*	*154.0*	*2.8*	*20.0*	*2.905*	*0.054*
1L class - A	*34.6*	*145.4*	*4.5*	*10.0*	*4.200*	*0.131*
2L class - A	*69.2*	*79.6*	*9.0*	*11.1*	*9.046*	*0.131*
3L class - A	*93.5*	*65.4*	*12.2*	*13.9*	*0.700*	*0.131*
1L class 70 - R + 1L class - A	*78.8*	*112.4*	*6.6*	*18.8*	*1.426*	*0.084*

Vertical reaction due to braking has been neglected.

Maximum Reaction due Live Load including Impact	78.83	MT	=	788.27	KN
Maximum Longitudinal moment due to Live Load including Impact and Breaking Force	12.21	T-M	=	122.13	KNM
Maximum Transverse moment due to Live Load including Impact and Breaking Force	112.4	T-M	=	1123.94	KNM

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

Deck Level	**99.950 M**		
Foundation Level	**92.690 M**		
Thickness of Deck Slab	**750 mm**		
Thickness of Approach Slab	**300 mm**		
Height below Approach Slab	**6960 mm**		
Length of Heel projection	**4500 mm**	**Offset**	**1000 mm**
Length of Toe projection	**2500 mm**	**Offset**	**1000 mm**
Width of Stem	**1050 mm**		
Thickness of Abutment Cap	**1200 mm**		
Thickness of Dirt Wall	**300 mm**		
Depth of Footing	**1000 mm**		



TYPICAL SECTION OF THE ABUTMENT TYPABUT-01

Design of ABUTMENT

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

(a) Data

Preliminary dimensions	*: Assumed as in Fig.* **TYPABUT-01**		
Superstructure	*: RCC Slab Bridge*	*Total Width of Slab =*	*8.40 M*
	overall length = 8.80 m		
Type of abutment	*: Reinforced concrete*		
Loading	*: As for National Highway*		
Back fill	*: Gravel with angle of repose*	*Φ =*	*35 °*
	Unit weight of back fill, w =		*18 kN/m3*
	Angle of internal friction of soil on wall, z =		*17.5 °*
Approach slab	*: R.C. slab 300 mm thick, adequately reinforced*		

Load from superstructure per running foot of abutment wall:

Dead load	=	*239.50*	*kN/m*
Live load	=	*93.84*	*kN/m*

(Refer Stability Analysis for sub structure. The above two values are obtained from the calculations for superstructure, and are taken to act over a width of 15 m).

Bearing : Tar Paper Bearings

(C) Self weight of abutment

Treating the section as composed of 6 elements as shown in Fig. 1the weight of each element and moment about the point O on the front toe are computed as in Table 1

(d) Longitudinal forces

(i) Force due to braking

Force due to 70 R wheeled vehicle =	*0.2*	*x*	*1000*	*=*	*200*	*kN*

This force acts at 1.2 m above the road level(Clause 214.3).

Force on one abutment wall =	*200*	*/*	*2*	*=*	*100*	*kN*
Horizontal force per m of wall =	*100*	*/*	*8.40*	*=*	*11.91*	*kN/ m*

(ii) Force due to temperature variation and shrinkage

Assuming moderate climate, variation in temperature is taken as + *17 oC as per Clause 218.5 of Bridge Code.*

Coefficient of Thermal expansion =	*1.17E-05*	*/°C*			
Strain due to temperature variation =	*17*	*x*	*1.17E-05*	*=*	*1.99E-04*
From Clause 220.3, strain due to concrete shrinkage =	*2.00E-04*				
Total strain due to temperature and shrinkage =	*1.99E-04*	*+*	*2.00E-04*	*=*	*3.99E-04*

Horizontal deformation of deck due to temperature and shrinkage affecting one abutment = 3.99E-04 x 8800 /2 = 1.76E+00 mm

Modulus of Elasticity Ec = $5000 \times fck^{1/2}$ = 31220.19 N/mm2

Horizontal Stress due to strain in longitudinal direction at bearing level = 3.99E-04 x 31220.19 = 12.45 N/mm2

Horizontal Force due to strain in longitudinal direction at bearing level (For 1 m width of Slab) =

1.25E+01 x 750 = 9340.30 N/m

= 9.34 kN/m

(iii) *Vertical reaction due to braking*

$$\text{Vertical reaction at one abutment} = \frac{200(1.2 + 0.975)}{11.10 \times 15} = 2.61 \text{ kN/m}$$

(d)Earth pressure

Active earth pressure $P = 0.5\, wh^2\, K_a$

where K_a *is obtained from Equation (3.5)*

$K_a = \sec\Theta \sin(\Theta-\Phi)/[(\sin(\Theta+z)^{1/2} + \{\sin(\Phi+z)\sin(\Phi-\delta)/\sin(\Theta-\delta)\}^{1/2}]$

Where P= Total active pressure, acting at a height of 0.42 h inclined at z to the normal to the wall on the earth side

w = unit weight of earth fill

h = height of wall

Θ = Angle subtended by the earthside wall with thw horizontal on the earth side

Φ = Angle of internal friction of the earthfill

z = angle of friction of the earthside wall with the earth

δ = Inclination of earthfill surface with the horizontal

Θ = 90^0 Φ = 35^0

z = 17.5^0 δ = 0^0

Substituting values in Equation (3.5), we get K_a = 0.496 Coefficient

Height of backfill below approach slab = 6.96 m

Active earth pressure =

$0.5 \times 18 \times 6.96^2 \times 0.496$

= 216.25 kN/m

Height above base of centre of pressure = 0.42 x 6.96 = 2.93 m

Passive pressure in front of toe slab is neglected.

(e) Live load surcharge and approach slab

Equivalent height of earth for live load surcharge as per clause 714.4 is 1.20 m

Horizontal force due to L.L. surcharge =1.2 x 18 x 0.496 x 9.20 =		74.57	kN/m
Horizontal force due to approach slab = 0.3 x 24 x 0.496 x 9.20 =		24.86	kN/m
	Total	**99.43**	**kN/m**

The above two forces act at **3.48 m above the base.**

Vertical load due to L.L. surcharge and approach slab

= (1.2 x 18 + 0.3 x 24) x 4.5 = 129.6 kN/m

(f) Weight of earth on heel slab

Vertical load = 18 x4.5x (6.96000000C = 53.65 kN/m

(g) Check for stability - overturning

The forces and their position are as shown in Fig. 1

The forces and moments about the point O at toe on the base are tabulated as in Table 1 Two cases of lading condition are examined (i) Span loaded condition and (ii) Span unloaded condition.

Case (i) Span loaded condition

See Row 15 of Table 12.3

Overturning moment about toe = 1118.18 kN-m

Restoring moment about toe = 5691.89 kN-m

Factor of safety against overturning = 5691.89 / 1118.18 = **5.09**

Location of Resultant from O **> 1.5 Hence Safe**

$X_0 = (M_V - M_H) / V = (1740.9 - 623.1) / 691.4 = 1.62$ m

=(5691.894 - 1118.182) / 1368.582) = 3.34 m

Eccentricity of resultant

$e_{max} = B/6 =$ 8.05 /6 = 1.34 m

$e = (B/2 - X_{0)} = 0.78$ m < 0.80 m 4.03 - 3.34 = 0.69 m

< 1.34 m

Case (ii) Span unloaded condition

See Row 11 of Table 12.3

Overturning moment about toe = 1040.53 kN-m

Restoring moment about toe = 5414.58 kN-m

Factor of safety against overturning = 5414.58 / 1040.53 = **5.2**

Location of Resultant from O **> 1.5 Hence Safe**

$X_0 = (M_V - M_H) / V=$

=(5414.576 - 1040.528) / 1272.128) = 3.44 m

(h)Check for stresses at base

For Span loaded condition

Total downward forces = 1368.58 kN

1368.58 6 x 0.78

Extreme stresses at base =

Maximum Stress = 1368.582/(8.05x1)(1 +(6x0.69/8.05)) = 257.45 kN/m2

Minimum Stress = 1368.582/(8.05x1)(1 -(6x0.69/8.05)) = 82.58 kN/m2

Table 1 Forces and Moments About Base for Abutment.

Sl. No.	Details	Force, kN		Moment about O, kn-m		
		V	H	Arm m	Mv	M_H
1.	D.L. from superstructure	239.50	-	2.88	689.760	-
2.	Horizontal force due to temperatre and shrinkage	0	9.34	6.52	-	60.899
3.	Active earth pressure	0	216.25	2.93	-	633.613
4.	Horizontal force due to L.L surcharge and approach slab	0	99.43	3.48	-	346.016
5.	Vertical load due to L.L. surcharge and approach slab	129.60	-	5.8	751.68	-
6.	Self weight - part 1 8.05x1x 24 =	193.20	-	4.025	777.63	-
7.	Self weight - part 2 4.31000000000001x1.05x 24 =	108.62	-	3.03	329.119	-
8.	Self weight - part 3 1.2x1.05x 24 =	30.24	-	1.68	50.8032	-
9.	Self weight - part 4 0.3x0.45x 24 =	3.24	-	2.05	6.642	-
9.	Self weight - part 5 Triangular River Side 1/2x2x4.76000000000001x24=	114.24	-	1.83	209.44	-
9.	Self weight - part 5 Triangular Earth Fill Side 1/2x4x4.96000000000001x24=	228.48	-	4.88	1115.74	-
10.	Weight of earth on heel slab part 1 Rectangular Portion 0.5 x 5.96000000000001 x 18=	53.65	-	7.8	418.47	-
10.	Weight of earth on heel slab part 2 Triangular Portion 1/2x4x5.96000000000001x18=	171.36	-	6.22	1065.29	-

11.	**Items 1 to 10 (Span unloaded condition)**	**1272.13**			**5414.58**	**1040.53**
12.	*L.L. from Superstructure Class 70 R wheeled vehicle*	*93.84*	*-*	*2.875*	*269.794*	*-*
13.	*Vertical force due to braking*	*2.61*	*-*	*2.88*	*7.524*	*-*
14.	*Horizontal force due to braking*	*0.00*	*11.91*	*6.52*		*77.6532*
15.	**Items 11 to 14 (Span loaded condition)**	**1368.58**	**336.93**	**-**	**5691.89**	**1118.18**

NET LONGITUDINAL MOMENT *5691.89 - 1118.18 = 4573.71*

Maximum pressure = *257.45 kN/m2 < 200.00 kN/m2 permissible HENCE OK.*

Minimum pressure = *82.58 kN/m2 >0 (No tension) HENCE OK.*

(i) Check for sliding

See Row 15 of Table 1

Sliding force = *336.93 kN*

Force resisting sliding = *0.6 x 1368.58 = 821.15 kN*

Factor of Safety against sliding = *821.15 / 336.93 =* **2.44**

(j) Summary **> 1.5 Hence Safe**

The assumed section of the abutment is adequate.

DESIGN OF ABUTMENT FOOTING

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

REDISTRIBUTION OF PRESSURE

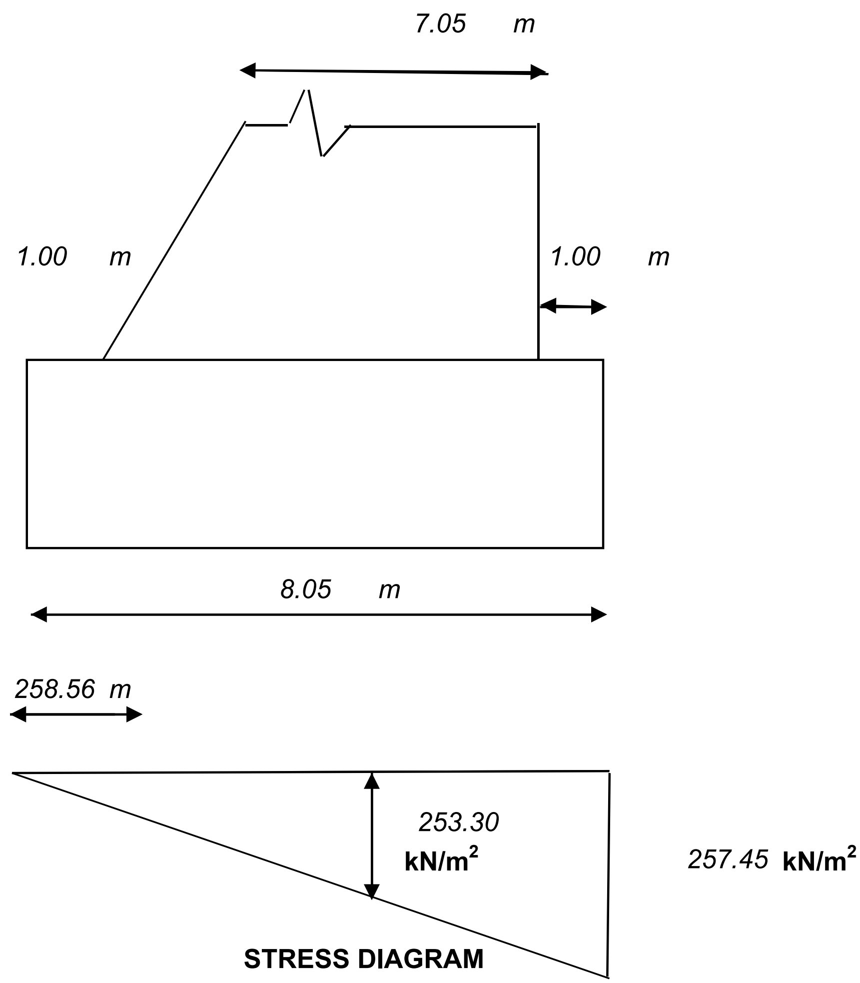
FOR WIND AT SERVICE CONDITION

Length of footing	l_f	17.00	m		
Width of Footing	l_b	8.05	m		
Width of Abutment just above footing		6.05	m		
Vertical Load	P	1368.58	kN		
Longitudinal Moment	M_e	4573.71	kN-m		
Transverse Moment	M_b	0.00	kN-m		
Area in Tension = y x l_b			0.00	m^2	0.00 %
Maximum Pressure before Redistribution			257.45	kN/m^2	
Maximum Pressure After Redistribution = pxK			257.45	kN/m^2	
Maximum Stress at Edge of Pier			257.45	kN/m^2	
Distance From Face of Pier to the Edge			1.00	m	
Stress at the Edge of Pier			225.47	kN/m^2	
Average Stress on Cantilevered Area			241.46	kN/m^2	
Area of the Cantilever Portion			1.00	m^2	
Distance of Centroid of the Stress in Cantilever Portion			0.51	m	
Moment about the Face of Pier			**123.39**	**kN-m**	
CONCRETE GRADE			**M-25**		
FOR THIS GRADE σcbc			**10**	N/mm2	
m			**9.33**		
σst			**200**		
factor k			0.318		
j			0.894		
R			1.422		
Effective Depth Required			295	mm	
Adopt Total Depth			1000	mm	
Cover			50	mm	
Assume Bar Dia			16	mm	
Keeping A Cover Of 50 mm Effective Depth			942	mm	
Adopt Effective Depth			942	mm	
Steel Required Ast			733	mm^2	
Area Of One Bar			201	mm^2	

Spacing S		274	mm	
Provide Bars Of Dia And Spacing	16 mm	**150**	mm	**Adopt spacing as 150 mm**
Area Of Distribution Steel		1884	mm^2	
Dia Of Bar For Distribution Steel		20	mm	
Area Of One Bar In Distribution Reinforcement		314	mm^2	
Using The Bars Spacing Required		167	mm	
Provide Bars Of Dia And Spacing	16 mm	160	mm	**Adopt spacing as 150 mm**
Provide Bars Of Dia And Spacing for Top Main Steel	12 mm	150	mm	
Provide Bars Of Dia And Spacing for Top Distribution Steel	12 mm	150	mm	

CHECK FOR SHEAR *(As per IRC 21-1987 Cl. 304.7)*

Critical Section is at a distance equal to effective depth from pier face		942	mm	
Section of Shear from end of pier		0.06	m	
Maximum Stress at Edge of Pier		257.45	**kN/m^2**	
Stress at the Section for Shear Check		253.30	**kN/m^2**	
Average Stress on Cantilevered Area		255.38	**kN/m^2**	
Shear Force		14.81	kN	
V=V' + M/d tanB	*(B=0) Hence V =V'*			
Actual Shear Stress		0.02	**N/mm^2**	
Percentage Steel	*100As/bd*	0.14		
Tc		0.23	**N/mm^2**	
k=1				
Permissble Shear Stress = k Tc		0.23	**N/mm^2**	
	< Actual Shear Stress hence Shear Reinforcement should be provided			
Dia Of two Legged Stirrups		16	mm	
Area Of One Bar In Distribution Reinforcement		201	mm^2	
Using The Bars Spacing Required s= Asw ts d/V		5112	mm	
Provide Bars Of Dia And Spacing	16 mm	150	mm	**Adopt spacing as 150 mm**



DESIGN OF ABUTMENT FOOTING

REINFORCEMENT CALCULATION IN ABUTMENT SUBMERSIBLE BRIDGE

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

Minimum Shrinkage and Temperature reinforcement required as per Clause 305.10 IRC 21-2000
in any RC structure is 250 Sq mm per m in each direction. Allowable maximum spacing is 300 mm.

Shrinkage and Temperature reinforcement required per metre =			250 mm^2			
Area Of One Bar	12 mm dia		113 mm^2			
Spacing S			452 mm			
Provide Bars Of Dia And Spacing	12 mm		**125** mm			
Provide Bars Of Dia And Spacing	12 mm		125 mm			
HORIZONTAL SHRINKAGE &TEMPERATURE REINFORCEMENT	**12**	**MM BARS**	**125**	**MM**	**In Vertical direction on all FOUR faces**	
VERTICAL SHRINKAGE &TEMPERATURE REINFORCEMENT	**12**	**MM BARS**	**125**	**MM**	**In Lateral direction on all FOUR faces**	

DESIGN OF Abutment CAP SUBMERSIBLE BRIDGE

Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road , across Som River.

DESIGN OF Abutment CAP :-

D.L./ M Width along bridge									
DL. Of Slab =	*0.975*	*x*	*15*	*x.*	*2.4*	*=*	*35.10*	*T*	
D.L. of Wearing coat =	*0.075*	*x*	*12*	*x.*	*2.4*	*=*	*2.16*	*T*	
					TOTAL		**37.26**	**T**	
D.L. of Slab & Wearing coat on half of the Abutment		*=*							
			37.26	*/*	*2*	*=*	*18.63*	*T*	
L.L. on Abutment cap including impact along bridge									
		=	*82.50*	*x*	*1.1375*	*=*	*93.84*	*T*	
(Refer Live Load Computation)									
Dispersion width across the span for									
70 T TRACKED VEHTCLE		*=*	*6.695*	*M*					
(Refer Solid slab design page SS-16)									
Live Load u.d.l. on Abutment		*=*	*93.84*	*/*	*6.695*	*=*	*14.02*	*T*	
Per M width									
Total Load on Half =	*18.63*	*+*	*14.02*			*=*	*32.65*	*T*	
of Abutment along bridge							*Per M width*		
Effective depth of slab =90-2.5-2.5/2 =	*86.25*	*cm*							
Placement of the live load at effective depth from the support (taking support width 750 mm)									
Eccentricity = 71.25 -75/2		*=*	*33.75*	*cm*	*=*	*0.34*	*M*		
Bending Moment along the bridge =									
	32.65	*x*	*0.34*				*11.02*	*T - M/M width*	
=									
	11.02	*x*	*10.00*	*=*		**110.2 kN-M/M width**			
This moment is too small hence it will not/be the governing B.M.									

Moment in Abutment cap		**110.20**	**kN-m**	
CONCRETE GRADE		**M30**		
FOR THIS GRADE σcbc		**10**	*N/mm2*	
m		**9.33**		
σst		**200**		
factor k		*0.318*		
j		*0.894*		
R		*1.422*		
Effective Depth Required		*278*	*mm*	
Adopt Total Depth		*1200*	*mm*	
Cover		*50*	*mm*	
Assume Bar Dia		*25*	*mm*	
Keeping A Cover Of 50 mm Effective Depth		*1138*	*mm*	
Adopt Effective Depth		*1137.5*	*mm*	
Steel Required Ast		*542*	*mm^2*	
Area Of One Bar		*491*	*mm^2*	
Spacing S		*905*	*mm*	
Provide Bars Of Dia And Spacing	*25 mm*	**100**	*mm*	**Adopt spacing as 100 mm**
Provide Bars Of Dia And Spacing for Top Main Stee	*25 mm*	*100*	*mm*	
Provide Bars Of Dia And Spacing for Bottom Steel	*16 mm*	*100*	*mm*	

Abutment SECTION ACROSS BRIDGE

DEAD LOAD MOMENT PER METRE Width across bridge :-								
Slab D.L.	*0.975*	*x*	*15*	*x.*	*2.4*	*=*	*35.10*	*T*
D.L. of Wearing coat =	*0.075*	*x*	*12*	*x.*	*2.4*	*=*	*2.16*	*T*
					TOTAL		**37.26**	*T*
D.L. of Slab & Wearing coat on half of the Abutment		*=*						
			37.26	*/*	*2*	*=*	*18.63*	*T/ M width*
L.L on Abutment		*=*					*64.69*	*T*
Dispersion width along the span for								
70 T Tracked vehical	*=*	*5.3*	*M*					

L.L. . per M width on Abutment =	64.69 /	5.3 =	12.21 T/ M width	
Total D.L. + L.L. on half of Abutment across bridge per M width	18.63 +	12.21 =	30.84 T Per M width	

The Live Load is with clearance from the Footpath and kerb. The cantilever portion of Abutment cap and width of footpath is 1500 mm
Hence There is no eccentricity.

Bending Moment across the bridge = 30.84 x 0 = 0.00 T - M/M width

Provide Minimum steel

Minimum Reinforcement calculation for Abutment cap :-

As per clause 710.8.2, IRC- 78 - 2000, the thickness of Abutment cap shall be at least 200 mm However the thickness of Abutment cap here is 1200 MM.

Grade of Concrete M 30

Minimum Shrinkage and Temperature reinforcement required as per Clause 305.10 IRC 21-2000 in any RC structure is 250 Sq mm per m in each direction. Allowable maximum spacing is 300 mm.

Shrinkage and Temperature reinforcement required = 250 x 1.2 = 300 mm^2

Provide 25 mm tor reiforcement @ 100 mm c/c (14 Nos.) in top along the Abutment cap
Provide 16 mm tor reiforcement @ 100 mm c/c (14 Nos.) in bottom along the Abutment cap

Area of Steel Provided at top
= (14x 491) = 6874 mm^2 > 300 mm^2 OK

Area of Steel Provided at bottom
= (14x 201) = 2814 mm^2 > 300 mm^2 OK

CHECK FOR SHEAR ALONG BRIDGE DIRECTION

V =		30.84 T	
Shear Force		308.40	kN
V=V' + M/d tanB	(B=0) Hence V =V'		
Actual Shear Stress		0.27	**N/mm²**
Percentage Steel	100As/bd	0.25	
Tc		0.23	**N/mm²**
k=1			
Permissble Shear Stress = k Tc		0.23	**N/mm²**
		< Actual Shear Stress hence Shear Reinforcement should be provided	
Dia Of two Legged Stirrups		16	mm
Area Of One Bar In Distribution Reinforcement		201	mm²
Using The Bars Spacing Required s= Asw ts d/V		296	mm
Provide Bars Of Dia And Spacing	16 mm	100	mm **Adopt spacing as 100 mm**

HOWEVER
Provide 16 mm tor 2 legged vertical stirrups @ 100 mm centre to centre along the Abutment cap
Provide 16 mm tor 2 legged horizontal stirrups @ 100 mm centre to centre along the Abutment cap

SHEAR CHECK ACROSS BRIDGE DIRECTION

V =		20.3 T	
Shear Force		203.00	kN
V=V' + M/d tanB	(B=0) Hence V =V'		
Actual Shear Stress		0.18	**N/mm²**
Percentage Steel	100As/bd	0.25	
Tc		0.23	**N/mm²**
k=1			
Permissble Shear Stress = k Tc		0.23	**N/mm²**
		> Actual Shear Stress hence No Shear Reinforcement is required.	

HOWEVER
Provide 16 mm tor 2 legged vertical stirrups @ 100 mm centre to centre along the Abutment cap
Provide 16 mm tor 2 legged horizontal stirrups @ 100 mm centre to centre along the Abutment cap

DESIGN OF DIRT WALL AS COLUMN WITH BENDING

AXIAL LOAD ON THE DIRT WALL	**31.60**	*KN*		
ASSUME WIDTH OF DIRT WALL	*1000*	*MM*	*EMIN/B*	*0.00*
ASSUME DEPTH OF DIRT WALL	*300*	*MM*	*EMIN/D*	*0.01*
MOMENT TRANSFERRED TO DIRT WALL	*12.80*	*KN-M*		
FACTORED AXIAL LOAD	**47.40**	*KN*		
FACTORED MOMENT	*19.20*	*KN-M*		
DIA OF LONGITUDINAL REINFORCEMENT	**10**	*MM*		
CLEAR COVER	*40*	*MM*		
d'	*45*	*MM*		
d'/D	*0.15*			
ADOPT d'/D	*0.15*			
PU/FCKBD	*0.01*			
MU/FCKBD^2	*0.01*			
REINFORCEMENT EQUALLY DISTRIDUTED ON **TWO** *SIDES*				
USING CHART NO- OF RCC DESIGN AIDS	**33**		**CONC GRADE M-30**	
P/FCK	*0.01*			
P	*0.3*		*> Minimum Steel 0.2% Hence OK*	
AS	*900*	*SQ MM*		
TOTAL NUMBER OF BARS REQUIRED	*12*			
NUMBER OF BARS ON EACH SIDE	*6*			
SPACING	**200**	*MM*		

Alternate design Considering dirt wall as cantilever

B.M. = *12.80* *KN-M*

deff reqd. = $\dfrac{12.80 \times 10^6}{1000 \times 0.972}$ = *118.7* *mm*

dpro *300* - *50* - $\dfrac{16}{2}$ = *245* *mm* > *118.7* *mm* *(OK)*

Ast = $\dfrac{12.80 \times 10^6}{200 \times 0.917 \times 245}$ = *284.87* *mm^2*

This steel is to be provided on back *i.e.* *approach slab side*

Provide Vertical steel as follows

On River side 10mm bars @ 150 mm c/c = *524* *mm^2*

On Approach Slab side 10mm bars @ 150 Mm c/c = *524* *mm^2*

Minimum steel required in Horizontal direction

= *0.002* x *1000* x *250*

= *500* *mm^2*

i.e. 250 mm^2 *on each face*

provide 10 *@ 250 mm* *c/c* = *314* *mm^2*

<u>ABSTRACT</u>

VERTICAL REINFORCEMENT IN SHAPE OF STIRRUPS on both faces

DIA	10 mm
SPACING	150 mm

HORIZONTAL REINFORCEMENT BAR DIA on both faces

DIA	10 mm
SPACING	250 mm

Design of Dirt Wall

Dirt wall is subjected to

(1) Live load

(2) Live load surcharge

(3) Braking force

(3) Earth Pressure

1) Consider 70 T tracked vehicle case is governing & 14 T Axle over dirt wall, Dispersion width at top of DIRT WALL

= 2.90 + (1.2 + 0.305) + 0.83

= 2.90 + 1.53 + 0.825

= 5.255 M

$$\frac{\text{Live Load}}{\text{M Length}} = \frac{14}{5.255} = 2.66 \text{ T/M}$$

2) Self wt. of dirt wall

= 0.6 x 0.3 x 2.4

= 0.495 T/M

Say 0.5 T/M

Total direct loads = 2.66 + 0.5 = 3.16 T/M = **31.6 kN**

Here considering that only 70% of Braking force will be on dirt wall & the rest of braking force will be on soil.

$$= \text{Braking force/mt.} = \frac{0.2 \times 14 \times 1}{5.255} = 0.53 \text{ T}$$

= B.M. due to Braking force

= 0.53 x (1.2 + [0.83])

= 1.07 T-M

Intensity of Earth Pressure at Deck Level

= 0.224 x 1.8 x 1.2

= 0.483 T/M^2

Intensity of Earth Pressure at top of Abutment Ca =

= 0.224 x 1.8 x (1.2 + 0.825)

= 0.816 T/M^2

B.M. due to Earth Pressure & Live Load Surcharge/M width

$= \frac{1}{2} = (0.816 - 0.483) \times 0.83 \times 0.42 \times 0.875$

$+ 0.483 \times 0.825 \times \frac{0.53}{2}$

= 0.048 + 0.164

= 0.21 T-M

Total BM at top of DIRT WALL

= 1.07 + 0.21

= 1.28 T-M = **12.8 kN-m**

Direct Stress $= \frac{3.16 \times 10^3}{30 \times 100}$

= 1.05 $Kg./Cm^2$

Bending Stres. $= \frac{1.28 \times 10^3}{\frac{1}{6} \times 100 \times 30^2}$

= 0.09 $Kg./Cm^2$

For M 30 Grade,

Permissible Bending Stress = *67* *Kg./Cm*^{2}

Permissible Direct Compressive Stress = *50* *Kg./Cm*^{2}

$$= \frac{1.05}{50} + \frac{0.09}{67} \leq$$

$$= 0.021 + 0.001 \leq$$

$$= 0.022 \leq$$ **HENCE OK.**

DEAD LOAD CALCULATION :-					
DEPTH OF DECK SLAB =		925 mm			
DEPTH OF WEARING COAT =		75 mm			
DIA OF MAIN BAR =		25 mm			
Clear cover =		25 mm			
Effective depth of slab deffective =		925 -	25 -	25 /2 =	887.5 mm
Effective SpanLeffective =		10 m			
DESIGN DEAD LOAD :-					
(1) Weight / Sqm of Slab		0.925 x	2.4 =	2.22 T/ Sqm	
(2) Weight / Sqm of wearing coat		0.075 x	2.4 =	0.18 T/ Sqm	
	Total DL			**2.4** T/ Sqm	
DEAD LOAD BENDING MOMENT			2.4x10x10/8 =	30.00 T-M	

LIVE LOAD CALCULATION :-

[1] CLASS AA TRACKED VEHICLE :-

(a) <u>Dispersion width along the span</u>

= Length of Contact + 2 (Wearing coat + depth of Slab)

= 3.6+2(0.075+0.925)= = **5.60** m

(b) <u>Dispersion width across the span</u>

be = K x (1 - x/Le) + Bw

K = A Constant having the value depending upon the ratio (be/Le) where ---

be = the effective width of the slab on which the load acts.

Le = Effective Span

x = the distance of c.g. of concentrate load from the near support

bw = The breadth of concentration area of the load i.e. Dimension of the tyre or track contact area over the road surface

Here ,

be = 7.50 m

Le = 10.00 m

be/Le = 0.75

Value of K = 2.4

Bw = 0.85 + (2 x 0.075) = 1.00 m

x = Le/2 = 10.00 /2 = 5.00 m

be = 2.20 m

Impact factor is 13.75% as pere IRC Section-II, Clause - 211-3 (a) (i)

DISPERSION ACROSS SPAN (CLASS AA TRACKED VEHICAL)

The tracked vehicle is placed at a distance of minimum clearence of 1.2 m from Kerb

Dispersion across span = C/C distance between wheels + width from centre of wheel on clearence side

+ Least on other side or half the dispersion of one wheel.

= 2.05 + 1.93 + **Least of 3.825 Or 5.6/2** 5.75

= 2.05 + 1.93 + 2.8 = 6.78 M

Impact factor = 1.1375

Total load with impact = 70 x 1.1375

= 79.63 T

Intensity of Load = 79.63 /(2.20 x 6.78) =

= 5.34 T

DISPERSION ALONG SPAN (CLASS AA TRACKED VEHICLE

Maximum Bending Moment due to Live load , at centre

$$= 5.34 \times \frac{5.6}{2} \left(10.00 - \frac{5.6}{5}\right)$$

= **132.77** T - M

Class AA wheeled vehicle :-

For Maximum B.M. at Centre of the span, the Centre of gravity of the loads and the centre of the span should coincide

(a) Dispersion width along the span :-

tp = tc = 2 (tw + ts)

tp = width of dispersion parallel to span

tc = width of tyre contact area parallel to span

ts = Overall depth of slab

tw = Thickness of Wearing coat

Dispersion along the span

= 0.15 + 2 (0.075 + 0.75) = 1.8 m

Dispersion between two wheel is overlapping hence restricted to 1.2 M
= Dispersion combined for two wheels

= C/c distance between two wheels + Longitudinal dispersion

= 1.2 + 1.8

= 3.0 m (along the span)

DISPERSION ALONG SPAN (CLASS AA WHEELED VEHICLE)

(B) Dispersion width across the span :-

be = k x (1 - X/L) + w

Le = 10.0 M & L1 = 7.5 M

= Value of K = 2.4

4.8

X = L/2 = 10/2 = 5.00 M

Bw = 0.30 + 2 (0.075) = 0.45 M

be = 2.4 x 5 x (1 - 5.00/10.00) + 0.45 = 6.45 M (For one Wheel)

DISPERSION ACROSS THE SPAN (CLASS AA WHEELED HEVHICLE)

When the wheel is placed at a distnace of minimum clearance of 1-2 M from Kerb,

Combined effective width

= c/c distance between wheels
+ 1/2 of the dispersion of one wheel
+ least of available width from centre of wheel on clearance side or half the dispersion of one wheel

$= 2.2 + \frac{6.45}{2}$ + Lesser of 1.655 & $\frac{6.45}{2}$

= 2.2 + 3.225 + 1.655

= **7.08** m

According to clause 211.3 (a) (ii) section-III, IRC 6- 1966
Impact factor = 25% = 1.25
= Total load of tracks with impact
= 20 x 1.25

= 25 T

Intensity = $\dfrac{\text{Load}}{\text{dispersion along x across the span}}$

$= \dfrac{25 \times 2}{3.00 \times 7.08}$

= 2.35 T/M

DISPERSION ACROSS THE SPAN (CLASS AA WHEELED HEVHICLE)

Maximum B.M. due to Live load at centre

$= 2.35 \times \dfrac{7.08}{2} \left(10.00 - \dfrac{7.08}{5}\right)$

= **71.41** T - M

$= 2.35 \dfrac{x3}{2} \left(5 \dfrac{-3}{2}\right)$

=

Here from bending moment view point class AA tracked vehical is governing

Hence Maximum Bending Moment due to Live load = 15.527 T - M **132.77** T - M

Total B.M = B.M due to Dead load + BM. Due to Live load

= **30.00** + 132.77

= 162.77 T-M