

PUBLIC WORKS DEPARTMENT

DESIGN OF SUBMERSIBLE BRIDGE ON LARATHI – LARATHI “B” ROAD ACROSS SOM RIVER

**DESIGN OF SUBMERSIBLE BRIDGE DESIGN
ON LARATHI TO LARATHI “B” ROAD
ACROSS RIVER SOM**

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DESIGN OF SUBMERSIBLE BRIDGE ON LARATHI TO LARATHI “B” ROAD ACROSS RIVER SOM

PREAMBLE **Type of Bridge**

The bridge shall be a Submersible bridge. The HFL is 99.500 m and the proposed deck level is 99.950 m.

Decking Arrangement

The Deck Slab shall standard RCC deck slabs each 8400 mm wide i.e. 7500 mm carriage way and guard stones on both sides. There shall be 25 mm wide expansion joint between the adjacent deck slabs along the length of the bridge. The location of proposed road is right angle to the direction of flow.

There shall be 11 Nos. of spans. The centre to centre distance for THE spans shall be 8.8 m.

Standard RCC Solid Slab Superstructure with right effective span 8 M without footpath shall be provided in accordance to the Ministry of Surface Transport (Roads Wing), New Delhi drawings.

It is proposed to construct 7500 mm wide slabs of these standard drawings. As per requirement of use in the proposed bridge the deviation with respect to these drawings shall be as follows:-

1. Pier Cap Width 1200 mm [In the reference drawing the pier cap width is 800 mm]. The width of piers shall be 1200 mm. Due to this change the Centre to Centre distance shall be 8800 mm (centre to centre over piers). For all spans the clear span shall be 7600 mm and the centre to centre distance shall be 8800 mm. The length of reinforcement shall be modified as per these geometrical requirements however spacing of the reinforcement shall not be altered.
2. Footpath & Railing: - There shall be guard poles on both sides only.
3. Reinforcement Detailing: - The reinforcement detailing is suitably modified as required for the modifications referred above in points 1 to 2.

The proposed decking arrangement is shown in Drawing – D-01 titled as Decking arrangement.

Design Loads

The following loads have been considered in the design of deck slab and for the stability of the sub structure:-

[A] Maximum of the following cases

- I. One lane of IRC class 70R on carriage way
- II. One lanes of IRC Class A on carriage way
- III. Two lanes of IRC Class A on carriage way
- IV. Three lanes of IRC Class A on carriage way

- V. One lane of IRC class 70R and one lane of IRC Class A on carriage way
- VI. One lane of IRC class AA TRACKED VEHICLE on carriage way

In order to account for two adjacent slabs the resultant reactions and moments have been multiplied by 2 for stability check of the sub structure.

[B] Other Loads

- a) Footpath load of 5KN/Sqm.
- b) Wearing coat land of 2 KN/Sqm.

Safe Bearing Capacity

The detailed sub soil investigation report for a bridge constructed in the vicinity of the bridge is enclosed.

The foundation rock is safe against the eroding effects of the water flow and other climatic conditions.

As per detailed test of foundation rock the lowest safe bearing capacity for rectangular footing at depth 4.5 m and downwards is 200 kN/ Sq M; Hence the Safe Bearing Capacity adopted for design is 200 kN/ Sq M.

Depth of Foundation/Founding Level

For all the footings no hard rock available hence the foundation shall be laid at 4.5 m depth on gravel base as found uniformly across the river section.

Scour Depth

The maximum scour depth computed is 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 we shall provide foundation at 1.5 m ANCHORED IN BED ROCK AVAILABLE.

Reinforcement Detail & other Detail of Deck slab

Ministry of surface transport details drawings are enclosed which contains miscellaneous details of deck slab including reinforcement drawing.

The right effective span of the proposed bridge is 7.60 m. The length along the centre line of road between pier centers is 8.80 m.

The deck slab pertaining to 8 m. right effective span shall be provided as given in MOST drawings No. SD/101, SD/102, SD/103, SD/104 AND SD/112.

In the drawing the clear right span is 7600 mm. The proposed bridge shall have clear right span as 7600 mm conforming to the standard drawing adopted.

Bearing detail

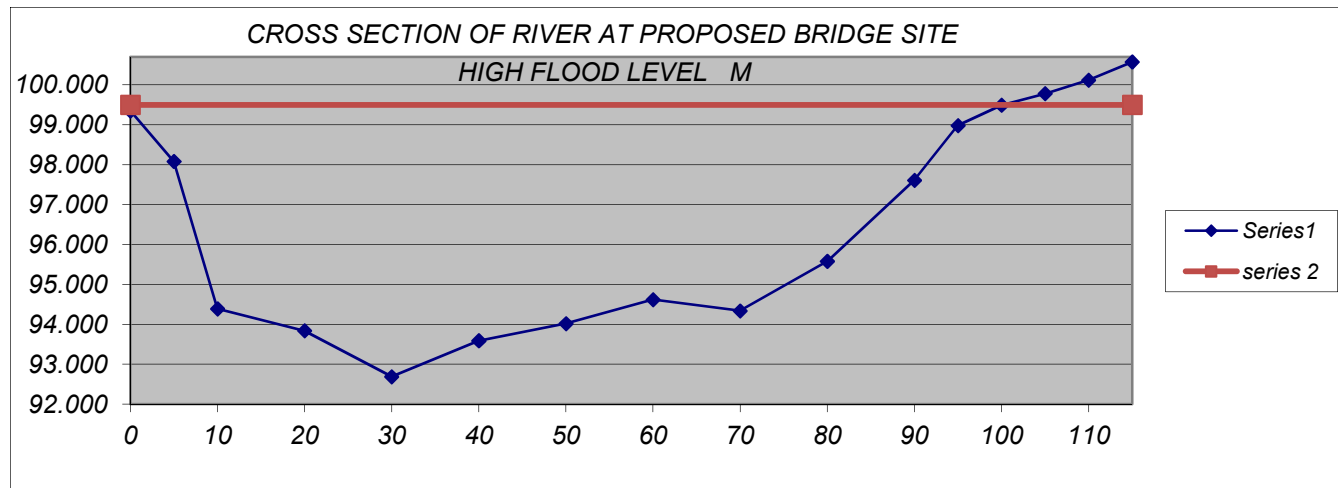
Tar paper bearing shall be providing on top of pier cap & abutment cap.

Approach slab

The detail of approach slab is enclosed as drawing **D-03**.

Pier Cap Detail

Pier cap drawing is enclosed as annexure **D-05**.

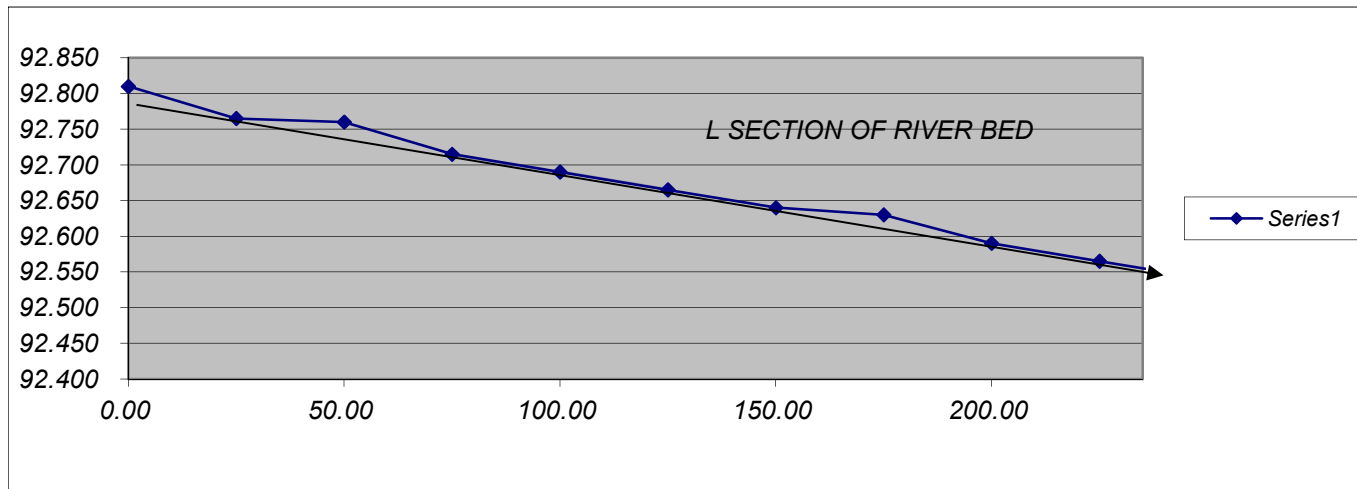


SLOPE

1

IN

926



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 m ²	A =	Cross sectional area in m ²
P =	117.02 m	P =	Perimeter calculated in m
S =	1 IN	S =	Slope as per drain LS taken at Proposal site
n =	0.033	n =	Rugosity coefficient (As per IRC SP-13)
V =	$1/n \times (A/P)^{2/3} \times (S)^{1/2}$	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 :-

$$L = 4.8 (Q)^{1/2}$$

$$= 156.78 \text{ m}$$

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)

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

	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

$$\text{Afflux } h = ((V^2/17.85) + 0.0152) \times (A^2/a^2 - 1)$$

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

$$\begin{aligned} \text{Unobstructed Area of Flow after Bridge Construction} &= 94.800 \times 3.78 = 358.48 \text{ m}^2 \\ A &= 440.83 \text{ m}^2 \\ V &= 2.42 \text{ m/sec.} \end{aligned}$$

Computation of Area obstructed by Deck Slab

$$\begin{aligned} \text{HFL :} & 99.500 \text{ m} \\ \text{Top Level of Deck slab :} & 99.950 \text{ m} \\ \text{Thickness of Slab and Wearing Coat} & 0.830 \text{ m} \\ \text{Length Of Slab} & 94.800 \text{ m} \\ \text{Height of Obstruction} & 0.830 \text{ m} \\ \text{Area obstructed by deck slab} & 94.800 \times 0.83 \\ & = 78.68 \text{ m}^2 \end{aligned}$$

Computation of Area obstructed by Piers

$$\begin{aligned} \text{HFL :} & 99.500 \text{ m} \\ \text{Soffit of Deck slab :} & 99.120 \text{ m} \\ \text{Average river bed level} & 96.169 \text{ m} \\ \text{Nos. of pier} & 10 \\ \text{Height of Obstruction} & 99.500 - 96.169 = 3.331 \text{ m} \\ \text{Area obstructed by one pier :} & 1.2 \times 3.33 \\ & = 3.998 \text{ m}^2 \\ \text{For 10 Nos. of piers} & 10 \times 3.998 \\ A1 & = 39.98 \text{ m}^2 \end{aligned}$$

Computation of Area obstructed by Abutments

$$\begin{aligned} \text{Average ground level} & 96.169 \text{ m} \\ \text{Height of Obstruction} & 99.500 - 96.169 = 3.331 \text{ m} \\ \text{Area obstructed by one Abutment : } A2 &= (0.40+0.75)/2 \times 3.33 \\ &= 1.92 \text{ m}^2 \\ \text{For two Abutments} & 2 \times 1.92 \\ &= 3.83 \text{ m}^2 \\ \text{Total area of obstruction due to slab,} & \\ \text{piers and abutments } A &= A0 + A1 + A2 \\ &= 78.68 + 39.98 + 3.83 \\ &= 122.50 \text{ m}^2 \end{aligned}$$

Actual Area of flow $a =$ $440.825 - 122.50 = 318.33 \text{ m}^2$

Afflux $h =$ 0.32 m

Afflux flood level $=$ $99.500 + 0.32 = 99.820 \text{ m}$

Obstructed Velocity $V = Q/a =$

Obstructed Velocity $= 1066.8 / 318.33 = 3.36 \text{ m/sec}$

However we consider design velocity 3.36 m/sec.

Afflux flood level $= 99.820 \text{ M}$

Top of deck slab $= 99.950 \text{ M}$

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
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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		
<i>Road top level (RTL)</i>	99.950	M
<i>Average Ground Level (AGL)</i>	96.169	M
<i>Average Height Of Bridge</i>	3.780	M
<i>Lowest Nala Bed level (NBL)</i>	92.690	M
<i>Ordinary flood level (OFL)</i>	97.369	M
<i>Foundation level (FL)</i>	89.690	M
<i>Ht. of bridge $h = (RTL - NBL)$</i>	7.260	M
<i>Ht. of bridge $H = (RTL - FL)$</i>	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 Vm 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 HPL = 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

Permissible Shear Stress 32 mm 190 N/mm²

Shear Force Resisted by one Anchor Bar =

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

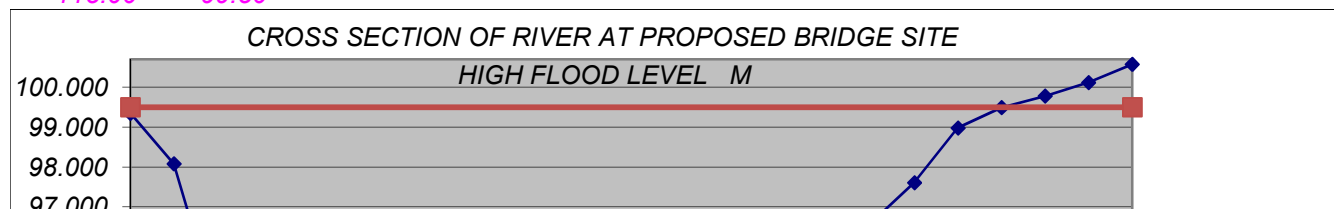
CROSS SECTION OF RIVER DOWN-STREAM

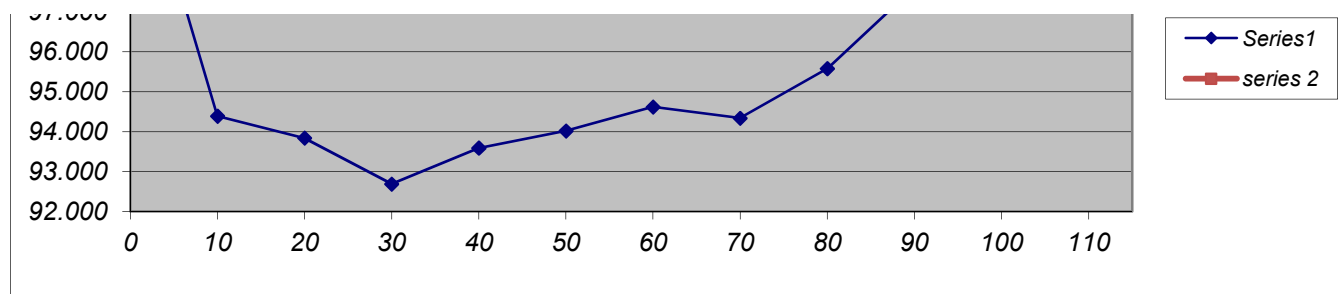
**Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road ,
across Som River.**

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





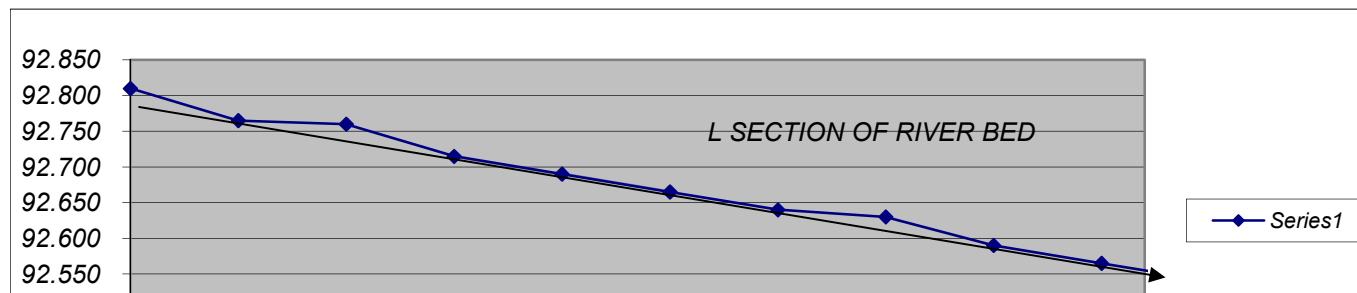
DETERMINATION OF BED SLOPE OF THE RIVER

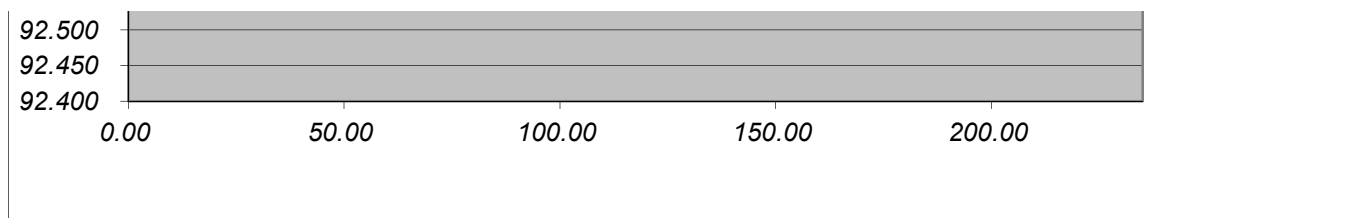
**Name Of Work :- Construction of Submersible Bridge on Larathi to Larathi "B" Road ,
across Som River.**

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





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

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 HIGHEST PIER	=	92.69 M
13 SAFE BEARING CAPACITY	=	20.00 t/m ² 200.00 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	8.40 x	2.00 x	24.00 =	18.144 kN		
	=	0.50 x	0.15 x	0.60 x	3.14 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.	=						0.900 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		
Footings	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			
Refer Live load Computation sheet showing maximum reaction	=	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	0.50	M
PCC Offset	0.20	M
Length Variant	1.00	M
Width Variant	0.50	M

TOTAL LONGITUDINAL MOMENT DUE TO LIVE LOAD & BREAKING FORCE

Maximum Longitudinal moment due to Live Load including Impact and Breaking Force			
Refer Live load Computation sheet showing maximum reaction	=	122.13 x	2.00 = 244.25 kN-m
	=	12.21 T m	122.13 kN-m
which is =			

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			
Refer Live load Computation sheet showing maximum reaction	=	1123.94 x	2.00 = 2247.88 kN-m
	=	112.39 T m	1123.94 kN-m
which is =			

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.

$$\text{Obstructed Velocity} = V \sin 20^\circ = 2.41 \times \sin 20^\circ$$

12/67 4264-f40e-e461-b8e6.xls STABILITY CHECK FOR PIER

$\bar{X} = (0.90 \times 0.90) + (0.81 \times 0.30) /$		Total	1.71 Sqm
		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	=
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
Pier from R.L.	99.125 to	92.69 M	
Area =	1.20 x	6.44	=
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	=
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 = 28.88 m ⁴
I _{yy} =	1/6x 12.00 x 3.80 = 91.20 m ⁴
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/m ²
	< 250 kN/m ² Hence O.K.
P _{min} =	109.85 - 15.12 - 26.76
	= 67.97 kN/m ²
	> 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
	= 164.49 kN/m ²
	< 250 kN/m ² Hence O.K.
P _{min} =	122.61 - 15.12 - 26.76
	= 80.73 kN/m ²
	> 0 Hence O.K.

CASE-2 FOR IDLE CONDITION AT R.L.88.19 M

(WHEN THERE IS NO LIVE LOAD)

A CHECK OF STABILITY DUE TO BUOYANCY EFFECT	
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
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/m ²
	< 250 kN/m ² Hence O.K.
P _{min} =	92.56 - 6.66 - 2.11
	= 83.79 kN/m ²
	> 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/m ²
	< 250 kN/m ² Hence O.K.
P _{min} =	105.32 - 6.66 - 2.11
	= 96.55 kN/m ²
	> 0 Hence O.K.

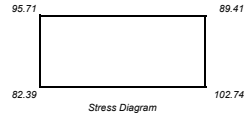
CASE-3 FOR WIND FORCE AT SERVICE CONDITION AT R.L.88.19 M

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
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

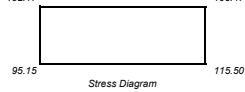
$$\begin{aligned}
 &= 153.13 \text{ kN/m}^2 \\
 &< 250 \text{ kN/m}^2 \text{ Hence O.K.} \\
 P_{min} &= 109.85 \quad - \quad 15.12 \quad - \quad 28.16 \\
 &= 66.57 \text{ kN/m}^2 \\
 &> 0 \text{ Hence O.K.} \\
 \text{STRESS without Buoyancy} &= (\quad 5590.95 \quad / \quad 45.60 \quad) + / - (\quad 436.69 \quad / \quad 28.88 \quad) + / - (\quad 2568.29 \quad / \quad 91.20 \quad) \\
 &= 122.61 \quad + / - \quad 15.12 \quad + / - \quad 28.16 \\
 P_{max} &= 122.61 \quad + \quad 15.12 \quad + \quad 28.16 \\
 &= 153.89 \text{ kN/m}^2 \\
 &< 250 \text{ kN/m}^2 \text{ Hence O.K.} \\
 P_{min} &= 122.61 \quad - \quad 15.12 \quad - \quad 28.16 \\
 &= 79.33 \text{ kN/m}^2 \\
 &> 0 \text{ Hence O.K.}
 \end{aligned}$$

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	+ / - (
	=	92.56	+ / -	6.66	+ / -	3.51	320.41 /
	=	92.56	+	6.66	+	3.51	91.20)
	=	102.74 kN/m ²					
	< 250 kN/m ² Hence O.K.						
P _{min}	=	92.56	-	6.66	-	3.51	
	=	82.39 kN/m ²					
	> 0 Hence O.K.						
P ₃	=	92.56	+	6.66	-	3.51	
	=	95.71 kN/m ²					
	< 250 kN/m ² Hence O.K.						
P ₄	=	92.56	-	6.66	+	3.51	
	=	89.41 kN/m ²					
	> 0 Hence O.K.						
STRESS without Buoyancy	= (	4802.69 /	45.60	+ / - (	192.44 /	28.88	+ / - (
	=	105.32	+ / -	6.66	+ / -	3.51	320.41 /
	=	105.32	+	6.66	+	3.51	91.20)
	=	115.50 kN/m ²					
	< 250 kN/m ² Hence O.K.						
P _{min}	=	105.32	-	6.66	-	3.51	
	=	95.15 kN/m ²					
	> 0 Hence O.K.						



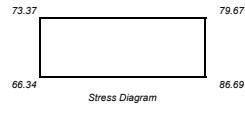
Stress Diagram



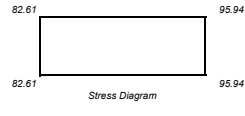
Stress Diagram

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	+ / - (
	=	76.52	+ / -	6.66	+ / -	3.51	320.41 /
	=	76.52	+	6.66	+	3.51	91.20)
	=	86.69 kN/m ²					
	< 250 kN/m ² Hence O.K.						
P _{min}	=	76.52	-	6.66	-	3.51	
	=	66.34 kN/m ²					
	> 0 Hence O.K.						
P ₃	=	76.52	+	6.66	-	3.51	
	=	79.67 kN/m ²					
	< 250 kN/m ² Hence O.K.						
P ₄	=	76.52	-	6.66	+	3.51	
	=	73.37 kN/m ²					
	> 0 Hence O.K.						
STRESS without Buoyancy	= (	4070.88 /	45.60	+ / - (	192.44 /	28.88	+ / - (
	=	89.27	+ / -	6.66	+ / -	3.51	0.00 /
	=	89.27	+	6.66	+	3.51	91.20)
	=	95.94 kN/m ²					
	< 250 kN/m ² Hence O.K.						
P _{min}	=	89.27	-	6.66	-	3.51	
	=	82.61 kN/m ²					
	> 0 Hence O.K.						
P ₃	=	89.27	+	6.66	-	3.51	
	=	95.94 kN/m ²					
	< 250 kN/m ² Hence O.K.						
P ₄	=	89.27	-	6.66	+	3.51	
	=	82.61 kN/m ²					
	> 0 Hence O.K.						



Stress Diagram



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 m²
 $I_{xx} = \frac{1}{6}x \cdot 12.00^2 = 2.88 \text{ m}^3$
 $I_{yy} = \frac{1}{6}x \cdot 12.00^2 = 28.80 \text{ m}^3$
 STRESS with Buoyancy = $\left(\frac{4370.82}{303.53} \pm \frac{14.40}{131.16} \right) \pm \left(\frac{377.74}{82.69} \pm \frac{2381.37}{28.80} \right)$
 $P_{max} = 517.38 \text{ kN/m}^2$
 $P_{min} = 303.53$
 < 8000 kN/m² (that is 8 N/mm²) Hence O.K.
 > (- 3600 kN/m² (that is 3.6 N/mm²)) Hence O.K.

STRESS without Buoyancy = $\left(\frac{4496.55}{312.26} \pm \frac{14.40}{131.16} \right) \pm \left(\frac{377.74}{82.69} \pm \frac{2381.37}{28.80} \right)$
 $P_{max} = 526.11 \text{ kN/m}^2$
 $P_{min} = 312.26$
 < 8000 kN/m² (that is 8 N/mm²) Hence O.K.
 > (- 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 = $\left(\frac{3582.55}{248.79} \pm \frac{14.40}{46.35} \right) \pm \left(\frac{133.49}{4.64} \pm \frac{2381.37}{28.80} \right)$
 $P_{max} = 299.77 \text{ kN/m}^2$
 $P_{min} = 248.79$
 < 8000 kN/m² (that is 8 N/mm²) Hence O.K.
 > (- 3600 kN/m² (that is 3.6 N/mm²)) Hence O.K.
 STRESS without Buoyancy = $\left(\frac{3708.29}{257.52} \pm \frac{14.40}{46.35} \right) \pm \left(\frac{133.49}{4.64} \pm \frac{2381.37}{28.80} \right)$
 $P_{max} = 308.51 \text{ kN/m}^2$
 $P_{min} = 257.52$
 < 8000 kN/m² (that is 8 N/mm²) Hence O.K.
 > (- 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 = 272.34 kN-m
 STRESS with Buoyancy = $\left(\frac{4370.82}{303.53} \pm \frac{14.40}{131.16} \right) \pm \left(\frac{377.74}{87.51} \pm \frac{2520.23}{28.80} \right)$
 $P_{max} = 522.20 \text{ kN/m}^2$
 $P_{min} = 303.53$
 < 8000 kN/m² (that is 8 N/mm²) Hence O.K.
 > (- 3600 kN/m² (that is 3.6 N/mm²)) Hence O.K.
 STRESS without Buoyancy = $\left(\frac{4496.55}{312.26} \pm \frac{14.40}{131.16} \right) \pm \left(\frac{377.74}{87.51} \pm \frac{2520.23}{28.80} \right)$
 $P_{max} = 530.93 \text{ kN/m}^2$
 $P_{min} = 312.26$
 < 8000 kN/m² (that is 8 N/mm²) Hence O.K.
 > (- 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 + 138.86 = 272.34 kN-m
 Total TRANSVERSE MOMENT = 133.49 + 9.46 = 142.95 kN-m
 STRESS with Buoyancy = $\left(\frac{4370.82}{303.53} \pm \frac{14.40}{46.35} \right) \pm \left(\frac{142.95}{9.46} \pm \frac{272.34}{28.80} \right)$
 $P_{max} = 359.34 \text{ kN/m}^2$
 $P_{min} = 303.53$
 < 8000 kN/m² (that is 8 N/mm²) Hence O.K.
 > (- 3600 kN/m² (that is 3.6 N/mm²)) Hence O.K.

$$\begin{aligned}
 &= 247.72 \text{ kN/m}^2 \\
 &> (-3600 \text{ kN/m}^2 \text{ (that is } 3.6 \text{ N/mm}^2 \text{) Hence O.K.} \\
 \text{STRESS without Buoyancy} &= (4496.55 / 14.40) + / - (133.49 / 2.88) + / - (272.34 / 28.80) \\
 &= 312.26 + / - 46.35 + / - 9.46 \\
 P_{max} &= 312.26 + 46.35 + 9.46 \\
 &= 368.07 \text{ kN/m}^2 \\
 &< 8000 \text{ kN/m}^2 \text{ (that is } 8 \text{ N/mm}^2 \text{) Hence O.K.} \\
 P_{min} &= 312.26 - 46.35 - 9.46 \\
 &= 256.45 \text{ kN/m}^2 \\
 &> (-3600 \text{ kN/m}^2 \text{ (that is } 3.6 \text{ N/mm}^2 \text{) Hence O.K.}
 \end{aligned}$$

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
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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
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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		σ_{bc}	=	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	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'/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					
$M_u/(f_{ck} b d^2)$	=	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 $P_t = 0.8$ % OF GROSS 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 $P_t = 0.3$ % 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
SPACING
FOR TRANSVERSE MOMENT

=

25 MM BARS = 88 Nos.
290 MM

$$\frac{Mu}{(f_{ck} b d^2)} = \frac{3780.34 \times 1000000}{12001.2 \times 1201.2^2} = 0.0073$$

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

$$\frac{2520.23}{11.87} = 212.27 \text{ kN}$$

Check for Shear

$$\text{Nominal Shear Stress} = \frac{212.27}{0.01} = 21227 \text{ N/mm}^2$$

$$P_t = 0.30$$

$$0.40 \text{ N/mm}^2 \text{ Refer table 61}$$

Permissible Shear Stress =

Nominal Shear Reinforcement will suffice

According to IRC 21-1987 Clause 306.3

$$\text{Dia of Transverse Reinforcement} = \frac{25}{4} = 6.25 \text{ mm}$$

Provide

12 mm dia rings

Pitch of the Transverse should be least of

a) Least lateral Dimension =

$$1201.2 \text{ mm}$$

b) $12 d =$

$$12 \times 25 = 300 \text{ mm}$$

$$12 \times 12 = 144 \text{ mm}$$

c) 300 mm =

$$300 \text{ mm}$$

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

$$100 \text{ mm}$$

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

$$A_{sh} = 0.18 S_h (F_{ck}/F_y) \times (A_g/A_k - 1)$$

$$S = 100.00 \text{ mm}$$

$$h = 300.00 \text{ N/mm}^2$$

$$F_{ck} = 30.00 \text{ N/mm}^2$$

$$F_y = 415.00 \text{ N/mm}^2$$

$$A_g = 1201.20 \text{ mm}^2$$

$$A_k = 1100.20 \text{ mm}^2$$

$$\text{Hence } A_{sh} = 35.84 \text{ mm}^2$$

$$A_{sh} \text{ Provided} = 113.04 \text{ mm}^2$$

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

$$100 \text{ mm}$$

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

ABSTRACT

LONGITUDINAL REINFORCEMENT

25 MM BARS 290

MM However Adopt spacing as 250 mm

TRANSVERSE REINFORCEMENT

12mm dia rings @100mm c/c.

$$= 0.0071$$

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

$$\frac{2440.32}{11.87} = 205.54 \text{ kN}$$

Check for Shear

$$\text{Nominal Shear Stress} = \frac{205.54}{2440.32} \times \frac{1000}{0.01} = 8.42 \text{ N/mm}^2$$

$$\text{Pt} = \frac{0.30}{0.40} = 0.75 \text{ Refer table 61}$$

Permissible Shear Stress =

Nominal Shear Reinforcement will suffice

According to IRC 21-1987 Clause 306.3

Dia of Transverse Reinforcement

$$= \frac{25}{4} = 6.25 \text{ mm}$$

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 13920:1993 Cl. 7.4.6

$$< \text{or} = \frac{100}{12} = 8.33 \text{ mm}$$

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

$$\text{Ash} = 0.18 \text{ Sh } (F_{ck}/F_y) \times (A_g/A_k - 1)$$

$$S = \frac{100.00}{300.00} = 0.33 \text{ mm}$$

$$h = \frac{300.00}{30.00} = 10 \text{ N/mm}^2$$

$$F_{ck} = \frac{30.00}{415.00} = 0.07 \text{ N/mm}^2$$

$$F_y = \frac{415.00}{1200.00} = 0.34 \text{ N/mm}^2$$

$$A_g = \frac{1200.00}{1099.00} = 1.1 \text{ mm}^2$$

$$A_k = \frac{1099.00}{35.87} = 30.6 \text{ mm}^2$$

$$\text{Hence Ash} = \frac{35.87}{113.04} = 0.31 \text{ mm}^2$$

$$\text{Ash Provide} = \frac{113.04}{100} = 1.13 \text{ mm}^2$$

d) As per IS 13920:1993 Cl. 7.4.6

$$< \text{or} = \frac{100}{12} = 8.33 \text{ mm}$$

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

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.

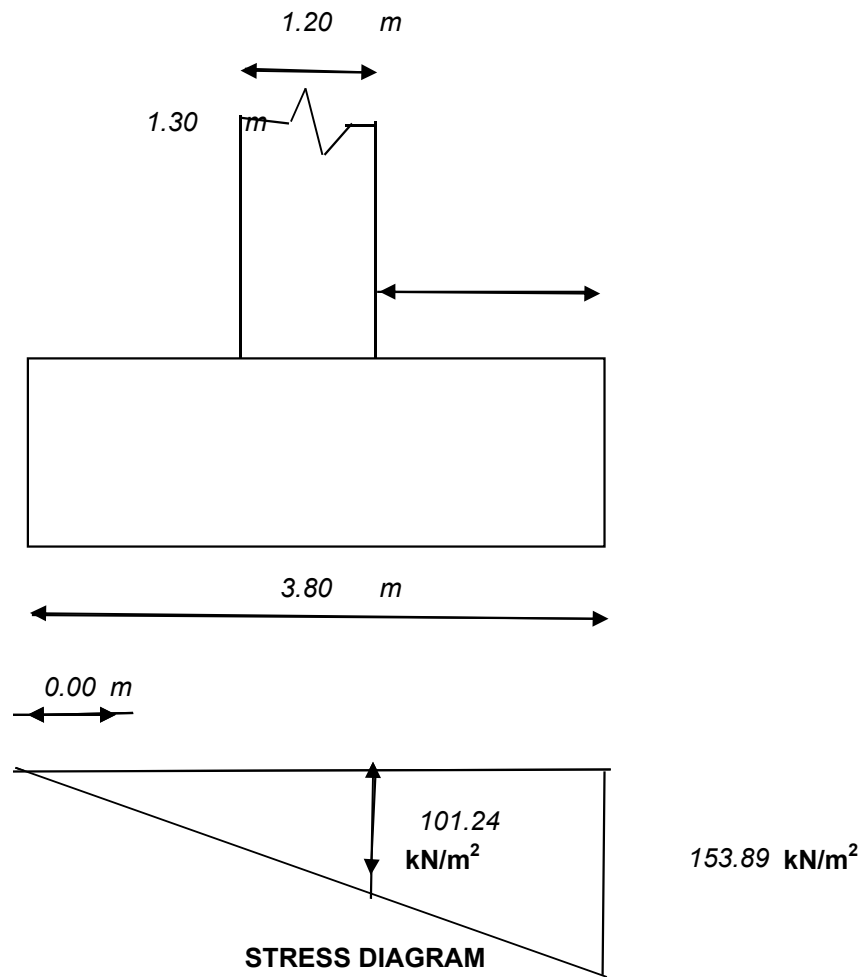
FOR WIND AT SERVICE CONDITION

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 = $y \times l_b$		0.00	m ²	0.00 %
Maximum Pressure before Redistribution		153.89	kN/m ²	
Maximum Pressure After Redistribution = $p \times k$		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 σ_{cbc}		10	N/mm ²	
m		9.33		
σ_{st}		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 A_{st}		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
$V=V' + M/d \tan B$	$(B=0)$ Hence $V = V'$	
Actual Shear Stress		0.06 N/mm ²
Percentage Steel	100As/bd	0.07
Tc		0.23 N/mm ²
$k=1$		
Permissible 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 $s = A_{sw} t_s d/V$		1423 mm
Provide Bars Of Dia And Spacing	16 mm	Adopt spacing as 250 mm



DESIGN OF PIER FOOTING

LIVE LOAD CALCULATION :-

[1] CLASS AA TRACKED VEHICLE :-

(a) Dispersion width along the span

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) Dispersion width across the span

According to clause 305.13 IRC- 21-2000

$b_e = K \times (1 - x/L_e) + b_w$

K = A Constant having the value depending upon the ratio (L_1/L_e) where.

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

L_e = Effective Span

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

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

Here ,

$L_e = 10.00 \text{ M}$ & $L_1 = 7.00 \text{ M}$

$= \frac{L_1}{L_e} = \frac{7.00}{10.0} = 0.7$

Value of $K = 2.4$

$b_w = 0.85 + 2 \times 0.075 = 1.0 \text{ M}$

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

$b_e = 2.4 \times 4 (1 - 5/10) + 1$

$$= 5.8 \text{ M}$$

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

DISPERSION ACROSS SPAN (CLASS AA TRACKED VEHICLE)

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

Dispersion across span

= C/C distance between wheels

+ width from centre of wheel on clearance side

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

$$= 2.05 + 1.93 + \text{Least of } 2.715 \text{ OR } 5.8/2$$

$$= 2.05 + 1.93 + 2.715$$

$$= 6.695$$

$$\text{Impact factor} = 1.1375$$

Total load with impact

$$= 70 \times 1.1375$$

$$= 79.63 \text{ T}$$

= Intensity of Load

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

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

$$\text{Reaction } R_A = 2.24 \times 3.00 \times 1.50 / 10.00$$

$$= 1.01 \text{ T}$$

$$\text{Reaction } R_B = 2.24 \times 3.00 - 1.01$$

$$= 5.71 \text{ T}$$

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

$$= 0.15 + 2 (0.075 + 0.775)$$

$$= 1.9 \text{ M}$$

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

= Dispersion combined for two wheels

$$= \text{C/c distance between two wheels} + \text{Longitudinal dispersion}$$

$$= 1-2 + 1.9$$

$$= 3.1 \text{ M (along the span)}$$

Impact factor = 1.1375

Total load with impact

$$= 70 \times 1.1375$$

$$= 79.63 \text{ T}$$

= Intensity of Load

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

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

$$\text{Reaction } R_A = 7.91 \times 3.00 \times 1.50 / 10.00$$

$$= 3.56 \text{ T}$$

$$\text{Reaction } R_B = 7.91 \times 3.00 - 3.56$$

$$= 20.17 \text{ T}$$

DESIGN OF PIER CAP :-

D.L./ M Width along bridge

DL. Of Slab =

D.L. of Wearing coat =

D.L. of Slab & Wearing coat on half of the pier

L.L. on Pier cap including impact along bridge

(Refer Live Load Computation)

Dispersion width across the span for

70 T TRACKED VEHTCLE

(Refer Solid slab design page SS-16)

Live Load u.d.l. on Pier

Per M width

Total Load on Half =

of pier along bridge

Effective depth of slab =90-2.5-2.5/2 =

Placement of the live load at effective depth from the support (taking support width 750 mm)

Eccentricity = 71.25 -75/2

Bending Moment along the bridge =

=

This moment is too small hence it will not/be the governing B.M.

Moment in pier cap**CONCRETE GRADE****FOR THIS GRADE σ_{cbc}** **m** **σ_{st}** **factor k****j****R****Effective Depth Required****Adopt Total Depth****Cover****Assume Bar Dia****Keeping A Cover Of 50 mm Effective Depth****Adopt Effective Depth****Steel Required Ast****Area Of One Bar****Spacing S****Provide Bars Of Dia And Spacing****Provide Bars Of Dia And Spacing for Top Main Steel****Provide Bars Of Dia And Spacing for Bottom Steel****PIER SECTION ACROSS BRIDGE****DEAD LOAD MOMENT PER METRE Width across bridge :-**

Slab D.L.

D.L. of Wearing coat =

D.L. of Slab & Wearing coat on half of the pier

L.L. on pier

Dispersion width along the span for

70 T Tracked vehical

L.L. . per M width on pier =

Total D.L. + L.L. on half of Pier across

$$\begin{array}{rclcl} 0.75 \times & 8.40 \times & 2.4 = & 15.12 \text{ T} \\ 0.08 \times & 8.40 \times & 2.4 = & 1.51 \text{ T} \end{array}$$

TOTAL		16.63 T
--------------	--	----------------

$$= \frac{16.63}{2} = 8.32 \text{ T}$$

$$= 82.50 \times 1.1375 = 93.84 \text{ T}$$

$$= 6.695 \text{ M}$$

$$= 93.84 / 6.695 = 14.02 \text{ T}$$

$$8.32 + 14.02 = 22.33 \text{ T}$$

Per M width

$$71.25 \text{ cm}$$

$$= 33.75 \text{ cm} = 0.34 \text{ M}$$

$$22.33 \times 0.34 = 7.54 \text{ T - M/M width}$$

$$7.54 \times 10.00 = 75.4 \text{ kN-M/M width}$$

75.40 kN-m**M30****10 N/mm²****9.33****200****0.318****0.894****1.422****230 mm****1200 mm****50 mm****25 mm****1138 mm****1137.5 mm****371 mm²****491 mm²****1323 mm****25 mm 100 mm****Adopt spacing as 100 mm****25 mm 100 mm****16 mm 100 mm**

$$\begin{array}{rclcl} 0.975 \times & 15 \times & 2.4 = & 35.10 \text{ T} \\ 0.075 \times & 12 \times & 2.4 = & 2.16 \text{ T} \end{array}$$

TOTAL		37.26 T
--------------	--	----------------

$$= \frac{37.26}{2} = 18.63 \text{ T/M width}$$

$$= 64.69 \text{ T}$$

$$= 5.3 \text{ M}$$

$$18.63 + 64.69 / 5.3 = 12.21 \text{ T/M width}$$

$$18.63 + 12.21 = 30.84 \text{ T}$$

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 =

$$30.84 \times 0 = 0.00 \text{ T - M/M width}$$

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 =

$$250 \times 1.2 = 300 \text{ mm}^2$$

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

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

Area of Steel Provided at top

$$= (14 \times 491)$$

$$= 6874 \text{ mm}^2 > 300 \text{ mm}^2 \quad \text{OK}$$

Area of Steel Provided at bottom

$$= (14 \times 201)$$

$$= 2814 \text{ mm}^2 > 300 \text{ mm}^2 \quad \text{OK}$$

CHECK FOR SHEAR ALONG BRIDGE DIRECTION

V =

$$30.84 \text{ T}$$

Shear Force

$$308.40 \text{ kN}$$

$V = V' + M/d \tan B$

(B=0) Hence $V = V'$

Actual Shear Stress

$$0.27 \text{ N/mm}^2$$

Percentage Steel

$$100A_s/bd$$

$$0.25$$

Tc

$$0.23 \text{ N/mm}^2$$

k=1

Permissible Shear Stress = k Tc

$$0.23 \text{ N/mm}^2$$

< Actual Shear Stress hence Shear Reinforcement should be provided

$$16 \text{ mm}$$

Dia Of two Legged Stirrups

Area Of One Bar In Distribution Reinforcement

$$201 \text{ mm}^2$$

Using The Bars Spacing Required $s = A_{sw} t_s d/V$

$$296 \text{ mm}$$

Provide Bars Of Dia And Spacing

$$16 \text{ mm}$$

$$100 \text{ mm}$$

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 =

$$20.3 \text{ T}$$

Shear Force

$$203.00 \text{ kN}$$

$V = V' + M/d \tan B$

(B=0) Hence $V = V'$

Actual Shear Stress

$$0.18 \text{ N/mm}^2$$

Percentage Steel

$$100A_s/bd$$

$$0.25$$

Tc

$$0.23 \text{ N/mm}^2$$

k=1

Permissible Shear Stress = k Tc

$$0.23 \text{ N/mm}^2$$

> 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

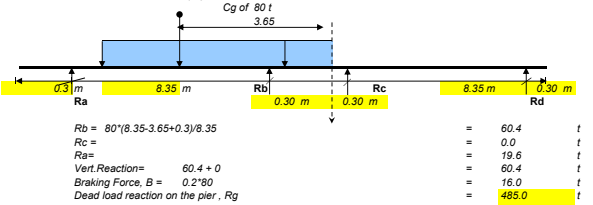
Centre line of pier w.r.t. the bearings :-

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)



$R_b = 80 \times (8.35 - 3.65 + 0.3) / 8.35 = 60.4 \text{ t}$
 $R_c = 0.0 \text{ t}$
 $R_a = 19.6 \text{ t}$
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

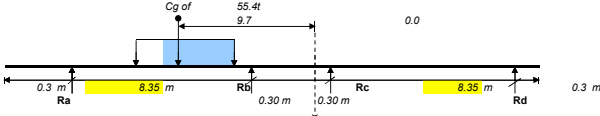
Value of "μ" = 0.00
Horizontal force due to temperature, T = μ * (Rg + Ra) = 0.0 t
Design horizontal force is higher of either (B/2 + T) or (B - T) = 16.0 t
(neglecting shear rating of elastomeric bearing in the adjacent span, which is on the conservative side)

CL of 70-R = 2.595 m
CL of c/w = 1.605 m
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



$R_c = 0 \times (8.35 - 0.3) / 8.35 = 0.0 \text{ t}$
 $R_b = 55.4 \times (8.35 - 9.7 + 0.3) / 8.35 = 7.0 \text{ t}$
 $R_a = 48.4 \text{ t}$
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)

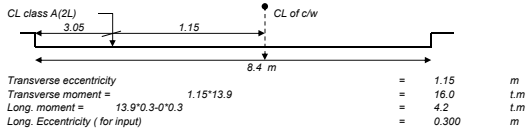
CL class A(1L) = 1.30 m
CL of c/w = 2.90 m
Transverse eccentricity = 2.90 m
Transverse moment = 2.9 * 55.4 = 160.7 t.m
Long. moment = 7 * 0.3 - 0 * 0.3 = 2.1 t.m
Long. Eccentricity (for input) = 0.038 m

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

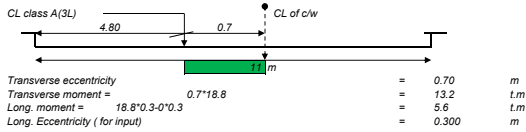
$R_c = 2 \times 0 = 0.0 \text{ t}$
 $R_b = 2 \times 7 = 13.9 \text{ t}$
 $R_a = 96.9 \text{ t}$
Vert. Reaction = 0 + 13.9 = 13.9 t
Braking Force(For single lane only) = 11.1 t
Dead load reaction on the pier, Rg = 485.0 t
Value of "μ" = 0.00
Horizontal force due to temperature, T = μ * (Rg + Ra) = 0.0 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)



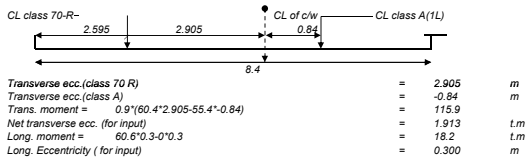
Case 4 : Three lane of class-A

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 t
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)



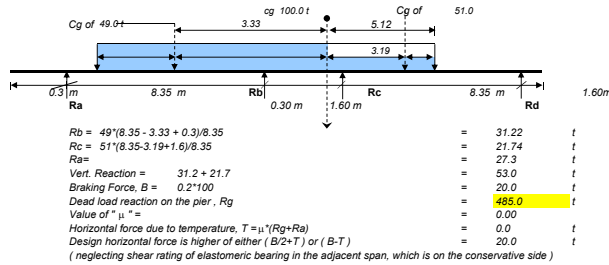
Case 5 : One lane of class-70R(W)+One lane of class-A

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)



Condition B: MAXIMUM TRANSVERSE MOMENT / REACTION CASE

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

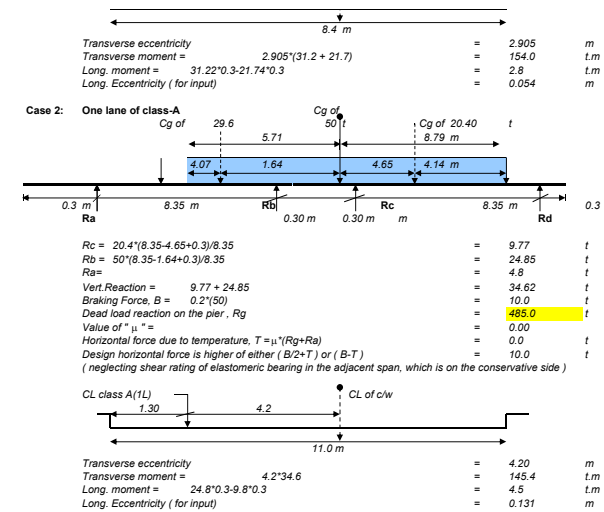


first span	LOAD	CG
8.28	49	3.33
5.04	58	2.18
8.95		

second span	LOAD	CG
4.4	34	3.715
5.12	51	3.19
11.55		

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

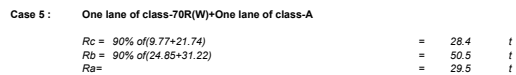
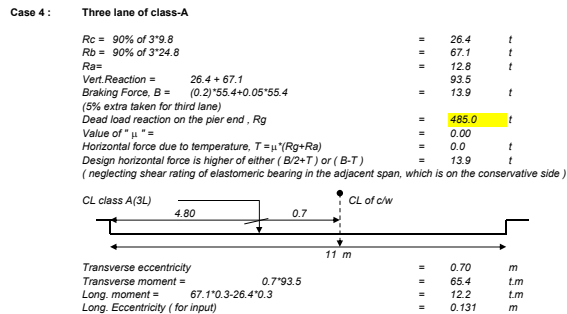
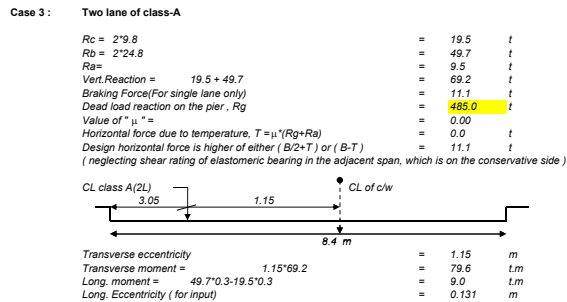
first span	LOAD	CG
3	17	0.87
4.52	29	1.75
8.48	41	2.56
24	49	3.53
8.95		



two span length	load	cg 6.8 end	cg 2.7 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	load	Span2 load	cg 6.8
27.2	13.6	1.5	55.4	27.2	4.5
38.6	20.4	4.14	52.7	27.2	4.5
50	20.4	4.14	50	20.4	4.14
52.7	27.2	4.5	38.6	20.4	4.14
55.4	27.2	4.5	27.2	13.6	1.5
	span2	8.78			

load 1	Cg 2.7 end	load 1	Cg 2.7 end
13.6	1.5	28.2	4.07
18.2	1.81	25.5	3.4
25.5	3.4	29.6	1.73
28.2	4.07	18.2	1.81



CL class 70-R

2.595

2.905

CL of c/w

0.84

CL class A(1L)

8.4

Transverse ecc.(class 70 R)	=	2.905	m
Transverse ecc.(class A)	=	-0.84	m
Trans. moment = $0.9'(60.4^{\circ}2.9^{\circ}0-0.8)$	=	112.4	
Net transverse ecc. (for input)	=	1.426	t.m
Long. moment = $50.5^{\circ}0.3:28.4^{\circ}0.3$	=	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

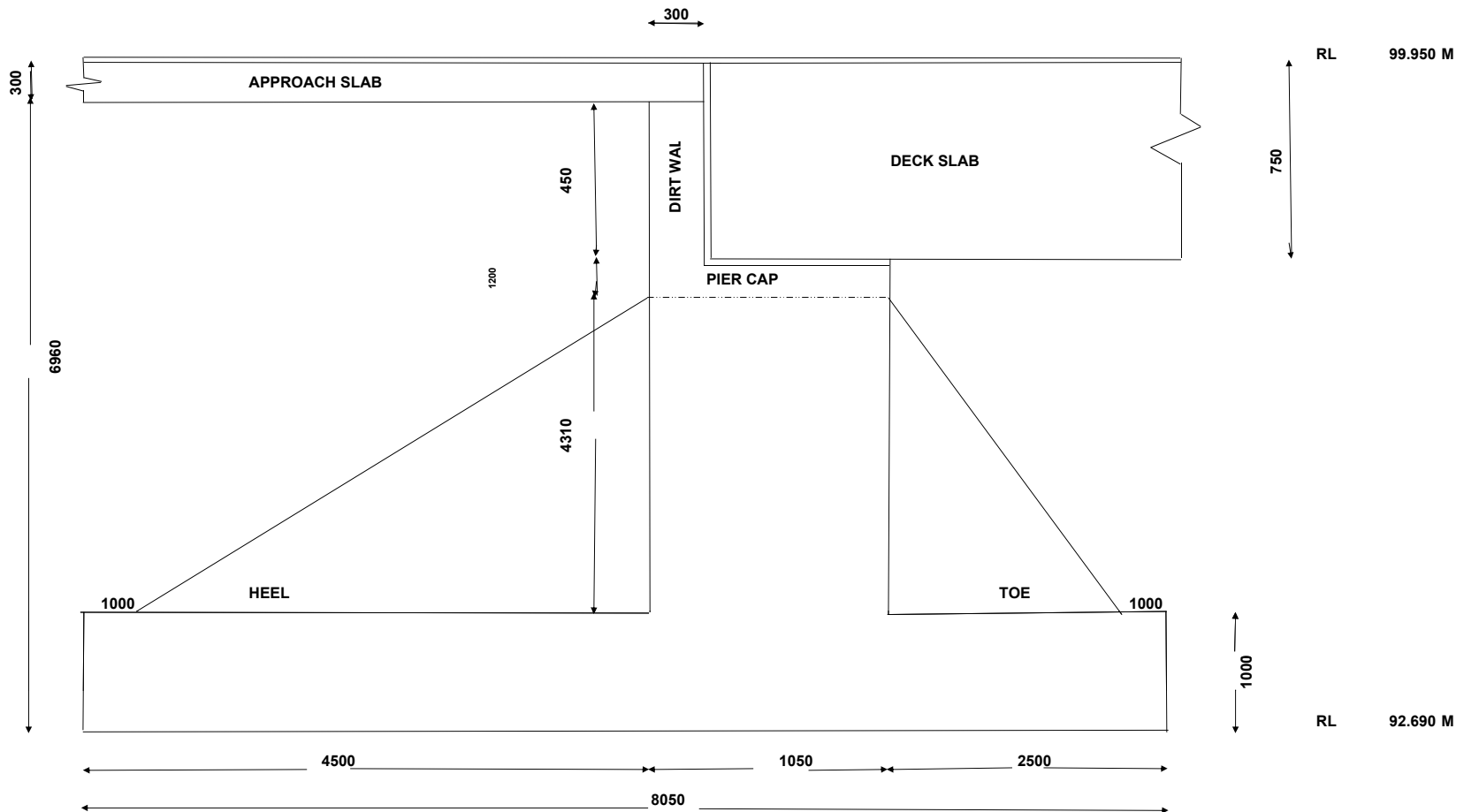
Load case	Max. Transverse Moment			Design horizontal force (t)	Transverse ecc. (m)	Longitudinal ecc. (m)
	Max. vertical reaction (t)	Transverse moment (t.m)	Longitudinal moment (t.m)			
1L class 70 - R	53.0	154.0	2.8	20.0	2.905	0.054
1L class - A	34.6	145.4	4.5	10.0	4.200	0.131
2L class - A	69.2	79.6	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.

<i>Maximum Reaction due Live Load including Impact</i>	78.83	MT	=	788.27	KN
<i>Maximum Longitudinal moment due to Live Load including Impact and Breaking Force</i>	12.21	T-M	=	122.13	KNM
<i>Maximum Transverse moment due to Live Load including Impact and Breaking Force</i>	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	<i>Preliminary dimensions</i>	: Assumed as in Fig. TYPABUT-01	
	<i>Superstructure</i>	: RCC Slab Bridge Total Width of Slab =	8.40 M
		overall length = 8.80 m	
	<i>Type of abutment</i>	: Reinforced concrete	
	<i>Loading</i>	: As for National Highway	
	<i>Back fill</i>	: Gravel with angle of repose $\phi =$	35 °
		Unit weight of back fill, w =	18 kN/m ³
		Angle of internal friction of soil on wall, z =	17.5 °
	<i>Approach slab</i>	: R.C. slab 300 mm thick, adequately reinforced	
	<i>Load from superstructure per running foot of abutment wall:</i>		
	<i>Dead load</i>	=	239.50 kN/m
	<i>Live load</i>	=	93.84 kN/m
	<i>(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).</i>		
	<i>Bearing : Tar Paper Bearings</i>		

(C) Self weight of abutment

Treating the section as composed of 6 elements as shown in Fig. 1 the 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

<i>Force due to 70 R wheeled vehicle =</i>	0.2 x	1000 =	200 kN
<i>This force acts at 1.2 m above the road level(Clause 214.3).</i>			
<i>Force on one abutment wall =</i>	200 /	2 =	100 kN
<i>Horizontal force per m of wall =</i>	100 /	8.40 =	11.91 kN/m

(ii) Force due to temperature variation and shrinkage

<i>Assuming moderate climate, variation in temperature is taken as +</i>	17 °C as per		
<i>Clause 218.5 of Bridge Code.</i>			
<i>Coefficient of Thermal expansion =</i>	1.17E-05 /°C		
<i>Strain due to temperature variation =</i>	17 x	1.17E-05 =	1.99E-04
<i>From Clause 220.3, strain due to concrete shrinkage =</i>			
	2.00E-04		
<i>Total strain due to temperature and shrinkage =</i>	1.99E-04 +	2.00E-04 =	3.99E-04

Horizontal deformation of deck due to temperature and shrinkage affecting one abutment =

$$\begin{aligned} \text{Modulus of Elasticity } E_c &= 5000 \times f_{ck}^{1/2} = 3.99E-04 \times 8800 / 2 = 1.76E+00 \text{ mm} \\ \text{Horizontal Stress due to strain in longitudinal direction at bearing level} &= 3.99E-04 \times 31220.19 = 12.45 \text{ N/mm}^2 \\ \text{Horizontal Force due to strain in longitudinal direction at bearing level (For 1 m width of Slab)} &= 1.25E+01 \times 750 = 9340.30 \text{ N/m} \\ &= 9.34 \text{ kN/m} \end{aligned}$$

(iii) Vertical reaction due to braking

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

(d) Earth pressure

Active earth pressure $P = 0.5 w h^2 K_a$

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 the 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

$$\begin{aligned} \Theta &= 90^\circ & \Phi &= 35^\circ \\ z &= 17.5^\circ & \delta &= 0^\circ \\ \text{Substituting values in Equation (3.5), we get } K_a &= 0.496 \text{ Coefficient} \\ \text{Height of backfill below approach slab} &= 6.96 \text{ m} \\ \text{Active earth pressure} &= 0.5 \times 18 \times 6.96^2 \times 0.496 = 216.25 \text{ kN/m} \\ \text{Height above base of centre of pressure} &= 0.42 \times 6.96 = 2.93 \text{ m} \end{aligned}$$

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 = $1.2 \times 18 \times 0.496 \times 9.20 =$ 74.57 kN/m

Horizontal force due to approach slab = $0.3 \times 24 \times 0.496 \times 9.20 =$ 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

= $(1.2 \times 18 + 0.3 \times 24) \times 4.5 =$ 129.6 kN/m

(f) Weight of earth on heel slab

Vertical load = $18 \times 4.5 \times (6.9600000000) =$ 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 = $1368.582/(8.05 \times 1)(1 + (6 \times 0.69/8.05))$ = 257.45 kN/m²

Minimum Stress = $1368.582/(8.05 \times 1)(1 - (6 \times 0.69/8.05))$ = 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	M _v	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.

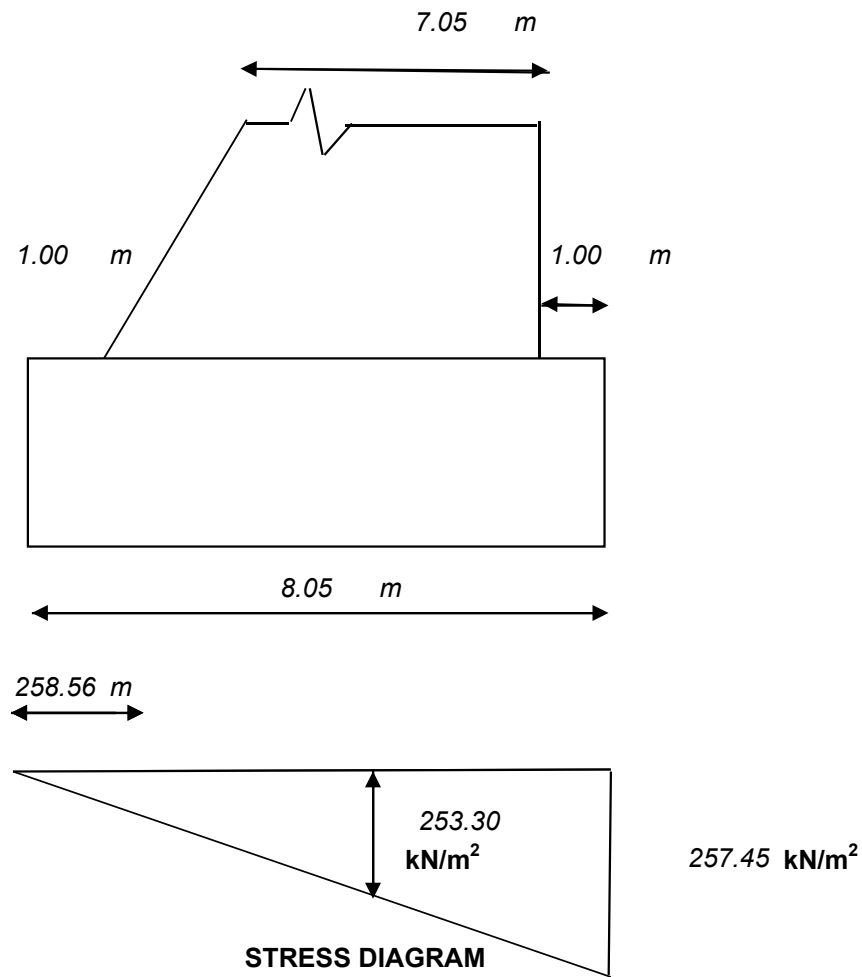
DESIGN OF ABUTMENT FOOTING

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 = $y \times l_b$			0.00 m ²	0.00 %	
Maximum Pressure before Redistribution			257.45 kN/m ²		
Maximum Pressure After Redistribution = $p \times K$			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 σ_{cbc}			10 N/mm²		
m			9.33		
σ_{st}			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 A_{st}			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	
$V=V' + M/d \tan B$	(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			
Permissible 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 $s = A_{sw} t_s d/V$		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 =

D.L. of Wearing coat =

0.975 x	15 x.	2.4 =	35.10 T
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

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 σ_{cbc}

10 N/mm²

m

9.33

σ_{st}

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 mm²

Area Of One Bar

491 mm²

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 Stee

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 =
 Total D.L. + L.L. on half of Abutment across
 bridge per M width

$$18.63 + \frac{64.69}{12.21} \times 5.3 = \frac{12.21}{30.84} \text{ T/M width}$$

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 =

$$30.84 \times 0 = 0.00 \text{ T - M/M width}$$

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 =

$$250 \times 1.2 = 300 \text{ mm}^2$$

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

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

Area of Steel Provided at top

$$= (14 \times 491) = 6874 \text{ mm}^2 > 300 \text{ mm}^2 \text{ OK}$$

Area of Steel Provided at bottom

$$= (14 \times 201) = 2814 \text{ mm}^2 > 300 \text{ mm}^2 \text{ OK}$$

CHECK FOR SHEAR ALONG BRIDGE DIRECTION

V =

$$30.84 \text{ T}$$

Shear Force

$$308.40 \text{ kN}$$

$V = V' + M/d \tan \theta$

(B=0) Hence $V = V'$

Actual Shear Stress

$$0.27 \text{ N/mm}^2$$

Percentage Steel

$$100A_s/bd$$

$$0.25$$

T_c

$$0.23 \text{ N/mm}^2$$

$k=1$

Permissible Shear Stress = $k T_c$

$$0.23 \text{ N/mm}^2$$

< Actual Shear Stress hence Shear Reinforcement should be provided

$$16 \text{ mm}$$

Dia Of two Legged Stirrups

Area Of One Bar In Distribution Reinforcement

$$201 \text{ mm}^2$$

Using The Bars Spacing Required $s = A_{sw} t_s d/V$

$$296 \text{ mm}$$

Provide Bars Of Dia And Spacing

$$16 \text{ mm}$$

$$100 \text{ mm}$$

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 =

$$20.3 \text{ T}$$

Shear Force

$$203.00 \text{ kN}$$

$V = V' + M/d \tan \theta$

(B=0) Hence $V = V'$

Actual Shear Stress

$$0.18 \text{ N/mm}^2$$

Percentage Steel

$$100A_s/bd$$

$$0.25$$

T_c

$$0.23 \text{ N/mm}^2$$

$k=1$

Permissible Shear Stress = $k T_c$

$$0.23 \text{ N/mm}^2$$

> 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 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

$$\begin{aligned}
 \text{B.M.} &= 12.80 \text{ KN-M} \\
 \text{deff reqd.} &= \frac{12.80}{1000} \times \frac{10^6}{0.972} = 118.7 \text{ mm} \\
 \text{dpro} &= 300 - 50 = 250 \text{ mm} \\
 \text{Ast} &= \frac{12.80}{200} \times \frac{10^6}{0.917} = 284.87 \text{ mm}^2 \\
 \text{This steel is to be provided on back i.e. approach slab side} &
 \end{aligned}$$

118.7 mm (OK)

Provide Vertical steel as follows

$$\begin{aligned}
 \text{On River side 10mm bars @ 150 mm c/c} &= 524 \text{ mm}^2 \\
 \text{On Approach Slab side 10mm bars @ 150 Mm c/c} &= 524 \text{ mm}^2 \\
 \text{Minimum steel required in Horizontal direction} & \\
 = 0.002 \times 1000 \times 250 & \\
 = 500 \text{ mm}^2 & \\
 \text{i.e. 250 mm}^2 \text{ on each face} & \\
 \text{provide 10 @ 250 mm c/c} &= 314 \text{ mm}^2
 \end{aligned}$$

ABSTRACT

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**

$$= 2.90 + (1.2 + 0.305) + 0.83$$

$$= 2.90 + 1.53 + 0.825$$

$$= 5.255 \text{ M}$$

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

- 2) Self wt. of dirt wall

$$= 0.6 \times 0.3 \times 2.4$$

$$= 0.495 \text{ T/M}$$

$$\text{Say } 0.5 \text{ T/M}$$

$$\text{Total direct loads} = 2.66 + 0.5 = 3.16 \text{ T/M} = \mathbf{31.6 \text{ kN}}$$

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

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

$$= \text{B.M. due to Braking force}$$

$$= 0.53 \times (1.2 + [0.83])$$

$$= 1.07 \text{ T-M}$$

Intensity of Earth Pressure **at Deck Level**

$$= 0.224 \times 1.8 \times 1.2$$

$$= 0.483 \text{ T/M}^2$$

Intensity of Earth Pressure at top of Abutment $C_e =$

$$= 0.224 \times 1.8 \times (1.2 + 0.825)$$

$$= 0.816 \text{ T/M}^2$$

B.M. due to Earth Pressure & Live Load

Surcharge/M width

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

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

$$= 0.048 + 0.164$$

$$= 0.21 \text{ T-M}$$

Total BM at top of DIRT WALL

$$= 1.07 + 0.21$$

$$= 1.28 \text{ T-M} = 12.8 \text{ kN-m}$$

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

$$= 1.05 \text{ Kg./Cm}^2$$

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

$$= 0.09 \text{ Kg./Cm}^2$$

For M 30 Grade,

Permissible Bending Stress = 67 Kg./Cm²

Permissible Direct Compressive
Stress = 50 Kg./Cm²

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

$$= 0.021 + 0.001 \leq$$

$$= 0.022 \leq \text{HENCE OK.}$$

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 defective =	925 -	25 -	25 /2 =	887.5 mm
Effective Span	Effective	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) Dispersion width along the span

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

$$= 3.6 + 2(0.075 + 0.925) = 5.60 \text{ m}$$

(b) Dispersion width across the span

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

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 ,

$$be = 7.50 \text{ m}$$

$$Le = 10.00 \text{ m}$$

$$be/Le = 0.75$$

$$\text{Value of } K = 2.4$$

$$Bw = 0.85 + (2 \times 0.075) = 1.00 \text{ m}$$

$$x = Le/2 = 10.00 /2 = 5.00 \text{ m}$$

$$be = 2.20 \text{ m}$$

Impact factor is 13.75% as per 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 clearance of 1.2 m from Kerb

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

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

$$= 2.05 + 1.93 + \text{Least of } 3.825 \text{ Or } 5.6/2$$

$$5.75$$

$$= 2.05 + 1.93 + 2.8 = 6.78 \text{ M}$$

Impact factor = 1.1375

Total load with impact = 70×1.1375

$$= 79.63 \text{ T}$$

Intensity of Load = $79.63 / (2.20 \times 6.78) =$

$$= 5.34 \text{ T}$$

DISPERSION ALONG SPAN (CLASS AA TRACKED VEHICLE)

Maximum Bending Moment due to Live load , at centre

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

$$= 132.77 \text{ T - M}$$

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 :-

$$tp = tc = 2 (tw + ts)$$

$$tp = \text{width of dispersion parallel to span}$$

$$tc = \text{width of tyre contact area parallel to span}$$

$$ts = \text{Overall depth of slab}$$

$$tw = \text{Thickness of Wearing coat}$$

Dispersion along the span

$$= 0.15 + 2 (0.075 + 0.75) = 1.8 \text{ m}$$

Dispersion between two wheel is overlapping hence restricted to 1.2 M

= Dispersion combined for two wheels

$$= \text{C/c distance between two wheels} + \text{Longitudinal dispersion}$$

$$= 1.2 + 1.8$$

$$= 3.0 \text{ m (along the span)}$$

DISPERSION ALONG SPAN (CLASS AA WHEELED VEHICLE)

(B) Dispersion width across the span :-

$$be = k \times (1 - X/L) + w$$

$$Le = 10.0 \text{ M} \text{ \& } L1 = 7.5 \text{ M}$$

$$= \text{Value of } K = 2.4$$

$$X = L/2 = 10/2 = 5.00 \text{ M}$$

$$Bw = 0.30 + 2 (0.075) = 0.45 \text{ M}$$

$$be = 2.4 \times 5 \times (1 - 5.00/10.00) + 0.45 = 6.45 \text{ M (For one Wheel)}$$

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

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

$$= 2.2 + 3.225 + 1.655$$

$$= 7.08 \text{ m}$$

According to clause 211.3 (a) (ii) section-III, IRC 6- 1966

Impact factor = 25%

$$= 1.25$$

= Total load of tracks with impact

$$= 20 \times 1.25$$

$$= 25 \text{ T}$$

$$\begin{aligned} \text{Intensity} &= \frac{\text{Load}}{\text{dispersion along x across the span}} \\ &= \frac{25 \times 2}{3.00 \times 7.08} \end{aligned}$$

$$= 2.35 \text{ T/M}$$

DISPERSION ACROSS THE SPAN (CLASS AA WHEELED HEVHICLE)

Maximum B.M. due to Live load at centre

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

$$= 71.41 \text{ T - M}$$

$$= 2.35 \times \frac{3}{2} \left(\frac{5 - 3}{2} \right)$$

$$=$$

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**

$$\begin{aligned} \text{Total B.M} &= \text{B.M due to Dead load} + \text{BM. Due to Live load} \\ &= 30.00 + 132.77 \\ &= 162.77 \text{ T-M} \end{aligned}$$

(A) GENERAL

1. These notes are applicable for the Standard Drawings for R.C.C. solid slab superstructure with and without footpaths.
2. These drawings are applicable only for right bridges with overall width of 12 m.
3. No raised footpaths shall be provided on the bridges having length less than 30m unless the same are otherwise indicated on the approaches.
4. All dimensions are in millimetres unless otherwise mentioned. Only written dimensions are to be followed. No drawing shall be scaled.

5. Design criteria:

- I. The design is according to the following codes:
 - (a) IRC : 5-1985
 - (b) IRC : 6-1986 (1985 reprint)
 - (c) IRC : 21-1967.
- II. The following loads have been considered in the design:
 - (a) One lane of IRC class 70R or two lanes of IRC class A on carriage way, whichever governs.
 - (b) Footpath load of 5 kN/m for superstructure having footpaths.
 - (c) Wearing coat load of 2 kN/m.
- III. The designs are applicable for 'MODERATE AND SEVERE' conditions of exposure.

(B) MATERIALS SPECIFICATIONS

Concrete

1. Concrete shall be of design mix and shall have minimum 28 days characteristic strength on 150mm cubes for all elements of superstructure as indicated below:

Conditions of exposure	Concrete grade	Characteristic Strength
'MODERATE'	M 25	25 MPa (for 3m to 9m span)
'MODERATE'	M 30	30 MPa (for 10m span)
'SEVERE'	M 30	30 MPa (for 3m to 10m span)

2. High strength ordinary portland cement conforming to IS 8112 or ordinary portland cement conforming to IS 268 capable of achieving the required design concrete strength shall only be used.
3. The minimum cement content and maximum water cement ratio in the concrete design mix shall be 310 kg/cu.m and 0.45 respectively for MODERATE conditions of exposure. The minimum cement content and maximum water cement ratio in the concrete design mix shall be 400 kg/cu.m and 0.40 respectively for SEVERE conditions of exposure.

Reinforcement

All reinforcing bars shall be High Yield Strength Deformed bars Grade designation S 415) conforming to IS 1786.

Water

Water to be used in concreting and curing shall conform to Clause 302.4 of IRC 21-1987.

C) WORKMANSHIP/DETAILING

1. Minimum clear cover to any reinforcement including stirrups shall be 50mm unless shown otherwise in the drawings.
2. For ensuring proper cover of concrete to reinforcement bars specially made polymer cover blocks shall only be used.
3. **Construction Joints**
 - i. The location and provision of construction joints shall be approved by Engineer-in-charge. The concreting operation shall be carried out continuously upto the construction joint.

- ii. The concrete surface at the joint shall be brushed with a stiff brush after casting while the concrete is still fresh and it has only slightly hardened.
- iii. Before new concrete is poured the surface of old concrete shall be prepared as under:
 - a) For hardened concrete, the surface shall be thoroughly cleaned to remove debris/fallout and made rough so that 1/4 of the size of the aggregate or structurally damaging the concrete.
 - b) For partially hardened concrete, the surface shall be treated by wire brush followed by an air jet.
 - c) The old surface shall be soaked with water without leaving puddles immediately before starting concreting to prevent the absorption of water from new concrete.
- iv. New concrete shall be thoroughly compacted in the region of the joint.
- v. Welding of reinforcement bars shall not be permitted.
- vi. Laps in reinforcement:
 1. Minimum lap length of reinforcement shall be kept as 83 d where 'd' is the diameter of bar.
- vii. Not more than 50% of reinforcement shall be lapped at any one location.
- viii. Bending of reinforcement bars shall be as per IS : 2502.
- ix. Supporting chairs of 12mm diameter shall be provided at suitable intervals as per IS : 2502.
- x. Concrete shall be produced in a mechanical mixer of capacity not less than 200 litres having integral weigh-batching facility and automatic water measuring and dispensing device.
- xi. Proper compaction of concrete shall be ensured by use of full width spread vibrators for concrete in deck slab.
- xii. Property brood steel plates shall be used as shuttering.
- xiii. Sharp edges of concrete shall be chamfered.

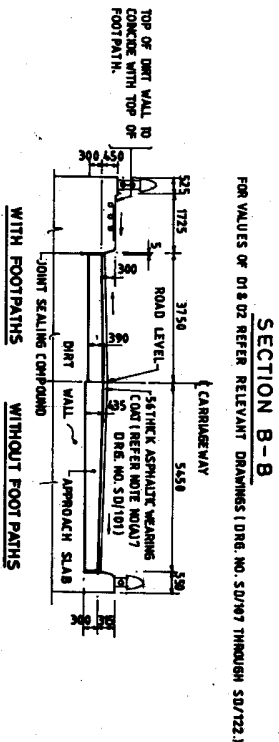
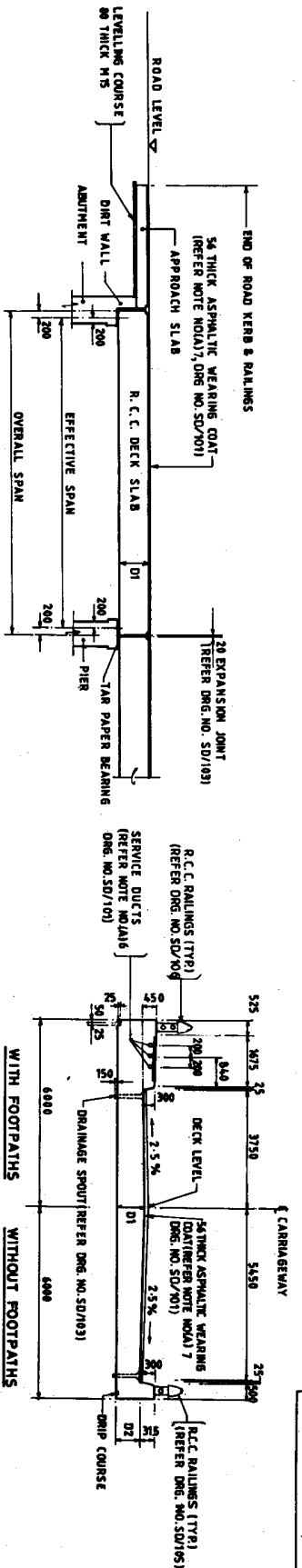
(D) GENERAL SPECIFICATIONS

The work shall be executed in accordance with MOST's Specification for Road and Bridge Works (Second Revision, 1988) except wherever otherwise mentioned.

(E) REFERENCE TO DRAWINGS

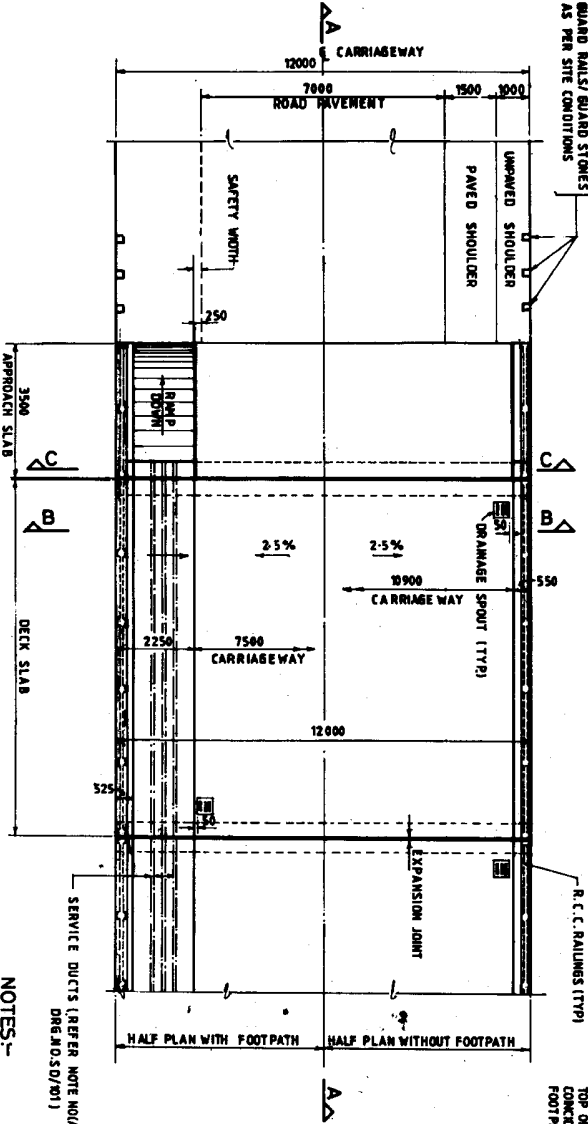
Drawing No.	Title.
SD/101	GENERAL NOTES
SD/102	GENERAL ARRANGEMENT
SD/103 & SD/104	MISCELLANEOUS DETAILS
SD/105	DETAILS OF R.C.C. RAILINGS (WITHOUT FOOTPATHS)
SD/106	DETAILS OF R.C.C. RAILINGS (WITH FOOTPATHS)
SD/107 THROUGH SD/114	R.C.C. SOLID SLAB SUPERSTRUCTURE (RIGHT) SPANS 3m To 10m (WITHOUT FOOTPATHS)
SD/115 THROUGH SD/122	R.C.C. SOLID SLAB SUPERSTRUCTURE (RIGHT) SPANS 3m To 10m (WITH FOOTPATHS)

MKD	DATE	DESCRIPTION	BY		
R E V I S I O N					
GOVERNMENT OF INDIA MINISTRY OF SURFACE TRANSPORT (ROADS WING), NEW DELHI					
STANDARD DRAWINGS FOR ROAD BRIDGES					
R.C.C. SOLID SLAB					
SUPERSTRUCTURE (RIGHT) SPAN 3.0m To 10.0 m (WITH AND WITHOUT FOOTPATHS)					
GENERAL NOTES					
RECOMMENDED BY			APPROVED BY	1980	
V.	S.K. JAISTHA (S.K. JAYAKUMAR) E.E.	[Signature]	P.V. Rajan (M.K. MUKHERJEE) C.E.	DWG. NO. SD/101	



SECTION C-C

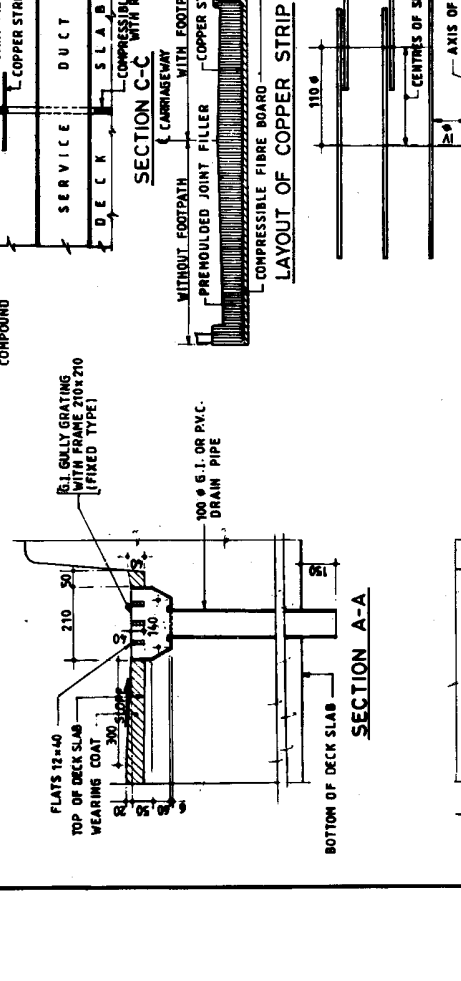
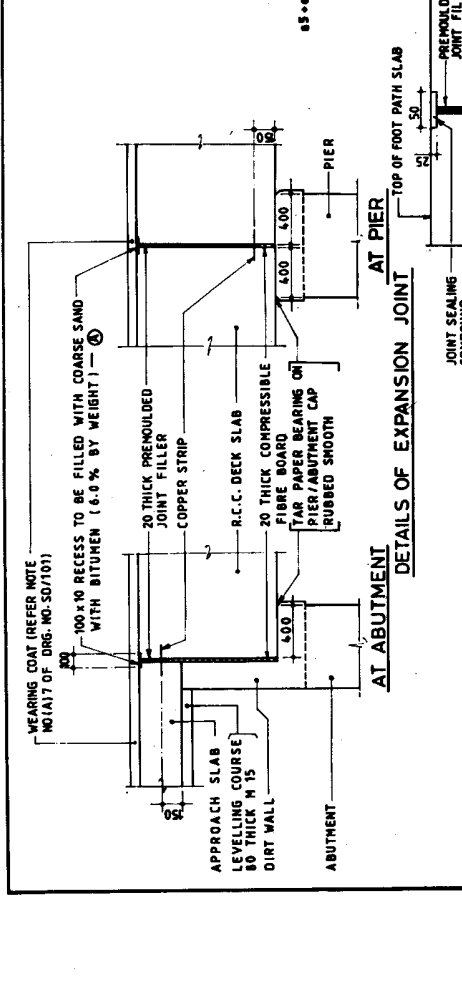
REFERENCE	TITLE
SD/101	GENERAL NOTES
SD/102 & SD/104	MISCELLANEOUS DETAILS
SD/105	DETAILS OF R.C.C. RAILINGS
SD/106	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/107	R.C.C. SOLID SLAB
SD/108	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/109	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/110	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/111	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/112	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/113	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/114	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/115	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/116	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/117	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/118	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/119	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/120	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/121	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS
SD/122	DETAILS OF R.C.C. RAILINGS WITH FOOTPATHS

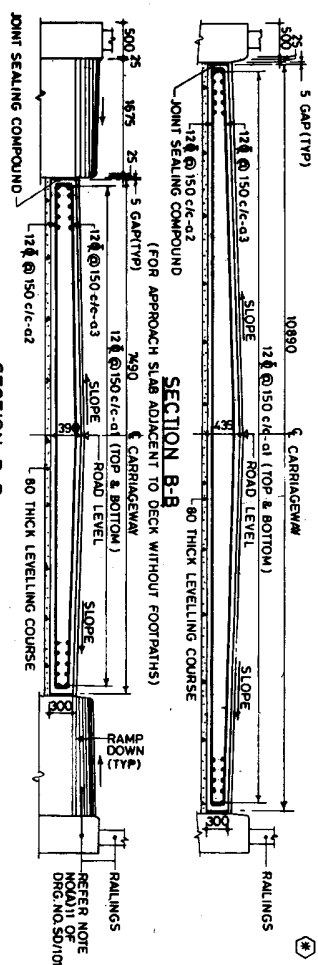


NOTES:-

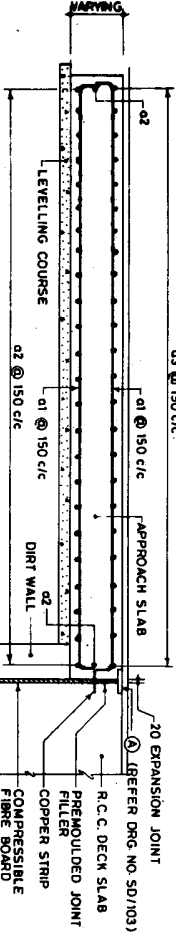
1. All dimensions are in millimetres unless otherwise mentioned.
2. Only written dimensions are to be followed.
3. Typical arrangement of drainage spouts has been shown in plan. Suitable modifications may be made by the Engineer-in-charge as per site conditions and intensity of rainfall.

REV	DATE	DESCRIPTION	BY
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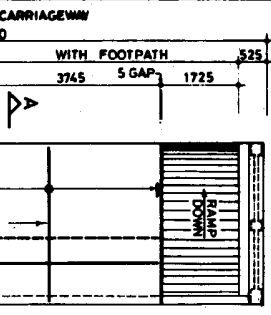


SECTION B-B
(FOR APPROACH SLAB ADJACENT TO DECK WITHOUT FOOTPATHS)



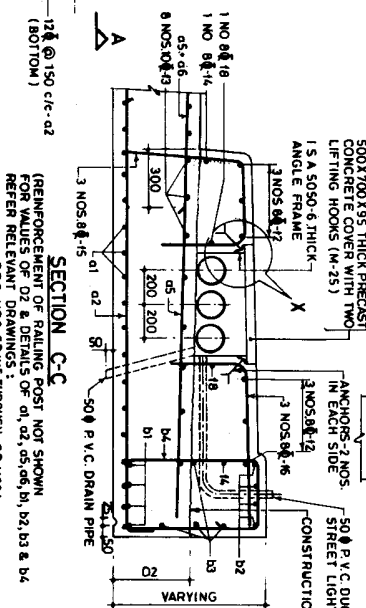
SECTION B-B
(FOR APPROACH SLAB ADJACENT TO DECK WITH FOOTPATHS)

PB



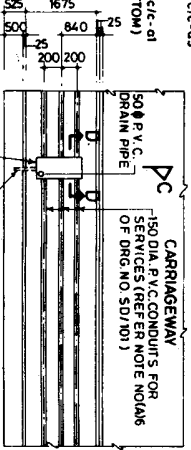
PLAN

(SHOWING REINFORCEMENT DETAILS OF APPROACH SLAB)
(ABUTMENT, DIRTWALL & LEVELLING COURSE NOT SHOWN)



SECTION A-A

(REINFORCEMENT OF RAILING POST NOT SHOWN)
(REFER RELEVANT DRAWINGS OF a1, a2, a3, a4, b1, b2, b3 & b4)
- DRG. NOS. SD/105 THROUGH SD/122



SECTION C-C

(SHOWING DETAILS OF INSPECTION CHAMBER IN FOOTPATH)
(LOCATION AND SPACING ALONG THE FOOTPATHS TO BE DECIDED BY ENGINEER-IN-CHARGE AS PER SITE CONDITIONS AND IN CONSULTATION WITH THE CONCERNED AUTHORITIES)

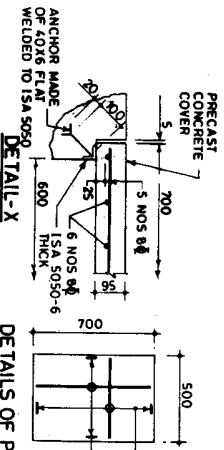
SLNO	LOCATION	BAR MKD	SHAPE	DIA. (mm)	SPACING LENGTH (mm)	NOS.	TOTAL LENGTH (m)	WEIGHT (kg)
APPROACH SLAB ADJACENT TO DECK WITHOUT FOOTPATHS								
1	SLAB TOP & BOTTOM ALONG-X	a1		12	150	3730	146	544.98
2	SLAB TOP & BOTTOM ALONG-Y	a2		12	150	11020	26	286.52
3	SLAB TOP & BOTTOM ALONG-Y	a3		12	150	11020	24	264.48
APPROACH SLAB ADJACENT TO DECK WITH FOOTPATHS								
4	SLAB TOP & BOTTOM ALONG-X	a1		12	150	3730	100	373.00
5	SLAB TOP & BOTTOM ALONG-Y	a2		12	150	7620	26	198.12
6	SLAB TOP & BOTTOM ALONG-Y	a3		12	150	7620	24	182.88
								162

QUANTITIES

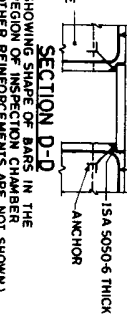
CONCRETE IN APPROACH SLAB (cu. m)	WITH FOOTPATHS	WITHOUT FOOTPATHS
9.04	14.01	7.02
STEEL INCLUDING 5% EXTRA FOR LAPS AND WASTE (kg)	1022	26.22
ASPHALTIC WEARING COAT (sq. m)	38.12	

REFERENCE DRAWINGS

DRAWING NO.	TITLE
SD/101	GENERAL NOTES
SD/102	GENERAL ARRANGEMENT
SD/103	MISCELLANEOUS DETAILS
SD/105	DETAILS OF R.C.C. RAILINGS (WITHOUT FOOTPATHS)
SD/106	DETAILS OF R.C.C. RAILINGS (WITH FOOTPATHS)
SD/107	R.C.C. SOLID SLAB SUPERSTRUCTURE (RIGHT) SPANS 30m TO 100.0m (WITHOUT FOOTPATHS)
SD/108	R.C.C. SOLID SLAB SUPERSTRUCTURE (RIGHT) SPANS 30m TO 100.0m (WITH FOOTPATHS)
SD/112	



DETAILS OF PRECAST CONCRETE COVER FOR INSPECTION CHAMBER



SECTION D-D

(SHOWING SHAPE OF BARS IN THE REGION OF INSPECTION CHAMBER)
(OTHER REINFORCEMENTS ARE NOT SHOWN)

NOTES:-

- All dimensions are in millimeters unless otherwise mentioned. Only written dimensions are to be followed.
- The reinforcement of railing posts shall be incorporated before casting of deck slab. The railings shall conform to drawing no. SD/105/SD/106 or any other approved type.
- Dimensions in schedule of reinforcement are given as per I.S. 2502.
- Schedule of reinforcement does not include change in reinforcement around inspection chamber, precast cover to chamber and railings.

REV	DATE	DESCRIPTION	BY
REVISION			
GOVERNMENT OF INDIA			
MINISTRY OF SURFACE TRANSPORT			
(ROADS WING), NEW DELHI			
STANDARD DRAWINGS FOR ROAD BRIDGES			
R.C.C. SOLID SLAB			
SUPERSTRUCTURE (RIGHT) SPAN 30m TO 100m			
(WITH AND WITHOUT FOOTPATHS)			
MISCELLANEOUS DETAILS			
RECOMMENDED BY	APPROVED BY	DRG. NO.	
(U. JAYAKODI)	(S. K. MATHIA)	SD/104	
E.E.	S.E.		

SCHEDULE OF REINFORCEMENT (PER SPAN)

SLAB LOCATION	BAR MKO	SHAPE	DIA (mm)	SPACING (mm)	LENGTH (mm)	NOS	TOTAL LENGTH (mm)	WEIGHT (kg)
1 SLAB-BOTTOM ALONG-X	a1		20	100	8900	120	1077.60	26.62
2 SLAB-BOTTOM ALONG-Y	a2		12	160	12430	61	758.23	6.73
3 SLAB-SIDE ALONG-Y	a3		10	—	11900	2	23.80	1.5
4 SLAB-TOP ALONG-X	a4		10	160	9040	79	716.36	4.41
5 SLAB-TOP ALONG-Y	a5		10	160	11600	61	707.60	4.37
6 KERB-BOTTOM	b1		12	—	9210	8	73.68	6.5
7 KERB-TOP	b2		12	—	9230	8	73.46	6.6
8 KERB-SIDE	b3		10	—	8850	8	70.80	4.4
9 KERB-STIRRUPS	b4		10	200	2580	62	159.96	9.9

● DOES NOT INCLUDE THE ADDITIONAL STIRRUPS AT LAPS OF LONGITUDINAL BARS - REFER DRG. NO. SD/103

Dead load of the superstructure per span including R.C.C. railings @ 3kN/m and wearing coat @ 2kN/sq.m = 1933 kN

REFERENCE DRAWINGS

DRAWING NO.

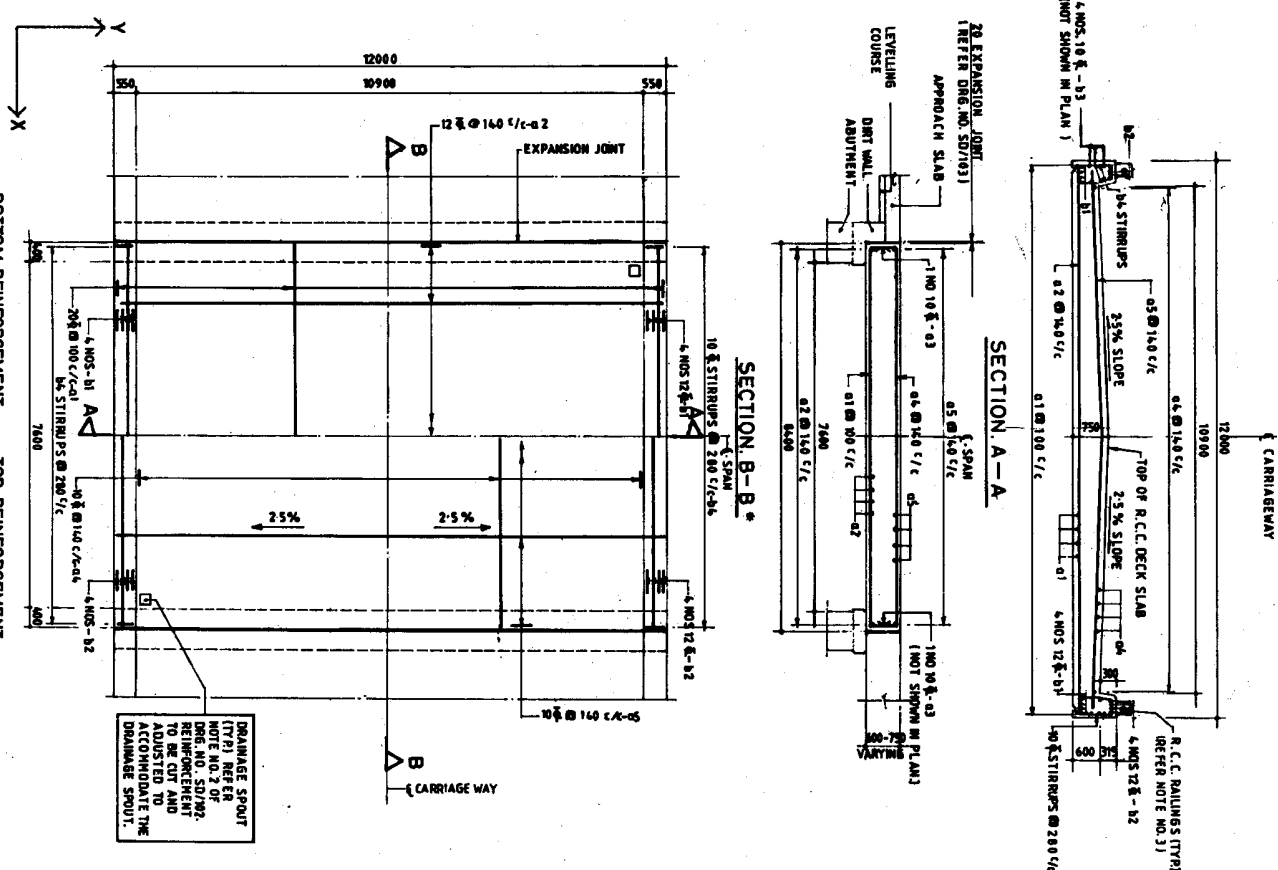
SD/101 GENERAL NOTES
SD/102 GENERAL ARRANGEMENT
SD/103 & SD/104 MISCELLANEOUS DETAILS
SD/105 DETAILS OF R.C.C. RAILINGS (WITHOUT FOOTPATHS)

QUANTITIES (PER SPAN)

EFFECTIVE SPAN (m)	QTY
CONCRETE (cu.m)	70.81
STEEL (TONNES) 5% EXTRA FOR WASTE AND WASTAGE (15%)	47.27
ASPHALTIC WEARING COAT (sq.m)	91.56

NOTES:-

- All dimensions are in millimetres unless otherwise mentioned.
- Special attention is invited to the use of drawing no SD/101 regarding the design mix to be adopted.
- The reinforcement of railing posts and be incorporated before casting of the deck slab.
- The railings shall conform to drawing no SD/105 or any other approved type.
- Dimensions in schedule of reinforcement are given as per IS:4502.
- Reinforcement of adjacent span superstructure, approach slab not shown.



PLAN SHOWING REINFORCEMENT DETAILS OF DECK SLAB *

REVISION			
NO.	DATE	DESCRIPTION	BY

GOVERNMENT OF INDIA
MINISTRY OF SURFACE TRANSPORT
(ROADS WING), NEW DELHI
STANDARD DRAWINGS FOR ROAD BRIDGES
R.C.C. SOLID SLAB
SUPERSTRUCTURE (RIGHT) SPAN 8.0m
(WITHOUT FOOTPATHS)

RECOMMENDED BY	APPROVED BY	DRG NO.
W. JAYARAM	P. L. JAYARAM	SD /112
E.E.	S.E.	C.E.