

DESIGN OF CONCRETE BRIDGE ("T" Beam Type)

1. DESIGN DATA

1.	Construction type	=	Reinforcement Concrete "T Beam"
2.	Bridge length	=	5 x 20.80 m
3.	Beam length	=	5 x 20.70 m
4.	Span bridge	=	5 x 20.00 m
5.	Width of bridge	=	4.60 m
6.	Class of bridge	=	I
7.	Width of side walk	=	2 x 0.50 m
8.	Thick of asphalt pavement	=	0.06 m
9.	Thick of concrete slab	=	0.25 m
10.	Material strength and allowable stress	=	
	a. Super structure		
	- Concrete compressive strength σ'_{bk}	=	225.00 kg/cm ² (K 225)
	- Allowable bending stress $\sigma'b$	=	65.00 kg/cm ²
	- Reinforcing bar allowable stress σ_a	=	1400.00 kg/cm ² (U 24)
	a. Sub structure		
	- Concrete compressive strength σ'_{bk}	=	225.00 kg/cm ² (K 225)
	- Allowable bending stress $\sigma'b$	=	65.00 kg/cm ²
	- Reinforcing bar allowable stress σ_a	=	1400.00 kg/cm ² (U 24)

2. CALCULATION OF CARRIAGE FLOOR

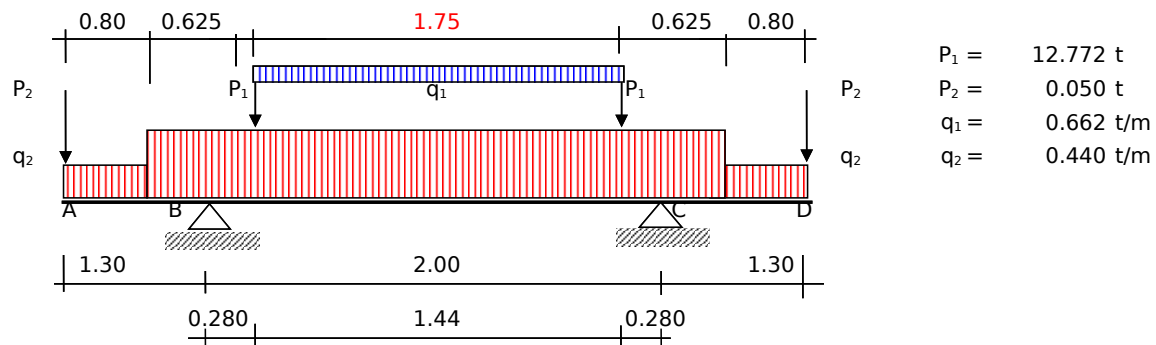
2.1 LIVE LOAD

a. Impact coefficient (K)					
$K = 1 + (20/(50+L))$	=			1.286	
where : L = length of span	=			2.00 m	
b. Effective width of slab (Le)					
$Le = 0.72 L' + g$	=			1.21 m	
where : L' = span of load between support	=			1.40 m	
g = width of wheel	=			0.20 m	
c. Moveable load (with impact)					
$P1 = P/Le * K$	=			12.77 ton	
where : P = moveable load	=			12.00 ton	

2.2 DEAD LOAD

- Slab floor	=	0.20	1.00	2.40	=	0.480 t/m
- Pavement	=	0.06	1.00	2.20	=	0.132 t/m
- Water	=	0.05	1.00	1.00	=	0.050 t/m
					q1 =	0.662 t/m
- Hand rail (P2) =					=	0.050 t
- Side walk load (q2) =		0.20	1.00	2.20	=	0.440 t/m

2.3 STRUCTURAL ANALYSIS ON LOADING

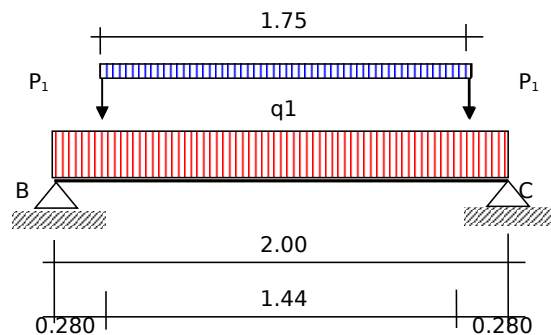


3. CALCULATION OF MOMENT

3.1 PRIMARY MOMENT

$$\begin{aligned}
 M_{BA} &= -P_2(L_1+L_2) - q_2 L_1 (1/2 L_1 + L_2) - 1/2 q_1 L_2^2 &= & -0.465 \text{ t m} \\
 L_1 &= 0.80 \text{ m} \\
 L_2 &= 0.50 \text{ m} \\
 M_{BC} &= -(1/12 q_1 L^2) - (P_1 * L_3 * L_4^2)/l^2 - (P_1 * L_4 * L_3^2)/L^2 &= & -3.296 \text{ t m} \\
 L_3 &= 0.28 \\
 L_4 &= 1.72 \\
 M_{CB} &= M_{BC} &= & -3.296 \text{ t m} \\
 M_{CD} &= M_{BA} &= & -0.465 \text{ t m} \\
 \text{End Moment} &= (M_{BA} + M_{BC})/2 &= & -1.880 \text{ t m}
 \end{aligned}$$

3.2 MOMENT OF SPAN B - C



$$\begin{aligned}
 P_1 &= 12.772 \text{ t} \\
 P_2 &= 0.050 \text{ t} \\
 q_1 &= 0.662 \text{ t/m} \\
 q_2 &= 0.440 \text{ t/m}
 \end{aligned}$$

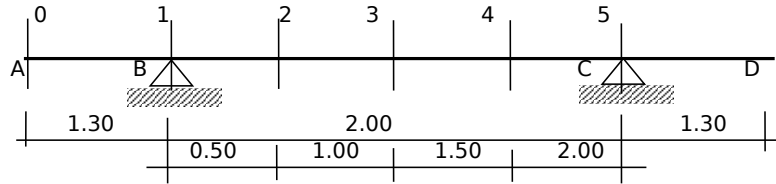
$$\begin{aligned}
 R_B &= 1/2 q L + 2P_1 / 2 &= & 13.434 \text{ ton} \\
 R_C &= &= & 13.434 \text{ ton} \\
 0 &< x <= 0.280 \\
 M_x &= R_B * x - 1/2 q_1 x^2 \\
 0.280 &< x <= 1.720 \\
 M_x &= R_B * x - 1/2 q x^2 - P (x - 0.13)
 \end{aligned}$$

Moment of span at sections

x	=	0.00	Mx	=	0.000 t m
x	=	0.28	Mx	=	3.736 t m
x	=	0.50	Mx	=	3.824 t m
x	=	1.00	Mx	=	3.907 t m
x	=	1.50	Mx	=	3.824 t m
x	=	1.72	Mx	=	3.736 t m
x	=	2.00	Mx	=	0.000 t m

3.3 TOTALLY MOMENT AT SPAN B - C

Section	x	MBC	Mx	MBC+Mx
	0.00	-1.880	0.000	-1.880
	0.28	-1.880	3.736	1.855
	0.50	-1.880	3.824	1.944
	1.00	-1.880	3.907	2.027
	1.50	-1.880	3.824	1.944
	1.72	-1.880	3.736	1.855
	2.00	-1.880	0.000	-1.880



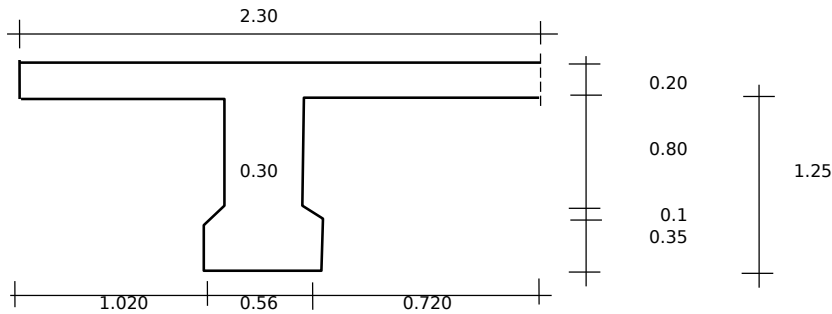
4. CALCULATION OF REINFORCEMENT BAR OF SLAB

Section		0	1	2	3	4	5
M = MD + ME	(t m)	0.000	-1.880	1.944	2.027	1.944	-1.880
M	(kg cm)	0	-188036	194405	202680	194405	-188036
H	(cm)	20	20	20	20	20	20
b	(cm)	100	100	100	100	100	100
d'	(cm)	2	2	2	2	2	2
h = H - d'	(cm)	18	18	18	18	18	18
n		21	21	21	21	21	21
σ_a		1400	1400	1400	1400	1400	1400
Ca = $h/((n.M)/(b.\sigma_a))^{0.5}$	max		3.389	3.333	3.265	3.333	3.389
δ		0.400	0.400	0.400	0.400	0.400	0.400
100n ω (table of n value)		0.000	4.091	2.191	2.632	2.191	4.091
As = $\omega b h$			3.507	1.878	2.256	1.878	3.507
Use steel bar							
D	(mm)		12	12	12	12	12
units	(nos)		5.0	5.0	5.0	5.0	5.0
Distance of bar			20.0	20.0	20.0	20.0	20.0
A	(cm ²)		5.655	5.655	5.655	5.655	5.655
Result			OK !	OK !	OK !	OK !	OK !
As' = $\delta \times As$			1.403	0.751	0.902	0.751	1.403
Use steel bar							
D	(mm)		12	12	12	12	12
units	(nos)		2.5	2.5	2.5	2.5	2.5
Distance of bar			40.0	40.0	40.0	40.0	40.0
A'	(cm ²)		2.827	2.827	2.827	2.827	2.827
Result			OK !	OK !	OK !	OK !	OK !

DESIGN OF CONCRETE BRIDGE ("T" Beam type)

CALCULATION OF MAIN BEAM

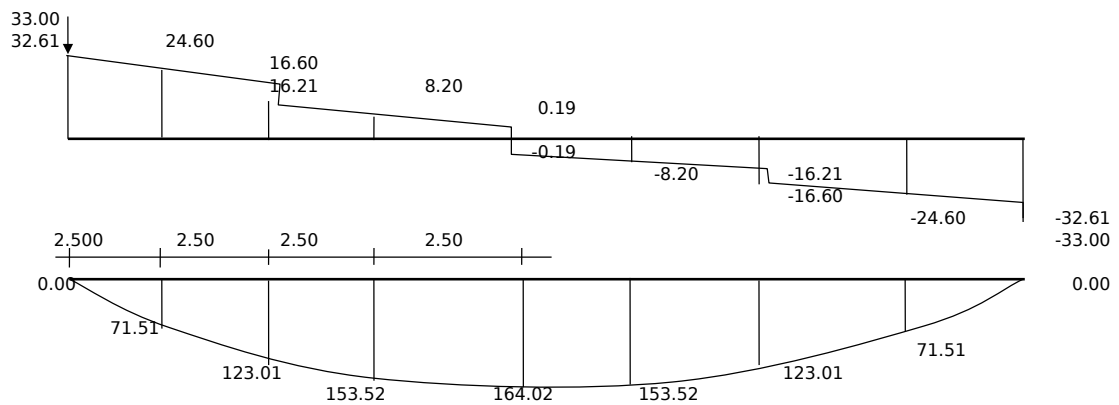
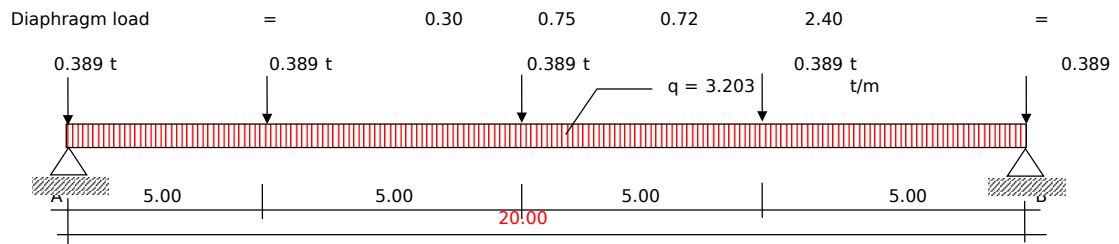
A. MIDLE BEAM



1. LOADING ANALYSIS

1.1. DEAD LOAD :

weight of beam	=	0.56	x	0.35	x	2.40	=
		0.30	x	0.80	x	2.40	=
		0.43	x	0.10	x	2.40	=
slab weight	=	0.20	x	2.30	x	2.40	=
pavement weight	=	0.06	x	1.50	x	2.20	=
side walk	=	0.20	x	0.65	x	2.20	=
hand rail	=						=
water	=	0.05	x	2.30	x	1.00	=
load service	=	1.00	x	0.60	x	0.50	=
						q	=



$$\begin{aligned}
 RA = RB &= q \cdot L \cdot x / 2 + 5P / 2 = 32.998 \text{ ton} \\
 M_x &= RA \cdot x - 1/2 \cdot q \cdot x^2 - P_1 \cdot x - P_2(1/2L \cdot x) \quad ; x = 1/2 L = 10.00 \text{ m} \\
 M_{\max} &= 164.018 \text{ t m} \\
 D_x &= RA - q \cdot X - P \quad ; x = 0 \\
 D_{\max} &= 32.998 \text{ t}
 \end{aligned}$$

1.2. LIVE LOAD

$$\text{Impact Coefficient } K = 1 + 20 / (50 + L) = 1.286$$

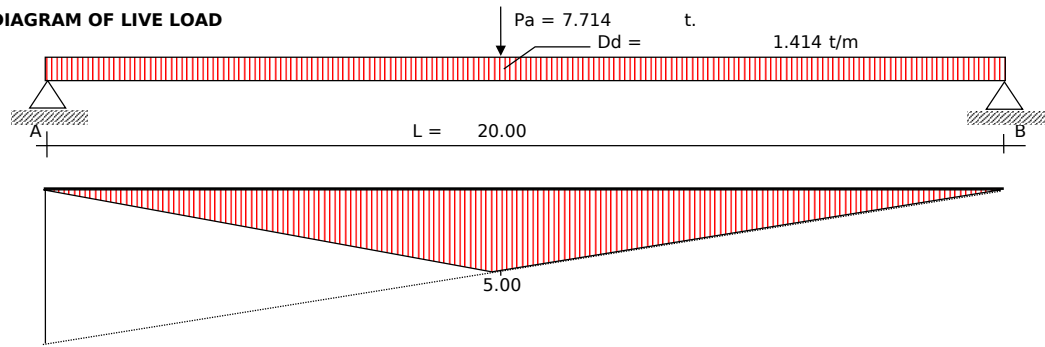
Load "D" for bridge class III :

$$\begin{aligned}
 P &= 12.00 \text{ t} \\
 D &= 2.20 \text{ t/m}
 \end{aligned}$$

Distribution load :

$$\begin{aligned}
 Dd &= 0,5 \times D \times K \\
 &= 1.414 \text{ t/m} \\
 \text{Line load} \\
 Pa &= 0,5 \times P \times K \\
 &= 7.714 \text{ t}
 \end{aligned}$$

DIAGRAM OF LIVE LOAD



$$\begin{aligned}
 ME &= Pa \cdot Y + Pd \cdot F \\
 &= 38.571 + 70.714 \\
 &= 109.286 \text{ t m}
 \end{aligned}$$

1.3.

WIND FORCE

Calculation per meter of bridge

$$ha = 100 \% (hb + hp)$$

where :

$$\begin{aligned}
 hb &= \text{height of beam} = 1.80 \text{ m} \\
 hp &= \text{height of pavement} = 0.06 \text{ m}
 \end{aligned}$$

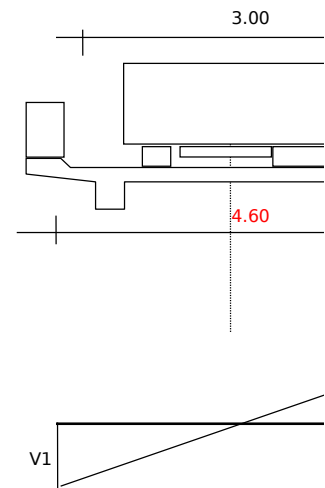
$$\begin{aligned}
 ha &= 1.86 \text{ m} \\
 Ha &= P (ha + 2.00) ; P = 100 \text{ kg} \\
 &= 386 \text{ kg/m}
 \end{aligned}$$

$$\begin{aligned}
 Za &= 1/2 (ha + 2.00) \\
 &= 1.93 \text{ m} \\
 M1 &= Ha \cdot Za \\
 &= 744.98 \text{ kg m} \\
 M2 &= 2 (V1 \cdot 1/2 b + v2 \cdot 1/6 b)
 \end{aligned}$$

where :

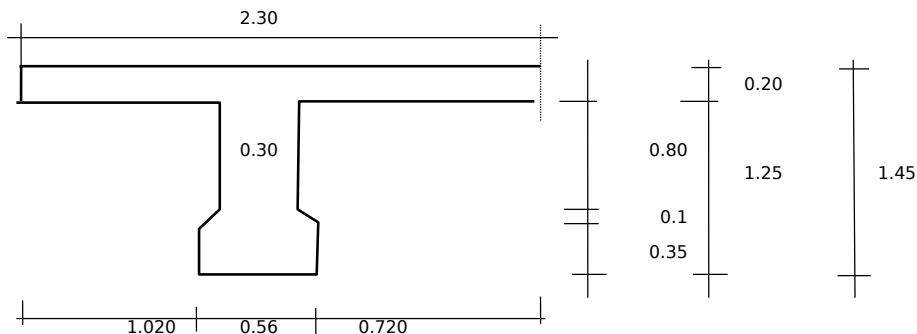
$$\begin{aligned}
 b &= \text{width of wheel floor} = 3.00 \text{ m} \\
 V2 &= 0 \\
 M2 &= 3.00 \cdot V1 \\
 M1 &= M2 \\
 744.98 &= 3.00 \cdot V1 \\
 V1 &= 248.33 \text{ kg/m'} \\
 &= 0.248 \text{ t/m'}
 \end{aligned}$$

$$\begin{aligned}
 RA = RB &= 1/2 \cdot V1 \cdot L \\
 &= 2.483 \text{ t} \\
 Ma &= RA \cdot 1/2 L - 1/8 \cdot V1 \cdot L^2 \\
 &= 12.416 \text{ t m}
 \end{aligned}$$



1.4.

BREAK FORCE



Area = A				A (cm ²)	Y (cm)
Slab area	230	20	=	4600	10
Beam area	30	80	=	2400	60
	43	10	=	430	105
	56	35	=	1960	127.5
				9390	

$$Y = \frac{\Sigma(A.Y)}{\Sigma A} = 51.66 \text{ cm}$$

$$Z_r = \frac{Y + 125}{176.66 \text{ cm}} = 1.767 \text{ m.}$$

$$\begin{aligned} \text{Line load} &= 12.00 \text{ ton} \\ \text{Distribution load} &= 2.20 \text{ ton/m} \end{aligned}$$

$$\begin{aligned} \text{Distribution load :} \\ D_d &= 0.5 \times D \\ &= 1.100 \text{ t/m} \end{aligned}$$

$$\begin{aligned} \text{Line load} \\ P_a &= 0.5 \times P \\ &= 6.000 \text{ t} \end{aligned}$$

$$\begin{aligned} \text{Break force} &= 5 \% (L \times D_d + P_a) \\ &= 1.400 \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{Moment result of break force} \\ M_r &= 1.400 \times 1.767 \\ &= 2.473 \text{ t m} \end{aligned}$$

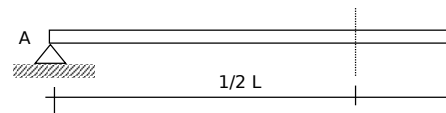
2. MAXIMUM MOMENT

PERMANENT LOADING

$$\begin{aligned} \text{Total moment} &= M_D + M_E \\ &= 164.018 + 109.286 \\ &= 273.304 \text{ t m} \end{aligned}$$

TEMPORARY LOADING

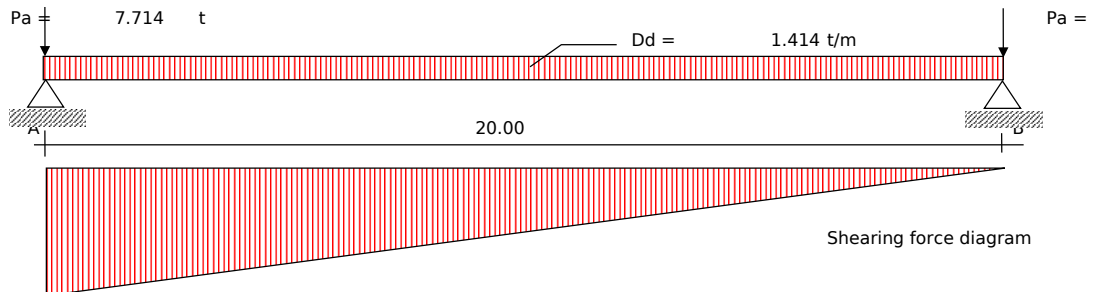
$$\begin{aligned} M_{ps} &= M_d + M_l + M_a + M_r \\ &= 164.018 + 109.286 + 12.416 + 2.473 \\ &= 288.193 \text{ t m} \end{aligned}$$



3. SHEARING FORCE

$$\begin{aligned} \text{Dead Load} \\ R_A = R_B &= 32.998 \text{ ton} \end{aligned}$$

Live Load
a). Load D



$$\begin{aligned} D_A &= P_a.Y + P_d \times F \\ &= 21.857 \text{ ton} \end{aligned}$$

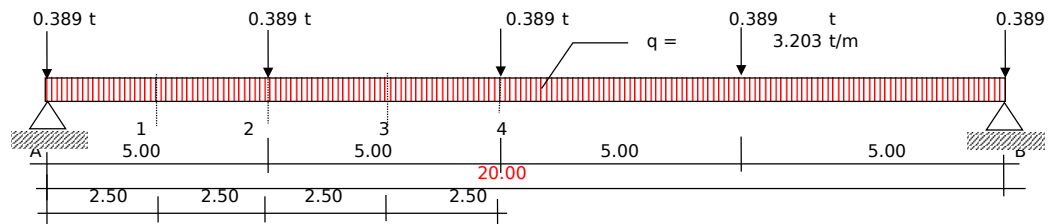
$$\begin{aligned} \text{b). Wind Force} \\ D_A &= \frac{1}{2} (V_1 \times L) \\ &= 2.483 \text{ ton} \end{aligned}$$

RESULT OF SHEARING FORCE (D)

$$\begin{aligned} \text{Permanent load} \\ \text{Total D} &= 32.998 + 21.857 = 54.855 \end{aligned}$$

$$\begin{aligned} \text{Temporary load} \\ \text{Total D} &= 32.998 + 21.857 + 2.483 = 57.338 \end{aligned}$$

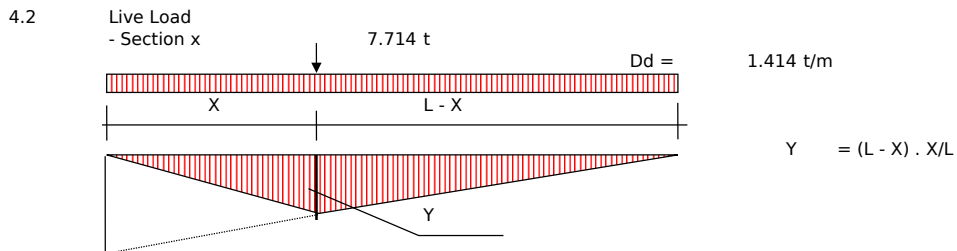
4. CALCULATION MOMENT ON SECTION MAIN BEAM



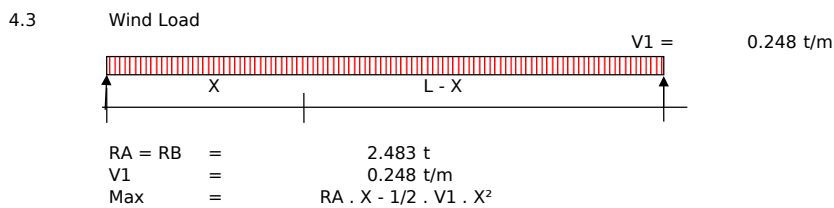
LOADING ANALYSIS

4.1 Dead Load
 $R_a = 32.998 \text{ ton}$
 $M_{dx} = R_a \cdot x - 1/2 q x^2 - P \cdot x_1$

Section	R_a (ton)	x (m)	q (t/m)	$R_a \cdot X$ (t m)	$1/2 q x^2$ (t m)	P (t)	x_1 (m)	x_2 (m)	$P \cdot x_1$ (t m)
1	33.00	2.500	3.203	82.495	10.008	0.389	2.500	0.000	0.972
2	33.00	5.000	3.203	164.990	40.033	0.389	5.000	0.000	1.944
3	33.00	7.500	3.203	247.485	90.073	0.389	7.500	2.500	2.916
4	33.00	10.000	3.203	329.980	160.130	0.389	10.000	5.000	3.888



Section	X (m)	$(L-X)$ (m)	$(L-X)/L$	Y	F	$P_a \cdot Y$ (t m)	$D_d \cdot F$ (t m)	M_{lx} (t m)
1	2.50	17.50	0.875	2.188	21.875	16.875	30.938	47.813
2	5.00	15.00	0.750	3.750	37.500	28.929	53.036	81.964
3	7.50	12.50	0.625	4.688	46.875	36.161	66.295	102.455
4	10.00	10.00	0.500	5.000	50.000	38.571	70.714	109.286



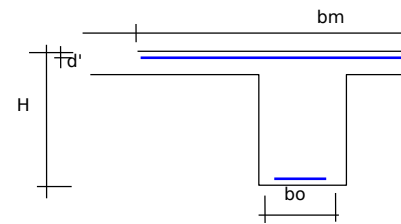
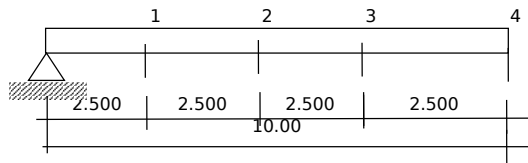
Section	R_a (ton)	X (m)	V_1 (t/m)	$R_A \cdot X$ (t m)	$1/2 V_1 \cdot X^2$ (t m)	Max (t m)
1	2.483	2.50	0.248	6.208	0.776	5.432
2	2.483	5.00	0.248	12.416	3.104	9.312
3	2.483	7.50	0.248	18.625	6.984	11.640
4	2.483	10.00	0.248	24.833	12.416	12.416

4.4 Break Force
 $M_r = 2.473 \text{ t m}$

4.5 RESULT OF MOMENT ON SECTION BEAM

Section	X (m)	M_{dx} (t m)	M_{lx} (t m)	Max (t m)	M_r (t m)	M_{pt} (t m)	M_{tp} (t m)
1	2.500	71.51	47.813	5.432	2.473	119.327	127.233
2	5.000	123.01	81.964	9.312	2.473	204.978	216.763
3	7.500	153.52	102.455	11.640	2.473	255.979	270.093
4	10.000	164.02	109.286	12.416	2.473	273.304	288.193

5. **CALCULATION OF REINFORCEMENT BAR OF MAIN BEAM**



Section	units	1	2	3	4
Mtp	(t m)	127.233	216.763	270.093	288.193
M	(kg cm)	12,723,271	21,676,322	27,009,273	28,819,323
H	(cm)	145	145	145	145
bm	= 6 hot + bo (cm)	176	176	176	176
bo	(cm)	56	56	56	56
ho	(cm)	20	20	20	20
d'	(cm)	5	5	5	5
h = H - d'	(cm)	140	140	140	140
n		21	21	21	21
σa	(kg/cm ²)	1400	1400	1400	1400
Ca	=h/((n.M)/(b.σa))^0.5	4.251	3.257	2.918	2.825
100nω	(table of n value)	6	11.230	12.800	14.000
φ		8.09	2.279	1.740	1.632
φ'		89	3.390	2.396	2.214
ζ		0.963	0.898	0.882	0.876
δ		0.200	0.200	0.200	0.200
As	= ω b h (cm ²)	70.400	131.765	150.187	164.267
Use steel bar					
D	(mm)	32	32	32	32
units	(nos)	10	18	19	20
A	(cm ²)	80.425	144.765	152.807	160.850
Result		OK !	OK !	OK !	not safe !
As' = δ x As	(cm ²)	14.080	26.353	30.037	32.853
Use steel bar					
D	(mm)	32	32	32	32
units	(nos)	2	3	4	4
A'	(cm ²)	16.085	24.127	32.170	32.170
Result		OK !	not safe !	OK !	not safe !
σ'a = M / (A.ζ.h)	(kg/cm ²)	1173.42	1191.02	1431.44	1460.94
Allowable stress of reinforcement bar :					
Gsa	(kg/cm ²)	1400	1400	1400	1400
Result		OK !	OK !	Not safe !	Not safe !
σ'b = M / (b.h ² .n.ω.φ.ζ)		7.890	27.341	39.858	41.741
Allowable stress of concrete :					
Gca	(kg/cm ²)	65	65	65	65
Result		Ok !	Ok !	Ok !	Ok !

SHEARING STRESS

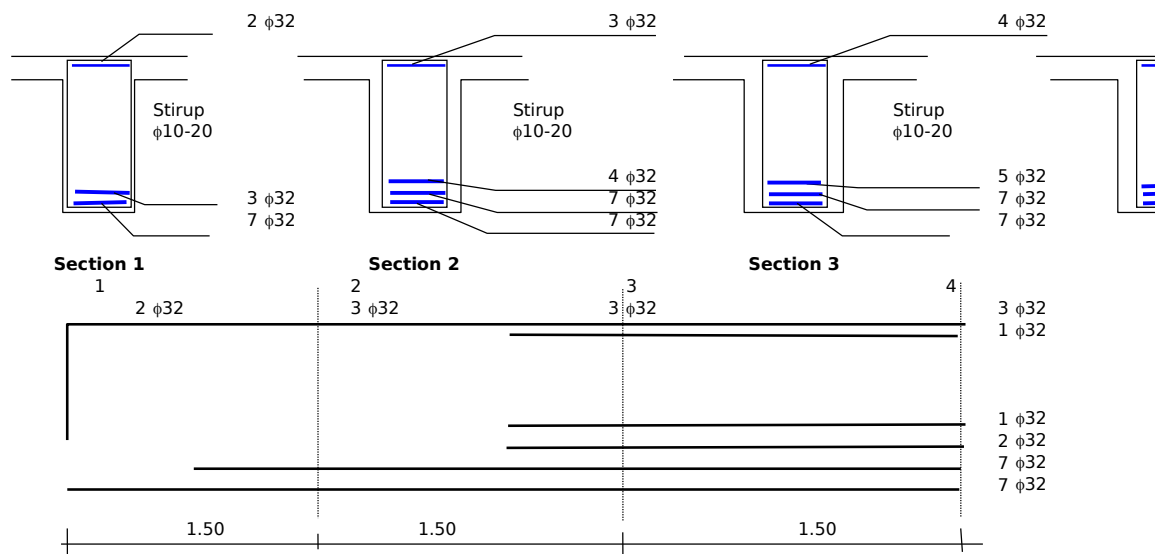
Item	Unit	Value
Shearing force, S at supporting point	kg	57338
Width of beam, bo	cm	56
Flange thickness, t	cm	20
effective depth, d	cm	140
Stress $\tau = S/(bo (d - t/2))$	kg/cm ²	7.876
Allowable shearing stress for concrete τ_a	kg/cm ²	6.5
Vertical stirrups shall be provided The concrete is assumed no to carry external vertical stirrups		
Stress being carried by vertical stirrups		
Item	Unit	Value
Used steel bar, As	mm	10
	nos	2
Av	cm ²	1.571
Spacing of stirrups, as	cm	20
Allowable stress of steel, σa	kg/cm ²	1400

Width of beam, b_o	cm	56
Stress $\tau_s = (\sigma_a \cdot A_s) / (a_s \cdot b_o)$	kg/cm ²	3.927

Stress remaining shear also being carried by oblique bars

Item	Unit	Value
Used steel bar, Aob	mm	12
	nos	0
Aob	cm ²	0.000
Spacing of oblique bar, a_{ob}	cm	20
Allowable stress of steel, G_{sa}	kg/cm ²	1400
Width of beam, b_o	cm	56
Stress $\tau_{ob} = (G_{sa} \cdot A_{ob}) / (a_{ob} \cdot b_o)$	kg/cm ²	0.000
The remaining shear	kg/cm ²	1.376
Total stress of vertical stirrups: and oblique bars	(kg/cm ²)	3.927
Result		OK !

6. REINFORCING BARS DRAWING OF MAIN BEAM



0.470 t/m
0.576 t/m
0.103 t/m
1.104 t/m
0.198 t/m
0.286 t/m
0.050 t/m
0.115 t/m
0.300 t/m

3.203 t/m

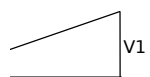
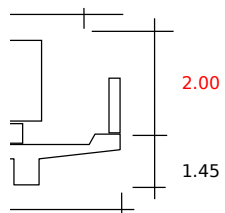
0.389 t

t

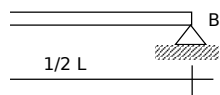
D Diagram

ton

M Diagram



A.Y (cm3)
46000
144000
45150
249900
485050



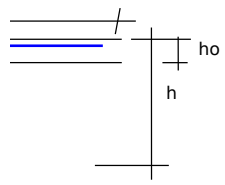
7.714 t

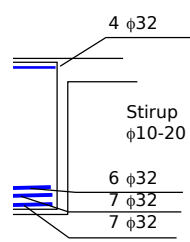
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ton

t

P.x2 (t m)	Mx (t m)
0.000	71.515
0.000	123.013
0.972	153.524
1.944	164.018





Section 4

0.5 x D
0.5*R[-5]C[1]

0.5 x P
0.5*R[-10]C[1]

#VALUE!

0

0
0

2*R[-1]C
3*R[-2]C

0

3

3

3

0.681

7.112

11.23

25
5

25
7

25
11
12

h

0

3

12.8

25
13