1-3. DESIGN OF CANAL BRIDGE

(1) SUPERSTRUCTURE

CONSTRUCTION OF THE BRIDGE OVER THE RIVER RUPSA (PHASE-2)

(DESIGN CALCULATION OF SUPERSTRUCTURE OF CANAL BRIDGES)

DESIGNED BY : PRASANTA KUMAR BHOWMIK — DATE : 2/14/00

GENERAL INPUT

Total Length of one Girder	29950	mm,
Distance of center of Bearing from end of Girder	450	mm,
Live Load	HS 20	
Total no. of Lane	2	Lane,
Aggregate Size of Chips	19.05	mm,
Mention Deck type to be used	2	
Total no. of girder below deck	4	
Put 1.0 for working stress design or 2.0 for load factor design.	2	
Put 1.0 for non-composite or 2.0 for composite wearing course	2	
Percentage of Jack loss (assumed)	3	%
Total load due temp. (-ve for compn, +ve for tension)	200	Kn,
Total load due to utility pipe (equally distributed in all girder)	0.0	Kn/m,
Unit Wt. of concrete for prestressed member	23.563	kN/m^3
Unit Wt. of concrete for non prestressed member	23.563	kN/m^3
Unit Wt. of Wearing Course	23.563	kN/m^3

STRESS INPUT

Put 1.0 for Post-Tensioned or 2.0 for Pre-Tensioned	1.0	
28 days Concrete Strength for :		
PC Girder	35	N/mm^2
Deck Slab, Sidewalk, Railing	30	N/mm^2
At time of Transfer for :		
PC Girder	30	N/mm^2
Ultimate strength of Prestressing Tendon fpu	1860	N/mm^2
Put 1.0 for low relaxation wire or strand, 2.0 for stress relieved wire or strand, 3.0 for smooth high strength bar or 4.0 for deformed high strength bar	2.0	
Put 1.0 for wire, 2.0 for strand, 3.0 for bar	2.0	
Modulus of Elasticity of Prestressing Reinforcement	193053	N/mm^2
Yield strength of Non-Prestressing Rebar	414	N/mm^2
Put 1 for plain bar or 2 for Deformed bar	2	
Quantity limiting distribution of flexural reinforcemrnt, z	22766.48	kN/m

CLEAR COVERS

Parapet	40 mm,	Curb	50 mm,
Pedestal of Parapet	50 mm,	Top of Deck Slab	50 mm,
Top of Sidewalk	50 mm,	Bottom of Deck Slab	40 mm,
Bottom of Sidewalk	50 mm,	Ducts	50 mm,

INPUT RELATING LOSSES

Wobble coefficient, K	0.000656 per m,
Curvature co-efficient, μ	0.25
Relative Humidity	70 %
Amount of slip	8 mm,

REDUCTION FACTORS

Phi for Moment	0.95
Phi for Shear	0.9

ALLOWABLE STRESSES

For normal R.C.C. Member

Concrete in Compression	12.000	N/mm^2
Modulus of Rupture	3.411	N/mm^2
Plain Concrete in Tension	0.716	N/mm^2
Concrete in Shear	0.432	N/mm^2
Tension in Reinforcement	165.600	N/mm^2
n 8 — k	0.367	
J 0.878 — R	1.932	N/mm^2
Modulus of Elasticity	27572	N/mm^2
Beta1	0.8324	

For Prestressed Member

Modulus of Elasticity	29781	N/mm^2
Modulus of Elasticity at time of transfer	27572	N/mm^2
Basic Creep-coefficient	2.65	
A. Concrete		
Stresses immediately after transfer		
i) Compression	-16.50	N/mm^2
ii) Tension with no bonded Reinforcement	1.36	N/mm^2
Tension with bonded Reinforcement	3.41	N/mm^2
Stresses at service load after losses have occured		
i) Compression		
x) under all loads except (y) & (z)	-21.00	N/mm^2
y) under Prestressed force + all permanent dead loads	-14.00	N/mm^2
z) under Live loads + 1/2 of (y)	-14.00	N/mm^2
ii) Tension		
x) with bonded Reinforcement	2.95	N/mm^2
with bonded reinforcement at severe condition	1.47	N/mm^2
y) without bonded reinforcement	0.00	N/mm^2
Modulus of Rupture	3.68	N/mm^2

MULTIPLYING FACTOR FOR DESIGN LOAD/STRESS FOR DESIGN IN LOAD FACTOR METHOD

General	1.3
β_d	1
Dead load	1
Live load,	
• for exterior beam supports S.W. L.L., traffic L.L. + Impact	1.25
• Live load + Impact, Normal condition	1.67
• Live load + Impact, Over load criterion	2.2
• Live load 1' from face of rail	1
ϕ value — For moment	0.9
For shear	0.85

B. Prestressing Reinforcement

Yield Strength	1581	N/mm^2
<u>Stress during tensioning</u>	1423	N/mm^7
<u>Stress immediately after seating</u>		
At anchorage	1302	N/mm^2
At the end of seating loss zone	1312	N/mm^3
<u>Stress at service load after all losses</u>	1265	N/mm^5
Y_p	0.4	

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PARAPET

LEFT / SYMMETRIC PARAPET

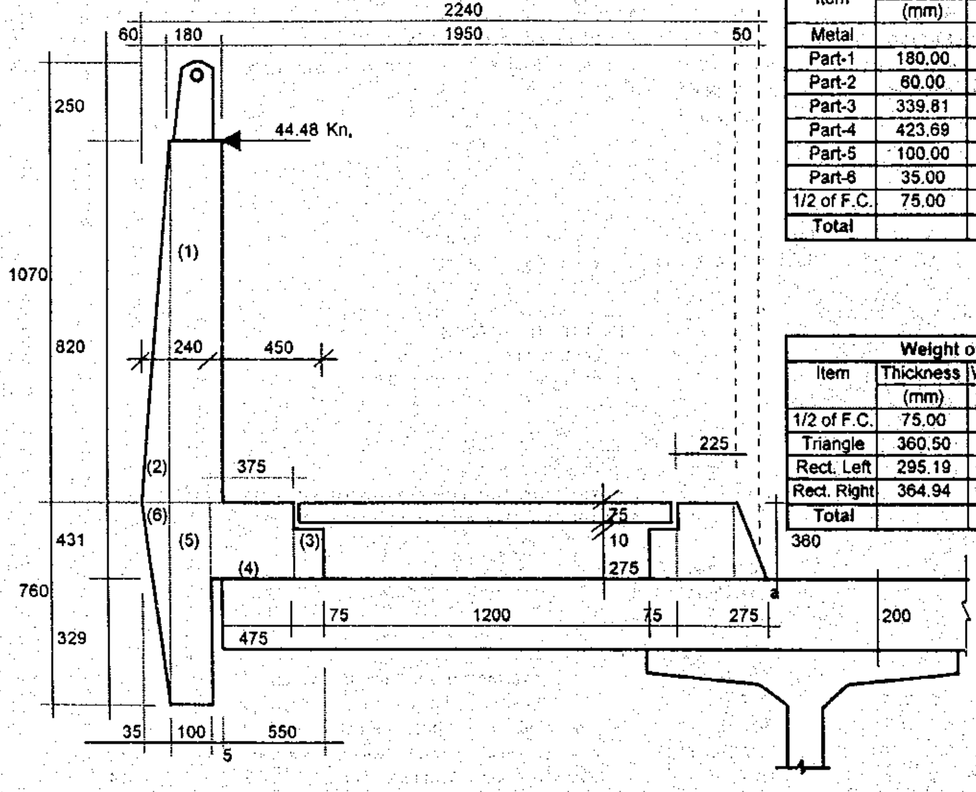
Put 1.0 for traffic, 2.0 for combination & 3.0 for Pedestrian Railing	=	2
Width of each pre-cast segment of parapet	=	1500 mm,
Maximum c/c spacing of metalic post	=	1500 mm,
Total no. of post required	=	21 Nos.,

P	44.4822 kN,
h	820 mm,
C	1

Unit wt. Of metalic part of post & rail	77 kN/m^3,
Bottom dimension of top post	125 mm,
Top dimension top post	100 mm,
Thickness of top post	8 mm,
Weight of metalic post per linear meter	0.012 kN/m,
Dia of metalic rail	100 mm,
Thickness rail pipe	6 mm,
Weight of rail per linear meter	0.07 kN/m,

Weight of End Parapet with 1/2 F.C.

Item	Thickness (mm)	Weight (kN/m)	Dist. of cg from a (mm)
Metal		0.083	2090
Part-1	180.00	3.478	2090
Part-2	60.00	0.580	2200
Part-3	339.81	0.601	1587.5
Part-4	423.69	4.792	1865
Part-5	100.00	1.791	2155
Part-6	35.00	0.313	2217
1/2 of F.C.	75.00	1.193	1588
Total		12.830	1952.855



Weight of Curb with 1/2 F.C.

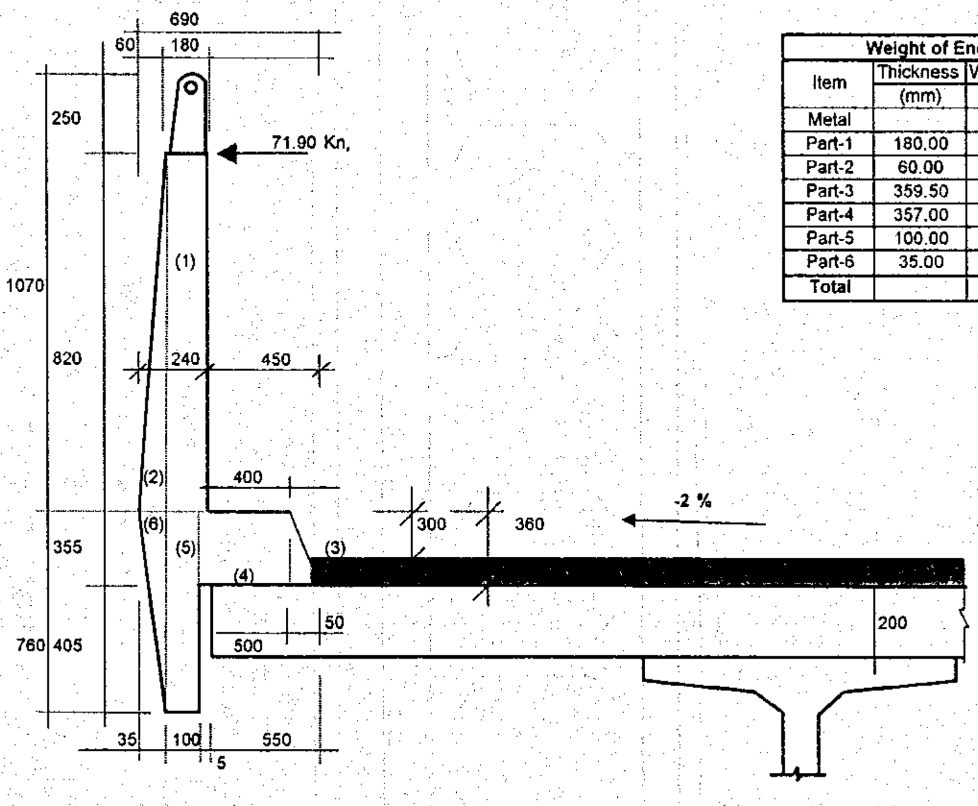
Item	Thickness (mm)	Weight (kN/m)	Dist. of cg from a (mm)
1/2 of F.C.	75.00	1.193	313
Triangle	360.50	0.212	33
Rect. Left	295.19	0.522	313
Rect. Right	364.94	1.935	163
Total		3.862	222.00

RIGHT PARAPET (if other type)

Put 1.0 for traffic, 2.0 for combination & 3.0 for Pedestrian Railing	=	2
Width of each pre-cast segment of parapet	=	1500 mm,
Maximum c/c spacing of metalic post	=	1500 mm,
Total no. of post required	=	21 Nos.,

P	44.4822 kN,
h	1120 mm,
C	1.61636

Unit wt. Of metalic part of post & rail	77 kN/m^3,
Bottom dia. Of top post	125 mm,
Top dia. Top post	100 mm,
Thickness of top post	8 mm,
Weight of metalic post per linear meter	0.012 kN/m,
Dia of metalic rail	100 mm,
Thickness rail pipe	6 mm,
Weight of rail per linear meter	0.07 kN/m,



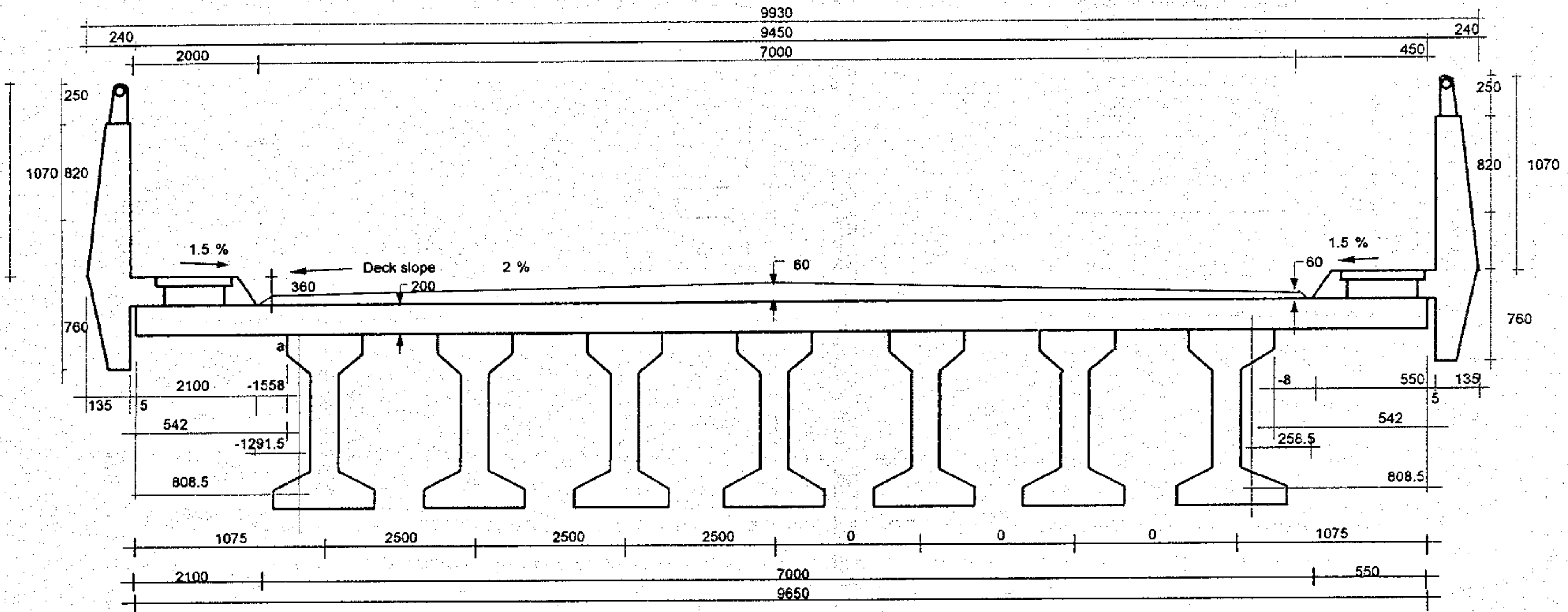
Weight of End Parapet with 1/2 F.C.			
Item	Thickness (mm)	Weight (kN/m)	Dist. of cg from a (mm)
Metal		0.083	540
Part-1	180.00	3.478	540
Part-2	60.00	0.580	650
Part-3	359.50	0.212	33
Part-4	357.00	4.248	303
Part-5	100.00	1.791	605
Part-6	35.00	0.313	667
Total		10.704	456.261

DESIGN OF DECK SLAB (For Canal Bridge)

GENERAL

Date : 2/14/00

Total No of girder below Deck	4 Nos.
Strength of Railing/Parapet against Traffic Load	100 %
Load due to false work	1.0 kN/m2
Put 1.0 for both side having symmetric parapet & 2.0 for different type	2.0



DEAD LOAD MOMENT AT SPAN END OF CANTILEVERE SLAB

FROM LEFT PARAPET SYSTEM

Components	Weight	Dist. from span end	Mom. at Span end
	kN/m	(mm)	kN-m/m
Parapet	12.830	661.4	8.485
Curb	3.862	-1069.5	0.000
C. Slab	3.810	404.3	1.540
Wearing Course 1	0.000	-645.8	0.000
Total	20.502		10.025

FROM RIGHT PARAPET SYSTEM

Components	Weight	Dist. from span end	Mom. at Span end
	kN/m	(mm)	kN-m/m
Parapet	10.704	714.8	7.651
Curb	0.000	0.0	0.000
C. Slab	3.810	404.3	1.540
Wearing Course 1	0.365	129.3	0.047
Total	14.880		9.238

DESIGN OF CANTILEVER SLAB

LEFT CANTILEVER SLAB

Moment Table

Effective Width for			Moment due to					Factored Moment Combination		
Post Load	Wheel Load over Deck Slab	Wheel Load over Sidewalk	Dead Load	Post Load	Wheel load over Deck Slab + Impact	Wheel load over Sidewalk + Impact	Wheel load at Curb	D+P (working combin-ation)	(D+WD+ WC)	((D+WS)/ 1.5)
m	m	m	kN-m/m	kN-m/m	kN-m/m	kN-m/m	kN-m/m	kN-m/m	kN-m/m	kN-m/m
2.1868	0.000	1.4660	10.025	26.037	0.000	25.479	0.000	36.062	13.033	46.156

Design Table

Item with design procedure	Design Moment	Effective depth available	Effective depth required	Comment regarding Thickness	Dia. of Rebar	Area of Rebar Reqd.	Minimum Area Reqd.	Spacing Reqd.	Spacing Provided	Z value for flex. cracking
	kN-m/m	mm	mm		mm	mm2	mm2	mm	mm	Mpa
Other combination, designed by method directed	46.156	140.00	82	OK	20	936.9	466.31	335.33		14377
Due to Post Load, designed by working stress method.	36.062	140.00	136.60	OK	20	1772.262	466.31	177.26	150	
Due to Post Load, designed by ultimate stress method.	69.559	140.00	100.55	OK	20	1459.692	466.31	215.22		O.K.

RIGHT CANTILEVER SLAB

Moment Table

Effective Width for			Moment due to					Factored Moment Combination		
Post Load	Wheel Load over Deck Slab	Wheel Load over Sidewalk	Dead Load	Post Load	Wheel load over Deck Slab + Impact	Wheel load over Sidewalk + Impact	Wheel load at Curb	D+P (working combin-ation)	(D+WD+ WC)	((D+WS)/ 1.5)
m	m	m	kN-m/m	kN-m/m	kN-m/m	kN-m/m	kN-m/m	kN-m/m	kN-m/m	kN-m/m
2.2668	0.000	0.000	9.238	40.441	0.000	0.000	2.627	49.679	17.713	12.010

Design Table

Item with design procedure	Design Moment	Effective depth available	Effective depth required	Comment regarding Thickness	Dia. of Rebar	Area of Rebar Reqd.	Minimum Area Reqd.	Spacing Reqd.	Spacing Provided	Z value for flex. cracking
	kN-m/m	mm	mm		mm	mm2	mm2	mm	mm	Mpa
Other combination, designed by method directed	17.713	140.00	50.74	OK	22	346.7279	462.30	822.26		16550
Due to Post Load, designed by working stress method.	49.679	140.00	160.34		22	2441.482	466.31	155.70	150	
Due to Post Load, designed by ultimate stress method.	99.807	140.00	120.45	OK	22	2199.858	466.31	172.80		O.K.

DESIGN OF INTERIOR SLAB BY COEFFICIENT METHOD

Dead Load from Wearing Course 1.414 kN/m^2 6.12642

Dead Load from self wt. of Slab 4.713 kN/m^2

Span of Slab	Moment due to		Design Moment	Effective depth available	Effective depth required	Comment regarding Thickness	Dia. of Rebar	Area of Rebar Reqd.	Minimum Area Reqd.	Spacing Reqd.	Spacing Provided	Working steel stress	Z value for flex. craqcking	Comment regarding crack
	Dead Load	Live Load with Impact												
m	kN-m/m	kN-m/m	kN-m/m	mm	mm		mm	mm2	mm2	mm	mm	Mpa	kN/m	
1.967	2.370	19.553	45.532	142.00	81.36	OK	16	908.9	473.0	221.2	150	131	13164	O.K.

DISTRIBUTION REINFORCEMENT

% of +ve reinforcement	Area of Rebar Required	Dia. of Rebar	Spacing Reqd.	Spacing Provided
	mm2	mm	mm	mm
67	609	12	186	150

DATA FOR PRESTRESSED GIRDER

Effective web width for Exterior Girder :

(1)	2841.0
(2)	1066.0
Final	1066.0

Effective width of flange for Exterior Girder :

(1)	3495.8
(2)	2808.0
(3)	2325.0
Final	2325.0

Fraction of Wheel Load on left exterior Girder	0.34616
Fraction of Wheel Load on right exterior Girder	1.201
Fraction of Wheel load on left exterior Girder when Wheel over Side	1.80464
Fraction of Wheel load on right exterior Girder when Wheel over Sid	1.44464
Fraction of Wheel Load on interior Girder	1.491291

Effective web width for Interior Girder :

(1)	2841
(2)	1066
Final	1066.0

Effective width of flange for Interior Girder :

(1)	7262.5
(2)	3468
(3)	2500
Final	2500

SUMMERY OF LOAD ON GIRDERS

Load Type	Girder No.						
	1	2	3	4	5	6	7
	Left Exterior	1st Interior	2nd Interior	3rd Interior	4th Interior	5th Interior	Right Exterior
Non-composite dead load	11.354	11.920	11.920	0.268	0.268	0.268	11.354
Composite dead load	21.235	-0.571	-1.390	0.000	0.000	0.000	18.019

SUMMERY OF LOADS FROM DECK SYSTEM ON GIRDERS

Press 1.0 for distribution of load from deck system using moment distribution method or 2.0 for AASHTO method **2**

Mention Girder you Like to design now **2**

INTERIOR GIRDER

Non-composite dead load on girder	11.78157	kN/m,
Composite dead load on girder + utility pipe	9.323034	kN/m,
Effective web width	1066	mm,
Effective flange width	2500	mm,
Fr--tion of wheel load on girder	1.491291	
F. .ion of wheel load on girder, when wheel over sidewalk	0	
Effective width for sidewalk	0	mm,
Difference in elev. Between girder top and slab bottom	**0**	mm,
Uniform load on girder from false work	2.5	kN/m,

10.66 ← **Concentrate**

RIGHT EXTERIOR GIRDER

Non-composite dead load on girder	10.95686	kN/m,
Composite dead load on girder + utility pipe	9.323034	kN/m,
Effective web width	1066	mm,
Effective flange width	2325	mm,
Fraction of wheel load on girder	1.2008	
Fraction of wheel load on girder, when wheel over sidewalk	1.44464	
Effective width for sidewalk	0	mm,
Difference in elev. Between girder top and slab bottom	11	mm,
Uniform load on girder from false work	2.325	kN/m,

LEFT EXTERIOR GIRDER

Non-composite dead load on girder	10.95686	kN/m,
Composite dead load on girder + utility pipe	9.323034	kN/m,
E .ive web width	1066	mm,
Effective flange width	2325	mm,
Fraction of wheel load on girder	0.34616	
Fraction of wheel load on girder, when wheel over sidewalk	1.80464	
Effective width for sidewalk	1950	mm,
Difference in elev. Between girder top and slab bottom	**11**	mm,
Uniform load on girder from false work	2.325	kN/m,

DESIGN OF INTERIOR PRESTRESSED GIRDER
(Dead load from curb/rail/pedestal equally distributed on girder)

DESIGNED BY : PRASANTA KUMAR BHOWMIK

GENERAL

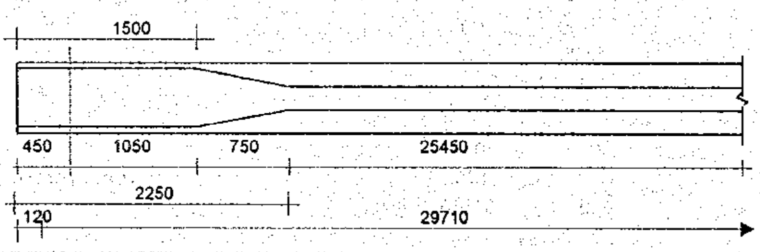
Total Length of one Girder	29950	mm,
Distance of center of Bearing from end of Girder	450	mm,
Span of Girder	29050	mm,
Distance of center of Diaphragm from end of Girder	350	mm,
C/c. spacing between girders	2500	mm,
Effective width of sidewalk	0	mm,
Fraction of wheel load on Girder	1.491	
Fraction of wheel load on girder when wheel over sidewalk	0.000	
Live Load Magnitude	HS 20	
Put 1.0 or 2.0 for Deck type		
Mention AASHTO or WASHINGTON Pattern	AASHTO	
Mention Type	6	
Mention end section 1 or 2?	2	
Anchorage indent	120	mm,
Tensile Stress due to temparature change	0.0423	Mpa,

DIAPHRAGM DETAILS

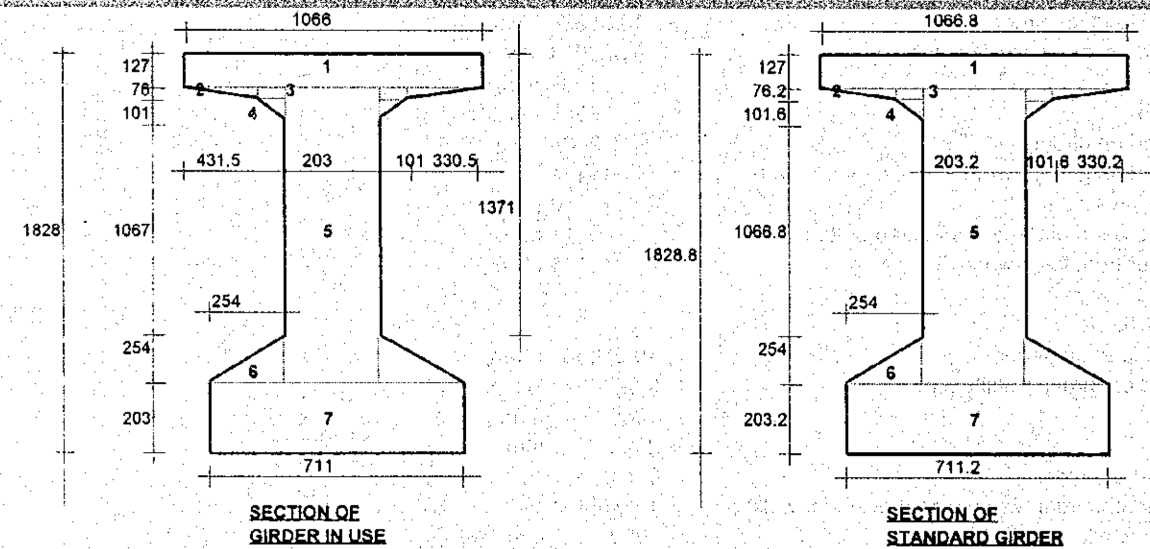
Total no. of interior diaphragm reqd	2	
Total no. of interior diaphragm provided	1	
Width of diaphragm	300	mm,
Depth of end diaphragm	1887	mm,
Depth of interior diaphragm	1625	mm,
Wt. of exterior diaphragm	28.11	kN,
Wt. of interior diaphragm	24.80	kN,

NOTE: In designing this girder following references are followed :
1. AASHTO - 16th edition, 1996.
2. Design of Prestressed Concrete, 2nd edition, by : Arthur H. Nilson.
3. Design of Prestressed Concrete Structure, 3rd edition, by : T. Y. Lin & Ned H. Burns.

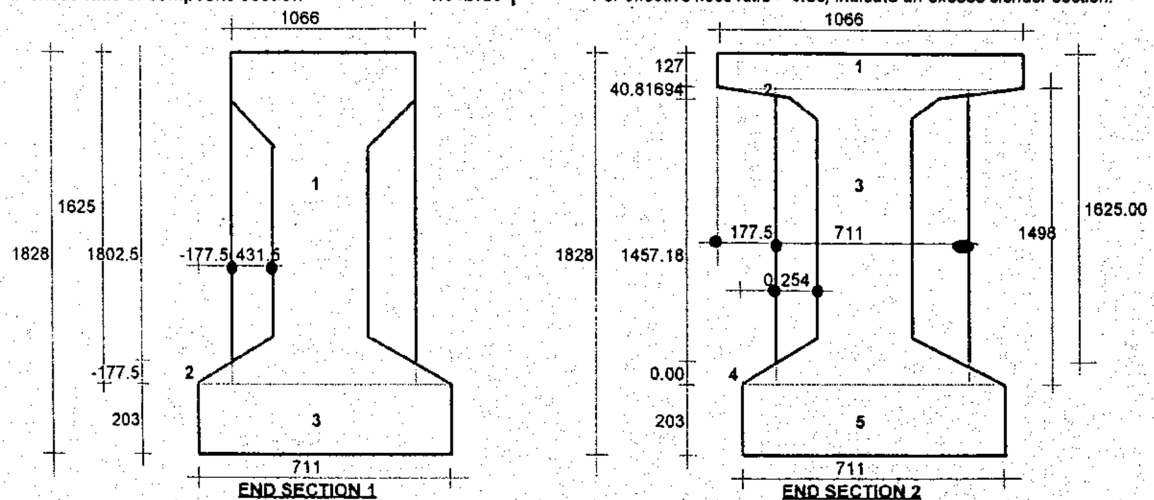
All notations are followed from reference-2

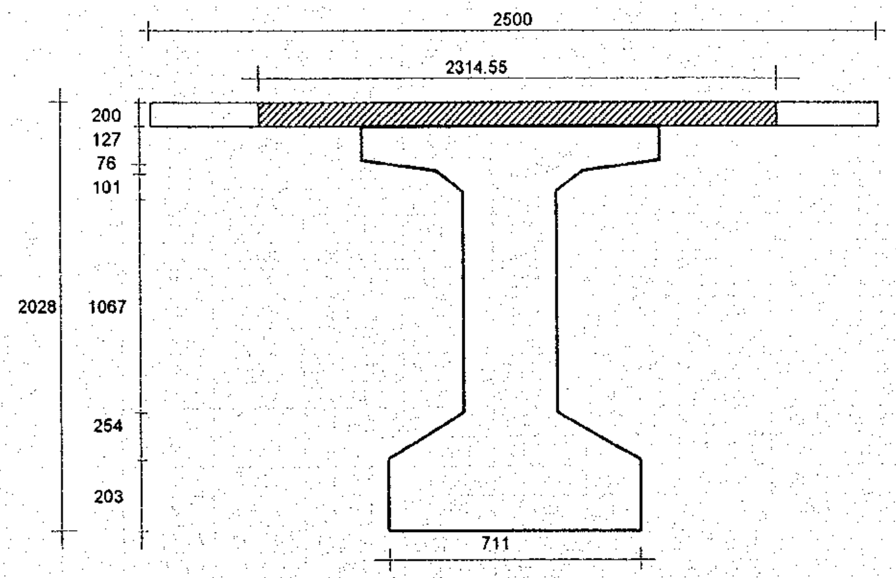


GIRDER SECTION



Effectiveness ratio of non-composite section	0.521613	**Note** : *For effectiveness ratio < 0.45, indicate too heavy a section*
Effectiveness ratio of composite section	0.542025	*For effective ness ratio > 0.55, indicate an excess slender section.*





COMPOSITE SECTION

PROPERTIES OF PRECAST MIDDLE SECTION

Segment	Area	Distance of CG from Top C_{1P}	Distance of CG from Bottom C_{2P}	Moment of Inertia of Components I_O	Moment of Inertia of Block Ic	Radius of Gyration r^2
	mm^2	mm	mm	mm^4	mm^4	mm^2
1	135382	904.62	923.38	1.82E+08	3.05E+11	435707.6
2	12559			4030044		
3	7676			3694715		
4	5100.5			2890567		
5	304094			5.69E+10		
6	32258			1.16E+08		
7	144333			4.96E+08		
Total	698996					

Weight per linear metre = 16.47 kN/m.

PROPERTIES OF PRECAST END SECTION

Segment	Area	Distance of CG from Top C1P	Distance of CG from Bottom C2P	Moment of Inertia of Components IO	Moment of Inertia of Block Ic	Radius of Gyration r2
	mm2	mm	mm	mm4	mm4	mm2
1	135382	881.49	946.51	1.82E+08	3.98E+11	294002
2	3623			335287		
3	1065078			1.99E+11		
4	0			0		
5	144333			4.96E+08		
Total	1352038					

Weight per linear metre = 31.86 kN/m.

PROPERTIES OF EQUIVALENT COMPOSITE SECTION AT MIDDLE

Segment	Area	Distance of CG of Composite section from Top of precast section C_{1C}	Bot. of precast section C_{2C}	Bottom of Slab C_{4C}	Top of Slab C_{3C}	Moment of Inertia of Components I_O	Moment of Inertia of Block Ic	Radius of Gyration r^2
	mm^2	mm	mm	mm	mm	mm^4	mm^4	mm^2
Precast Section	698996	504.3719	1323.628	504.3719	704.3719	3.05E+11	5.87E+11	505344.2
Eqv. Slab	462910					1.54E+09		
Total	1161906							

Weight per linear ft. = 27.38 kN/m.

PROPERTIES OF EQUIVALENT COMPOSITE SECTION AT END

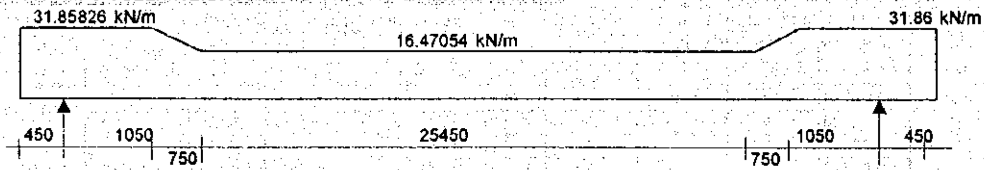
Segment	Area	Distance of CG of Composite section from Top of precast section C_{1C}	Bot. of precast section C_{2C}	Bottom of Slab C_{4C}	Top of Slab C_{3C}	Moment of Inertia of Components I_O	Moment of Inertia of Block Ic	Radius of Gyration r^2
	mm^2	mm	mm	mm	mm	mm^4	mm^4	mm^2
Precast Section	1352038	631.1606	1196.839	631.1606	831.1606	3.98E+11	7.31E+11	402900.5
Eqv. Slab	462910					1.54E+09		
Total	1814948							

Weight per linear ft. = 42.77 kN/m.

SUMMERY OF SECTION PROPERTIES AT DIFFERENT LOCATIONS

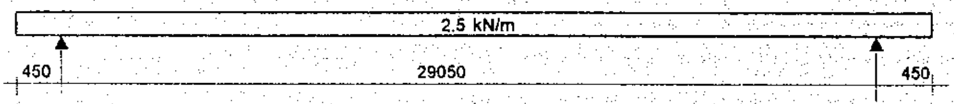
Section			1	2	3	4	5	6	7	8	9
Distance from end		(mm)	0	450.00	2250	7712.5	14975	22237.5	27700	29500	29950
Total area of duct		(mm)	13273.23	13273.23	13273.23	13273.23	13273.23	13273.23	13273.229	13273.23	13273.23
Dist.of c.g. of duct from bot.		(mm)	895.27	849.24	679.17	300.61	117.73	300.61	679.17	849.24	895.27
Duct deducted properties of noncomposite section	Acp	(mm)	1338765	1338765	685723	685723	685723	685723	685723	1338765	1338765
	C_{1P}	(mm)	880.99	880.53	899.89	892.56	889.02	892.56	899.89	880.53	880.99
	C_{2P}	(mm)	947.01	947.47	928.11	935.44	938.98	935.44	928.11	947.47	947.01
	Ic	(mm^4)	3.97E+11	3.97E+11	3.04E+11	2.99E+11	2.96E+11	2.99E+11	3.04E+11	3.97E+11	3.97E+11
	r^2	(mm^2)	296888	296819	442937	436335	431081	436335	442937	296819	296888
Duct grouted properties of noncomposite section	Acp	(mm^2)	1352038	1352038	698996	698996	698996	698996	698996	1352038	1352038
	C_{1P}	(mm)	881.49	881.49	904.62	904.62	904.62	904.62	904.62	881.49	881.49
	C_{2P}	(mm)	946.51	946.51	923.38	923.38	923.38	923.38	923.38	946.51	946.51
	Ic	(mm^4)	3.98E+11	3.98E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.98E+11	3.98E+11
	r^2	(mm^2)	294002	294002	435707.6	435707.6	435707.6	435707.6	435707.6	294002.2	294002.2
Duct grouted properties of composite section	Acc	(mm^2)	1814948	1814948	1161906	1161906	1161906	1161906	1161906	1814948	1814948
	C_{1c}	(mm)	631.16	631.16	504.37	504.37	504.37	504.4	504.4	631.2	631.2
	C_{2c}	(mm)	1196.84	1196.84	1323.63	1323.63	1323.63	1323.6	1323.6	1196.8	1196.8
	C_{4c}	(mm)	631.16	631.16	504.37	504.37	504.37	504.4	504.4	631.2	631.2
	C_{3c}	(mm)	831.16	831	704.4	704.4	704.4	704.4	704.4	831.2	831.2
	Ic	(mm^4)	7.31E+11	7.31E+11	5.87E+11	5.87E+11	5.87E+11	5.87E+11	5.87E+11	7.31E+11	7.31E+11
	r^2	(mm^2)	402900.5	402900.5	505344.2	505344.2	505344.2	505344.2	505344.2	402900.5	402900.5

LOAD DIAGRAM FOR SELF WEIGHT



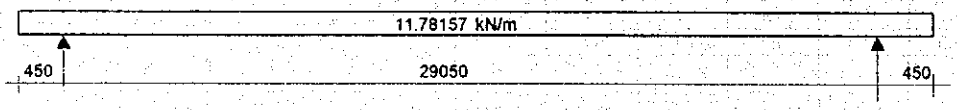
Reaction 275.4983 kN,

LOAD DIAGRAM FOR FALSE-WORK DEAD LOAD



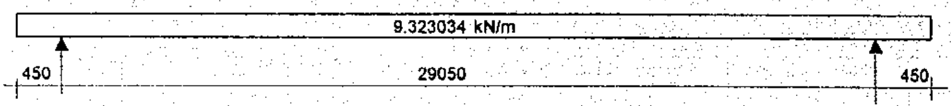
Reaction 37.4375 kN,

LOAD DIAGRAM FOR NON-COMPOSITE DEAD LOAD



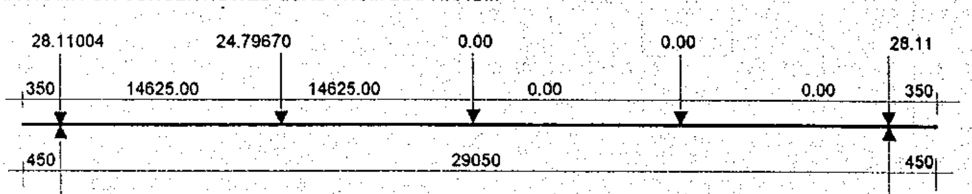
Reaction 176.429 kN,

LOAD DIAGRAM FOR COMPOSITE DEAD LOAD



Reaction 139.6124 kN,

LOAD DIAGRAM FOR CONCENTRATED LOAD FROM DIAPHRAGM



Reaction 40.50839 kN,

ANALYSIS MOR MOMENT

Section	Distance from end	Moment due to									Total Dead load Moment	Total Factored Moment
		Self wt M_O (a)	Cross Girder (Non-Composite dead load (b)	Non Composite dead load (c)	Composite dead load M_{OC} (d)	Live Load with Impact (e)	Live Load with Impact when wheel on Sidewalk (f)	Sidewalk Live Load (g)	Total (Non-Composite dead load) M_{OP} (b+c)	Falsework (Non-Composite dead load		
	(mm)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	450	-3.23	-2.81	-1.19	-0.94	0.00	0.00	0.00	-4.00	-0.25	-8.17	-10.63
2a	1364	222.17	8.52	150.30	118.93	233.12	0.00	0.00	158.82	31.89	499.92	1156.00
3	2250	416.70	19.51	287.75	227.70	443.02	0.00	0.00	307.26	61.06	951.66	2198.94
4	7712.5	1315.84	87.23	930.92	736.66	1387.37	0.00	0.00	1018.15	197.54	3070.64	7003.81
5	14975	1750.20	177.28	1241.62	982.52	1780.37	0.00	0.00	1418.89	263.47	4151.62	9262.29
6	22237.5	1315.84	87.23	930.92	736.66	1387.37	0.00	0.00	1018.15	197.54	3070.64	7003.81
7	27700	416.70	19.51	287.75	227.70	443.02	0.00	0.00	307.26	61.06	951.66	2198.94
8	29500	-3.23	-2.81	-1.19	-0.94	0.00	0.00	0.00	-4.00	-0.25	-8.17	-10.63
9	29950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LOSSES

r_{ps}	144.20			
Frictional loss per unit length	14.27407 kN/m,			
For 8mm Anchorage draw in, x(dist. Of anchorage loss zone)	21.6768 mm,			
ΔP_A	618.8313 kN,			
Prestress force after friction losses (before elastic shortening) :-				
Tensioning end	5361 kN,			
Seating loss zone	5671 kN,	No. of cable reqd	3.66	
Midspan	5575 kN,			
Dead end	5552 kN,			

SUMMERY OF INITIAL LOSSES

Section	Distance from end	Jacking Force	Losses due to friction and anchorage pull-in	Prestress Force after friction loss (before elastic shortening)	Conc. Stress at the level of steel centroid at sec.of maxm. mom. (f_{cir})	Loss due to elastic shortening	Final initial loss (after immediate losses)	Final initial prestress force (after immediate losses) (Pi)
	(mm)	(kN)	(kN)	(kN)	(mPa)	(kN)	(kN)	(kN)
1	0		619	5361	3.956	60.14	679	5301
2	450		612	5368	4.052	61.60	674	5306
2a	1364		599	5381	4.292	65.25	665	5315
3	2250		587	5393	8.234	125.19	712	5268
4	7712.5	5980	509	5471	11.626	176.76	686	5294
5	14975		405	5575	14.445	219.61	625	5355
6	22237.5		317	5663	12.123	184.32	502	5478
7	27700		395	5585	8.538	129.81	525	5455
8	29500		421	5559	4.196	63.79	485	5495
9	29950		428	5552	4.097	62.29	490	5490

SUMMERY OF TIME-DEPENDENT & FINAL LOSSES

Section	Distance from end	Conc. Stress at the level of st-eel cg. Due to dead loads except self wt. (f_{cds})	Loss due to creep	Loss due to shrinkage	Loss due to relaxation of pre-stressing steel	Final Time dependent loss	Total loss	Loss in percent	Final effective pre-stress force (Pe)
	(mm)	(mPa)	(kN)	(kN)	(kN)	(kN)	(kN)		(kN)
1	0	0.000	206.15		316.77	678.63	1357.60	22.70	4622.40
2	450	-0.002	211.21		317.11	684.02	1358.02	22.71	4621.98
2a	1364	0.166	218.62		318.08	692.40	1357.02	22.69	4622.98
3	2250	0.587	411.26		259.37	826.33	1538.23	25.72	4441.77
4	7712.5	3.057	512.94		241.80	910.44	1595.94	26.69	4384.06
5	14975	4.932	602.85	155.70	237.77	996.32	1621.01	27.11	4358.99
6	22237.5	3.057	538.84		290.99	985.53	1487.26	24.87	4492.74
7	27700	0.587	427.09		311.75	894.54	1419.74	23.74	4560.26
8	29500	-0.002	218.73		372.12	746.56	1231.43	20.59	4748.57
9	29950	0.000	213.51		371.84	741.05	1230.85	20.58	4749.15

EFFECT OF DIFFERENTIAL SHRINKAGE

Ultimate shrinkage co-efficient, ε_{SHU}	0.0008	
Correction by humidity, (RH = 70) , $F_{SH,H}$	0.7	
Assumed day of slab casting after girder concrete placed, t	60	days
Shrinkage of girder at t days, $\varepsilon_{SH,t}$	0.632	
Differential (remaining) shrinkage, $\varepsilon_{SH,D}$	0.000206	
Ultimate creep coefficient for girder, φ_{cgu}	2.6	
Ultimate creep coefficient for slab, φ_{csu}	2.8	
Correction by humidity for creep coefficient, (RH = 70), $F_{C,H}$	0.801	
Remaining creep of girder after t days, φ_{cg}	0.961267	
Remaining creep of slab, φ_{cs}	2.2428	

Horizontal Shear & Bending Moment on contact surface of girder & slab due to Differential Shrinkage
At all section like mid section

m	B	C	F	φ_{cg}	φ_{cs}	Girder		Slab	
						V_{SH}	M_{SH}	V_{SH}	M_{SH}
		(m)	(m2)			(kN)	(kN-m)	(kN)	(kN-m)
213.190	214.190	-20.414	4.097	0.961	2.243	443.601	42.279	268.293	25.571

	Girder		Slab	
	Bottom	Top	Bottom	Top
Stress at concrete due to differential shrinkage	0.710	-1.952	0.612	0.461

Horizontal Shear & Bending Moment on contact surface of girder & slab due to Differential Shrinkage
At all section like end section

m	B	C	F	φ_{cg}	φ_{cs}	Girder		Slab	
						V_{SH}	M_{SH}	V_{SH}	M_{SH}
		(m)	(m2)			(kN)	(kN-m)	(kN)	(kN-m)
278.251	279.251	-27.044	4.781	0.961	2.243	575.987	55.780	348.361	33.736

	Girder		Slab	
	Bottom	Top	Bottom	Top
Stress at concrete due to differential shrinkage	0.916	-1.676	0.763	0.631

DESIGN FOR MOMENT AT MID SECTION

Total Jacking tension canbe taken by supplied cable (after jack loss) 5993.99 kN,

Initial Tension				Total	Jacking	Effective	(Row) ρ	f_{ps}	a	Ultimate	Ultimate	Comment
Maximum (1)	Maximum (2)	Can be taken by supplied Cable	Actual at mid Section	no. of Cable reqd.	Tension (after Jack loss)	Tension at mid section				Design Moment	Moment Capacity	
(kN)	(kN)	(kN)	(kN)		(kN)	(kN)		(N/mm²)	(mm)	(kN-m)	(kN-m)	
6552	5424	5654	5355	3.66	**5980**	4359	0.000909	1809.61	123.27	9262.2922	13792.4	OK

PRESTRESSING REINFORCEMENT DETAILS

Total no. of cable reqd.	Total no. of duct used	Area factor	Total no. of strand in one cable	Dia of one strand	Area of			Minimum inside diameter of Ducts	Outer diameter of Duct Provided	C/c. Spacing of Ducts		
					One Strand	One cable	Total Cable (Ap)			Reqd.	Allowed mid	Allowed end
(nos)	(nos)			(mm)	(mm2)	(mm2)	(mm2)	(mm)	(mm)	(mm)	(mm)	(mm)
3.55	4	3.666667	12	12.7	98.7	1184.40	4342.80	54.92	65	103.1	125	125

Reinforcement Index	0.054853	**OK against maxm. reinforcrment.**
Cracking Moment	3307.522 kN-m,	**OK against minm. reinforcement.**

8065.63 2.20

STRESSES AT DIFFERENT LOCATION OF MID-SECTION OF GIRDER

	Initial Tension				Effective Tension									
	Pi (alone)		Pi+Mo (A)		$P_e+M_o+M_{dp}$ (B)		$P_e+M_o+M_{dp}+M_{dc}$ (C)		$P_e+M_o+M_{dp}+M_{dc}+M_l$ +SH (D)		$0.5(P_e+M_o+M_{dp}+M_{dc})$ +Ml (E)		At top of Deck Slab	At bot. of D eck Slab
	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	(N/mm²)	(N/mm²)
Stress	5.15	-20.74	0.15	-16.22	-5.96	-6.43	-6.80	-4.22	-9.50	-0.29	-4.52	1.53	-2.57	-1.54
All. stress			1.36	-16.50	-14.00	1.47	-14.00	1.47	-21.00	1.47	-14.00	1.47	-12	0.72
Comment			OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

CHECK AT MID SECTION FOR EXTERIOR GIRDER WHEN WHEEL ON SIDEWALK

	Effective Tension					
	$P_e+M_o+M_{dp}+M_{dc}+M_l$ +SH (D)		$0.5(P_e+M_o+M_{dp}+M_{dc})$ +Ml (E)		At top of Deck Slab	At bot. of D eck Slab
	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	(N/mm²)	(N/mm²)
Stress	0.00	0.00	0.00	0.00	0.00	0.00
All. stress	-31.50	2.21	-21.00	2.21	-18	1.07
Comment	OK	OK	OK	OK	OK	OK

Factor of safety against cracking 1.86

CABLE LAYOUT

Total no. of Row at mid Section: 2	Row 1	Row 2							
No. of Cable in	3	1							
Area factor	3	0.666667							
Cumilitive No.	3	4	0	0	0	0	0	0	0
Maxm. no. of cable allowed	5	5	5	5	5	5	5	5	5
Distance between Row	95	125							
Cumilitive distance	95	220	0	0	0	0	0	0	0
Distance of C.G. from bot. face of girder	117.73								
Eccentricity for non composite section	805.6555								
Eccentricity for Composite section	1205.90								
Total no. of Row at end Section: 4	**Row 1**	**Row 2**	**Row 3**	**Row 4**					
No. of Cable in	1	1	1	1					
Area factor	1	1	1	0.666667					
Maxm. no. of cable allowed									
Distance between Row	418	350	350	350					
Cumilitive distance	418	768	1118	1468	0	0	0	0	0
Distance of C.G. from bot. face of girder	895.3								
Eccentricity for non composite section	51.23								
Eccentricity for Composite section	301.57								

STRESSES AT DIFFERENT LOCATION OF GIRDER

Cable No.	Mention Row No. at end section	Ordinates from bottom: at end section (mm)	At mid section (mm)	at following distances from end: 450 (mm)	2250 (mm)	7712.5 (mm)	14975 (mm)	22237.5 (mm)	27700 (mm)	29500 (mm)	1364 (mm)		
1	1	418	95	398.88	328.23	170.97	95.00	170.97	328.23	398.88	361.84	29959.29	30659.29
2	2	768	95	728.16	580.96	253.29	95.00	253.29	580.96	728.16	650.98	29990.33	30690.33
3	3	1118	95	1057.44	833.68	335.61	95.00	335.61	833.68	1057.44	940.13	30043.18	30743.18
4	4	1468	220	1394.12	1121.15	513.53	220.00	513.53	1121.15	1394.12	1251.01	30088.68	30788.68
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		122881.5
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Dist. of cg from bot.		895.27	117.73	849.24	679.17	300.61	117.73	300.61	679.17	849.24	760.08		
	C1p	881.49	904.62	881.49	904.62	904.62	904.62	904.62	904.62	881.49	881.49		
	C2p	946.51	923.38	946.51	923.38	923.38	923.38	923.38	923.38	946.51	946.51		
	C1c	631.16	504.37	631.16	504.37	504.37	504.37	504.37	504.37	631.16	631.16		
	C2c	1196.84	1323.63	1196.84	1323.63	1323.63	1323.63	1323.63	1323.63	1196.84	1196.84		
	C3c	831.16	704.37	831.16	704.37	704.37	704.37	704.37	704.37	831.16	831.16		
	C4c	631.16	504.37	631.16	504.37	504.37	504.37	504.37	504.37	631.16	631.16		
	Acp	1352038	698996	1352038	698996	698996	698996	698996	698996	1352038	1352038		
	Acc	1814948	1161906	1814948	1161906	1161906	1161906	1161906	1161906	1814948	1814948		
	Icp	3.98E+11	3.05E+11	3.98E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.98E+11	3.98E+11		
	Icc	7.31E+11	5.87E+11	7.31E+11	5.87E+11	5.87E+11	5.87E+11	5.87E+11	5.87E+11	7.31E+11	7.31E+11		
	ep	51.23	805.66	97.26	244.21	622.78	805.66	622.78	244.21	97.26	186.43		
	ec	301.57	1205.90	347.60	644.46	1023.02	1205.90	1023.02	644.46	347.60	436.76		
	r_p^2	294002	435708	294002	435708	435708	435708	435708	435708	294002	294002		
For Load case (A) stresses at	top fibre	Allowable stresses		-2.801	-5.032	-1.620	0.154	-1.540	-5.166	-2.901			
	bot fibre	Tension	1.36	-5.214	-10.417	-14.115	-16.221	-14.748	-10.831	-5.399			
	comment	Compn.	-16.50	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
For Load case (B) stresses at	top fibre	Allowable stresses		-2.36	-5.35	-5.64	-5.96	-5.59	-5.51	-2.43			
	bot fibre	Tension	1.47	-4.46	-7.22	-6.83	-6.43	-7.19	-7.48	-4.59			
	comment	Compn.	-14.00	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
For Load case (C) stresses at	top fibre	Allowable stresses		-2.32	-5.70	-6.23	-6.76	-6.18	-5.66	-2.39			
	bot fibre	Tension	1.47	-4.42	-6.67	-5.13	-4.18	-5.49	-6.92	-4.55			
	comment	Compn.	-14.00	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
For Load case (D) stresses at	top fibre	Allowable stresses		-4.00	-7.85	-8.79	-9.46	-8.74	-7.81	-4.06			
	bot fibre	Tension	1.47	-3.51	-5.14	-1.89	-0.25	-2.25	-5.40	-3.63			
	comment	Compn.	-21.00	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
	top of slab	Allowable stresses		0.63	-0.28	-1.90	-2.61	-1.90	-0.28	0.63			
	bot of slab	Tension	0.72	0.76	0.08	-1.08	-1.59	-1.08	0.08	0.76			
	comment	Compn.	-12.00	OK-NOK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-NOK			
For Load case (E) stresses at	top fibre	Allowable stresses		-1.16	-3.08	-4.01	-4.52	-3.99	-3.12	-1.19			
	bot fibre	Tension	1.47	-2.21	-2.43	0.26	1.53	0.08	-2.56	-2.27			
	comment	Compn.	-14.00	OK-OK	OK-OK	OK-OK	OK-NOK	OK-OK	OK-OK	OK-OK			

TENSION REINFORCEMENT

Yield strength of rebar 414 Mpa, Allowable strength iof rebar 165.6 Mpa,

On Girder top for Girder casting

Stress at Top fibre (Mpa)	Stress at Bot. fibre (Mpa)	Depth of ten. Area (mm)	Total tension (kN)	Rebar Area reqd. (mm^2)	Dia. of Rebar (mm)	No. of rebar reqd.
0.154	-16.221	17.16	1.41	8.48	12	0.08

On Girder bottom for service load

Stress at Top fibre (Mpa)	Stress at Bot. fibre (Mpa)	Depth of ten. Area (mm)	Total tension (kN)	Rebar Area reqd. (mm^2)	Dia. of Rebar (mm)	No. of rebar reqd.
-4.518	1.526	461.44	222.21	1341.85	20	4.27

DESIGN FOR SHEAR

Yield strength of rebar 276 Mpa, Allowable strength iof rebar 124.2 Mpa,

ANALYSIS FOR SHEAR

Section	Distance from end	Shear due to								
		Self wt V_O (a)	Cross Girder (Non-Composite dead load (b)	Non Composite dead load (c)	Composite dead load V_{OC} (d)	Live Load with Impact (e)	Live Load with Impact when wheel on Sidewalk (f)	Sidewalk Live Load (g)	Total Dead Load	Factored Design Shear V_U
	(mm)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)
2	450	261.16	12.398	171.127	135.417	264.31	0.00	0.00	580.10	1327.96
2a	1364	232.04	12.398	160.359	126.896	255.75	0.00	0.00	531.70	1246.43
3	2250	209.59	12.398	149.920	118.636	247.41	0.00	0.00	490.54	1174.84
4	7712.5	119.62	12.398	85.564	67.709	195.35	0.00	0.00	285.29	794.98
5	14975	0.00	12.398	0.000	0.000	123.83	0.00	0.00	12.40	284.94
6	22237.5	119.62	12.398	85.564	67.709	195.35	0.00	0.00	285.29	794.98
7	27700	209.59	12.398	149.920	118.636	247.41	0.00	0.00	490.54	1174.84
8	29500	261.16	12.398	171.127	135.417	264.31	0.00	0.00	580.10	1327.96

Section	Distance from end	Diameter of stirrup	No. of Leg	Effective depth for Shear (d)	f2p (stress in the conc. due to Pe) (N/mm^2)	fo (tensile stress at bot.due to self wt.) (N/mm^2)	Mcr (moment causing flexural crack) (kN-m)	Vci (kN)	Vp (kN)	Vcw (kN)	Vc (shear strength provided by conc.) (kN)	Spacing Reqd. (mm)
2	450	12	2	1462	-4.488932	-0.0077	3126.27	480073	472.76	1287.63	1287.63	337
2a	1364	12	2	1462	-5.471447	0.5290	3313.50	3929.53	458.21	1273.15	1273.15	337
3	2250	12	2	1462	-9.643245	1.2634	3736.07	2331.40	426.61	1502.95	1502.95	337
4	7712.5	12	2	1527	-14.54985	3.9895	4455.26	749.24	338.03	1454.53	749.24	344
5	14975	12	2	1710	-16.88355	5.3064	4790.62	297.70	226.33	1472.78	297.70	364
6	22237.5	12	2	1527	-14.91052	3.9895	4574.22	763.62	346.41	1477.38	763.62	344
7	27700	12	2	1462	-9.900504	1.2634	3820.92	2377.60	437.99	1529.43	1529.43	337
8	29500	12	2	1462	-4.611878	-0.0077	3177.90	488007	485.71	1308.92	1308.92	337

HORIZONTAL SHEAR TRANSFER

Section	Distance from end (mm)	Effective depth for Shear (d) (mm)	Contact surface width (mm)	Factored Design Shear (kN)	Allowable shear strength (ϕVnh) (kN)	Comment	Diameter of stirrup (mm)	No. of Leg	Minimum spacing required (mm)
2	450	979	1066	1327.96	2263	O.K.	16	2	301.78
3	2250	1149	1066	1174.84	2656	O.K.	16	2	301.78
4	7712.5	1527	1066	794.98	3532	O.K.	16	2	301.78
5	14975	1710	1066	284.94	3954	O.K.	16	2	301.78
6	22237.5	1527	1066	794.98	3532	O.K.	16	2	301.78
7	27700	1149	1066	1174.84	2656	O.K.	16	2	301.78
8	29500	979	1066	1327.96	2263	O.K.	16	2	301.78

ELONGATION OF CABLE

Outside jack cable length (assumed), l_j = 700 mm,

Dead anchor width, l_a = 70 mm,

Cable stress at jack (after jack loss), f_j' = 1377 N/mm^2,

Cable stress at dead anchor, f_{LP} = 1264 N/mm^2,

Average cable length of anchor to anchor, L_p = 30004 mm,

Average elongation of cables by one side jacking, ΔL_p = 211 mm,

ANCHORAGE ZONE DESIGN

Minimum longitudinal extent of anchorage zone = 1066 mm,
Maximum longitudinal extent of anchorage zone = 1599 mm,
Selected longitudinal extent of anchorage zone = 1500 mm,

- DESIGN of GENERAL ZONE

α, angle of inclination of the resultant of the tendon = 5.93 deg,

Size of bearing plate	Thickness of bearing plate	Diameter of cone	Effective bearing area (Ab)	Factored tandon load	Total factored tendon load	C/c spacing of anchorage	Longitudinal extent of local zone (lc)	Correction factor (k)	Concrete compressive stress (fca)	Allowable Concrete compressive stress	Comment
(mm)	(mm)	(mm)	(mm^2)	(kN)	(kN)	(mm)	(mm)		(Mpa)	(Mpa)	
230	35	152	49581.69	1957.091	7176	350	264.5	1.271	16.93	21	O.K.

DESIGN FOR VERTICAL DIRECTION

Cable no.	1	2	3	4	0	0	0	0	0	0	0
Eccentricity	528.51	178.51	171.49	521.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
dburst	658.44	827.68	831.07	661.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Reinforcement distribution distance	=	1861.895 mm,	Maximum = 2742 mm,
Bursting force, Tburst	=	1938.884 kN,	
Area of reinforcement required for bursting force	=	5509.758 mm^2,	
Diameter of bursting stirrup	=	16 mm,	
Total no of 2 legged stirrup required	=	13.70 nos.,	

DESIGN FOR HORIZONTAL DIRECTION

Eccentricity (e)	Lateral dimension (h)	Angle of tendon (α)	Bursting distance (dburst)	Bursting force (Tburst)	Area of rebar required	Dia. Of rebar	No. of rebar reqd	Rebar distribution distance
(mm)	(mm)	(deg)	(mm)	(kN)	(mm^2)	(mm)		(mm)
0	711	0	355.5	1213.662	3448.884	16	8.58	888.75

DESIGN FOR EDGE TENSION

Spalling force (Tspal)	Area of rebar required	Dia. Of rebar	No. of rebar reqd
(kN)	(mm^2)	(mm)	
143.52	408	12	0.05

DEFLECTION CALCULATION

Deflection due to						Instantaneous Deflection	Deflection at erection	Long-time Deflection	Live load	Live load rotation at support
Initial Prestress	Effective Prestress	Self wt. (at initial period)	Self wt. (after 28 days)	Non-composite dead load	Composite dead load					
(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(rad.)
45.5	37.0	-18.322	-16.96	-13.8	-4.9	27.2	48.0	-5.7	-7.6	0.001286

DESIGN OF LEFT EXTERIOR PRESTRESSED GIRDER
(Dead load from curb/rail/pedestal equally distributed on girder)

DESIGNED BY : PRASANTA KUMAR BHOWMIK

GENERAL

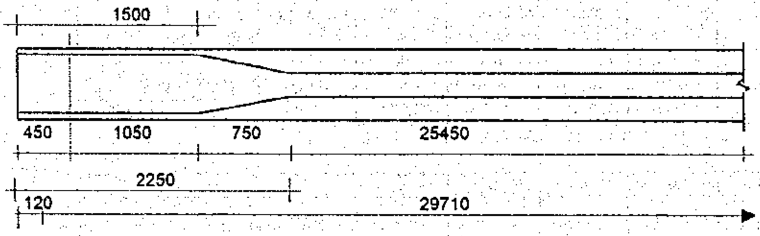
Total Length of one Girder	29950	mm,
Distance of center of Bearing from end of Girder	450	mm,
Span of Girder	29050	mm,
Distance of center of Diaphragm from end of Girder	350	mm,
C/c. spacing between girders	2500	mm,
Effective width of sidewalk	1950	mm,
Fraction of wheel load on Girder	0.346	
Fraction of wheel load on girder when wheel over sidewalk	1.805	
Live Load Magnitude	HS 20	
Put 1.0 or 2.0 for Deck type		
Mention AASHTO or WASHINGTON Pattern	AASHTO	
Mention Type	6	
Mention end section 1 or 2?	2	
Anchorage indent	120	mm,
Tensile Stress due to temparature change	0.0423	Mpa,

DIAPHRAGM DETAILS

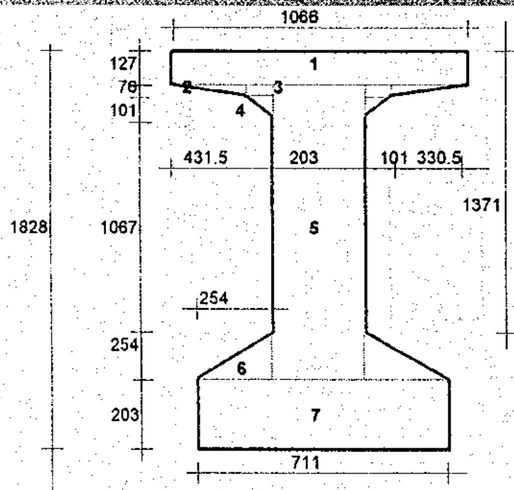
Total no. of interior diaphragm reqd	2	
Total no. of interior diaphragm provided	1	
Width of diaphragm	300	mm,
Depth of end diaphragm	1887	mm,
Depth of interior diaphragm	1625	mm,
Wt. of exterior diaphragm	14.06	kN,
Wt. of interior diaphragm	12.40	kN,

NOTE: In designing this girder following references are followed :
1. AASHTO - 16th edition, 1996.
2. Design of Prestressed Concrete, 2nd edition, by : Arthur H. Nilson.
3. Design of Prestressed Concrete Structure, 3rd edition, by : T. Y. Lin & Ned H. Burns.

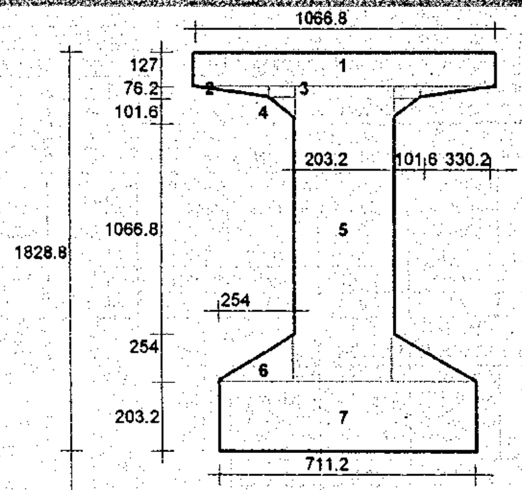
All notations are followed from reference-2



GIRDER SECTION



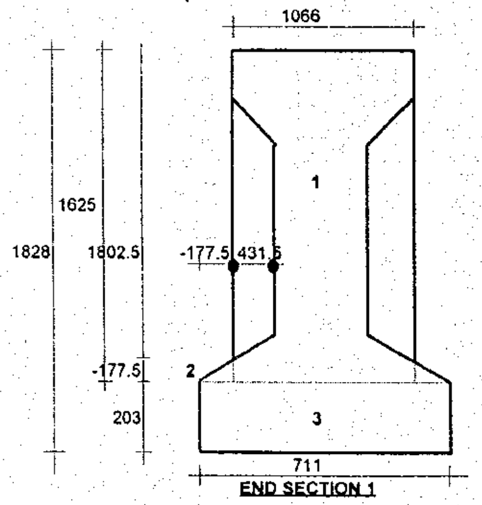
SECTION OF GIRDER IN USE



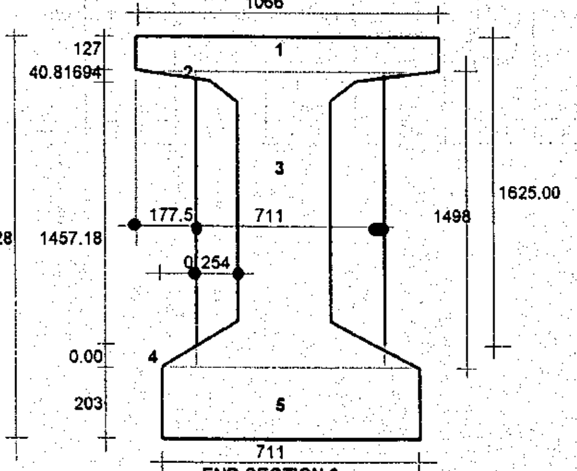
SECTION OF STANDARD GIRDER

Effectiveness ratio of non-composite section	0.521613
Effectiveness ratio of composite section	0.539867

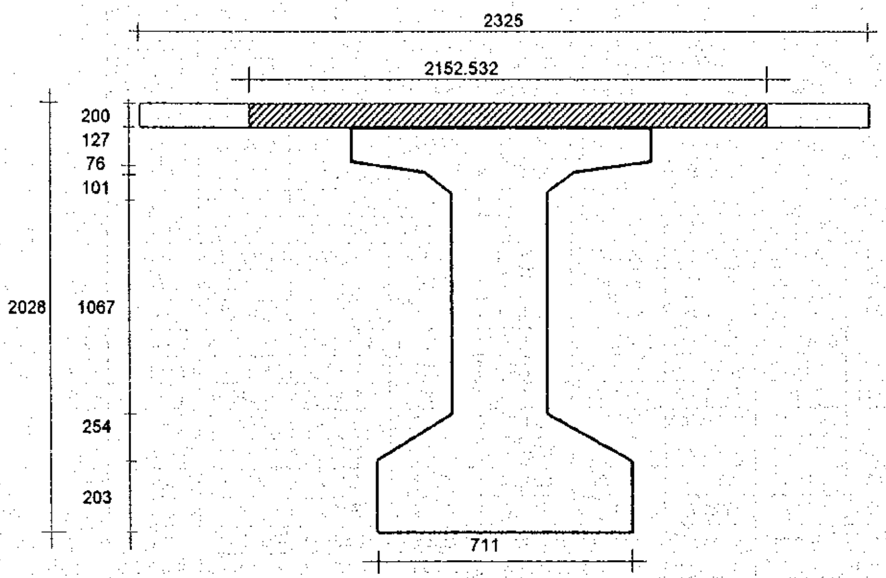
Note : *For effectiveness ratio < 0.45, indicate too heavy a section*
For effective ness ratio > 0.55, indicate an excess slender section.



END SECTION 1



END SECTION 2



COMPOSITE SECTION

PROPERTIES OF PRECAST MIDDLE SECTION

Segment	Area	Distance of CG from		Moment of Inertia of		Radius of
		Top C_{1P}	Bottom C_{2P}	Components I_O	Block Ic	Gyration r^2
	mm^2	mm	mm	mm^4	mm^4	mm^2
1	135382			1.82E+08		
2	12559			4030044		
3	7676			3694715		
4	5100.5	904.62	923.38	2890567	3.05E+11	435707.6
5	304094			5.69E+10		
6	32258			1.16E+08		
7	144333			4.96E+08		
Total	698996					

Weight per linear metre = 16.47 kN/m.

PROPERTIES OF PRECAST END SECTION

Segment	Area	Distance of CG from		Moment of Inertia of		Radius of
		Top C1P	Bottom C2P	Components IO	Block Ic	Gyration r2
	mm2	mm	mm	mm4	mm4	mm2
1	135382			1.82E+08		
2	3623			335287		
3	1065078	881.49	946.51	1.99E+11	3.98E+11	294002
4	0			0		
5	144333			4.96E+08		
Total	1352038					

Weight per linear metre = 31.86 kN/m.

PROPERTIES OF EQUIVALENT COMPOSITE SECTION AT MIDDLE

Segment	Area	Distance of CG of Composite section from				Moment of Inertia of		Radius of
		Top of precast section C_{1C}	Bot. of precast section C_{2C}	Bottom of Slab C_{4C}	Top of Slab C_{3C}	Components I_O	Block Ic	Gyration r^2
	mm^2	mm	mm	mm	mm	mm^4	mm^4	mm^2
Precast Section	698996					3.05E+11		
Eqv. Slab	430506.3	521.7104	1306.290	521.7104	721.7104	1.44E+09	5.75E+11	508966.6
Total	1129502							

Weight per linear ft. = 26.61 kN/m.

PROPERTIES OF EQUIVALENT COMPOSITE SECTION AT END

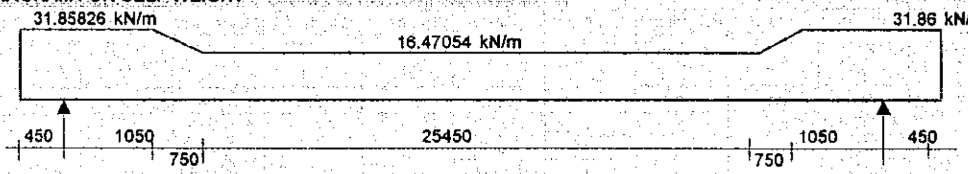
Segment	Area	Distance of CG of Composite section from				Moment of Inertia of		Radius of
		Top of precast section C_{1C}	Bot. of precast section C_{2C}	Bottom of Slab C_{4C}	Top of Slab C_{3C}	Components I_O	Block Ic	Gyration r^2
	mm^2	mm	mm	mm	mm	mm^4	mm^4	mm^2
Precast Section	1352038					3.98E+11		
Eqv. Slab	430506.3	644.4519	1183.548	644.4519	844.4519	1.44E+09	7.13E+11	400269.3
Total	1782544							

Weight per linear ft. = 42.00 kN/m.

SUMMERY OF SECTION PROPERTIES AT DIFFERENT LOCATIONS

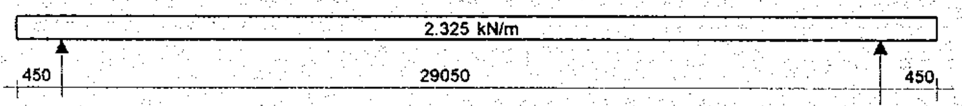
Section			1	2	3	4	5	6	7	8	9
Distance from end		(mm)	0	450.00	2250	7712.5	14975	22237.5	27700	29500	29950
Total area of duct		(mm)	13273.23	13273.23	13273.23	13273.23	13273.23	13273.23	13273.229	13273.23	13273.23
Dist.of c.g. of duct from bot.		(mm)	895.27	849.24	679.17	300.61	117.73	300.61	679.17	849.24	895.27
Duct deducted properties of noncomposite section	Acp	(mm)	1338765	1338765	685723	685723	685723	685723	685723	1338765	1338765
	C_{1P}	(mm)	880.99	880.53	899.89	892.56	889.02	892.56	899.89	880.53	880.99
	C_{2P}	(mm)	947.01	947.47	928.11	935.44	938.98	935.44	928.11	947.47	947.01
	Ic	(mm^4)	3.97E+11	3.97E+11	3.04E+11	2.99E+11	2.96E+11	2.99E+11	3.04E+11	3.97E+11	3.97E+11
	r^2	(mm^2)	296888	296819	442937	436335	431081	436335	442937	296819	296888
Duct grouted properties of noncomposite section	Acp	(mm^2)	1352038	1352038	698996	698996	698996	698996	698996	1352038	1352038
	C_{1P}	(mm)	881.49	881.49	904.62	904.62	904.62	904.62	904.62	881.49	881.49
	C_{2P}	(mm)	946.51	946.51	923.38	923.38	923.38	923.38	923.38	946.51	946.51
	Ic	(mm^4)	3.98E+11	3.98E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.98E+11	3.98E+11
	r^2	(mm^2)	294002	294002	435707.6	435707.6	435707.6	435707.6	435707.6	294002.2	294002.2
Duct grouted properties of composite section	Acc	(mm^2)	1782544	1782544	1129502	1129502	1129502	1129502	1129502	1782544	1782544
	C_{1c}	(mm)	644.45	644.45	521.71	521.71	521.71	521.7	521.7	644.5	644.5
	C_{2c}	(mm)	1183.55	1183.55	1306.29	1306.29	1306.29	1306.3	1306.3	1183.5	1183.5
	C_{4c}	(mm)	644.45	644.45	521.71	521.71	521.71	521.7	521.7	644.5	644.5
	C_{3c}	(mm)	844.45	844	721.7	721.7	721.7	721.7	721.7	844.5	844.5
	Ic	(mm^4)	7.13E+11	7.13E+11	5.75E+11	5.75E+11	5.75E+11	5.75E+11	5.75E+11	7.13E+11	7.13E+11
	r^2	(mm^2)	400269.3	400269.3	508966.6	508966.6	508966.6	508966.6	508966.6	400269.3	400269.3

LOAD DIAGRAM FOR SELF WEIGHT



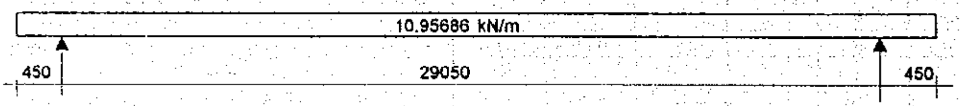
Reaction 275.4983 kN.

LOAD DIAGRAM FOR FALSE-WORK DEAD LOAD



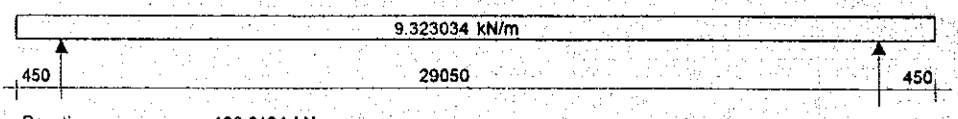
Reaction 34.81688 kN.

LOAD DIAGRAM FOR NON-COMPOSITE DEAD LOAD



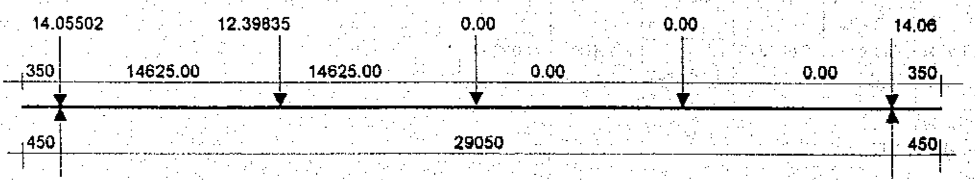
Reaction 164.079 kN.

LOAD DIAGRAM FOR COMPOSITE DEAD LOAD



Reaction 139.6124 kN.

LOAD DIAGRAM FOR CONCENTRATED LOAD FROM DIAPHRAGM



Reaction 20.25419 kN.

ANALYSIS MOR MOMENT

Section	Distance from end	Moment due to									Total Dead load Moment	Total Factored Moment
		Self wt M_O (a)	Cross Girder (Non-Composite dead load (b)	Non Composite dead load (c)	Composite dead load M_{DC} (d)	Live Load with Impact (e)	Live Load with Impact when wheel on Sidewalk (f)	Sidewalk Live Load (g)	Total (Non-Composite dead load) M_{OP} (b+c)	Falsework (Non-Composite dead load		
	(mm)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	450	-3.23	-1.41	-1.11	-0.94	0.00	0.00	0.00	-2.51	-0.24	-6.68	-8.69
2a	1364	222.17	4.26	139.78	118.93	54.11	282.10	72.02	144.04	29.66	485.14	997.41
3	2250	416.70	9.75	267.61	227.70	102.83	536.10	137.37	277.36	56.79	921.76	1895.22
4	7712.5	1315.84	43.62	865.75	736.66	322.04	1678.88	443.14	909.37	183.71	2961.86	6032.97
5	14975	1750.20	88.64	1154.71	982.52	413.26	2154.46	590.85	1243.34	245.02	3976.07	7969.69
6	22237.5	1315.84	43.62	865.75	736.66	322.04	1678.88	443.14	909.37	183.71	2961.86	6032.97
7	27700	416.70	9.75	267.61	227.70	102.83	536.10	137.37	277.36	56.79	921.76	1895.22
8	29500	-3.23	-1.41	-1.11	-0.94	0.00	0.00	0.00	-2.51	-0.24	-6.68	-8.69
9	29950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LOSSES

f_{ps} 144.20

Frictional loss per unit length 14.27407 kN/m,

For 8mm Anchorage draw in, x(dist. Of anchorage loss zone) 21.6768 mm,

ΔP_A 618.8313 kN,

Prestress force after friction losses (before elastic shortening) :-

- Tensioning end 5361 kN,
- Seating loss zone 5671 kN, No. of cable reqd 3.66
- Midspan 5575 kN,
- Dead end 5552 kN,

SUMMERY OF INITIAL LOSSES

Section	Distance from end	Jacking Force	Losses due to friction and anchorage pull-in	Prestress Force after friction loss (before elastic shortening)	Conc. Stress at the level of steel centroid at sec.of maxm. mom. (f_{cir})	Loss due to elastic shortening	Final initial loss (after immediate losses)	Final initial prestress force (after immediate losses) (Pi)
	(mm)	(kN)	(kN)	(kN)	(mPa)	(kN)	(kN)	(kN)
1	0		619	5361	3.956	60.14	679	5301
2	450		612	5368	4.052	61.60	674	5306
2a	1364		599	5381	4.292	65.25	665	5315
3	2250		587	5393	8.234	125.19	712	5268
4	7712.5	5980	509	5471	11.626	176.76	686	5294
5	14975		405	5575	14.445	219.61	625	5355
6	22237.5		317	5663	12.123	184.32	502	5478
7	27700		395	5585	8.538	129.81	525	5455
8	29500		421	5559	4.196	63.79	485	5495
9	29950		428	5552	4.097	62.29	490	5490

SUMMERY OF TIME-DEPENDENT & FINAL LOSSES

Section	Distance from end	Conc. Stress at the level of steel cg. Due to dead loads except self wt. (f_{cds})	Loss due to creep	Loss due to shrinkage	Loss due to relaxation of pre-stressing steel	Final Time dependent loss	Total loss	Loss in percent	Final effective pre-stress force (Pe)
	(mm)	(mPa)	(kN)	(kN)	(kN)	(kN)	(kN)		(kN)
1	0	0.000	206.15		316.77	678.63	1357.60	22.70	4622.40
2	450	-0.002	211.19		317.11	684.00	1358.01	22.71	4621.99
2a	1364	0.156	218.92		318.02	692.64	1357.26	22.70	4622.74
3	2250	0.551	412.36		259.15	827.21	1539.11	25.74	4440.89
4	7712.5	2.880	518.35		240.71	914.76	1600.27	26.76	4379.73
5	14975	4.602	612.88	155.70	235.77	1004.35	1629.04	27.24	4350.96
6	22237.5	2.880	544.24		289.91	989.86	1491.59	24.94	4488.41
7	27700	0.551	428.19		311.53	895.42	1420.62	23.76	4559.38
8	29500	-0.002	218.71		372.13	746.54	1231.42	20.59	4748.58
9	29950	0.000	213.51		371.84	741.05	1230.85	20.58	4749.15

EFFECT OF DIFFERENTIAL SHRINKAGE

Ultimate shrinkage co-efficient, ε_{SHU}	0.0008
Correction by humidity, (RH = 70) , $F_{SH,H}$	0.7
Assumed day of slab casting after girder concrete placed, t	60 days
Shrinkage of girder at t days, $\varepsilon_{SH,t}$	0.632
Differential (remaining) shrinkage, $\varepsilon_{SH,D}$	0.000206
Ultimate creep coefficient for girder, φ_{cgu}	2.6
Ultimate creep coefficient for slab, φ_{csu}	2.8
Correction by humidity for creep coefficient, (RH = 70), $F_{C,H}$	0.801
Remaining creep of girder after t days, φ_{cg}	0.961267
Remaining creep of slab, φ_{cs}	2.2428

Horizontal Shear & Bending Moment on contact surface of girder & slab due to Differential Shrinkage
At all section like mid section

m	B	C	F	φ_{cg}	φ_{cs}	Girder V_{SH}	Girder M_{SH}	Slab V_{SH}	Slab M_{SH}
		(m)	(m2)			(kN)	(kN-m)	(kN)	(kN-m)
229.237	230.237	-22.019	4.311	0.961	2.243	432.773	41.389	261.744	25.032

	Girder		Slab	
	Bottom	Top	Bottom	Top
Stress at concrete due to differential shrinkage	0.693	-1.905	0.637	0.489

Horizontal Shear & Bending Moment on contact surface of girder & slab due to Differential Shrinkage
At all section like end section

m	B	C	F	φ_{cg}	φ_{cs}	Girder V_{SH}	Girder M_{SH}	Slab V_{SH}	Slab M_{SH}
		(m)	(m2)			(kN)	(kN-m)	(kN)	(kN-m)
299.195	300.195	-29.138	5.060	0.961	2.243	557.921	54.154	337.435	32.753

	Girder		Slab	
	Bottom	Top	Bottom	Top
Stress at concrete due to differential shrinkage	0.887	-1.623	0.790	0.662

DESIGN FOR MOMENT AT MID SECTION

Total Jacking tension canbe taken by supplied cable (after jack loss) 5993.99 kN.

Initial Tension Maximum (1)	Initial Tension Maximum (2)	Can be taken by supplied Cable	Actual at mid Section	Total no. of Cable reqd.	Jacking Tension (after Jack loss)	Effective Tension at mid section	(Row) ρ	f_{ps}	a	Ultimate Design Moment	Ultimate Moment Capacity	Comment
(kN)	(kN)	(kN)	(kN)		(kN)	(kN)		(N/mm²)	(mm)	(kN-m)	(kN-m)	
6552	5424	5654	5355	3.66	5980	4351	0.000978	1805.817	132.28	7969.6891	13729.3	OK

PRESTRESSING REINFORCEMENT DETAILS

Total no. of cable reqd.	Total no. of duct used	Area factor	Total no. of strand in one cable	Dia of one strand	Area of One Strand	Area of One cable	Area of Total Cable (Ap)	Minimum inside diameter of Ducts	Outer diameter of Duct Provided	C/c Spacing of Ducts Reqd.	C/c Spacing of Ducts Allowed mid	C/c Spacing of Ducts Allowed end
(nos)	(nos)			(mm)	(mm2)	(mm2)	(mm2)	(mm)	(mm)	(mm)	(mm)	(mm)
3.55	4	3.666667	12	12.7	98.7	1184.40	4342.80	54.92	65	103.1	125	125

Reinforcement Index 0.058858 **OK against maxm. reinforcrment.**
Cracking Moment 3360.056 kN-m, **OK against minm. reinforcement.** 8072.42 9.91

STRESSES AT DIFFERENT LOCATION OF MID-SECTION OF GIRDER

	Initial Tension: Pi (alone)		Initial Tension: Pi+Mo (A)		Effective Tension: $P_e+M_o+M_{dp}$ (B)		$P_e+M_o+M_{dp}+M_{dc}$ (C)		$P_e+M_o+M_{dp}+M_{dc}+M_l$ +SH (D)		$0.5(P_e+M_o+M_{dp}+M_{dc})$ +Ml (E)		At top of Deck Slab	At bot. of D eck Slab
	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	(N/mm²)	(N/mm²)
Stress	5.15	-20.74	0.15	-16.22	-5.39	-6.99	-6.28	-4.76	-7.83	-3.87	-3.13	-1.79	-1.09	-0.49
All. stress			1.36	-16.50	-14.00	1.47	-14.00	1.47	-21.00	1.47	-14.00	1.47	-12	0.72
Comment			OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

CHECK AT MID SECTION FOR EXTERIOR GIRDER WHEN WHEEL ON SIDEWALK

	Effective Tension: $P_e+M_o+M_{dp}+M_{dc}+M_l$ +SH (D)		$0.5(P_e+M_o+M_{dp}+M_{dc})$ +Ml (E)		At top of Deck Slab	At bot. of D eck Slab
	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	(N/mm²)	(N/mm²)
Stress	-9.41	0.09	-4.71	2.17	-3.11	-1.96
All. stress	-31.50	2.21	-21.00	2.21	-18	1.07
Comment	OK	OK	OK	OK	OK	OK

Factor of safety against cracking 8.13

CABLE LAYOUT

Total no. of Row at mid Section 2	Row 1	Row 2						
No. of Cable in	3	1						
Area factor	3	0.666667						
Cumilitive No.	3	4	0	0	0	0	0	0	0
Maxm. no. of cable allowed	5	5	5	5	5	5	5	5	5
Distance between Row	95	125							
Cumilitive distance	95	220	0	0	0	0	0	0	0
Distance of C.G. from bot. face of girder	117.73								
Eccentricity for non composite section	805.6555								
Eccentricity for Composite section	1188.56								
Total no. of Row at end Section 4	**Row 1**	**Row 2**	**Row 3**	**Row 4**					
No. of Cable in	1	1	1	1					
Area factor	1	1	1	0.666667					
Maxm. no. of cable allowed									
Distance between Row	418	350	350	350					
Cumilitive distance	418	768	1118	1468	0	0	0	0	0
Distance of C.G. from bot. face of girder	895.3								
Eccentricity for non composite section	51.23								
Eccentricity for Composite section	288.28								

STRESSES AT DIFFERENT LOCATION OF GIRDER

Cable No.	Mention Row No. at end section	Ordinates from bottom at end section (mm)	At mid section (mm)	at following distances from end 450 (mm)	2250 (mm)	7712.5 (mm)	14975 (mm)	22237.5 (mm)	27700 (mm)	29500 (mm)	1364 (mm)		
1	1	418	95	398.88	328.23	170.97	95.00	170.97	328.23	398.88	361.84	29959.29	**30659.29**
2	2	768	95	728.16	580.96	253.29	95.00	253.29	580.96	728.16	650.98	29990.33	**30690.33**
3	3	1118	95	1057.44	833.68	335.61	95.00	335.61	833.68	1057.44	940.13	30043.18	**30743.18**
4	4	1468	220	1394.12	1121.15	513.53	220.00	513.53	1121.15	1394.12	1251.01	30088.68	**30788.68**
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**122881.5**
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Dist. of cg from bot.		895.27	117.73	849.24	679.17	300.61	117.73	300.61	679.17	849.24	760.08		
C1p		881.49	904.62	881.49	904.62	904.62	904.62	904.62	904.62	881.49	881.49		
C2p		946.51	923.38	946.51	923.38	923.38	923.38	923.38	923.38	946.51	946.51		
C1c		644.45	521.71	644.45	521.71	521.71	521.71	521.71	521.71	644.45	644.45		
C2c		1183.55	1306.29	1183.55	1306.29	1306.29	1306.29	1306.29	1306.29	1183.55	1183.55		
C3c		844.45	721.71	844.45	721.71	721.71	721.71	721.71	721.71	844.45	844.45		
C4c		644.45	521.71	644.45	521.71	521.71	521.71	521.71	521.71	644.45	644.45		
Acp		1352038	698996	1352038	698996	698996	698996	698996	698996	1352038	1352038		
Acc		1782544	1129502	1782544	1129502	1129502	1129502	1129502	1129502	1782544	1782544		
Icp		3.98E+11	3.05E+11	3.98E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.98E+11	3.98E+11		
Icc		7.13E+11	5.75E+11	7.13E+11	5.75E+11	5.75E+11	5.75E+11	5.75E+11	5.75E+11	7.13E+11	7.13E+11		
ep		51.23	805.66	97.26	244.21	622.78	805.66	622.78	244.21	97.26	186.43		
ec		288.28	1188.56	334.30	627.12	1005.68	1188.56	1005.68	627.12	334.30	423.47		
r_p^2		294002	435708	294002	435708	435708	435708	435708	435708	294002	294002		
For Load case (A) stresses at	top fibre	Allowable stresses		-2.801	-5.032	-1.620	0.154	-1.540	-5.166	-2.901			
	bot fibre	Tension	**1.36**	-5.214	-10.417	-14.115	-16.221	-14.748	-10.831	-5.399			
	comment	Compn.	**-16.50**	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
For Load case (B) stresses at	top fibre	Allowable stresses		-2.37	-5.45	-5.28	-5.39	-5.23	-5.40	-2.43			
	bot fibre	Tension	**1.47**	-4.46	-7.32	-7.19	-6.99	-7.55	-7.58	-4.58			
	comment	Compn.	**-14.00**	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
For Load case (C) stresses at	top fibre	Allowable stresses		-2.32	-5.61	-5.90	-6.24	-5.86	-5.57	-2.39			
	bot fibre	Tension	**1.47**	-4.42	-6.76	-5.47	-4.72	-5.83	-7.02	-4.54			
	comment	Compn.	**-14.00**	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
For Load case (D) stresses at	top fibre	Allowable stresses		-3.95	-7.44	-7.55	-7.79	-7.51	-7.40	-4.01			
	bot fibre	Tension	**1.47**	-3.53	-6.01	-4.61	-3.83	-4.97	-6.27	-3.66			
	comment	Compn.	**-21.00**	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
	top of slab	Allowable stresses		0.66	0.11	-0.74	-1.13	-0.74	0.11	0.66			
	bot of slab	Tension	**0.72**	0.79	0.36	-0.25	-0.54	-0.25	0.36	0.79			
	comment	Compn.	**-12.00**	OK-NOK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-NOK			
For Load case (E) s-tresses at	top fibre	Allowable stresses		-1.16	-2.75	-2.97	-3.13	-2.95	-2.79	-1.19			
	bot fibre	Tension	**1.47**	-2.21	-3.23	-2.28	-1.79	-2.46	-3.36	-2.27			
	comment	Compn.	**-14.00**	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			

TENSION REINFORCEMENT

Yield strength of rebar 414 Mpa, Allowable strength iof rebar 165.6 Mpa,

On Girder top for Girder casting

Stress at		Depth of	Total	Rebar	Dia. of	No. of
Top fibre	Bot. fibre	ten. Area	tension	Area reqd.	Rebar	rebar reqd.
(Mpa)	(Mpa)	(mm)	(kN)	(mm^2)	(mm)	
0.154	-16.221	17.16	1.41	8.48	12	0.08

On Girder bottom for service load

Stress at		Depth of	Total	Rebar	Dia. of	No. of
Top fibre	Bot. fibre	ten. Area	tension	Area reqd.	Rebar	rebar reqd.
(Mpa)	(Mpa)	(mm)	(kN)	(mm^2)	(mm)	
-3.131	-1.791	0.00	#VALUE!	#VALUE!	20	#VALUE!

DESIGN FOR SHEAR

Yield strength of rebar 276 Mpa, Allowable strength iof rebar 124.2 Mpa,

ANALYSIS FOR SHEAR

Section	Distance from end	Shear due to								
		Self wt V_O (a)	Cross Girder (Non-Composite dead load (b)	Non Composite dead load (c)	Composite dead load V_{DC} (d)	Live Load with Impact (e)	Live Load with Impact when wheel on Sidewalk (f)	Sidewalk Live Load (g)	Total Dead Load	Factored Design Shear V_U
	(mm)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)
2	450	261.16	6.199	159.148	135.417	61.35	319.85	0.27	561.93	1146.31
2a	1364	232.04	6.199	149.134	126.896	59.36	309.48	0.25	514.27	1070.88
3	2250	209.59	6.199	139.426	118.636	57.43	299.40	0.23	473.85	1005.22
4	7712.5	119.62	6.199	79.574	67.709	45.34	236.39	0.15	273.10	662.34
5	14975	0.00	6.199	0.000	0.000	28.74	149.84	0.07	6.20	202.86
6	22237.5	119.62	6.199	79.574	67.709	45.34	236.39	0.15	273.10	662.34
7	27700	209.59	6.199	139.426	118.636	57.43	299.40	0.23	473.85	1005.22
8	29500	261.16	6.199	159.148	135.417	61.35	319.85	0.27	561.93	1146.31

Section	Distance from end	Diameter of stirrup	No. of Leg	Effective depth for Shear (d)	f2p (stress in the conc. due to Pe) (N/mm^2)	fo (tensile stress at bot.due to self wt.) (N/mm^2)	Mcr (moment causing flexural crack) (kN-m)	Vci (kN)	Vp (kN)	Vcw (kN)	Vc (shear strength provided by conc.) (kN)	Spacing Reqd. (mm)
2	450	12	2	1462	-4.48895	-0.0077	3126.27	560596	472.76	1287.63	1287.63	337
2a	1364	12	2	1462	-5.471164	0.5290	3313.38	3916.44	458.19	1273.11	1273.11	337
3	2250	12	2	1462	-9.641334	1.2634	3735.44	2319.36	426.52	1502.76	1502.76	337
4	7712.5	12	2	1527	-14.53549	3.9895	4450.53	732.87	337.70	1453.63	732.87	344
5	14975	12	2	1710	-16.85247	5.3064	4780.37	289.94	225.91	1471.17	289.94	364
6	22237.5	12	2	1527	-14.89616	3.9895	4569.49	746.82	346.08	1476.47	746.82	344
7	27700	12	2	1462	-9.898593	1.2634	3820.29	2365.29	437.90	1529.24	1529.24	337
8	29500	12	2	1462	-4.611895	-0.0077	3177.91	569860	485.71	1308.92	1308.92	337

HORIZONTAL SHEAR TRANSFER

Section	Distance from end (mm)	Effective depth for Shear (d) (mm)	Contact surface width (mm)	Factored Design Shear (kN)	Allowable shear strength (ϕVnh) (kN)	Comment	Diameter of stirrup (mm)	No. of Leg	Minimum spacing required (mm)
2	450	979	1066	1146.31	2263	O.K.	16	2	301.78
3	2250	1149	1066	1005.22	2656	O.K.	16	2	301.78
4	7712.5	1527	1066	662.34	3532	O.K.	16	2	301.78
5	14975	1710	1066	202.86	3954	O.K.	16	2	301.78
6	22237.5	1527	1066	662.34	3532	O.K.	16	2	301.78
7	27700	1149	1066	1005.22	2656	O.K.	16	2	301.78
8	29500	979	1066	1146.31	2263	O.K.	16	2	301.78

ELONGATION OF CABLE

Outside jack cable length (assumed), l_j = 700 mm,

Dead anchor width, l_a = 70 mm,

Cable stress at jack (after jack loss), f_j' = 1377 N/mm^2,

Cable stress at dead anchor, f_{LP} = 1264 N/mm^2,

Average cable length of anchor to anchor, L_p = 30004 mm,

Average elongation of cables by one side jacking, ΔL_p = 211 mm,

ANCHORAGE ZONE DESIGN

Minimum longitudinal extent of anchorage zone = 1066 mm,
Maximum longitudinal extent of anchorage zone = 1599 mm,
Selected longitudinal extent of anchorage zone = 1500 mm,

- DESIGN of GENERAL ZONE

α, angle of inclination of the resultant of the tendon = 5.93 deg,

Size of bearing plate	Thickness of bearing plate	Diameter of cone	Effective bearing area (Ab)	Factored tandon load	Total factored tendon load	C/c spacing of anchorage	Longitudinal extent of local zone (lc)	Correction factor (k)	Concrete compressive stress (fca)	Allowable Concrete compressive stress	Comment
(mm)	(mm)	(mm)	(mm²)	(kN)	(kN)	(mm)	(mm)		(Mpa)	(Mpa)	
230	35	152	49581.69	1957.091	7176	350	264.5	1.271	16.93	21	O.K.

DESIGN FOR VERTICAL DIRECTION

Cable no.	1	2	3	4	0	0	0	0	0	0	0
Eccentricity	528.51	178.51	171.49	521.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
dburst	658.44	827.68	831.07	661.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Reinforcement distribution distance	=	1861.895 mm,	Maximum = 2742 mm,
Bursting force, Tburst	=	1938.884 kN,	
Area of reinforcement required for bursting force	=	5509.758 mm²,	
Diameter of bursting stirrup	=	16 mm,	
Total no of 2 legged stirrup required	=	13.70 nos.,	

DESIGN FOR HORIZONTAL DIRECTION

Eccentricity (e)	Lateral dimension (h)	Angle of tendon (α)	Bursting distance (dburst)	Bursting force (Tburst)	Area of rebar required	Dia. Of rebar	No. of rebar reqd	Rebar distribution distance
(mm)	(mm)	(deg)	(mm)	(kN)	(mm²)	(mm)		(mm)
0	711	0	355.5	1213.662	3448.884	16	8.58	888.75

DESIGN FOR EDGE TENSION

Spalling force (Tspal)	Area of rebar required	Dia. Of rebar	No. of rebar reqd
(kN)	(mm²)	(mm)	
143.52	408	12	0.05

DEFLECTION CALCULATION

Deflection due to						Instantaneous Deflection	Deflection at erection	Long-time Deflection	Live load	Live load rotation at support
Initial Prestress	Effective Prestress	Self wt. (at initial period)	Self wt. (after 28 days)	Non-composite dead load	Composite dead load					
(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(rad.)
45.5	37.0	-18.322	-18.96	-12.1	-5.0	27.2	48.0	-2.3	-1.8	0.000298

DESIGN OF RIGHT EXTERIOR PRESTRESSED GIRDER
(Dead load from curb/rail/pedestal equally distributed on girder)

DESIGNED BY : PRASANTA KUMAR BHOWMIK

GENERAL

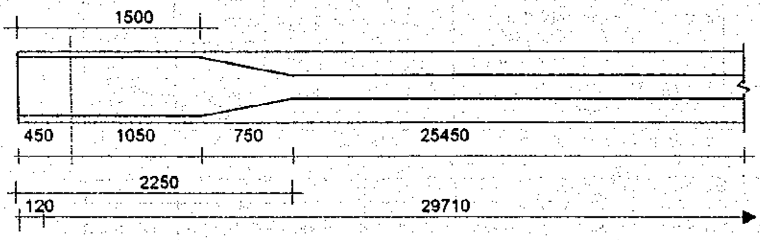
Total Length of one Girder	29950	mm,
Distance of center of Bearing from end of Girder	450	mm,
Span of Girder	29050	mm,
Distance of center of Diaphragm from end of Girder	350	mm,
C/c. spacing between girders	2500	mm,
Effective width of sidewalk	0	mm,
Fraction of wheel load on Girder	1.201	
Fraction of wheel load on girder when wheel over sidewalk	1.445	
Live Load Magnitude	HS 20	
Put 1.0 or 2.0 for **Deck** type		
Mention AASHTO or WASHINGTON Pattern	AASHTO	
Mention Type	6	
Mention end section 1 or 2?	2	
Anchorage indent	120	mm,
Tensile Stress due to temparature change	0.0423	Mpa,

DIAPHRAGM DETAILS

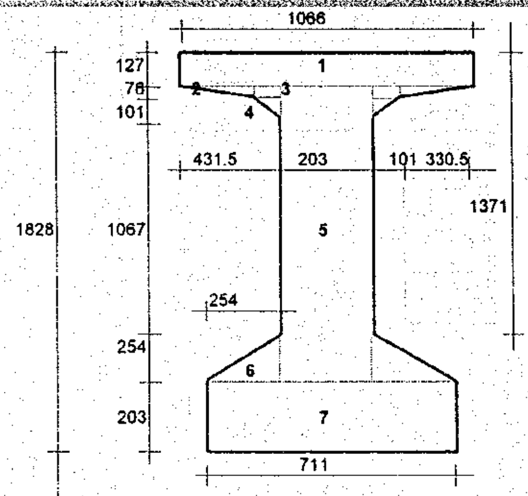
Total no. of interior diaphragm reqd	2	
Total no. of interior diaphragm provided	1	
Width of diaphragm	300	mm,
Depth of end diaphragm	1887	mm,
Depth of interior diaphragm	1625	mm,
Wt. of exterior diaphragm	14.06	kN,
Wt. of interior diaphragm	12.40	kN,

NOTE: In designing this girder following references are followed :
1. AASHTO - 16th edition, 1996.
2. Design of Prestressed Concrete, 2nd edition, by : Arthur H. Nilson.
3. Design of Prestressed Concrete Structure, 3rd edition, by : T. Y. Lin & Ned H. Burns.

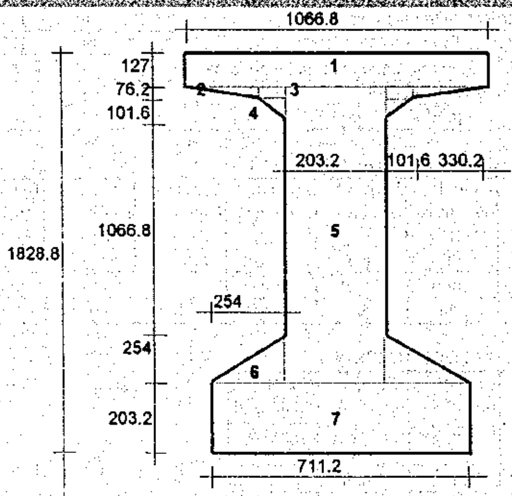
All notations are followed from reference-2



GIRDER SECTION



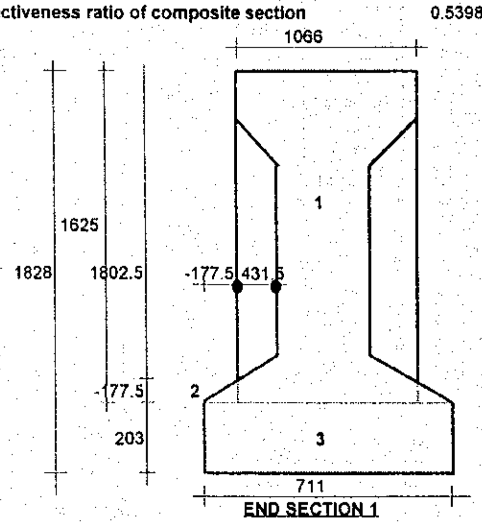
SECTION OF GIRDER IN USE



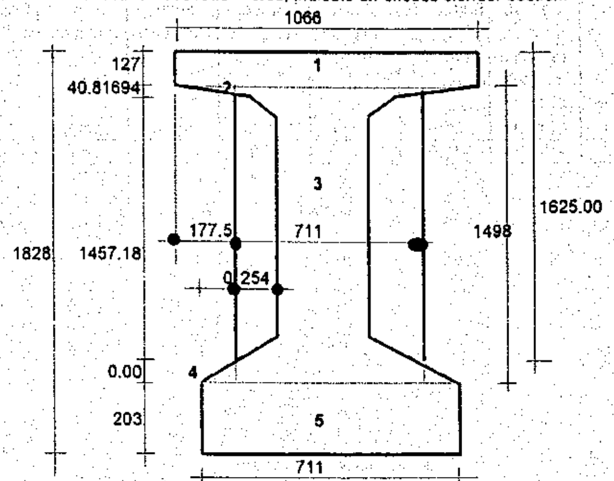
SECTION OF STANDARD GIRDER

Effectiveness ratio of non-composite section	0.521613
Effectiveness ratio of composite section	0.539867

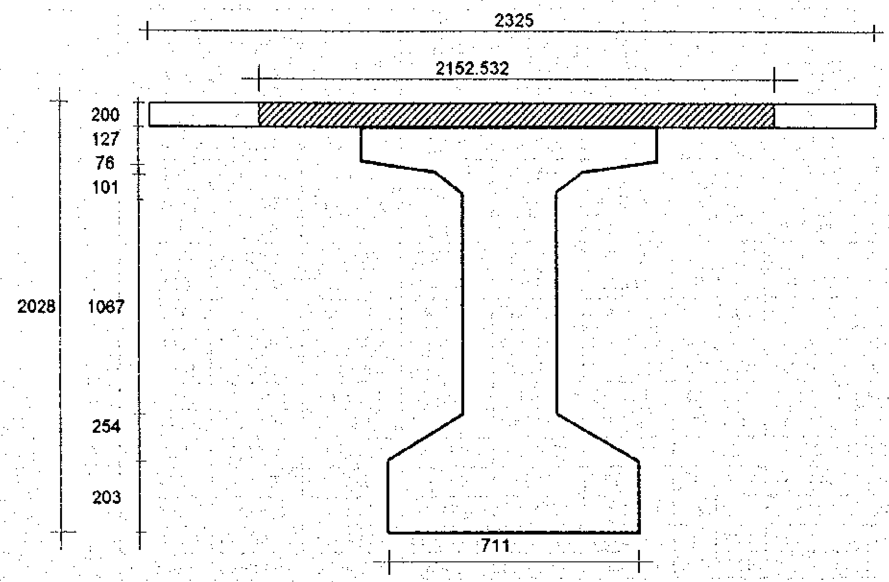
Note : *For effectiveness ratio < 0.45, indicate too heavy a section*
For effective ness ratio > 0.55, indicate an excess slender section.



END SECTION 1



END SECTION 2



COMPOSITE SECTION

PROPERTIES OF PRECAST MIDDLE SECTION

Segment	Area	Distance of CG from Top C_{1P}	Distance of CG from Bottom C_{2P}	Moment of Inertia of Components I_O	Moment of Inertia of Block Ic	Radius of Gyration r^2
	mm^2	mm	mm	mm^4	mm^4	mm^2
1	135382			1.82E+08		
2	12559			4030044		
3	7676			3694715		
4	5100.5	904.62	923.38	2890567	3.05E+11	435707.6
5	304094			5.69E+10		
6	32258			1.16E+08		
7	144333			4.96E+08		
Total	698996					

Weight per linear metre = 16.47 kN/m.

PROPERTIES OF PRECAST END SECTION

Segment	Area	Distance of CG from Top C1P	Distance of CG from Bottom C2P	Moment of Inertia of Components IO	Moment of Inertia of Block Ic	Radius of Gyration r2
	mm2	mm	mm	mm4	mm4	mm2
1	135382			1.82E+08		
2	3623			335287		
3	1065078	881.49	946.51	1.99E+11	3.98E+11	294002
4	0			0		
5	144333			4.96E+08		
Total	1352038					

Weight per linear metre = 31.86 kN/m.

PROPERTIES OF EQUIVALENT COMPOSITE SECTION AT MIDDLE

Segment	Area	Distance of CG of Composite section from Top of precast section C_{1C}	Bot. of precast section C_{2C}	Bottom of Slab C_{4C}	Top of Slab C_{3C}	Moment of Inertia of Components I_O	Moment of Inertia of Block Ic	Radius of Gyration r^2
	mm^2	mm	mm	mm	mm	mm^4	mm^4	mm^2
Precast Section	698996	521.7104	1306.290	521.7104	721.7104	3.05E+11	5.75E+11	508966.6
Eqv. Slab	430506.3					1.44E+09		
Total	1129502							

Weight per linear ft. = 26.61 kN/m.

PROPERTIES OF EQUIVALENT COMPOSITE SECTION AT END

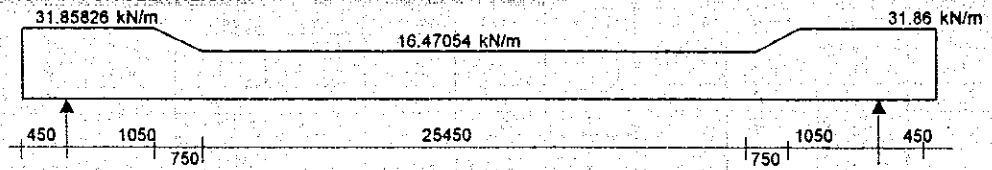
Segment	Area	Distance of CG of Composite section from Top of precast section C_{1C}	Bot. of precast section C_{2C}	Bottom of Slab C_{4C}	Top of Slab C_{3C}	Moment of Inertia of Components I_O	Moment of Inertia of Block Ic	Radius of Gyration r^2
	mm^2	mm	mm	mm	mm	mm^4	mm^4	mm^2
Precast Section	1352038	644.4519	1183.548	644.4519	844.4519	3.98E+11	7.13E+11	400269.3
Eqv. Slab	430506.3					1.44E+09		
Total	1782544							

Weight per linear ft. = 42.00 kN/m.

SUMMERY OF SECTION PROPERTIES AT DIFFERENT LOCATIONS

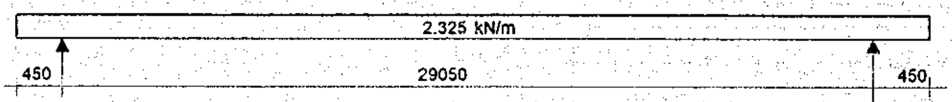
Section			1	2	3	4	5	6	7	8	9
Distance from end		(mm)	0	450.00	2250	7712.5	14975	22237.5	27700	29500	29950
Total area of duct		(mm)	13273.23	13273.23	13273.23	13273.23	13273.23	13273.23	13273.229	13273.23	13273.23
Dist.of c.g. of duct from bot.		(mm)	895.27	849.24	679.17	300.61	117.73	300.61	679.17	849.24	895.27
Duct deducted properties of noncomposite section	Acp	(mm)	1338765	1338765	685723	685723	685723	685723	685723	1338765	1338765
	C_{1P}	(mm)	880.99	880.53	899.89	892.56	889.02	892.56	899.89	880.53	880.99
	C_{2P}	(mm)	947.01	947.47	928.11	935.44	938.98	935.44	928.11	947.47	947.01
	Ic	(mm^4)	3.97E+11	3.97E+11	3.04E+11	2.99E+11	2.96E+11	2.99E+11	3.04E+11	3.97E+11	3.97E+11
	r^2	(mm^2)	296888	296819	442937	436335	431081	436335	442937	296819	296888
Duct grouted properties of noncomposite section	Acp	(mm^2)	1352038	1352038	698996	698996	698996	698996	698996	1352038	1352038
	C_{1P}	(mm)	881.49	881.49	904.62	904.62	904.62	904.62	904.62	881.49	881.49
	C_{2P}	(mm)	946.51	946.51	923.38	923.38	923.38	923.38	923.38	946.51	946.51
	Ic	(mm^4)	3.98E+11	3.98E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.98E+11	3.98E+11
	r^2	(mm^2)	294002	294002	435707.6	435707.6	435707.6	435707.6	435707.6	294002.2	294002.2
Duct grouted properties of composite section	Acc	(mm^2)	1782544	1782544	1129502	1129502	1129502	1129502	1129502	1782544	1782544
	C_{1c}	(mm)	644.45	644.45	521.71	521.71	521.71	521.7	521.7	644.5	644.5
	C_{2c}	(mm)	1183.55	1183.55	1306.29	1306.29	1306.29	1306.3	1306.3	1183.5	1183.5
	C_{4c}	(mm)	644.45	644.45	521.71	521.71	521.71	521.7	521.7	644.5	644.5
	C_{3c}	(mm)	844.45	844	721.7	721.7	721.7	721.7	721.7	844.5	844.5
	Ic	(mm^4)	7.13E+11	7.13E+11	5.75E+11	5.75E+11	5.75E+11	5.75E+11	5.75E+11	7.13E+11	7.13E+11
	r^2	(mm^2)	400269.3	400269.3	508966.6	508966.6	508966.6	508966.6	508966.6	400269.3	400269.3

LOAD DIAGRAM FOR SELF WEIGHT



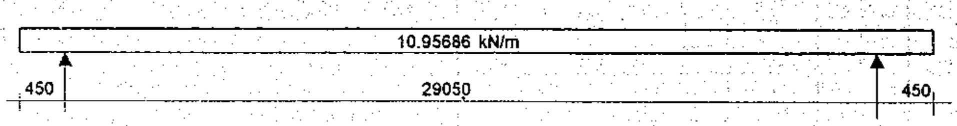
Reaction 275.4983 kN,

LOAD DIAGRAM FOR FALSE-WORK DEAD LOAD



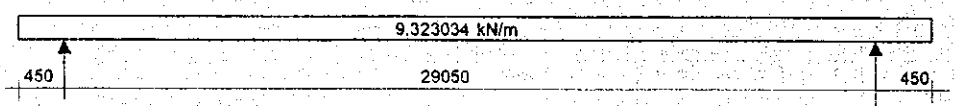
Reaction 34.81688 kN,

LOAD DIAGRAM FOR NON-COMPOSITE DEAD LOAD



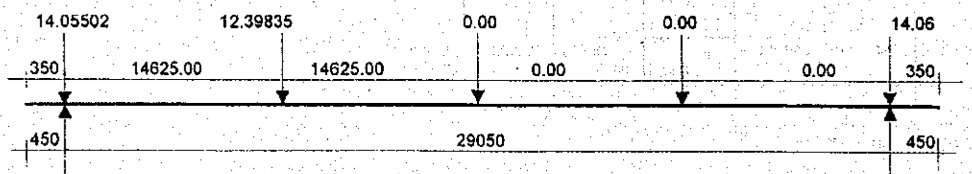
Reaction 164.079 kN,

LOAD DIAGRAM FOR COMPOSITE DEAD LOAD



Reaction 139.6124 kN,

LOAD DIAGRAM FOR CONCENTRATED LOAD FROM DIAPHRAGM



Reaction 20.25419 kN,

ANALYSIS FOR MOMENT

Section	Distance from end	Moment due to									Total Dead load Moment	Total Factored Moment
		Self wt M_O (a)	Cross Girder (Non-Composite dead load (b)	Non Composite dead load (c)	Composite dead load M_{DC} (d)	Live Load with Impact (e)	Live Load with Impact when wheel on Sidewalk (f)	Sidewalk Live Load (g)	Total (Non-Composite dead load) M_{DP} (b+c)	Falsework (Non-Composite dead load		
	(mm)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)	(kN-m)
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	450	-3.23	-1.41	-1.11	-0.94	0.00	0.00	0.00	-2.51	-0.24	-6.68	-8.69
2a	1364	222.17	4.26	139.78	118.93	187.71	225.83	0.00	144.04	29.66	485.14	1038.20
3	2250	416.70	9.75	267.61	227.70	356.72	429.16	0.00	277.36	56.79	921.76	1972.73
4	7712.5	1315.84	43.62	865.75	736.66	1117.12	1343.97	0.00	909.37	183.71	2961.86	6275.69
5	14975	1750.20	88.64	1154.71	982.52	1433.57	1724.68	0.00	1243.34	245.02	3976.07	8281.17
6	22237.5	1315.84	43.62	865.75	736.66	1117.12	1343.97	0.00	909.37	183.71	2961.86	6275.69
7	27700	416.70	9.75	267.61	227.70	356.72	429.16	0.00	277.36	56.79	921.76	1972.73
8	29500	-3.23	-1.41	-1.11	-0.94	0.00	0.00	0.00	-2.51	-0.24	-6.68	-8.69
9	29950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LOSSES

r_{ps} 144.20
Frictional loss per unit length 14.27407 kN/m,
For 8mm Anchorage draw in, x(dist. Of anchorage loss zone) 21.6768 mm,
ΔP_A 618.8313 kN,
Prestress force after friction losses (before elastic shortening) :-
Tensioning end 5361 kN,
Seating loss zone 5671 kN, No. of cable reqd 3.66
Midspan 5575 kN,
Dead end 5552 kN,

SUMMERY OF INITIAL LOSSES

Section	Distance from end	Jacking Force	Losses due to friction and anchorage pull-in	Prestress Force after friction loss (before elastic shortening)	Conc. Stress at the level of steel centroid at sec.of maxm. mom. (f_{cir})	Loss due to elastic shortening	Final initial loss (after immediate losses)	Final initial prestress force (after immediate losses) (Pi)
	(mm)	(kN)	(kN)	(kN)	(mPa)	(kN)	(kN)	(kN)
1	0		619	5361	3.956	60.14	679	5301
2	450		612	5368	4.052	61.60	674	5306
2a	1364		599	5381	4.292	65.25	665	5315
3	2250		587	5393	8.234	125.19	712	5268
4	7712.5	5980	509	5471	11.626	176.76	686	5294
5	14975		405	5575	14.445	219.61	625	5355
6	22237.5		317	5663	12.123	184.32	502	5478
7	27700		395	5585	8.538	129.81	525	5455
8	29500		421	5559	4.196	63.79	485	5495
9	29950		428	5552	4.097	62.29	490	5490

SUMMERY OF TIME-DEPENDENT & FINAL LOSSES

Section	Distance from end	Conc. Stress at the level of steel cg. Due to dead loads except self wt. (f_{cds})	Loss due to creep	Loss due to shrinkage	Loss due to relaxation of prestressing steel	Final Time dependent loss	Total loss	Loss in percent	Final effective pre-stress force (Pe)
	(mm)	(mPa)	(kN)	(kN)	(kN)	(kN)	(kN)		(kN)
1	0	0.000	206.15		316.77	678.63	1357.60	22.70	4622.40
2	450	-0.002	211.19		317.11	684.00	1358.01	22.71	4621.99
2a	1364	0.156	218.92		318.02	692.64	1357.26	22.70	4622.74
3	2250	0.551	412.36		259.15	827.21	1539.11	25.74	4440.89
4	7712.5	2.880	518.35		240.71	914.76	1600.27	26.76	4379.73
5	14975	4.602	612.88	155.70	235.77	1004.35	1629.04	27.24	4350.96
6	22237.5	2.880	544.24		289.91	989.86	1491.59	24.94	4488.41
7	27700	0.551	428.19		311.53	895.42	1420.62	23.76	4559.38
8	29500	-0.002	218.71		372.13	746.54	1231.42	20.59	4748.58
9	29950	0.000	213.51		371.84	741.05	1230.85	20.58	4749.15

EFFECT OF DIFFERENTIAL SHRINKAGE

Ultimate shrinkage co-efficient, ε_{SHU}	0.0008
Correction by humidity, (RH = 70) , $F_{SH,H}$	0.7
Assumed day of slab casting after girder concrete placed, t	60 days
Shrinkage of girder at t days, $\varepsilon_{SH,t}$	0.632
Differential (remaining) shrinkage, $\varepsilon_{SH,O}$	0.000206
Ultimate creep coefficient for girder, φ_{cgu}	2.6
Ultimate creep coefficient for slab, φ_{csu}	2.8
Correction by humidity for creep coefficient, (RH = 70), $F_{C,H}$	0.801
Remaining creep of girder after t days, φ_{cg}	0.961267
Remaining creep of slab, φ_{cs}	2.2428

Horizontal Shear & Bending Moment on contact surface of girder & slab due to Differential Shrinkage
At all section like mid section

m	B	C	F	φ_{cg}	φ_{cs}	Girder		Slab	
						V_{SH}	M_{SH}	V_{SH}	M_{SH}
		(m)	(m2)			(kN)	(kN-m)	(kN)	(kN-m)
229.237	230.237	-22.019	4.311	0.961	2.243	432.773	41.389	261.744	25.032

	Girder		Slab	
	Bottom	Top	Bottom	Top
Stress at concrete due to differential shrinkage	0.693	-1.905	0.637	0.489

Horizontal Shear & Bending Moment on contact surface of girder & slab due to Differential Shrinkage
At all section like end section

m	B	C	F	φ_{cg}	φ_{cs}	Girder		Slab	
						V_{SH}	M_{SH}	V_{SH}	M_{SH}
		(m)	(m2)			(kN)	(kN-m)	(kN)	(kN-m)
299.195	300.195	-29.138	5.060	0.961	2.243	557.921	54.154	337.435	32.753

	Girder		Slab	
	Bottom	Top	Bottom	Top
Stress at concrete due to differential shrinkage	0.887	-1.623	0.790	0.662

DESIGN FOR MOMENT AT MID SECTION

Total Jacking tension canbe taken by supplied cable (after jack loss) 5993.99 kN,

Initial Tension				Total	Jacking	Effective	(Row) p	f_{ps}	a	Ultimate	Ultimate	Comment
Maximum (1)	Maximum (2)	Can be taken by supplied Cable	Actual at mid Section	no. of Cable reqd.	Tension (after Jack loss)	Tension at mid section				Design Moment	Moment Capacity	
(kN)	(kN)	(kN)	(kN)		(kN)	(kN)		(N/mm²)	(mm)	(kN-m)	(kN-m)	
6552	5424	5654	5355	3.66	**5980**	4351	0.000978	1805.817	132.28	8281.1696	13729.3	OK

PRESTRESSING REINFORCEMENT DETAILS

Total no. of cable reqd.	Total no. of duct used	Area factor	Total no. of strand in one cable	Dia of one strand	Area of			Minimum inside diameter of Ducts	Outer diameter of Duct Provided	C/c. Spacing of Ducts		
					One Strand	One cable	Total Cable (Ap)			Reqd.	Allowed mid	Allowed end
(nos)	(nos)			(mm)	(mm2)	(mm2)	(mm2)	(mm)	(mm)	(mm)	(mm)	(mm)
3.55	4	3.666667	12	12.7	98.7	1184.40	4342.80	54.92	65	103.1	125	125

Reinforcement Index 0.058858 **OK against maxm. reinforcrment.**
Cracking Moment 3360.056 kN-m, **OK against minm. reinforcement.**

8072.42	2.86

STRESSES AT DIFFERENT LOCATION OF MID-SECTION OF GIRDER

	Initial Tension				Effective Tension									
	Pi (alone)		Pi+Mo (A)		$P_e+M_o+M_{dp}$ (B)		$P_e+M_o+M_{dp}+M_{dc}$ (C)		$P_e+M_o+M_{dp}+M_{dc}+M_l$ +SH (D)		$0.5(P_e+M_o+M_{dp}+M_{dc})$ +Ml (E)		At top of Deck Slab	At bot. of D eck Slab
	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	(N/mm²)	(N/mm²)
Stress	5.15	-20.74	0.15	-16.22	-5.39	-6.99	-6.28	-4.76	-8.76	-1.55	-4.06	0.53	-2.28	-1.35
All. stress			1.36	-16.50	-14.00	1.47	-14.00	1.47	-21.00	1.47	-14.00	1.47	-12	0.72
Comment			OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

CHECK AT MID SECTION FOR EXTERIOR GIRDER WHEN WHEEL ON SIDEWALK

	Effective Tension					
	$P_e+M_o+M_{dp}+M_{dc}+M_l$ +SH (D)		$0.5(P_e+M_o+M_{dp}+M_{dc})$ +Ml (E)		At top of Deck Slab	At bot. of D eck Slab
	Top (N/mm²)	Bottom (N/mm²)	Top (N/mm²)	Bottom (N/mm²)	(N/mm²)	(N/mm²)
Stress	0.00	0.00	0.00	0.00	0.00	0.00
All. stress	-31.50	2.21	-21.00	2.21	-18	1.07
Comment	OK	OK	OK	OK	OK	OK

Factor of safety against cracking 2.34

CABLE LAYOUT

Total no. of Row at mid Section	Row 1	Row 2							
2									
No. of Cable in	3	1							
Area factor	3	0.666667							
Cumilitive No.	3	4	0	0	0	0	0	0	0
Maxm. no. of cable allowed	5	5	5	5	5	5	5	5	5
Distance between Row	95	125							
Cumilitive distance	95	220	0	0	0	0	0	0	0
Distance of C.G. from bot. face of girder	117.73								
Eccentricity for non composite section	805.6555								
Eccentricity for Composite section	1188.56								
Total no. of Row at end Section	**Row 1**	**Row 2**	**Row 3**	**Row 4**					
4									
No. of Cable in	1	1	1	1					
Area factor	1	1	1	0.666667					
Maxm. no. of cable allowed									
Distance between Row	418	350	350	350					
Cumilitive distance	418	768	1118	1468	0	0	0	0	0
Distance of C.G. from bot. face of girder	895.3								
Eccentricity for non composite section	51.23								
Eccentricity for Composite section	288.28								

STRESSES AT DIFFERENT LOCATION OF GIRDER

Cable No.	Mention Row No. at end section	at end section (mm)	At mid section (mm)	450 (mm)	2250 (mm)	7712.5 (mm)	14975 (mm)	22237.5 (mm)	27700 (mm)	29500 (mm)	1364 (mm)		
		Ordinates from bottom		at following distances from end									
1	1	418	95	398.88	328.23	170.97	95.00	170.97	328.23	398.88	361.84	29959.29	30659.29
2	2	768	95	728.16	580.96	253.29	95.00	253.29	580.96	728.16	650.98	29990.33	30690.33
3	3	1118	95	1057.44	833.68	335.61	95.00	335.61	833.68	1057.44	940.13	30043.18	30743.18
4	4	1468	220	1394.12	1121.15	513.53	220.00	513.53	1121.15	1394.12	1251.01	30088.68	30788.68
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		122881.5
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0		0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Dist. of cg from bot.		895.27	117.73	849.24	679.17	300.61	117.73	300.61	679.17	849.24	760.08		
C1p		881.49	904.62	881.49	904.62	904.62	904.62	904.62	904.62	881.49	881.49		
C2p		946.51	923.38	946.51	923.38	923.38	923.38	923.38	923.38	946.51	946.51		
C1c		644.45	521.71	644.45	521.71	521.71	521.71	521.71	521.71	644.45	644.45		
C2c		1183.55	1306.29	1183.55	1306.29	1306.29	1306.29	1306.29	1306.29	1183.55	1183.55		
C3c		844.45	721.71	844.45	721.71	721.71	721.71	721.71	721.71	844.45	844.45		
C4c		644.45	521.71	644.45	521.71	521.71	521.71	521.71	521.71	644.45	644.45		
Acp		1352038	698996	1352038	698996	698996	698996	698996	698996	1352038	1352038		
Acc		1782544	1129502	1782544	1129502	1129502	1129502	1129502	1129502	1782544	1782544		
Icp		3.98E+11	3.05E+11	3.98E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.05E+11	3.98E+11	3.98E+11		
Icc		7.13E+11	5.75E+11	7.13E+11	5.75E+11	5.75E+11	5.75E+11	5.75E+11	5.75E+11	7.13E+11	7.13E+11		
ep		51.23	805.66	97.26	244.21	622.78	805.66	622.78	244.21	97.26	186.43		
ec		288.28	1188.56	334.30	627.12	1005.68	1188.56	1005.68	627.12	334.30	423.47		
r_p^2		294002	435708	294002	435708	435708	435708	435708	435708	294002	294002		
For Load case (A) stresses at	top fibre	Allowable stresses		-2.801	-5.032	-1.620	0.154	-1.540	-5.166	-2.901			
	bot fibre	Tension	1.36	-5.214	-10.417	-14.115	-16.221	-14.748	-10.831	-5.399			
	comment	Compn.	-16.50	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
For Load case (B) stresses at	top fibre	Allowable stresses		-2.37	-5.45	-5.28	-5.39	-5.23	-5.40	-2.43			
	bot fibre	Tension	1.47	-4.46	-7.32	-7.19	-6.99	-7.55	-7.58	-4.58			
	comment	Compn.	-14.00	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
For Load case (C) stresses at	top fibre	Allowable stresses		-2.32	-5.61	-5.90	-6.24	-5.86	-5.57	-2.39			
	bot fibre	Tension	1.47	-4.42	-6.76	-5.47	-4.72	-5.83	-7.02	-4.54			
	comment	Compn.	-14.00	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
For Load case (D) stresses at	top fibre	Allowable stresses		-3.95	-7.67	-8.28	-8.72	-8.23	-7.63	-4.01			
	bot fibre	Tension	1.47	-3.53	-5.43	-2.80	-1.51	-3.16	-5.69	-3.66			
	comment	Compn.	-21.00	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			
	top of slab	Allowable stresses		0.66	-0.19	-1.67	-2.32	-1.67	-0.19	0.66			
	bot of slab	Tension	0.72	0.79	0.15	-0.92	-1.39	-0.92	0.15	0.79			
	comment	Compn.	-12.00	OK-NOK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-NOK			
For Load case (E) stresses at	top fibre	Allowable stresses		-1.16	-2.98	-3.69	-4.06	-3.67	-3.02	-1.19			
	bot fibre	Tension	1.47	-2.21	-2.66	-0.48	0.53	-0.66	-2.79	-2.27			
	comment	Compn.	-14.00	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK	OK-OK			

TENSION REINFORCEMENT

Yield strength of rebar 414 Mpa, Allowable strength iof rebar 165.6 Mpa,

On Girder top for Girder casting

Stress at		Depth of	Total	Rebar	Dia. of	No. of
Top fibre	Bot. fibre	ten. Area	tension	Area reqd.	Rebar	rebar reqd.
(Mpa)	(Mpa)	(mm)	(kN)	(mm^2)	(mm)	
0.154	-16.221	17.16	1.41	8.48	12	0.08

On Girder bottom for service load

Stress at		Depth of	Total	Rebar	Dia. of	No. of
Top fibre	Bot. fibre	ten. Area	tension	Area reqd.	Rebar	rebar reqd.
(Mpa)	(Mpa)	(mm)	(kN)	(mm^2)	(mm)	
-4.057	0.528	210.49	39.50	238.53	20	0.76

DESIGN FOR SHEAR

Yield strength of rebar 276 Mpa, Allowable strength iof rebar 124.2 Mpa,

ANALYSIS FOR SHEAR

Section	Distance from end	Shear due to								
		Self wt V_O (a)	Cross Girder (Non-Composite dead load (b)	Non Composite dead load (c)	Composite dead load V_{DC} (d)	Live Load with Impact (e)	Live Load with Impact when wheel on Sidewalk (f)	Sidewalk Live Load (g)	Total Dead Load	Factored Design Shear V_U
	(mm)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)
2	450	261.16	6.199	159.148	135.417	212.83	256.05	0.00	561.93	1192.55
2a	1364	232.04	6.199	149.134	126.896	205.93	247.75	0.00	514.27	1115.63
3	2250	209.59	6.199	139.426	118.636	199.22	239.67	0.00	473.85	1048.51
4	7712.5	119.62	6.199	79.574	67.709	157.30	189.24	0.00	273.10	696.52
5	14975	0.00	6.199	0.000	0.000	99.71	119.95	0.00	6.20	224.52
6	22237.5	119.62	6.199	79.574	67.709	157.30	189.24	0.00	273.10	696.52
7	27700	209.59	6.199	139.426	118.636	199.22	239.67	0.00	473.85	1048.51
8	29500	261.16	6.199	159.148	135.417	212.83	256.05	0.00	561.93	1192.55

Section	Distance from end	Diameter of stirrup	No. of Leg	Effective depth for Shear (d)	f2p (stress in the conc. due to Pe)	fo (tensile stress at bot.due to self wt.)	Mcr (moment causing flexural crack)	Vci	Vp	Vcw	Vc (shear strength provided by conc.)	Spacing Reqd.
					(N/mm^2)	(N/mm^2)	(kN-m)	(kN)	(kN)	(kN)	(kN)	(mm)
2	450	12	2	1462	-4.48895	-0.0077	3126.27	592747	472.76	1287.63	1287.63	337
2a	1364	12	2	1462	-5.471164	0.5290	3313.38	3918.51	458.19	1273.11	1273.11	337
3	2250	12	2	1462	-9.641334	1.2634	3735.44	2322.82	426.52	1502.76	1502.76	337
4	7712.5	12	2	1527	-14.53549	3.9895	4450.53	738.44	337.70	1453.63	738.44	344
5	14975	12	2	1710	-16.85247	5.3064	4780.37	289.94	225.91	1471.17	289.94	364
6	22237.5	12	2	1527	-14.89616	3.9895	4569.49	752.54	346.08	1476.47	752.54	344
7	27700	12	2	1462	-9.898593	1.2634	3820.29	2368.83	437.90	1529.24	1529.24	337
8	29500	12	2	1462	-4.611895	-0.0077	3177.91	602542	485.71	1308.92	1308.92	337

HORIZONTAL SHEAR TRANSFER

Section	Distance from end	Effective depth for Shear (d)	Contact surface width	Factored Design Shear	Allowable shear strength (ϕVnh)	Comment	Diameter of stirrup	No. of Leg	Minimum spacing required
	(mm)	(mm)	(mm)	(kN)	(kN)		(mm)		(mm)
2	450	979	1066	1192.55	2263	O.K.	16	2	301.78
3	2250	1149	1066	1048.51	2656	O.K.	16	2	301.78
4	7712.5	1527	1066	696.52	3532	O.K.	16	2	301.78
5	14975	1710	1066	224.52	3954	O.K.	16	2	301.78
6	22237.5	1527	1066	696.52	3532	O.K.	16	2	301.78
7	27700	1149	1066	1048.51	2656	O.K.	16	2	301.78
8	29500	979	1066	1192.55	2263	O.K.	16	2	301.78

ELONGATION OF CABLE

Outside jack cable length (assumed), l_j = 700 mm,

Dead anchor width, l_a = 70 mm,

Cable stress at jack (after jack loss), f_j' = 1377 N/mm^2,

Cable stress at dead anchor, f_{LP} = 1264 N/mm^2,

Average cable length of anchor to anchor, L_p = 30004 mm,

Average elongation of cables by one side jacking, ΔL_p = 211 mm,

ANCHORAGE ZONE DESIGN

Minimum longitudinal extent of anchorage zone = 1066 mm,
Maximum longitudinal extent of anchorage zone = 1599 mm,
Selected longitudinal extent of anchorage zone = 1500 mm,

- DESIGN of GENERAL ZONE

α, angle of inclination of the resultant of the tendon = 5.93 deg,

Size of bearing plate	Thickness of bearing plate	Diameter of cone	Effective bearing area (Ab)	Factored tandon load	Total factored tendon load	C/c spacing of anchorage	Longitudinal extent of local zone (lc)	Correction factor (k)	Concrete compressive stress (fca)	Allowable Concrete compressive stress	Comment
(mm)	(mm)	(mm)	(mm^2)	(kN)	(kN)	(mm)	(mm)		(Mpa)	(Mpa)	
230	35	152	49581.69	1957.091	7176	350	264.5	1.271	16.93	21	O.K.

DESIGN FOR VERTICAL DIRECTION

Cable no.	1	2	3	4	0	0	0	0	0	0	0
Eccentricity	528.51	178.51	171.49	521.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
d_{burst}	658.44	827.68	831.07	661.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reinforcement distribution distance					=	1861.895 mm,		Maximum	=	2742 mm,	
Bursting force, T_{burst}					=	1938.884 kN,					
Area of reinforcement required for bursting force					=	5509.758 mm^2,					
Diameter of bursting stirrup					=	16 mm,					
Total no of 2 legged stirrup required					=	13.70 nos.,					

DESIGN FOR HORIZONTAL DIRECTION

Eccentricity (e)	Lateral dimension (h)	Angle of tendon (α)	Bursting distance (d_{burst})	Bursting force (T_{burst})	Area of rebar required	Dia. Of rebar	No. of rebar reqd	Rebar distribution distance
(mm)	(mm)	(deg)	(mm)	(kN)	(mm^2)	(mm)		(mm)
0	711	0	355.5	1213.662	3448.884	16	8.58	888.75

DESIGN FOR EDGE TENSION

Spalling force (T_{spal})	Area of rebar required	Dia. Of rebar	No. of rebar reqd
(kN)	(mm^2)	(mm)	
143.52	408	12	0.05

DEFLECTION CALCULATION

Deflection due to						Instantaneous Deflection	Deflection at erection	Long-time Deflection	Live load	Live load rotation at support
Initial Prestress	Effective Prestress	Self wt. (at initial period)	Self wt. (after 28 days)	Non-composite dead load	Composite dead load					
(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(rad.)
45.5	37.0	-18.322	-16.96	-12.1	-5.0	27.2	48.0	-2.3	-6.3	0.001035

DESIGN OF REINFORCED ELASTOMERIC BEARING (AASHTO-1992, METHOD-A)

Developed & designed by : Prasanta Kumar Bhowmik.

50% SHEAR DEFORMATION DUE TO CREEP & SHRINKAGE ALLOWED

INPUT OF LOAD/STRESS/GEOMETRY

Dead Load Reaction	=	631	kN
Live Load Reaction without Impact	=	207	kN
Live Load Rotation	=	0.0013	Radian
Total length of Girder	=	30	m
Width of Girder	=	711	mm
Temperature Change	=	21	^{o}C
Hardness of Bearing Material	=	60	Dur.
Yield Strength of Steel Laminates, f_y	=	248	MPa
Fatigue Strength of Steel Laminates, f_{sr}	=	165	MPa

INPUT OF BEARING DIMENSIONS

Width of Elastomeric Bearing $_{(Trans.)}$	=	300	mm
Length of Elastomeric Bearing $_{(Long.)}$	=	400	mm
Thickness of internal layers, h_{ri}	=	10	mm
Thickness of Cover Layer	=	8.5	mm
Total no of Internal Layer of Elastomer	=	0	O.K.
Thickness of Steel Plates	=	3	mm
Total thickness of Bearing	=	20	mm

Design Shear Force To Substructure, H	=	75.7059	Kn

Creep & Shrinkage	=	7.500	mm
Temperature shortening	=	0.000	mm
Shear deformation of the Bearing, Δ_s	=	7.500	mm
Shear Modulus, G_{min}	=	0.930	MPa
Shear Modulus, G_{max}	=	1.430	MPa
Creep deflection at 25 years	=	35.000	%
Instantaneous Deflection k_b	=	0.600	
Minm. Elastomer Thickness for shear, h_{rt}	=	15.00	mm
Minimum Area Required	=	119998	mm^2
Minimum Dimension for Stability (L or W)	≥	45	mm
Minimum length against Compression	=	400	mm
Minimum Shape Factor	=	7.51	
Maxm. thick. of each elastomer layer, h_{ri}	=	11.4	mm
Total No. of Layer required, N	=	-0.20	
Thickness Reqd. for Steel Plates	=	0.71	mm
Actual Shape Factor, S	=	8.57	O.K.
Effective Compressive Modulus of the Elastomer, E_c	=	382.51	MPa
Instantaneous Compressive Deflection of Bearing Δ_c	=	0.31	mm
θL	=	0.4	mm
			O.K.

1-3. DESIGN OF CANAL BRIDGE

(2) SUBSTRUCTURE

A. Soil Spring

Following the article 16.15 of Foundation Analysis and design written by Bowles (5th. edition) Modulus of Subgrade reaction K_s can be given as follows :

$K_s = A_s + B_s Z^n$

where $A_s = F_{w1} C_m C (c N_c + 0.5 \gamma B_p N_\gamma)$ and

$B_s = F_{w2} C_m C (\gamma Nq Z^n)$ again where

$F_{w1} = 1.3$ to 1.7 say 1.5

$F_{w2} = 2.0$ to 4.4 say 3.2

$C_m = 1 + (457 / D)^{0.75} >= 1.5$ where D is pile diameter

$C_m = 1 + (457 / 900)^{0.75} = 1.6$

Assume C = 40, n = 0.6 and $\gamma = 10$ kn/m^3

Therefore $A_s = 1.5 \times 1.6 \times 40 (c N_c + 0.5 \times 10 \; B_p N_\gamma) = 90 (c Nc + 5 Bp N\gamma)$

$B_s = 3.2 \times 1.6 \times 40 \times 10 Nq Z^n = 1920 Nq Z^n$

In between the two boreholes of Hatia, borehole BH1EB2" is worse and hence it will be taken as the basis basis for estimating spring constant. The soil parameter is assumed as follows :

Top layer (Upto a depth of 18m i.e. RL = -16.0)

Avg. SPT = 3, $\phi = 0$, c = 6.25 x SPT = 18.75, $N_q = 1$, $N_\gamma = 0$, $N_c = 5.14$

Therefore, $Ks = 90 \times 18.75 \times 5.14 \times + 1920 \times 1 \times Z^{0.6} = 8,674 + 1920 Z^{0.6}$

Like main bridge here also, the spring stiffness is reduced by 35% to account for the group action on laterally loaded pile and hence multiplying the above equation by 0.65,

$Ks = 5,650 + 1,250 Z^{0.6}$

Bottom layer (For remaining depth of pile)

Avg. SPT = 13, $\phi = 0$, c = 6.25 x SPT = 81.25, $N_q = 1$, $N_\gamma = 0$, $N_c = 5.14$

Assuming reduction factor of 0.65 for Group action,

$Ks = 0.65 (90 \times 81.25 \times 5.14 \times + 1920 \times 1 \times Z^{0.6}) = 24,000 + 1250 Z^{0.6}$

R.L.	Abutments			Piers		
(MPWD)	Depth (m)	Ks	KFX / KFZ	Depth (m)	Ks	KFX / KFZ
0.00	0.75	6,702	42,222			
-1.50	2.25	7,683	48,405			
-3.00	3.75	8,413	53,000			
-4.50	5.25	9,031	56,893			
-6.00	6.75	9,581	60,360	0.75	6,702	10,555
-7.50	8.25	10,084	63,528	2.25	7,683	12,101
-9.00	9.75	10,551	66,473	3.75	8,413	13,250
-10.50	11.25	10,991	69,242	5.25	9,031	14,223
-12.00	12.75	11,407	71,866	6.75	9,581	15,090
-13.50	14.25	11,805	74,369	8.25	10,084	15,882
-15.00	15.75	12,185	76,769	9.75	10,551	16,618
-16.50	17.25	30,902	194,683	11.25	29,341	46,212
-18.00	18.75	31,256	196,914	12.75	29,757	46,868
-19.50	20.25	31,599	199,075	14.25	30,155	47,493
-21.00	21.75	31,932	201,172	15.75	30,535	48,093
-22.50	23.25	32,256	203,212	17.25	30,902	48,671
-24.00	24.75	32,571	205,200	18.75	31,256	49,229
-25.50	26.25	32,879	207,141	20.25	31,599	49,769
-27.00	27.75	33,181	209,037	21.75	31,932	50,293
-28.50	29.25	33,475	210,893	23.25	32,256	50,803

<u>Note :</u> Ks = 5,650 + 1250 x $Z^{0.6}$ (upto R.L. 16.00)
Ks = 24,000 + 1250 x $Z^{0.6}$ (beyond RL 16.00)
KFX = KFZ = Ks x 0.9 x 1.5 for pier
KFX = KFZ = Ks x 0.9 x 1.6 for abutment

B. DEAD LOAD FROM SUPERSTRUCTURE

(I) On Pier

a. Steel railing	= 50 kg/m x 2	=	1.00 kn/m		
b. Precast Parapet	= 0.469 sqm x 23.56 x	=	22.10 kn/m		
c. Sidewalk Slab	= 1.33 x 0.075 x 23.56	=	2.35 kn/m		
d. Curb	= 0.119 sqm x 23.56	=	2.80 kn/m		
			28.25 x 30 =		848 kn
e. 60mm Premix	= 30 x 7.00 x 0.06 = 12.60 Cum x 23.56			=	297 kn
f. RC Deck	= 30 x 9.65 x 0.20 = 57.9 Cum x 23.56			=	1365 kn
g. Girders	= 4 x 551 kn (See Girder design)			=	2204 kn
h. Diaphragm	= (See Girder design)			=	295 kn
					5009 kn

Dividing equally on each Girder = 5009 / 4 = **1255** kn

(ii) On abutment

From deck & Girder	= 4 x 1255 / 2	=	2510 kn
From approach Slab	= 8.55 x 2.5 x 0.36 x 23.56	=	181 kn
		Acting at Node 2 / 12 =	2691 kn

Moment Mz = 2510 x 0.275 - 181 x 0.45 = 609 knm acting at Node 2 / 12

Back fill	= 8.55 x 1.425 x 6.0 x 18.85	=	1378 kn
Return wall	= 2 x 1.425 x 6.3 x 0.55 x 23.56	=	233 kn
	= 2 x 5.075 x 1.75 x 0.55 x 23.56	=	230 kn
Railing etc.	= 23.59 x 2 x 6.5	=	307 kn
			2148 kn

UDL acting on member 9 & 40 = 2148 / 2.1 = 1023 kn/m

C. LIVE LOAD FROM SUPERSTRUCTURE

(I) On Pier

Assuming 2 Lanes

a. Live Load	= (30 x 9.4 + 116) x 2	=	796 kn
b. Impact	= 796 * 15.24 / (30+38)	=	179 kn
c. Sidewalk	= 30 x 2.0 x 2.875	=	173 kn
d. Utilities	= 2 kn/m x 30.0	=	60 kn
			1208 kn

Dividing equally on each Girder = 1208 / 4 = **300** kn

(ii) On Abutment

Vertical Load = 4 x 300 / 2 = 600 kn acting at Joint 2 & 12
Moment Mz = 600 x 0.275 = 165 knm acting at Joint 2 & 12

D. WIND LOAD ON SUPERSTRUCTURE

Design Wind Velocity, $V_d = 2.5 \times V_0 \times V_{10} / V_B \log_e (Z / Z_0)$

where V_b = Base wind velocity = 161 km/hr
V_0 = Friction Velocity = 13.21 km/hr for open country
V_{10} = Basic Wind Speed = 238 km/hr.
Z_0 = Friction Length = 0.07 for open country

$V_d = 2.5 \times 13.21 \times 238 / 161 (\log Z - \log 0.07) = 130 + 48.82 \log Z$

R.L. on top of deck	= 7.85 MPWD
R.L. on top of parapet	= 7.85 + 0.82 + 0.36 = 9.03 MPWD
R.L. of beam soffit	= 7.85 - 2.0 = 5.85 MPWD

Level at C.G. of Wind pressure = (9.03 + 5.85) / 2 = 7.44 MPWD
Normal Ground Level = 1.5 MPWD

Z for wind on superstructure = 7.44 - 1.5 = 5.94 = 6.0 (say)
Z for wind on Live load = 7.85 + 1.83 -1.5 = 8.18 = 8.0 (say)

Vd = 130 + 48.82 log 6.0 = 218 km/hr for Superstr.
Vd = 130 + 48.82 log 8.0 = 232 km/hr for Live load

Wind on Superstr. = 2.394 x $(218 / 161)^2$ = 4.39 kpa (Transverse)
0.575 x $(218 / 161)^2$ = 1.05 kpa (Longitudinal)
Wind on Live load = 1.460 x $(232 / 161)^2$ = 3.03 kn/m (Transverse)
0.584 x $(232 / 161)^2$ = 1.21 kn/m (Longitudinal)

Area of Superstructure exposed to wind = 30 x 3.2 = 96 sqm

Wind on Superstr. = 96 x 4.39 = 422 kn (Transverse)
96 x 1.05 = 101 kn (Longitudinal)
Wind on Live load = 30 x 3.03 = 91 kn (Transverse)
30 x 1.21 = 36 kn (Longitudinal)

E. LONGITUDINAL FORCES

5% of L.L = 2 x (30 x 9.4 + 116) x 5% = 40 kn

F. THERMAL FORCES

Mean temperature is assumed 26°C while the maximum and minimum temperature are assumed 38°C and 7°C respectively.

G. SHRINKAGE & CREEP DEFORMATION

See section H and I of design of Viaduct.

Shrinkage deformation per span = 16.8 x 10^{-5} x 30 = 5.04 x 10^{-3} m
Creep deformation per span = 14.5 x 10^{-5} x 30 = 4.35 x 10^{-3} m

Total deformation = $-9.39*10^{-3}$ m

H. EARTH PRESSURE BEHIND ABUTMENT

Joint	depth (m)	UDL
1,11	0	0.0
2,12	2	107.4
13,20	6	322.3

Note : UDL = 18.85 x depth x 8.55 / 3

The bridge is modeled in STAAD III (file name is Hatia.Std) as space frame to carry the loads described in section B to H. Piles are kept supported horizontally by providing the spring as described in section A. Output of this model is given in Appendix 'A'. Force due to thermal expansion is not considered because flexural tension in earth face of abutment caused by this is negligible (see appendix C of viaduct design).

I. DESIGN OF PIER HEAD

From Page 9 of Appendix 'A' =
Max. (-)ive moment = -2499.18 knm for member 12 & load 7
Max. (+) ive moment = 1056.96 knm for member 12 & load 7
Max . Shear = 2432.40 kn for member 12 & load 7

Design of Beam (USD method)

		Design Moment =	2500 knm
f'c =	30 mpa	Beta1 =	0.8324
fy =	410 mpa	ROWMX =	0.0231
b =	1650 mm	ROWMIN =	0.0034
Depth =	900 mm		
Bar dia =	28 mm	d =	805 mm
Str. Dia. =	16 mm	As =	8922 sqmm
Cl. Cover =	65 mm	p =	0.0067
Ast =	14 Nos	a =	86.9 mm

Resisting Moment = 2,507.2 knm O.K.

		Design Moment =	1057 knm
f'c =	30 mpa	Beta1 =	0.8324
fy =	410 mpa	ROWMX =	0.0231
b =	1650 mm	ROWMIN =	0.0034
Depth =	900 mm		
Bar dia =	28 mm	d =	805 mm
Str. Dia. =	16 mm	As =	4926 sqmm
Cl. Cover =	65 mm	p =	0.0037
Ast =	8 Nos	a =	48.0 mm

Resisting Moment = 1,419.6 knm > O.K.

f'c =	30 mpa	Design Shear =	2433 kn
fy =	410 mpa	vc =	0.909 mpa
b =	1650 mm	Vc =	1,207.7 kn
d =	805 mm	Vs =	1,769.6 kn
Str. dia =	16 mm		
Spacing =	150 mm	Vu =	2,530.7 kn O.K.
No. of legs =	4 Nos		

J. DESIGN OF COLUMN

For forces in column see Page 10 and for design see page 22 of appendix 'A'

K. DESIGN OF PILECAP OF PIER

Short direction :

From Page 12 of Appendix A

Design Moment = 2601.17 / 2.7 = 964 knm/m for member 18 & load 7

Design Shear = 2031.55 / 2.7 = 753 knm/m for member 18 load 7

Design of Beam (USD method)

		Design Moment =	964 knm
f'c =	30 mpa	Beta1 =	0.8324
fy =	410 mpa	ROWMX =	0.0231
b =	1000 mm	ROWMIN =	0.0034
Depth =	1200 mm		
Bar dia =	25 mm	d =	1038 mm
Str. Dia. =	0 mm	As =	3927 sqmm
Cl. Cover =	150 mm	p =	0.0038
Ast =	8 Nos	a =	63.1 mm

Resisting Moment = 1,457.7 knm O.K.

Beam shear is not critical because, pile lies entirely within critical area. However corner pile may be critical for punching shear having a force of 2031.62 kn (See member 320, load 7 at page 20 of appendix 'A').

Shear area = {2 x (1038/2 + 800 + 350) + 1038 + 800} x 1038 =5,372,688 sqmm

Shear stress = 2032 x 1000 / 5,372,688 = 0.378 mpa

Allowable Shear = 0.332 x $f'c^{0.5}$ = 1.54 mpa > 0.378 O. K.

Long direction :

From Page 14 of Appendix 'A'

Design Moment = 3168.94 /4.2 =754 knm/m

Design Shear = negligible

Design of Beam (USD method)

		Design Moment =	754 knm
f'c =	30 mpa	Beta1 =	0.8324
fy =	410 mpa	ROWMX =	0.0231
b =	1000 mm	ROWMIN =	0.0034
Depth =	1200 mm		
Bar dia =	25 mm	d =	1038 mm
Str. Dia. =	0 mm	As =	2454 sqmm
Cl. Cover =	150 mm	p =	0.0024
Ast =	5 Nos	a =	39.5 mm

Resisting Moment = 921.8 knm O.K.

N. DESIGN OF STEM OF ABUTMENT

From Page 15 of Appendix A and for members 8,
Design Moment = 13757.10 / 9.65 = 1425 knm/m for load 10
Design Shear = 3865.72 / 9.65 = 815 kn /m for load 10

Design of Beam (USD method)

		Design Moment =	1425 knm
f'c =	30 mpa	Beta1 =	0.8324
fy =	410 mpa	ROWMX =	0.0231
b =	1000 mm	ROWMIN =	0.0034
Depth =	1350 mm		
Bar dia =	25 mm	d =	1273 mm
Str. Dia. =	0 mm	As =	3274 sqmm
Cl. Cover =	65 mm	p =	0.0026
Ast =	6.67 Nos	a =	52.6 mm

Resisting Moment = 1,505.6 knm O.K.

f'c =	30 mpa	Design Shear =	815 kn
fy =	410 mpa	vc =	0.909 mpa
b =	1000 mm	Vc =	983.4 kn O.K.
d =	1273 mm		

O. DESIGN OF PILECAP OF ABUTMENT

From Page 16 of Appendix A and for members 10 & 40,
Design Moment = 10355 /10.5 =986 knm/m
Design Shear = 10305.33 / 10.5 = 863 kn /m

Design of Beam (USD method)

		Design Moment =	986 knm
f'c =	30 mpa	Beta1 =	0.8324
fy =	410 mpa	ROWMX =	0.0231
b =	1000 mm	ROWMIN =	0.0034
Depth =	1000 mm		
Bar dia =	25 mm	d =	838 mm
Str. Dia. =	0 mm	As =	3338 sqmm
Cl. Cover =	150 mm	p =	0.0040
Ast =	6.80 Nos	a =	53.7 mm

Resisting Moment = 998.5 knm O.K.

Beam shear is not critical because, pile lies entirely within critical area. However corner pile may be critical for punching shear having a force of 2576.33 kn I.e 10305 / 4 (See member 260, load 10 at page 19 of appendix 'A').

Shear area = (838 + 2 x 800 + 800 + 350) x 838 = 3,006,744 sqmm
Shear stress = 2576 x 1000 / 3,006,744 = 0.856 mpa
Allowable Shear = 0.332 x $f'c^{0.5}$ = 1.54 mpa > 0.856 O. K.

P. DESIGN OF RETURN WALL

Depth	Length	UDL	Moment	Mom/m
0.25	6.50	1.57	33.18	132.74
0.75	6.50	4.71	99.55	218.35
1.25	5.50	7.85	118.79	230.13
1.75	4.50	11.00	111.33	197.93
2.25	3.50	14.14	86.59	140.59
2.75	2.50	17.28	54.00	76.97
3.25	1.50	20.42	22.97	49.48
3.75	1.50	23.56	26.51	56.55
4.25	1.50	26.70	30.04	63.62
4.75	1.50	29.85	33.58	

Design Moment = 230.13 x 1.3 = 300 knm/m

Design of Beam (USD method)

		Design Moment =	300 knm
f'c =	30 mpa	Beta1 =	0.8324
fy =	410 mpa	ROWMX =	0.0231
b =	1000 mm	ROWMIN =	0.0034
Depth =	550 mm		
Bar dia =	22 mm	d =	474 mm
Str. Dia. =	0 mm	As =	2535 sqmm
Cl. Cover =	65 mm	p =	0.0053
Ast =	6.67 Nos	a =	40.8 mm

Resisting Moment = 424.4 knm O.K.

Q. DESIGN OF PILES

Structural :

See Page 17 to 21 for forces and appendix B for design

Geotechnical :

Please refer page no. 7 & 8 of appendix A for pile reaction and appendix C for pile capacity.
Please note further that reaction of piles under abutment shall have to be divided by 4

	Abutment	Pier
Reference bore hole :	BH1 EB2"	BH1 EB2"
Pile reaction for load 13 (kn) :	833	1420
Pile reaction for load 14 (kn) :	2133	1672
Uplift for load 14 (kn) :	590	-
Ultimate capacity of pile (kn) :	6565	6565
Depth of pile tip from G.L. (m) :	43.50	43.50
Top of bore hole R.L.. (MPWD) :	1.88	1.88
Pile tip R. L.. (MPWD) :	-41.62	-41.62
Length of pile (m) :	42.50	42.62
Weight of pile (kn) :	637.53	639.30
Net uplift deducting pile weight :	0.00	0.00
FS against load 13 :	7.88	4.62
FS against load 14 :	3.08	3.93

Minimum bearing capacity : Abutment = 2133 kn
Pier = 1672 kn