BEAM DESIGN CALCULATION

Project Name	:	ESW21-C-RCDC Connect edition V9-IS-RCC
Client Name	:	MAVENS
Engineer Name	:	APCA/RK
Design File	:	C:\Users\arpitchawla\OneDrive - L&T Construction\Jobs\Miscellaneous\Software Validation\RCDC\Staad Model\FMO_P01_01(02.12.2021)-Beam-2-0 m.rcdx
Analysis File	:	C:\Users\arpitchawla\OneDrive - L&T Construction\Jobs\Miscellaneous\Software Validation\RCDC\Staad Model\FMO_P01_01(02.12.2021).STD
Analysis Last Modified	:	28-12-2021 10:17:00
Level Designed	:	0 m

Sr.No.	Symbol		Definitions
1	α	=	Angle formed with horizontal by diagonal reinforcement
2	ε1	=	Strain at level considered, Calculated ignoring the stiffening of the concrete in tension zone
3	εm	=	Average steel strain at level considered
4	Acr	=	Distance from the point considered to the surface of the nearest longitudinal bar
5	Adr	=	Area of diagonal reinforcement in coupler beam
6	AstCalc	=	Area of Tension reinforcement required in sqmm
7	Ast comp	=	Ast at compression side
8	AstCrack	=	Area of Tension reinforcement for Crack Width required in sqmm
9	AstPrv	=	Area of reinforcement provided at given section in sqmm
10	Asv	=	Area of shear reinforcement required per meter length in sqmm
11	Asv Reqd	=	Min area shear reinforcement as per clause 41.4.3
12	Asv Total Prv	=	Total area of shear reinforcement provided, including that for torsion
13	Asv Torsion	=	Area of Stirrups over the corner bars to resist shear and torsion as per clause 41.4.3
14	Asv Torsion Prv	=	Area of shear reinforcement resisting torsion (outer legs only)
15	b	=	Width of the Beam in mm
16	bw	=	Width of Web in mm
17	Ceff	=	Effective Cover of Beam in mm
18	Cmin	=	Clear cover
19	d	=	Effective depth of Beam in mm
20	d'	=	Clear cover to reinforcement at compression side.
21	D	=	Depth of Beam in mm
22	D'	=	Distance (c/c) between top-most and bottom-most layer
23	Df	=	Thickness of Flange in mm
24	Ec	=	Modulus of elasticity of concrete
25	Es	=	Modulus of elasticity of steel
26	FcPerm	=	Permissible Stress in Concrete required in N/sqmm

27	Fst	=	Stress in steel
28	FstPerm	=	Permissible Stress in Steel required in N/sqmm
29	Legs	=	Number of legs of the shear reinforcement
30	lo	=	Effective Length of Beam in mm
31	Mh	=	Hogging Moment of Resistance in kNm
32	Ms	=	Sagging Moment of Resistance in kNm
33	M_{Tu}	=	Converted Bending Moment due to Torsion at a section in kNm
34	Mu	=	Factored Bending Moment in Limit State at a section in kNm
35	Mud	=	Total Design Moment = Mu + M_{Tu} in kNm
36	MuLim	=	Limiting Moment of Resistence of Singly Reinforced Section
37	NA angle (φ)	=	It is a neutral axis angle corresponding to load angle to find out MCap
38	Pcclc	=	Calculated percentage compression steel
39	Ptclc	=	Calculated percentage tension steel
40	Ptmin	=	Minimum percentage steel as per code
41	PtPrv	=	provided percentage steel
42	R	=	Moment Ratio Mud/Bd^2
43	Reinf	=	Rebar arrangement provided
44	sp	=	Spacing Between bars at outer most layer
45	Spc1 to Spc6	=	Max Stirrup Criteria in mm
46	Stirrup Dia	=	Diameter of shear stirrups in mm
47	SvCalc	=	Stirrup spacing calculated as per Asv in mm
48	SvPrv	=	Stirrup spacing provided in m
49	Tc	=	Permissible Shear stress in concrete at a given section in N/sqmm Calculated as per Tensile reinforcement
50	Tce	=	Earthquake inducted shear stress in N/sqmm
51	Tcep	=	Permissible value of shear stress for checking of coupling action in N/sqmm
52	Tu	=	Factored Torsional Moment in Limit State at a section in kNm
53	Tv	=	Shear stress due to Vud in N/sqmm
54	V^{D+L}	=	Shear force 1.2x(Dead Load + Live Load) in kN
55	Vc	=	Shear capacity of concrete section due to Tc in kN
56	Vu	=	Factored Shear Force in Limit State at a section in kN
57	Vu-A1	=	V^{D+L}Left - 1.4 x (MsLeft + MhRight)/L in kN
58	Vu-A2	=	V^{D+L}Left + 1.4 x (MhLeft + MsRight)/L in kN
59	Vu-B1	=	V^{D+L}Right + 1.4 x (MsLeft + MhRight)/L in kN
60	Vu-B2	=	V^{D+L}Right - 1.4 x (MhLeft + MsRight)/L in kN
61	Vud	=	Design Shear Force (Max of Vus and Vu-sway) in kN
62	Vue	=	Earthquake inducted shear in kN
63	Vu-sway	=	Max of (Vu-A1 and Vu-A2) & (Vu-B1 and Vu-B2) in kN
64	Vus	=	Vud - Vc Design Shear Force for reinforcement, in kN
65	Vut	=	Total Shear Force = Vu + V_{Tu} in kN
66	V_{Tu}	=	Converted Shear Force due to Torsion at a section in kN

67	Wcr	=	Surface Crack Width
68	WcrPerm	=	Permissible Crack Width required in mm
69	X1	=	Smaller c/c dimension of outermost Stirrups
70	Y1	=	Larger c/c dimension of outermost Stirrups
			All 6mm diameter bars are assumed 250 grade with fy = 250 N/sqmm

All Forces are in 'kN', 'kNm', Stress in 'N/sqmm' & Dimension are in 'mm'.

Code References

IS 456

Sr.No.	Item		Clause / Table
1.	Ptmax	:	26.5.1.1
2.	Ptmin	:	26.5.1.1
3.	M_{Tu}	:	41.4.2
4.	V_{Tu}	:	41.3.1
5.	Ptclc	:	38
6.	Tc	:	40.2.1
7.	Tcmax	:	40.2.3
8.	Asv	:	40.4
9.	Min Shear Reinf	:	26.5.1.6
10.	Max Stirrup Spacing	:	26.5.1.5
11.	Shear Reinf - Torsion	:	26.5.1.7
12.	Side Face Reinforcement	:	26.5.1.3
13.	crack width calculation	:	Annex-F
14.	cracking	:	Clause 35.3.2

IS 13920 - 2016

Sr.No.	Item		Clause / Table
1.	Ptmax	:	6.2.2
2.	Ptmin	:	6.2.1
3.	Astmin	:	6.2.3 & 6.2.4
4.	Svclc	:	6.3.5
5.	Shear Capacity	:	6.3.4
6.	Coupling Beams	:	10.5

Group	:	**G3**	
Beam No	:	**B5**	
Analysis Reference (Member)	$^{0}_{m}$:	7	
Beam Length	:	6150	mm
Breadth (B)	:	200	mm
Depth (D)	:	550	mm
Effective Depth (d)	:	490	mm

Design Code	:	IS 456 : 2000 + IS 13920 : 2016	
Beam Type	:	Ductile Beam	
Grade Of Concrete (Fck)	:	M25	N/sqmm
Grade Of Steel	:	Fe415	N/sqmm
Clear Cover (Cmin)	:	30	mm
Es	:	2x10^5	N/sqmm

Flexure Design

	Beam Bottom			Beam Top		
	Left	**Mid**	**Right**	**Left**	**Mid**	**Right**
Critical L/C - Analysis	147	147	147	147	147	147
Critical L/C - RCDC	3	3	3	3	3	3
Mu (kNm)	19.76	37.83	10.32	43.89	-	62.76
Tu (kNm)	0.67	0.05	0.58	1.29	0.67	1.2
M_{Tu} (kNm)	1.48	0.1	1.28	2.86	1.48	2.65
Mud (kNm)	21.24	37.93	11.6	46.75	1.48	65.41
MuLim (kNm)	166	166	166	166	166	166
R	0.442	0.79	0.242	0.974	0.031	1.362
Ptmin (%)	0.289	0.289	0.289	0.289	0.289	0.289
Ptclc (%)	0.289	0.289	0.289	0.289	0.289	0.405
Pcclc (%)	0	0	0	0	0.009	0
PtPrv (%)	0.346	0.346	0.346	0.346	0.346	0.577
AstCalc (sqmm)	283.37	283.37	283.37	283.37	283.37	396.5
AstCrack (sqmm)	283.37	283.37	283.37	297.54	0	481.95
AstPrv (sqmm)	339.3	339.3	339.3	339.3	339.3	565.5
Reinforcement Provided	3-T12	3-T12	3-T12	3-T12	3-T12	3-T12 2-T12

Shear Design

	Left	**Mid**	**Right**
Critical L/C - Analysis	147	147	147
Critical L/C - RCDC	3	3	3
PtPrv (%)	0.346	0.346	0.577
Vu (kN)	56.24	32.72	62.37
Tu (kNm)	1.3	0.58	1.2
V_{Tu} (kN)	10.36	4.63	9.62
Vut (kN)	66.59	37.35	71.99
V^{D+L} (kN)	50.98		50.68
Mh (kNm)	56.56		90.41
Ms (kNm)	56.56		56.56
Sway-Right (kN)	35.19		85.86
Sway-Left (kN)	78.05		27.06
Vu-Sway (kN)	78.05		85.86
Vud (kN)	78.05	37.35	85.86
Tv (N/sqmm)	0.8	0.38	0.88
Tc (N/sqmm)	0	0	0
Vc (kN)	0	0	0

V_{D+L}

Calculation for Sway Right at left end

V_{D+L} - 1.4 (M_{As} +M_{Bh}) / L_{AB}

=50.98 - 1.4 (56.56+90.41)/6.15

=17.5234 kN

Calculation for Sway Left at left end

V_{D+L} + 1.4 (M_{Ah} +M_{Bs}) / L_{AB}

=50.98 + 1.4 (56.56+56.56)/6.15

=76.73 kN (approx. OK)

Calculation for Sway Right at left end

V_{D+L} +1.4 (M_{As} +M_{Bh}) / L_{AB}

=50.68 + 1.4 (56.56+90.41)/6.15

=84.364 kN (approx. OK)

Calculation for Sway Left at left end

V_{D+L} - 1.4 (M_{Ah} +M_{Bs}) / L_{AB}

=50.68 - 1.4 (56.56+56.56)/6.15

=24.929 kN (approx. OK)

Vus=Vud-Vc (kN)	78.05	37.35	85.86
Legs	2	2	2
Stirrup Rebar	8	8	8
Asv Torsion (sqmm)	188.94	102.02	199.007
Asv Torsion Prv (sqmm)	1340.53	410.37	1340.53
Asv Reqd (sqmm/m)	441.18	221.58	485.31
SvCalc (mm)	75	245	75
SvPrv (mm)	75	245	75
Asv Total Prv (sqmm)	1340.53	410.37	1340.53

Maximum Spacing Criteria

Basic

Spc1 =0.75d = 368 mm

Spc2 = 300 mm

For Torsion

(X1 = 150, Y1 = 500)

Spc3 = X1 = 150 mm

Spc4=(X1+Y1)/4 = 160 mm

For Ductility

Left Section

Spc5 = d / 4 = 122 mm

Spc6 = 6 x Small Longitudinal Dia = 75 mm

Spc7 = 100 mm

Mid Section

Spc5 = d / 2 = 245 mm

Right Section

Spc5 = d / 4 = 122 mm

Spc6 = 6 x Small Longitudinal Dia = 75 mm

Spc7 = 100 mm

SFR Design

Beam Width = 200 mm

Beam Depth = 550 mm

Torsion = 1.29 > 0 kNm

Beam Depth >750 Or Torsion > 0,
Hence SFR Provided

Asr = 110 sqmm

SFR Provided = 2-T8EF

ASFR Provided = 201.08 sqmm

Spacing Criteria

Provided Spacing = 145.8 mm

1.<= beam Width	= 200	mm
2. Not Greater Than	= 300	mm

Crack width as per IS 456 : 2000 + IS 13920 : 2016						
	Beam Bottom			**Beam Top**		
	Left	**Mid**	**Right**	**Left**	**Mid**	**Right**
Critical L/C - Analysis	87	74	74	74	-	87
Critical L/C - RCDC	10002	10001	10001	10001	-	10002
BM (Unfactored) (kNm)	16.07	24.03	7.33	31.44	0	47.49
Reinf. In 1st layer	3-T12	3-T12	3-T12	3-T12		3-T12
sp (mm)	64	64	64	64		64
AstPrv (sqmm)	339.3	339.3	339.3	339.3		565.5
Xact (mm)	117.8	117.8	117.8	117.8		146.1
Icr (mm^4)	625103881.51	625103881.51	625103881.51	625103881.51		942272127.91
acr (mm)	42.17	42.17	42.17	42.17		42.17
Check for Stress in Concrete						
σ_{cbc} (N/sqmm)	3.03	4.53	1.38	5.92		7.36
$\sigma_{cbc(Actual)}$ (N/sqmm)	8.5	8.5	8.5	8.5		8.5
Check for Stress in Reinforcement						
Fst (N/sqmm)	105.06	157.14	47.91	205.58		190.31
FstPerm (N/sqmm)	228.25	228.25	228.25	228.25		228.25
Crack Width Check						
Epsilon-deff, ε1	0.00061	0.000912	0.000278	0.001194		0.001118
Epsilon-m, εm	0.000117	0.000419	-0.000215	0.000701		0.000838
Wcr (mm)	0.014	0.0502	-0.0257	0.0839		0.1
WcrPerm (mm)	0.3	0.3	0.3	0.3		0.3

Group : **G3**

Beam No : **B6**

Analysis Reference (Member) 0 : 8

m

Beam Length	:	3650	mm
Breadth (B)	:	200	mm
Depth (D)	:	550	mm
Effective Depth (d)	:	490	mm
Design Code	:	IS 456 : 2000 + IS 13920 : 2016	
Beam Type	:	Ductile Beam	
Grade Of Concrete (Fck)	:	M25	N/sqmm
Grade Of Steel	:	Fe415	N/sqmm
Clear Cover (Cmin)	:	30	mm
Es	:	2x10^5	N/sqmm

Flexure Design

	Beam Bottom			Beam Top		
	Left	**Mid**	**Right**	**Left**	**Mid**	**Right**
Critical L/C - Analysis	147	147	147	147	147	149
Critical L/C - RCDC	3	3	3	3	3	4
Mu (kNm)	-	9.29	5.39	33.27	4.33	17.61
Tu (kNm)	0.68	0.19	0.44	0.68	0.31	0.73
M_{Tu} (kNm)	1.49	0.42	0.96	1.49	0.67	1.61
Mud (kNm)	1.49	9.7	6.35	34.76	5	19.22
MuLim (kNm)	166	166	166	166	166	166
R	0.031	0.202	0.132	0.724	0.104	0.4
Ptmin (%)	0.289	0.289	0.289	0.289	0.289	0.289
Ptclc (%)	0.289	0.289	0.289	0.289	0.289	0.289
Pcclc (%)	0.009	0	0	0	0	0
PtPrv (%)	0.346	0.346	0.346	0.577	0.346	0.346
AstCalc (sqmm)	283.37	283.37	283.37	283.37	283.37	283.37
AstCrack (sqmm)	565.5	283.37	283.37	283.37	283.37	283.37
AstPrv (sqmm)	339.3	339.3	339.3	565.5	339.3	339.3
Reinforcement Provided	3-T12	3-T12	3-T12	3-T12 2-T12	3-T12	3-T12

Shear Design

	Left	**Mid**	**Right**
Critical L/C - Analysis	147	147	147
Critical L/C - RCDC	3	3	3
PtPrv (%)	0.577	0.346	0.346
Vu (kN)	40.52	17.06	29.87
Tu (kNm)	0.68	0.18	0.81
V_{Tu} (kN)	5.41	1.46	6.45
Vut (kN)	45.93	18.52	36.32
V^{D+L} (kN)	29.65		30.71
Mh (kNm)	90.41		56.56
Ms (kNm)	56.56		56.56
Sway-Right (kN)	47.15		77.98
Sway-Left (kN)	91.08		61.57

Vu-Sway (kN)	91.08		77.98
Vud (kN)	91.08	18.52	77.98
Tv (N/sqmm)	0.93	0.19	0.8
Tc (N/sqmm)	0	0	0
Vc (kN)	0	0	0
Vus=Vud-Vc (kN)	91.08	18.52	77.98
Legs	2	2	2
Stirrup Rebar	8	8	8
Asv Torsion (sqmm)	124.536	47.788	105.708
Asv Torsion Prv (sqmm)	1340.53	410.37	1340.53
Asv Reqd (sqmm/m)	514.8	221.58	440.78
SvCalc (mm)	75	245	75
SvPrv (mm)	75	245	75
Asv Total Prv (sqmm)	1340.53	410.37	1340.53

Maximum Spacing Criteria

Basic

Spc1 =0.75d = 368 mm

Spc2 = 300 mm

For Torsion

(X1 = 150, Y1 = 500)

Spc3 = X1 = 150 mm

Spc4=(X1+Y1)/4 = 160 mm

For Ductility

Left Section

Spc5 = d / 4 = 122 mm

Spc6 = 6 x Small Longitudinal Dia = 75 mm

Spc7 = 100 mm

Mid Section

Spc5 = d / 2 = 245 mm

Right Section

Spc5 = d / 4 = 122 mm

Spc6 = 6 x Small Longitudinal Dia = 75 mm

Spc7 = 100 mm

SFR Design

Beam Width = 200 mm

Beam Depth = 550 mm

Torsion = 0.81 > 0 kNm

Beam Depth >750 Or Torsion > 0,
Hence SFR Provided

Asr = 110 sqmm

SFR Provided = 2-T8EF

ASFR Provided = 201.08 sqmm

Spacing Criteria

Provided Spacing = 145.8 mm
1.<= beam Width = 200 mm
2. Not Greater Than = 300 mm

Crack width as per IS 456 : 2000 + IS 13920 : 2016						
	Beam Bottom			Beam Top		
	Left	Mid	Right	Left	Mid	Right
Critical L/C - Analysis	-	74	74	74	74	87
Critical L/C - RCDC	-	10001	10001	10001	10001	10002
BM (Unfactored) (kNm)	0	6.67	3.84	23.56	2.96	14.91
Reinf. In 1st layer		3-T12	3-T12	3-T12	3-T12	3-T12
sp (mm)		64	64	64	64	64
AstPrv (sqmm)		339.3	339.3	565.5	339.3	339.3
Xact (mm)		117.8	117.8	146.1	117.8	117.8
Icr (mm^4)		625103881.51	625103881.51	942272127.91	625103881.51	625103881.51
acr (mm)		42.17	42.17	42.17	42.17	42.17
Check for Stress in Concrete						
σ_{cbc} (N/sqmm)		1.26	0.72	3.65	0.56	2.81
$\sigma_{cbc(Actual)}$ (N/sqmm)		8.5	8.5	8.5	8.5	8.5
Check for Stress in Reinforcement						
Fst (N/sqmm)		43.59	25.08	94.4	19.35	97.47
FstPerm (N/sqmm)		228.25	228.25	228.25	228.25	228.25
Crack Width Check						
Epsilon-deff, ε1		0.000253	0.000146	0.000554	0.000112	0.000566
Epsilon-m, εm		-0.00024	-0.000347	0.000275	-0.000381	0.000073
Wcr (mm)		-0.0287	-0.0416	0.0328	-0.0456	0.0087
WcrPerm (mm)		0.3	0.3	0.3	0.3	0.3