

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	ϵ_1	= Strain at level considered, Calculated ignoring the stiffening of the concrete in tension zone
3	ϵ_m	= 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 = $M_u + M_{Tu}$ in kNm
36	MuLim	=	Limiting Moment of Resistance 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 A_{sv} 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 induced 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 V_{ud} in N/sqmm
54	V^{D+L}	=	Shear force $1.2 \times (\text{Dead Load} + \text{Live Load})$ 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	=	$V^{D+L}_{\text{Left}} - 1.4 \times (M_{s\text{Left}} + M_{h\text{Right}})/L$ in kN
58	Vu-A2	=	$V^{D+L}_{\text{Left}} + 1.4 \times (M_{h\text{Left}} + M_{s\text{Right}})/L$ in kN
59	Vu-B1	=	$V^{D+L}_{\text{Right}} + 1.4 \times (M_{s\text{Left}} + M_{h\text{Right}})/L$ in kN
60	Vu-B2	=	$V^{D+L}_{\text{Right}} - 1.4 \times (M_{h\text{Left}} + M_{s\text{Right}})/L$ in kN
61	Vud	=	Design Shear Force (Max of V_{us} and $V_{u\text{-sway}}$) in kN
62	Vue	=	Earthquake induced shear in kN
63	Vu-sway	=	Max of (Vu-A1 and Vu-A2) & (Vu-B1 and Vu-B2) in kN
64	Vus	=	$V_{ud} - V_c$ Design Shear Force for reinforcement, in kN
65	Vut	=	Total Shear Force = $V_u + V_{Tu}$ 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 $f_y = 250$ 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 : 7 m
Beam Length	: 6150 mm
Breadth (B)	: 200 mm
Depth (D)	: 450 mm
Effective Depth (d)	: 370 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	: 2×10^5 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)	-	37.83	10.32	43.89	-	62.76
Tu (kNm)	1.29	0.05	0.58	1.29	0.67	1.2
M _{Tu} (kNm)	2.47	0.09	1.11	2.47	1.28	2.3
Mud (kNm)	2.47	37.92	11.43	46.37	1.28	65.06
MuLim (kNm)	95	95	95	95	95	95
R	0.09	1.385	0.417	1.693	0.047	2.376
Ptmin (%)	0.289	0.289	0.289	0.289	0.289	0.289
Ptclc (%)	0.306	0.412	0.459	0.513	0.289	0.753
Pcclc (%)	0.025	0	0	0	0.013	0
PtPrv (%)	0.306	0.611	0.611	0.611	0.306	0.917
AstCalc (sqmm)	226.2	304.78	339.3	379.57	213.98	556.93
AstPrv (sqmm)	226.2	452.4	452.4	452.4	226.2	678.6
Reinforcement Provided	2-T12	2-T12 2-T12	2-T12 2-T12	2-T12 2-T12	2-T12	2-T12 2-T12 2-T12

Shear Design			
	Left	Mid	Right
Critical L/C - Analysis	147	147	147
Critical L/C - RCDC	3	3	3
PtPrv (%)	0.611	0.917	0.917
Vu (kN)	56.24	42.6	62.37
Tu (kNm)	1.3	0.79	1.2
V _{Tu} (kN)	10.36	6.29	9.62
Vut (kN)	66.59	48.9	71.99
V ^{D+L} (kN)	50.98		50.68
Mh (kNm)	54.27		76.78
Ms (kNm)	28.68		54.27
Sway-Right (kN)	25.74		75.92
Sway-Left (kN)	76.96		25.96
Vu-Sway (kN)	76.96		75.92
Vud (kN)	76.96	48.9	75.92
Tv (N/sqmm)	1.04	0.66	1.03
Tc (N/sqmm)	0	0	0
Vc (kN)	0	0	0

Vus=Vud-Vc (kN)	76.96	48.9	75.92
Legs	2	2	2
Stirrup Rebar	8	8	8
Asv Torsion (sqmm)	238.924	169.891	251.654
Asv Torsion Prv (sqmm)	1340.53	744.74	1340.53
Asv Reqd (sqmm/m)	576.07	366.02	568.34
SvCalc (mm)	75	135	75
SvPrv (mm)	75	135	75
Asv Total Prv (sqmm)	1340.53	744.74	1340.53

Maximum Spacing Criteria

Basic

$$\text{Spc1} = 0.75d = 278 \text{ mm}$$

$$\text{Spc2} = 300 \text{ mm}$$

For Torsion

$$(X1 = 150, Y1 = 400)$$

$$\text{Spc3} = X1 = 150 \text{ mm}$$

$$\text{Spc4} = (X1 + Y1) / 4 = 135 \text{ mm}$$

For Ductility

Left Section

$$\text{Spc5} = d / 4 = 92 \text{ mm}$$

$$\text{Spc6} = 6 \times \text{Small Longitudinal Dia} = 75 \text{ mm}$$

$$\text{Spc7} = 100 \text{ mm}$$

Mid Section

$$\text{Spc5} = d / 2 = 185 \text{ mm}$$

Right Section

$$\text{Spc5} = d / 4 = 92 \text{ mm}$$

$$\text{Spc6} = 6 \times \text{Small Longitudinal Dia} = 75 \text{ mm}$$

$$\text{Spc7} = 100 \text{ mm}$$

SFR Design

$$\text{Beam Width} = 200 \text{ mm}$$

$$\text{Beam Depth} = 450 \text{ mm}$$

$$\text{Web Depth} = 450 \leq 750 \text{ mm}$$

Side Face Reinforcement not required.

Group : G3

Beam No : B6

Analysis Reference (Member) : 0 : 8

Beam Length	: 3650	mm
Breadth (B)	: 200	mm
Depth (D)	: 450	mm
Effective Depth (d)	: 370	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	: 2×10^5	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)	1.29	0.36	0.83	1.29	0.58	1.4
Mud (kNm)	1.29	9.65	6.22	34.56	4.91	19.01
MuLim (kNm)	95	95	95	95	95	95
R	0.047	0.352	0.227	1.262	0.179	0.694
Ptmin (%)	0.289	0.289	0.289	0.289	0.289	0.289
Ptclc (%)	0.459	0.289	0.289	0.373	0.289	0.289
Pcclc (%)	0.013	0	0	0	0	0
PtPrv (%)	0.611	0.306	0.306	0.917	0.306	0.306
AstCalc (sqmm)	339.3	213.98	213.98	275.88	213.98	213.98
AstPrv (sqmm)	452.4	226.2	226.2	678.6	226.2	226.2
Reinforcement Provided	2-T12 2-T12	2-T12	2-T12	2-T12 2-T12 2-T12	2-T12	2-T12

Shear Design			
	Left	Mid	Right
Critical L/C - Analysis	147	147	147
Critical L/C - RCDC	3	3	3
PtPrv (%)	0.917	0.306	0.306
Vu (kN)	40.52	22.92	29.87
Tu (kNm)	0.68	0.31	0.81
V _{Tu} (kN)	5.41	2.45	6.45
Vut (kN)	45.93	25.37	36.32
V ^{D+L} (kN)	29.65		30.71
Mh (kNm)	76.78		28.68
Ms (kNm)	54.27		28.68
Sway-Right (kN)	34.54		65.37
Sway-Left (kN)	73.73		44.22
Vu-Sway (kN)	73.73		65.37

Vud (kN)	73.73	25.37	65.37
Tv (N/sqmm)	1	0.34	0.88
Tc (N/sqmm)	0	0	0
Vc (kN)	0	0	0
Vus=Vud-Vc (kN)	73.73	25.37	65.37
Legs	2	2	2
Stirrup Rebar	8	8	8
Asv Torsion (sqmm)	157.482	84.693	133.673
Asv Torsion Prv (sqmm)	1340.53	543.46	1340.53
Asv Reqd (sqmm/m)	551.89	221.58	489.34
SvCalc (mm)	75	185	75
SvPrv (mm)	75	185	75
Asv Total Prv (sqmm)	1340.53	543.46	1340.53

Maximum Spacing Criteria

Basic

$$\begin{aligned} \text{Spc1} &= 0.75d &= & 278 & \text{mm} \\ \text{Spc2} & &= & 300 & \text{mm} \end{aligned}$$

For Torsion

$$(X1 = 150, Y1 = 400)$$

$$\begin{aligned} \text{Spc3} &= X1 &= & 150 & \text{mm} \\ \text{Spc4} &= (X1+Y1)/4 &= & 135 & \text{mm} \end{aligned}$$

For Ductility

Left Section

$$\begin{aligned} \text{Spc5} &= d / 4 &= & 92 & \text{mm} \\ \text{Spc6} &= 6 \times \text{Small Longitudinal Dia} &= & 75 & \text{mm} \\ \text{Spc7} & &= & 100 & \text{mm} \end{aligned}$$

Mid Section

$$\text{Spc5} = d / 2 = 185 \text{ mm}$$

Right Section

$$\begin{aligned} \text{Spc5} &= d / 4 &= & 92 & \text{mm} \\ \text{Spc6} &= 6 \times \text{Small Longitudinal Dia} &= & 75 & \text{mm} \\ \text{Spc7} & &= & 100 & \text{mm} \end{aligned}$$

SFR Design

Beam Width = 200 mm
 Beam Depth = 450 mm
 Web Depth = 450 <= 750 mm
 Side Face Reinforcement not required.