BEAM DESIGN FOR FLEXURAL AND SHEAR (SINGLY REINFORCED-NON DUCTILE)

DESIGN CODE AS 3600 : 2018

Input / Defaults

$BeamNo$: B21

$Location$: Right Zone (Top)

$TypeOfBeam := 1$	----------	1- for Regular, 2 for IMRF
$B := 450\ mm$	----------	Width of the Beam
$D := 800\ mm$	----------	Depth of the Beam
$M := 479.89\ kN \cdot m$	----------	Ultimate moment from analysis
$V := 263.43\ kN$	----------	Ultimate Shear force at section considered
$Mshear := 19.27\ kN \cdot m$	----------	Design Bending Moment at c/s related to Shear force considered
$T := 152.77\ kN \cdot m$	----------	Ultimate Torsion force at section considered, For Shear
$f'c := 25\ MPa$	----------	Grade of Concrete (Cylindrical Strength)
$fsy := 500\ MPa$	----------	Grade of Reinforcement
$Cc := 40\ mm$	----------	Nominal Cover to Beam Tension Reinforcement
$Es := 200000\ MPa$	----------	Modulus of elasticity of reinforcement
$\phi shear := 0.75$	----------	Capacity reduction factor for Shear and torsion
$ptmax := 4$	----------	Maximum % reinforcement
$ptmin := 0.13$	----------	Minimum % reinforcement
$ptnominal := 0.13$	----------	Nominal % reinforcement
$\varepsilon cu := 0.003$	----------	Permissible Strain in Concrete

Tension reinforcement Provided

$\phi 1 := 24\ mm$	----------	Diameter of Tension Reinforcement at Bottom Most layer
$N1 := 4$	----------	No of Rebar at Bottom most Layer
$\phi 2 := 0\ mm$	----------	Diameter of Tension Reinforcement at Inner layer
$N2 := 3$	----------	No of Rebar at Inner Layer

$$Ast := \frac{\pi \cdot \phi 1^2}{4} \cdot N1 + \frac{\pi \cdot \phi 2^2}{4} \cdot N2 = \left(1.81 \cdot 10^3\right)\ mm^2$$ ---------- Area of Tension Reinforcement Provided

Shear reinforcement Provided

$\phi 3 := 12\ mm$	----------	Diameter of outer Fitment
$Legs1 := 2$	----------	Legs of outer Fitment
$\phi 4 := 12\ mm$	----------	Diameter of inner Fitment
$Legs2 := 2$	----------	Legs of inner Fitment

$Spc := 95\ mm$

$$Asvprv := \left(\frac{\pi \cdot \phi 3^2}{4} \cdot Legs1 + \frac{\pi \cdot \phi 4^2}{4} \cdot Legs2\right) \cdot \frac{1000 \cdot mm}{Spc} = \left(4.762 \cdot 10^3\right)\ mm^2$$ ---------- Area of Fitments Provided

Side Face Reinforcement (SFR) Provided

$\phi SFR := 12\ mm$	----------	Diameter of SFR
$NosSFR := 3$	----------	Number of SFR at Each Face

$$fsy_f := \left\| \begin{array}{l} \text{if } fsy > 500\ \textit{MPa} \\ \quad \| 500 \\ \text{else} \\ \quad \| fsy \end{array} \right\| = 500\ \textit{MPa}$$

---------- Characteristic yield strength of reinforcement used as fitment is limited to 500 N/sqmm

Check for Singly Reinforced Section

$do := 730\ \textit{mm}$ ---------- Effective Depth of the Section

$$kuo := \frac{\varepsilon cu}{\left(\varepsilon cu + \left(\frac{fsy}{Es}\right)\right)} = 0.545$$ ---------- Constant for the balanced section

$\phi BMbal := 0.65$ ---------- Capacity Reduction factor (Tension reinforcement)

$NAbal := kuo \cdot do = 398.182\ \textit{mm}$ ---------- Neutral Axis depth for Balanced section

$$\alpha 2 := \max\left(0.67, (0.85) - 0.0015 \cdot \frac{f'c}{\textit{MPa}}\right) = 0.813$$

---------- Constant used for calculation of stress in concrete for rectangular stress block. Clause 8.1.3

$$\gamma := \max\left(0.67, (0.97) - 0.0025 \cdot \frac{f'c}{\textit{MPa}}\right) = 0.908$$

---------- The ratio of the depth of the assumed rectangular compressive stress block to kuo. Clause 8.1.3

$C := \gamma \cdot \alpha 2 \cdot B \cdot f'c \cdot NAbal = \left(3.303 \cdot 10^3\right)\ \textit{kN}$

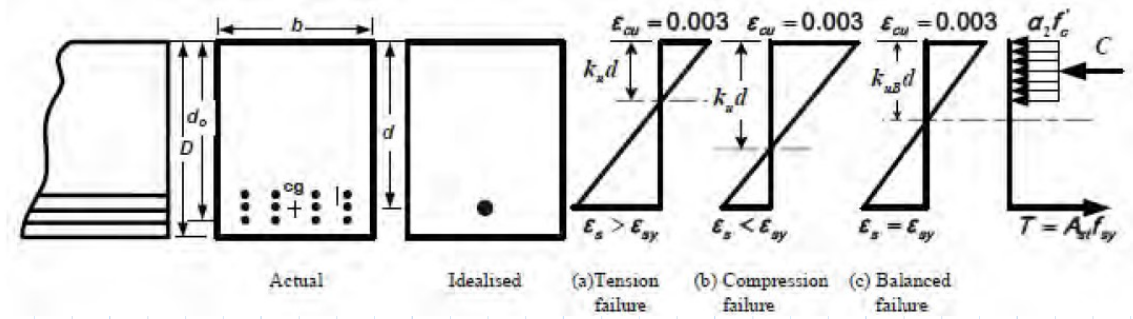
---------- Compressive force for rectangular stress block

$$\phi Muo := C \cdot \phi BMbal \cdot \left(do - \frac{NAbal \cdot \gamma}{2}\right) = \left(1.179 \cdot 10^3\right)\ \textit{kN·m}$$

---------- Moment capacity for Balanced section

$$Check := \left\| \begin{array}{l} \text{if } \phi Muo \geq M \\ \quad \| \text{“SinglyReinforced”} \\ \text{else} \\ \quad \| \text{“DoublyReinforced”} \end{array} \right\| = \text{“SinglyReinforced”}$$

---------- Check for Singly or Doubly Reinforced Section



STRESS AND STRAIN DIAGRAM

Design of Tension Reinforcement

$ku := 0.1365$ ---------- Neutral axis parameter being the ratio,at ultimate strength under any combination of bending and compression, of the depth to the neutral axis from the extreme compressive fiber to do

Note:

As per Table 2.2.2 of AS 3600:2018, the strength reduction factor for Bending Moment (ØBM), is dependent on the location of Neutral axis. Hence, to calculation tensile reinforcement for a given Bending Moment (M), the depth of neutral axis is calculated iteratively to check the capacity of the section. The reduction factor ØBM, ranges between from 0.65 to 0.85. Maximum possible value of kuo depends on strain in steel and concrete. For the maximum possible value of kuo, ØBM would be 0.65. For in between values of kuo, the ØBM value is calculated.

$$\phi BM := \left\| \begin{array}{l} \text{if } 0.85 \le \left(1.24 - \left(13 \cdot \frac{ku}{12}\right)\right) \\ \quad \| \, 0.85 \\ \text{else} \\ \quad \| \, \max\left(0.65, \left(1.24 - \left(13 \cdot \frac{ku}{12}\right)\right)\right) \end{array} \right\| = 0.85$$

---------- Strength Reduction factor for Bending Moment

$kud := ku \cdot do = 99.645 \ mm$ ---------- Depth of Neutral Axis

$f'ct.f := 0.6 \cdot \sqrt{f'c \cdot MPa} = 3 \ MPa$ ---------- Characteristic Uniaxial Tensile Strength of Concrete - Clause 3.1.1.3

$Astmin := 0.2 \cdot \left(\frac{D}{do}\right)^2 \cdot \frac{f'ct.f}{fsy} \cdot B \cdot do = 473.425 \ mm^2$ ---------- Minimum area of tension Reinforcement as per formula 8.1.6.1(2)

$Astmin_Userdefined := ptmin \cdot B \cdot \frac{do}{100} = 427.05 \ mm^2$ ---------- User Defined Minimum area of Tension Reinforcement

$AstBM := \frac{\gamma \cdot \alpha 2 \cdot B \cdot f'c \cdot kud}{fsy} = \left(1.653 \cdot 10^3\right) \ mm^2$ ---------- Area of Tension Reinforcement Required for M

$Astreq := \max\left(Astmin, Astmin_Userdefined, AstBM\right) = \left(1.653 \cdot 10^3\right) \ mm^2$ ---------- Final Area of Tension Reinforcement Required

Check for Maximum Reinforcement

$ptreq := \frac{Astreq}{B \cdot do} \cdot 100 = 0.503$ ---------- % Tension Reinforcement Required

$$CheckforMaxpt := \left\| \begin{array}{l} \text{if } ptreq \le ptmax \\ \quad \| \, \text{“Ok”} \\ \text{else} \\ \quad \| \, \text{“ Revise Section”} \end{array} \right\| = \text{“Ok”}$$

---------- Check for Maximum pt

Check for Compression Reinforcement

$Check1 :=$ if $M > 0.8\ \phi Muo$ "Required" else "Not Required" $=$ " Not Required"

---------- Clause 8.1.5

$Check2 :=$ if $ku > 0.36$ "Required" else "Not Required" $=$ " Not Required"

---------- Clause 8.1.5

Shear Design Check

$bv := B = 450\ mm$ ---------- Effective width of a web for shear. Clause 8.2.1.2

$Acp := B \cdot D = (3.6 \cdot 10^5)\ mm^2$ ---------- Total area enclosed by outside perimeter of concrete section. Clause 8.2.1.2

$uc := 2 \cdot B + 2 \cdot D = (2.5 \cdot 10^3)\ mm$ ---------- The length of outside perimeter of concrete cross section-Clause 8.2.1.2

$Tcr := 0.33 \cdot \sqrt{f'c \cdot MPa} \cdot \frac{Acp^2}{uc} = 85.536\ kN \cdot m$ ---------- Torsional cracking moment Eq. 8.2.1.2 (2)

$\phi Tcr := 0.25 \cdot \phi shear \cdot Tcr = 16.038\ kN \cdot m$ ---------- Permissible capacity of section for Torsional cracking moment Eq. 8.2.1.3(1)

$Check3 :=$ if $\phi Tcr < T$ "Consider Torsion" else "Ignore Torsion" $=$ "Consider Torsion"

---------- Check for Torsion to be considered or not

$Sheardia := 10\ mm$ ---------- Shear Diameter assumed

$x' := B - 2 \cdot Cc + Sheardia = 380\ mm$ ---------- Center line distance of the closed transverse torsion reinforcement along B

$y' := D - 2 \cdot Cc + Sheardia = 730\ mm$ ---------- Center line distance of the closed transverse torsion reinforcement along D

$uh := 2 \cdot x' + 2 \cdot y' = (2.22 \cdot 10^3)\ mm$ ---------- Perimeter of the center line of the closed transverse torsion reinforcement

$Aoh := x' \cdot y' = (2.774 \cdot 10^5)\ mm^2$ ---------- Area of the center line of the closed transverse torsion reinforcement

$Teq :=$ if $\phi Tcr < T$ $0.9 \cdot T \cdot \frac{uh}{2 \cdot Aoh}$ else $0\ kN$ $= 550.17\ kN$

---------- Equivalent shear force due to torsion

$Veq := \sqrt{(V)^2 + (Teq)^2} = 609.986\ kN$ ---------- Equivalent factored Shear force for co-existing applied shear force and applied torsion

$Mshear = 19.27\ kN \cdot m$ ---------- Design Bending Moment at cross section related to Shear force considered

$dv := \max(0.72 \cdot D, 0.9 \cdot do) = 657\ mm$ ---------- Effective depth to be considered for shear check

$Mshear1 := dv \cdot \sqrt{V^2 + Teq^2} = 400.761\ m \cdot kN$

$Mshearfinal := \left\| \begin{array}{l} \text{if } Mshear1 \le Mshear \\ \quad \| Mshear \\ \text{else} \\ \quad \| Mshear1 \end{array} \right\| = 400.761\ kN \cdot m$

Tension reinforcement Provided

$\phi 5 := 16\ mm$ ---------- Diameter of Tension Reinforcement at Bottom Most layer

$N3 := 4$ ---------- No of Rebar at Bottom most Layer

$\phi 6 := 0\ mm$ ---------- Diameter of Tension Reinforcement at Inner layer

$N4 := 3$ ---------- No of Rebar at Inner Layer

$Astshear := \frac{\pi \cdot \phi 5^2}{4} \cdot N3 + \frac{\pi \cdot \phi 6^2}{4} \cdot N4 = 804.248\ mm^2$

---------- Area of Tension Reinforcement Considered for Shear check

$\varepsilon x := \frac{Mshearfinal}{2 \cdot Astshear \cdot Es \cdot dv} + \frac{\sqrt{V^2 + Teq^2}}{2 \cdot Astshear \cdot Es} = 0.004$ ---------- Longitudinal strain in concrete formula 8.2.4.2.3(1)

$\varepsilon xfinal := \left\| \begin{array}{l} \text{if } \varepsilon x \le 0 \\ \quad \| 0 \\ \text{else} \\ \quad \| \varepsilon x \end{array} \right\| = 0.004$

---------- Longitudinal strain in concrete formula 8.2.4.2.3(1)

$kv := \frac{0.4}{(1 + 1500 \cdot \varepsilon xfinal)} = 0.06$ ---------- Constant for calculation of concrete section capacity Eq. 8.2.4.2(4)

$\theta v := 29 + 7000 \cdot \varepsilon xfinal = 55.546$ ---------- Angle of inclination of the compression strut Eq. 8.2.4.2(5)

$\alpha v := 90$ ---------- Angle between the inclined shear reinforcement and the longitudinal tensile reinforcement Clause 8.2.3.3

$cot\theta v := \cot\left(\theta v \cdot \frac{\pi}{180}\right) = 0.686$ ---------- Clause 8.2.3.3

$cot\alpha v := \cot\left(\alpha v \cdot \frac{\pi}{180}\right) = 6.123 \cdot 10^{-17}$ ---------- Clause 8.2.3.3

$$Vumax := 0.55 \cdot \left(f'c \cdot bv \cdot dv \cdot \frac{(\cot\theta v + \cot\alpha v)}{(1 + \cot\theta v^2)} \right) = (1.896 \cdot 10^3)\ \textbf{kN}$$

---------- Ultimate shear strength limited by web crushing failure Clause 8.2.3.3

$$\phi Vumax := \phi shear \cdot Vumax = (1.422 \cdot 10^3)\ \textbf{kN}$$

---------- Shear strength limited by web crushing failure Clause 8.2.3.3

$$Tdesign := \left\| \begin{array}{l} \text{if } \phi Tcr < T \\ \quad \| T \\ \text{else} \\ \quad \| 0\ \textbf{kN·m} \end{array} \right\| = 152.77\ \textbf{kN·m}$$

---------- Check for Torsion Value to be consider in design

$$StressV\&T := \sqrt{\left(\frac{V}{bv \cdot dv}\right)^2 + \left(\frac{Tdesign \cdot uh}{1.7 \cdot Aoh^2}\right)^2} = 2.741\ \textbf{MPa}$$

---------- Combined stress due to Shear and torsion. Eq.8.2.3.4 (3)

$$stress\phi Vumax := \frac{\phi Vumax}{bv \cdot dv} = 4.811\ \textbf{MPa}$$

---------- Maximum permissible stress due to shear and torsion. Eq.8.2.3.4 (3)

$$check4 := \left\| \begin{array}{l} \text{if } StressV\&T \le stress\phi Vumax \\ \quad \| \text{“Ok”} \\ \text{else} \\ \quad \| \text{“Revise Section”} \end{array} \right\| = \text{“Ok”}$$

---------- Check for Cross section capacity

$$f'cshear := \left\| \begin{array}{l} \text{if } f'c \le 64\ \textbf{MPa} \\ \quad \| f'c \\ \text{else} \\ \quad \| 64 \end{array} \right\| = 25\ \textbf{MPa}$$

---------- Maximum Allowed Concrete grade for shear Clause 8.2.4.1

$$\phi Vuc := \phi shear \cdot kv \cdot bv \cdot dv \cdot \sqrt{f'c \cdot \textbf{MPa}} = 66.305\ \textbf{kN}$$

---------- Ultimate Concrete shear strength excluding shear reinforcement Clause 8.2.4.1

$$check6 := \left\| \begin{array}{l} \text{if } Veq \le \phi Vuc \\ \quad \| \text{“Provide Minimum Shear Reinf.”} \\ \text{else} \\ \quad \| \text{“Provide Design Shear Reinf.”} \end{array} \right\| = \text{“Provide Design Shear Reinf.”}$$

---------- Check for Shear Reinforcement

$$\phi Vus := \frac{(Veq - \phi Vuc)}{\phi shear} = 724.908\ \textbf{kN}$$

---------- Contribution of shear reinforcement to the ultimate shear strength- Clause 8.2.3.1

$$Asvmin := 0.08 \cdot \sqrt{f'c \cdot \textbf{MPa}} \cdot \frac{bv}{fsy} \cdot 1000 \cdot \textbf{mm} = 360\ \textbf{mm}^2$$

---------- Minimum transverse shear reinforcement Clause 8.2.1.7

$$Asvshear := \frac{\phi Vus \cdot 1000 \cdot mm}{(fsy \cdot dv \cdot cot\theta v)} = (3.216 \cdot 10^3)\ mm^2$$

---------- Transverse shear reinforcement as per design Clause 8.2.5.2

$$Asv_final := \max(Asvmin, Asvshear) = (3.216 \cdot 10^3)\ mm^2$$

---------- Final transverse shear reinforcement

$$check7 := \left\| \begin{array}{l} \text{if } Asv_final \le Asvprv \\ \quad \| \text{“Ok”} \\ \text{else} \\ \quad \| \text{“Increase Fitment Area ”} \end{array} \right\| = \text{“Ok”}$$

---------- Check for Total Fitment Provided

$$Spc_Shear := \frac{\frac{\pi \cdot \phi 3^2}{4} \cdot Legs1 \cdot mm + \frac{\pi \cdot \phi 4^2}{4} \cdot Legs2 \cdot mm}{Asv_final} \cdot 1000 = 140.654\ mm$$

---------- Spacing required for Shear reinforcement

Design for Torsion Reinforcement as Fitment

$$AswT := \left\| \begin{array}{l} \text{if } \phi Tcr < T \\ \quad \left\| \frac{Tdesign \cdot 1000 \cdot mm}{(\phi shear \cdot 1.7 \cdot Aoh \cdot fsy_f \cdot cot\theta v)} \right. \\ \text{else} \\ \quad \| 0\ mm^2 \end{array} \right\| = (1.259 \cdot 10^3)\ mm^2$$

---------- Area of torsion reinforcement required as fitment for Torsion - Clause 8.2.5.6

$$AswTcr := \left\| \begin{array}{l} \text{if } \phi Tcr < T \\ \quad \left\| \frac{Tcr \cdot 1000 \cdot mm}{\left(1.7 \cdot Aoh \cdot fsy_f \cdot \frac{1}{\tan\left(\theta v \cdot \frac{\pi}{180}\right)}\right)} \right. \\ \text{else} \\ \quad \| 0\ mm^2 \end{array} \right\| = 528.732\ mm^2$$

---------- Area of torsion reinforcement required as fitment for Tcr - Clause 8.2.5.5 (1)

$$y1 := y' = 730\ mm$$

---------- Largest overall dimension of the closed fitment - Clause 8.2.5.5 (a) (ii)

$$Aswmin := \left\| \begin{array}{l} \text{if } \phi Tcr < T \\ \quad \left\| 0.2 \cdot \frac{y1 \cdot 1000 \cdot MPa \cdot mm}{fsy_f} \right. \\ \text{else} \\ \quad \| 0\ mm^2 \end{array} \right\| = 292\ mm^2$$

---------- Minimum torsional reinforcement as Closed fitments - Clause 8.2.5.5 (a) (ii)

$$Aswfinal := \max(AswT, AswTcr, Aswmin) = (1.259 \cdot 10^3)\ mm^2$$

---------- Area of Outer Fitment required

$$Aswprovided := \frac{\pi \cdot \phi 3^2}{4} \cdot Legs1 \cdot \frac{1000 \cdot mm}{Spc} = (2.381 \cdot 10^3)\ mm^2$$

$check8 := \left\| \begin{array}{l} \text{if } Aswfinal \le Aswprovided \\ \quad \| \text{“Ok”} \\ \text{else} \\ \quad \| \text{“Increase Fitment ”} \end{array} \right\| = \text{“Ok”}$ ---------- Check for Outer Fitment Provided

$Spc_Shear := \dfrac{\dfrac{\pi \cdot \phi 3^2}{4} \cdot Legs1 \cdot mm}{Aswfinal} \cdot 1000 = 179.647\ mm$

Spacing criteria for Fitments

$Spc1 := \left\| \begin{array}{l} \text{if } D \le 1200\ m \\ \quad \| 300\ mm \\ \text{else} \\ \quad \| 600\ mm \end{array} \right\| = 300\ mm$ ---------- Fitment Spacing - Clause 8.3.2.2

$Spc2 := 0.5 \cdot D = 400\ mm$ ---------- Fitment Spacing - Clause 8.3.2.2

$Spc3 := \left\| \begin{array}{l} \text{if } T > 0 \\ \quad \| 300\ mm \\ \text{else} \\ \quad \| 0\ mm \end{array} \right\| = 300\ mm$ ---------- Fitment Spacing for Torsion- Clause 8.3.3 (b)

$Spc4 := \left\| \begin{array}{l} \text{if } T > 0 \\ \quad \| 0.12 \cdot uh \\ \text{else} \\ \quad \| 0\ mm \end{array} \right\| = 266.4\ mm$ ---------- Fitment Spacing for Torsion- Clause 8.3.3 (b)

$Spc_final := min(Spc1, Spc2, Spc3, Spc4) = 266.4\ mm$ ---------- Fitment Spacing Required

$Spc_prv := Spc = 95\ mm$ ---------- Provided Spacing of Fitments

$Check9 := \left\| \begin{array}{l} \text{if } Spc_final \ge Spc_prv \\ \quad \| \text{“Ok”} \\ \text{else} \\ \quad \| \text{“Reduce Spacing”} \end{array} \right\| = \text{“Ok”}$ ---------- Check for Maximum Spacing

Design of Side face reinforcement

$B = 450\ mm$ ---------- Width of the Beam

$D = 800\ mm$ ---------- Depth of the Beam

$CheckforSFR := \left\| \begin{array}{l} \text{if } D > 750\ mm \\ \quad \| \text{“Provide SFR”} \\ \text{else} \\ \quad \| \text{“SFR not Required”} \end{array} \right\| = \text{“Provide SFR”}$ ---------- Check for SFR-Clause 8.6.4

$\phi SFR := 12\ mm$ ---------- Diameter of SFR provided

$NosSFR := 3$ ---------- Number of SFR at Each Face

$$SFR_MaxSpc := \left\| \begin{array}{l} \text{if } \phi SFR \le 12\ mm \\ \quad \| 300\ mm \\ \text{else} \\ \quad \| 600\ mm \end{array} \right| = 300\ mm$$

---------- Maximum Spacing for SFR- Clause 8.6.4

$$Actual_Spc := \frac{(D - 2 \cdot Cc - 20\ mm)}{NosSFR + 1} = 175\ mm$$

---------- Actual Spacing of SFR

$$CheckforSpacing := \left\| \begin{array}{l} \text{if } SFR_MaxSpc \ge Actual_Spc \\ \quad \| \text{“Ok”} \\ \text{else} \\ \quad \| \text{“Increase SFR”} \end{array} \right| = \text{“Ok”}$$

---------- Check for Maximum Spacing

RCDC Output - Design Calculation Report

Group		:	**G25**	
Beam No		:	**B21**	
Analysis Reference (Member)	7.858 m	:	50,185,062	
Beam Length		:	7790	mm
Breadth (b)		:	450	mm
Depth (D)		:	800	mm
Effective Depth (do)		:	730	mm
Effective width for flanged beam		:	730	mm
Design Code		:	AS 3600 : 2018	
Beam Type		:	Regular Beam	
Category		:	Internal	
Grade Of Concrete (f'c)		:	N25	N/sqmm
Grade Of Steel (fsy)		:	500N	N/sqmm
Clear Cover (c)		:	40	mm
Es		:	2x10^5	N/sqmm
α2		:	0.81	
γ		:	0.91	
Φ Muo		:	1179.36	kNm
As,min (flex) (B)		:	473.42	sqmm
As,nominal (Bn)		:	468	sqmm
As,min(user input)(B')		:	427.05	sqmm

Flexure Design						
	Beam Bottom			Beam Top		
	Left	Mid	Right	Left	Mid	Right
Critical L/C - RCDC	5	6	6	6	6	5
M* (kNm)	6.8	196.66	109.44	349.59	37.63	479.89
ku	0.36	0.36	0.36	0.36	0.36	0.36
kud (Distance Of N.A.) (mm)	262.8	262.8	262.8	262.8	262.8	262.8
Doubly Reinforced Section						
M*2 (Excess Moment for Doubly Reinforced section) (kNm)	0	0	0	0	0	0
fsc (Compressive Stress in Steel) (N/sqmm)	0	0	0	0	0	0
Asc (Area of Compression Reinf.) (sqmm) (C)	0	0	0	0	0	0
ρ (%) (Flexural)	0.007	0.198	0.109	0.359	0.144	0.502
Ast (sqmm) (A)	21.92	649.7	357.53	1178.88	121.86	1648.63
Asc (ku > 0.36 & M*>0.8 Φ Muo)						
Ac compression (kud x b) (sqmm)	0	0	0	0	0	0
Asc (sqmm) (D)	0	0	0	0	0	0
Asc reqd (sqmm)	0	0	0	0	0	0
Ast reqd (sqmm)	473.42	649.7	473.42	1178.88	473.42	1648.62
$A_{st\ prov}$ (sqmm)	804.24	804.24	804.24	1256.64	804.24	1809.52
Reinforcement Provided	4-N16	4-N16	4-N16	4-N20	4-N16	4-N24

Shear Design			
Aoh	=	277400	sqmm
uc	=	2500	mm
uh	=	2220	mm
Asv/s.min	=	360	sqmm/m
Tcr	=	85.54	kNm
0.25ΦTcr	=	16.04	kNm
Asw/s min (torsion)	=	292	sqmm/m

For Transverse Reinf			
	Left	Mid	Right
Critical L/C - RCDC	6	6	8
PtPrv (%)	0.383	0.245	0.245
V* (kN)	177.57	113.99	263.43
M*-Sect (kNm)	349.59	23.29	19.27
T* (kNm)	27.45	27.45	152.77
0.9xT*x uh/2Ao (N)	98869.87	98869.87	550173.57
V*eq (kN)	203.24	150.89	609.99
εx x 10^-3	1.46	0.94	3.79
kv	0.13	0.17	0.06
cot θv	1.22	1.4	0.69
v* (stress due to V* + T*) (N/sqmm)	0.76	0.6	2.74
Φ Vu,max / (bv x dv) (N/sqmm)	5.05	4.88	4.81
Φ Vuc (kN)	138.83	184.23	66.3
Φ Vus (kN)	85.87	44.45	724.91
Tu (kNm)	27.45	27.45	152.77
Asw/s (T*) (sqmm/m)	126.8	111.01	1259.13
Asw /s (Tcr) (sqmm/m)	296.29	259.4	528.74
Asw /s (torsion) (sqmm/m)	296.29	292	1259.13
Asv/s Reqd (sqmm/m)	360	360	3216.37
Legs	4	4	4
Fitment Rebar	10	10	10
SCalc (mm)	265	265	95
SPrv (mm)	265	265	95
Av Total Prv (sqmm/m)	1185.51	1185.51	3306.95

Maximum Spacing Criteria					
Basic					
Spc1		=	400		mm
Spc2		=	300		mm
For Torsion					
(x' = 380, y' = 730)					
Spc3		=	300		mm
Spc4= 0.12 x 2 x (x'+y')		=	266		mm
Side face reinforcement					
Beam Width	=	450	mm		
Depth of the Beam	=	800	mm		
		Beam Depth > 750 ,			
		Hence, Side face reinforcement is Provided			
Spacing Criteria					
SFR Rebar	=	12	mm		
Number of Rebar (EF)	=	3			
Maximum Spacing Permitted	=	200	mm		
Spacing Provided	=	175	mm Hence, OK		