DESIGN OF DIAGONAL REINFORCEMENT FOR COUPLING BEAM

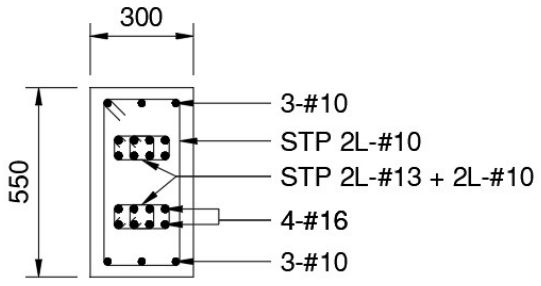
AS PER IS ACI 318M-2014

Input / Defaults

$BeamNo$: B2

$B := 300\ mm$	----------	Width of the Beam
$D := 550\ mm$	----------	Depth of the Beam
$f'c := 20\ MPa$	----------	Grade of Concrete (Cylindrical Strength)
$fy := 420\ MPa$	----------	Grade of Main Reinforcement
$fsy := 420\ MPa$	----------	Grade of Secondary Reinforcement
$Cc := 40\ mm$	----------	Nominal Cover to Beam Tension Reinforcement
$Es := 200000\ MPa$	----------	Modulus of elasticity of reinforcement
$Vu := 457.8\ kN$	----------	Earthquake Induced shear
$Ls := 1000\ mm$	----------	Clear span of Beam
$deff := 480\ mm$	----------	Effective Depth of the Beam
$\phi := 0.85$	----------	Strength Reduction Factor
$\lambda := 1$	----------	Modification factor

Beam Cross Section



B2

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Diagonal reinforcement

$\phi 1 := 15.9\ mm$	----------	Diameter of Diagonal Reinforcement
$N1 := 8$	----------	No of Diagonal Reinforcement

$$Avd := \frac{\pi \cdot \phi 1^2}{4} \cdot N1 = 1588.452\ mm^2$$ ---------- Area of Diagonal Reinforcement Provided

$\phi 2 := 12.7\ mm$	----------	Diameter of Outer Links to Diagonal Reinforcement
$\phi 3 := 9.5\ mm$	----------	Diameter of InnerLinks to Diagonal Reinforcement
$Spc\_Duct := 100\ mm$	----------	Spacing of Links to Diagonal Reinforcement
$Bundled\_1 := 1$	----------	Bundled Links

Checking for Coupling Action

$Ls := 1000\ mm$ ---------- Clear span of Beam

$D := 550\ mm$ ---------- Depth of the Beam

$Vu = 457.8\ kN$ ---------- Earthquake Induced shear

$D' := D - 2 \cdot Cc = 470\ mm$

$$Check1 := \left\| \begin{array}{l} \text{if } \frac{Ls}{D} < 2 \\ \quad \text{“Coupling Beam”} \\ \text{else} \\ \quad \text{“Regular Beam”} \end{array} \right\| = \text{“Coupling Beam”}$$

---------- Check for Coupling Beam

$$Vc := 0.33 \cdot \sqrt{f'c \cdot MPa} \cdot \lambda \cdot B \cdot D = 243.508\ kN$$

$$Check2 := \left\| \begin{array}{l} \text{if } Vc < Vu \\ \quad \text{“Coupling Beam”} \\ \text{else} \\ \quad \text{“Regular Beam”} \end{array} \right\| = \text{“Coupling Beam”}$$

---------- Check for Coupling Beam

$$Vn := 0.83 \cdot \sqrt{f'c \cdot MPa} \cdot \lambda \cdot B \cdot deff = 534.51\ kN$$

$$Check2 := \left\| \begin{array}{l} \text{if } Vn \geq Vu \\ \quad \text{“Ok”} \\ \text{else} \\ \quad \text{“Revise”} \end{array} \right\| = \text{“Ok”}$$

Design of Diagonal Reinforcement

$$\alpha := \operatorname{atan}\left(\frac{D'}{Ls}\right) \cdot \frac{180}{\pi} = 25.174$$

$$Adr := \frac{(Vu)}{\phi \cdot 2 \cdot fy \cdot \sin\left(\alpha \cdot \frac{\pi}{180}\right)} = 1507.37\ mm^2$$

---------- Clause 21.9.7.5

Diagonal reinforcement provided

$\phi 1 := 15.9\ mm$ ---------- Diameter of Diagonal Reinforcement

$N1 := 8$ ---------- No of Diagonal Reinforcement

$Avd = 1588.452\ mm^2$ ---------- Area of Diagonal Reinforcement Provided

$$Check := \left\| \begin{array}{l} \text{if } Avd > Adr \\ \quad \text{“Ok”} \\ \text{else} \\ \quad \text{“Revise”} \end{array} \right\| = \text{“Ok”}$$

Note:

1.Please refer to the design calculation of the regular beam for the design and detailing of longitudinal, skin and shear reinforcement of the coupling beam

2.Longitudinal and Shear reinforcement would be designed for load combinations other than having Earthquake load cases.

Hoop link for diagonal bars

$Legs1 := 4$

$Legs2 := 2$

$B'' := 195.899\ mm$

$D'' := 395.899\ mm$

$DSpc1 := 6 \cdot \phi 1 = 95.4\ mm$

$$Hx := \max\left(\frac{\left(D'' - 2 \cdot Cc + 2 \cdot \phi 2\right)}{Legs1 - 1}, \frac{\left(B'' - 2 \cdot Cc + 2 \cdot \phi 2\right)}{Legs2 - 1}\right) = 141.299\ mm$$

$$DSpc2 := min\left(\max\left(100 \cdot mm, 10 \cdot mm + \frac{\left(350 \cdot mm - Hx\right)}{3}\right), 150 \cdot mm\right) = 100\ mm$$

$$DSpcReq := min\left(DSpc1, DSpc2\right) = 95.4\ mm$$

$$Check := \left\| \begin{array}{l} \text{if } Spc\_Duct \le DSpcReq \\ \quad \left\| \text{“Ok”} \right. \\ \text{else} \\ \quad \left\| \text{“Reduce spacing”} \right. \end{array} \right\| = \text{“Reduce spacing”}$$

$$Ag := B'' \cdot D'' = 77556.218\ mm^2$$

$$bc1 := B'' - 2 \cdot Cc + 2 \cdot \phi 2 = 141.299\ mm$$

$$Ach := \left(D'' - 2 \cdot Cc + 2 \cdot \phi 2\right) \cdot \left(B'' - 2 \cdot Cc + 2 \cdot \phi 2\right) = 48225.207\ mm^2$$

$$Ash1 := 0.3 \cdot \left(\frac{Ag}{Ach} - 1\right) \cdot \frac{f'c}{fsy} \cdot bc1 \cdot Spc\_Duct = 122.77\ mm^2$$

$$Ash2 := 0.09 \cdot \frac{f'c}{fsy} \cdot bc1 \cdot Spc\_Duct = 60.557\ mm^2$$

$$Ash := \max\left(Ash1, Ash2\right) = 122.77\ mm^2$$

$$Ash\_D\_Provided := \frac{\pi \cdot \phi 2^2}{4} \cdot Bundled\_1 = 126.677\ mm^2$$

$$Check := \left\| \begin{array}{l} \text{if } Ash \le Ash\_D\_Provided \\ \quad \left\| \text{“Ok”} \right. \\ \text{else} \\ \quad \left\| \text{“Revise”} \right. \end{array} \right\| = \text{“Ok”}$$

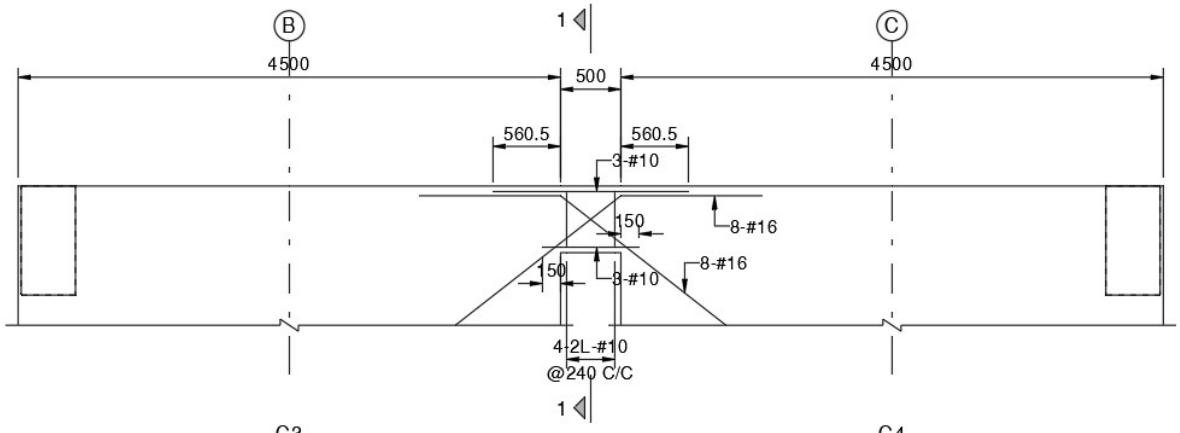
RCDC Output - Design Calculation Report

Group	:	**G2**
Beam No	:	**B2**
Analysis Reference (Member)	:	1304 (15 m)
Beam Length	:	1000 mm
Breadth (B)	:	300 mm
Depth (D)	:	550 mm
Effective Depth (d)	:	480 mm
Design Code	:	ACI 318M - 14
Beam Type	:	Coupling Beam
Grade Of Concrete (f'c)	:	C20 N/sqmm
Grade Of Steel (Main)	:	Fy420 N/sqmm
Grade Of Steel (Shear)	:	Fy420 N/sqmm
Grade Of Steel - Flexural Design	:	Fy420 N/sqmm
Grade Of Steel - Shear Design	:	Fy420 N/sqmm
Grade Of Steel - Torsion Design	:	Fy420 N/sqmm
Top/Bottom Clear Cover (Cmin)	:	40 mm
Side Clear Cover	:	40 mm
Es	:	2x10^5 N/sqmm
Mubal	:	350.08 kNm
As,min (flex) (B)	:	480 sqmm
As,nominal (Bn)	:	187.2 sqmm
As,min(user input)(B')	:	187.2 sqmm
Strength Reduction Factor φ (Shear)	:	0.6

Check for coupling action

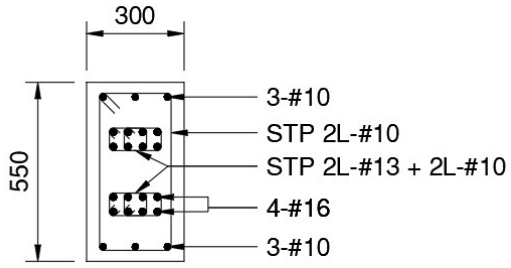
Design of diagonal reinforcement

Clear Span of Beam, Ln	=	1000 mm
Beam Depth, D	=	550 mm
Effective Depth, deff	=	480 mm
Angle with horizontal, (α)	=	25.174 deg
Shear for EQ case, Vu	=	457.8 kN
λ	=	1
Φ	=	0.85
Criteria		
1	=	Ln/D
	=	1000/550
	=	1.82 < 2, Hence coupling beam is applicable
2. Vc	=	0.33 x λ x sqrt(fck) x B x D
	=	243.51 kN
	=	Vc < Vu
	=	Hence, Beam Is coupling beam
Vn	=	0.83 x sqrt(fck) x B x Deff
	=	534.51 kN
Vu	<	Vn Hence Ok
Avd	=	(Vu x 1000 / (2 x Fy x sinα)) / Φ
	=	1507.36 sqmm
Reinforcement provided	=	4-#16
		4-#16 Both diagonals



B2:300x550

(SCALE: H = 1:50 / V = 1:50)



B2

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