DESIGN OF DIAGONAL REINFORCEMENT FOR COUPLING BEAM

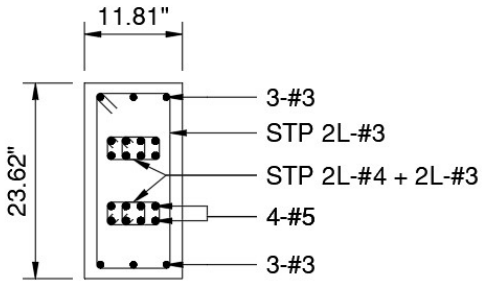
AS PER IS ACI 318-2014

Input / Defaults

$BeamNo$: B2

$B := 11.81\ in$	----------	Width of the Beam
$D := 23.62\ in$	----------	Depth of the Beam
$f'c := 3\ ksi$	----------	Grade of Concrete (Cylindrical Strength)
$fy := 60\ ksi$	----------	Grade of Main Reinforcement
$fsy := 60\ ksi$	----------	Grade of Secondary Reinforcement
$Cc := 1.5\ in$	----------	Nominal Cover to Beam Tension Reinforcement
$Es := 29007.55\ ksi$	----------	Modulus of elasticity of reinforcement
$Vu := 104.14\ kip$	----------	Earthquake Induced shear
$Ls := 39.37\ in$	----------	Clear span of Beam
$deff := 20.94\ in$	----------	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

$$Avd := \frac{\pi \cdot \phi 1^2}{4} \cdot N1 = 2.462\ in^2$$ ---------- 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
$Spc\_Duct := 4\ in$	----------	Spacing of Links to Diagonal Reinforcement
$Bundled\_1 := 1$	----------	Bundled Links

Checking for Coupling Action

$Ls = 39.37\ in$ ---------- Clear span of Beam

$D = 23.62\ in$ ---------- Depth of the Beam

$Vu = 104.14\ kip$ ---------- Earthquake Induced shear

$D' := D - 2 \cdot Cc = 20.62\ in$

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

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

$Vc := 4 \cdot \sqrt{f'c \cdot psi} \cdot \lambda \cdot B \cdot D = 61.115\ kip$

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

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

$Vn := 10 \cdot \sqrt{f'c \cdot psi} \cdot \lambda \cdot B \cdot deff = 135.453\ kip$

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

Design of Diagonal Reinforcement

$$\alpha := \operatorname{atan}\left(\frac{D'}{Ls}\right) \cdot \frac{180}{\pi} = 27.643$$

$$Adr := \frac{(Vu)}{\phi \cdot 2 \cdot fy \cdot \sin\left(\alpha \cdot \frac{\pi}{180}\right)} = 2.201\ in^2$$

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

Diagonal reinforcement provided

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

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

$Avd = 2.462\ in^2$ ---------- 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

$Legs1 := 4$

$Legs2 := 2$

$B'' := 7.626\ in$

$D'' := 15.626\ in$

$DSpc1 := 6 \cdot \phi 1 = 3.756\ in$

$$Hx := \max\left(\frac{(D'' - 2 \cdot Cc + 2 \cdot \phi 2)}{Legs1 - 1}, \frac{(B'' - 2 \cdot Cc + 2 \cdot \phi 2)}{Legs2 - 1}\right) = 5.626\ in$$

$$DSpc2 := min\left(\max\left(4 \cdot in, 0.374 \cdot in + \frac{(14 \cdot in - Hx)}{3}\right), 6 \cdot in\right) = 4\ in$$

$$DSpcReq := min(DSpc1, DSpc2) = 3.756\ in$$

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

$Ag := B'' \cdot D'' = 119.164\ in^2$

$bc1 := B'' - 2 \cdot Cc + 2 \cdot \phi 2 = 5.626\ in$

$Ach := (D'' - 2 \cdot Cc + 2 \cdot \phi 2) \cdot (B'' - 2 \cdot Cc + 2 \cdot \phi 2) = 76.66\ in^2$

$$Ash1 := 0.3 \cdot \left(\frac{Ag}{Ach} - 1\right) \cdot \frac{f'c}{fsy} \cdot bc1 \cdot Spc\_Duct = 0.187\ in^2$$

$$Ash2 := 0.09 \cdot \frac{f'c}{fsy} \cdot bc1 \cdot Spc\_Duct = 0.1\ in^2$$

$Ash := \max(Ash1, Ash2) = 0.187\ in^2$

$$Ash\_D\_Provided := \frac{\pi \cdot \phi 2^2}{4} \cdot Bundled\_1 = 0.196\ in^2$$

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

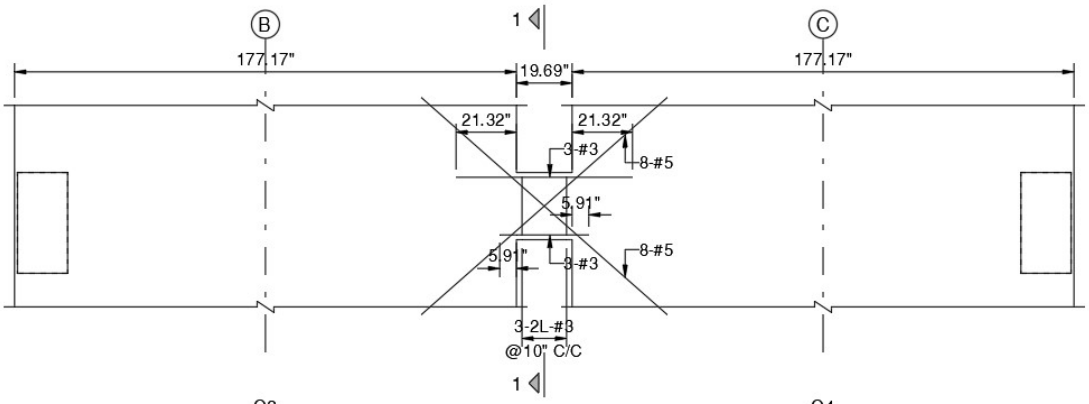
RCDC Output - Design Calculation Report

Group	:	**G2**
Beam No	:	**B2**
Analysis Reference (Member)	:	1304 (49.2125 ft)
Beam Length	:	39.37 in
Breadth (B)	:	11.81 in
Depth (D)	:	23.62 in
Effective Depth (d)	:	20.94 in
Design Code	:	ACI 318 - 14
Beam Type	:	Coupling Beam
Grade Of Concrete (f'c)	:	C3 ksi
Grade Of Steel (Main)	:	Fy60 ksi
Grade Of Steel (Shear)	:	Fy60 ksi
Grade Of Steel - Flexural Design	:	Fy60 ksi
Grade Of Steel - Shear Design	:	Fy60 ksi
Grade Of Steel - Torsion Design	:	Fy60 ksi
Top/Bottom Clear Cover (Cmin)	:	1.5 in
Side Clear Cover	:	1.5 in
Es	:	29007.55 ksi
Mubal	:	327.85 kip-ft
As,min (flex) (B)	:	0.82 in^2
As,nominal (Bn)	:	0.32 in^2
As,min(user input)(B')	:	0.32 in^2
Strength Reduction Factor φ (Shear)	:	0.6

Check for coupling action

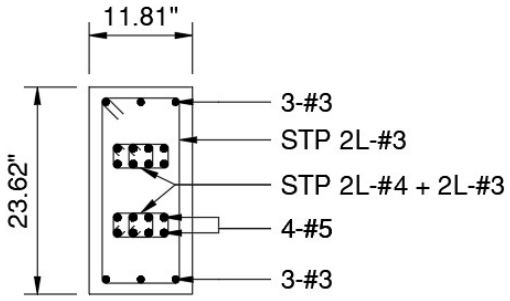
Design of diagonal reinforcement

Clear Span of Beam, Ln	=	39.37 in
Beam Depth, D	=	23.62 in
Effective Depth, deff	=	20.94 in
Angle with horizontal, (α)	=	27.646 deg
Shear for EQ case, Vu	=	104.14 kip
λ	=	1
Φ	=	0.85
Criteria		
1	=	Ln/D
	=	39.37/23.62
	=	0.07 < 0.08, Hence coupling beam is applicable
2. Vc	=	4 x λ x sqrt(fck) x B x D
	=	61.12 kip
	=	Vc < Vu
	=	Hence, Beam Is coupling beam
Vn	=	10 x sqrt(fck) x B x Deff
	=	135.46 kip
Vu	<	Vn Hence Ok
Avd	=	(Vu x 1000 / (2 x Fy x sinα)) / Φ
	=	2.2 in^2
Reinforcement provided	=	4-#5
		4-#5 Both diagonals



B2:11.81"x23.62"

(SCALE: H = 1:48 / V = 1:48)



B2

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