BEAM SWAY SHEAR CALCULATION (SPECIAL DUCTILE FRAME)

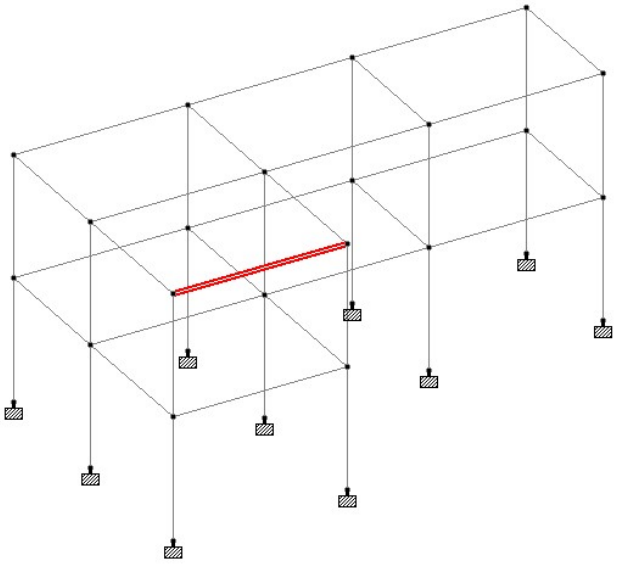
DESIGN CODE ACI 318-2014

Input / Defaults

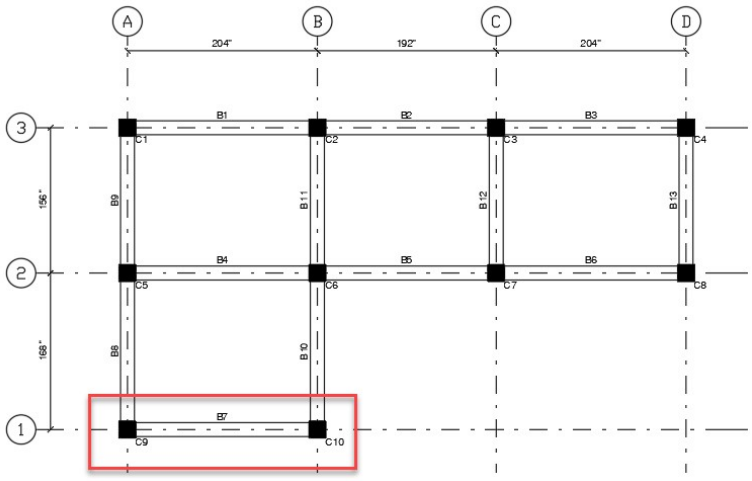
$BeamNo$: B1

$Location$: Left & Right Zone

$TypeOfBeam := 2$	----------	1- for Regular/Intermediate, 2 for Special Frame
$B := 15\ in$	----------	Width of the Beam
$D := 30\ in$	----------	Depth of the Beam
$L\_Clear := 186\ in$	----------	Clear Span of the Beam
$L\_Span := 204\ in$	----------	c/c Span of the Beam
$f'c := 3\ ksi$	----------	Grade of Concrete (Cylindrical Strength)
$fy := 60\ ksi$	----------	Grade of Main Reinforcement
$fsy := 60\ ksi$	----------	Grade of Shear Reinforcement
$Cc := 1.5\ in$	----------	Nominal Cover to Beam Tension Reinforcement
$\lambda := 1$	----------	Modification factor



Beam Location in STAAD



Beam Location in RCDC

Tension reinforcement Provided

Left Top

$\phi 1 := 12.7\ mm$ ---------- Diameter of Tension Reinforcement at Bottom Most layer

$N1 := 5$ ---------- No of Rebar at Bottom most Layer

$\phi 2 := 25.4\ mm$ ---------- Diameter of Tension Reinforcement at Inner layer

$N2 := 0$ ---------- No of Rebar at Inner Layer

$Ast1 := \frac{\pi \cdot \phi 1^2}{4} \cdot N1 + \frac{\pi \cdot \phi 2^2}{4} \cdot N2 = 0.982\ in^2$ ---------- Area of Tension Reinforcement Provided

Left Bottom

$\phi 1 := 12.7\ mm$ ---------- Diameter of Tension Reinforcement at Bottom Most layer

$N1 := 5$ ---------- No of Rebar at Bottom most Layer

$\phi 2 := 25.4\ mm$ ---------- Diameter of Tension Reinforcement at Inner layer

$N2 := 0$ ---------- No of Rebar at Inner Layer

$Ast2 := \frac{\pi \cdot \phi 1^2}{4} \cdot N1 + \frac{\pi \cdot \phi 2^2}{4} \cdot N2 = 0.982\ in^2$ ---------- Area of Tension Reinforcement Provided

Right Top

$\phi 1 := 12.7\ mm$ ---------- Diameter of Tension Reinforcement at Bottom Most layer

$N1 := 5$ ---------- No of Rebar at Bottom most Layer

$\phi 2 := 25.4\ mm$ ---------- Diameter of Tension Reinforcement at Inner layer

$N2 := 0$ ---------- No of Rebar at Inner Layer

$Ast3 := \frac{\pi \cdot \phi 1^2}{4} \cdot N1 + \frac{\pi \cdot \phi 2^2}{4} \cdot N2 = 0.982\ in^2$ ---------- Area of Tension Reinforcement Provided

Right Bottom

$\phi 1 := 12.7\ mm$ ---------- Diameter of Tension Reinforcement at Bottom Most layer

$N1 := 3$ ---------- No of Rebar at Bottom most Layer

$\phi 2 := 25.4\ mm$ ---------- Diameter of Tension Reinforcement at Inner layer

$N2 := 0$ ---------- No of Rebar at Inner Layer

$Ast4 := \frac{\pi \cdot \phi 1^2}{4} \cdot N1 + \frac{\pi \cdot \phi 2^2}{4} \cdot N2 = 0.589\ in^2$ ---------- Area of Tension Reinforcement Provided

Reinforcement Grades as per Table 20.2.2.4(a)

$fy\_M := \left| \begin{array}{l} \text{if } fy > 80\ ksi \\ \quad 80 \\ \text{else} \\ \quad fy \end{array} \right| = 60\ ksi$ ---------- Grade of reinforcement used for Bending of Special Frame Members. Table 20.2.2.4(a)

$deff := 27.32\ in$ ---------- Effective Depth of the Section

$LengthOfEachStatio := \frac{L\_Span}{12} = 17\ in$ ---------- Each Beam is divided in to 12 stations

$ShearEndZone := 2 \cdot D = 60\ in$ ---------- End zone length as per User input

$ShearEndZone\_Actual := 78.74\ in$ ---------- End Zone length adjusted as per each station length

End Moments from Analysis Forces for Dead and Live load (See forces from analysis at end of document)

$M\_LH\_DL := 32.95\ kip \cdot ft$ ---------- Moment due to Dead Load at Left End from Analysis forces

$M\_RH\_DL := 36.27\ kip \cdot ft$ ---------- Moment due to Dead Load at Right End from Analysis forces

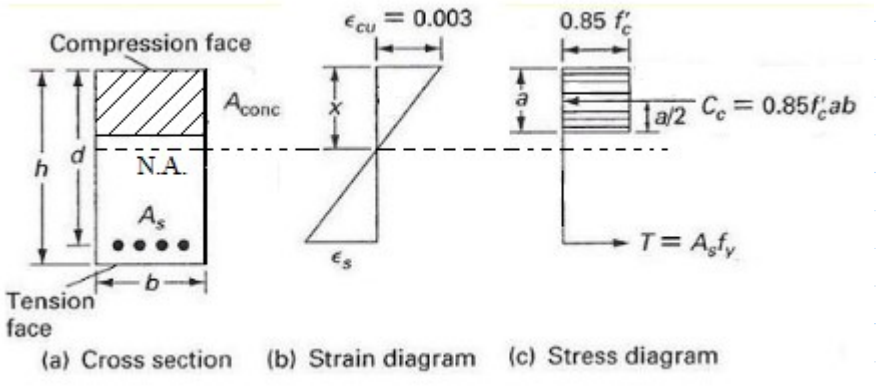
$M\_LH\_LL := 20.68\ kip \cdot ft$ ---------- Moment due to Live Load at Left End from Analysis forces

$M\_RH\_LL := 22.75\ kip \cdot ft$ ---------- Moment due to Live Load at Right End from Analysis forces

$$Reinf\_Factor := \begin{cases} 1 & \text{if } TypeOfBeam < 2 \\ 1.25 & \text{else} \end{cases} = 1.25$$

Notes on Fig. R18.6.5 (2)

Calculation of Compression block(a)



Where

Fy = fy_M (Main Reinforcement Grade)

b = B (Width of Beam)

As = Ast1 (Area of Tension reinforcement Provided)

$$a\_leftTop := Ast1 \cdot Reinf\_Factor \cdot \frac{fy\_M}{0.85 \cdot B \cdot f'c} = 1.925\ in$$

$$a\_leftBot := Ast2 \cdot Reinf\_Factor \cdot \frac{fy\_M}{0.85 \cdot B \cdot f'c} = 1.925\ in$$

$$a\_RightTop := Ast3 \cdot Reinf\_Factor \cdot \frac{fy\_M}{0.85 \cdot B \cdot f'c} = 1.925\ in$$

$$a\_RightBot := Ast4 \cdot Reinf\_Factor \cdot \frac{fy\_M}{0.85 \cdot B \cdot f'c} = 1.155\ in$$

Calculation of Moment Capacity for Provided Reinforcement

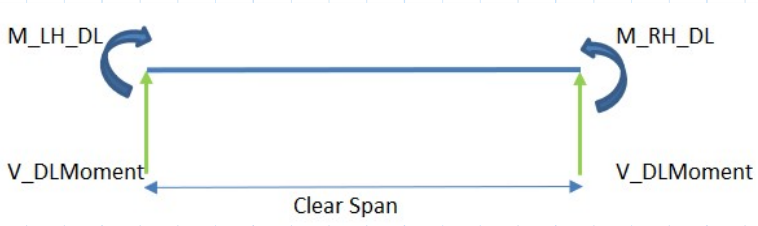
$$Mh\_left := Ast1 \cdot Reinf\_Factor \cdot fy\_M \cdot \left(deff - \frac{a\_leftTop}{2} \right) = 161.728\ kip \cdot ft$$

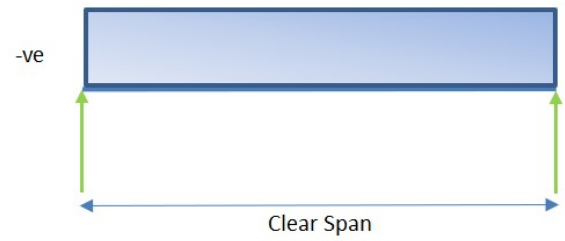
$$Ms\_left := -1 \cdot Ast2 \cdot Reinf\_Factor \cdot fy\_M \cdot \left(deff - \frac{a\_leftBot}{2} \right) = -161.728 \ \textit{kip} \cdot \textit{ft}$$

$$Mh\_right := Ast3 \cdot Reinf\_Factor \cdot fy\_M \cdot \left(deff - \frac{a\_RightTop}{2} \right) = 161.728 \ \textit{kip} \cdot \textit{ft}$$

$$Ms\_right := -1 \cdot Ast4 \cdot Reinf\_Factor \cdot fy\_M \cdot \left(deff - \frac{a\_RightBot}{2} \right) = -98.454 \ \textit{kip} \cdot \textit{ft}$$

Calculation of Shear Caused by End Moments

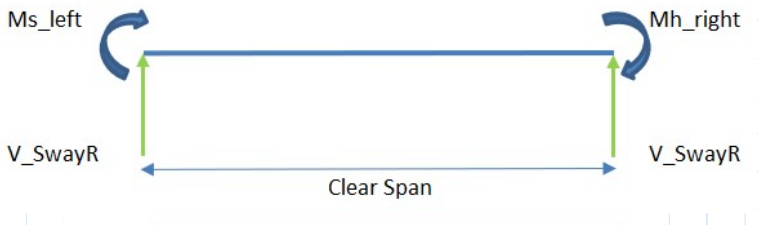


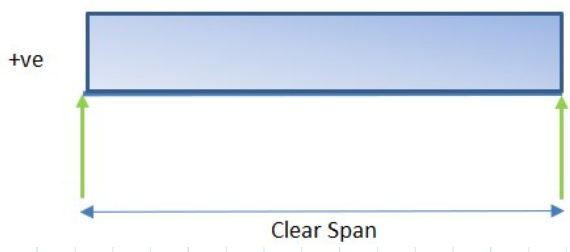


$$V\_DLMoment := \frac{(M\_LH\_DL - M\_RH\_DL)}{L\_Clear} = -0.214 \ \textit{kip}$$

$$V\_LLMoment := \frac{(M\_LH\_LL - M\_RH\_LL)}{L\_Clear} = -0.134 \ \textit{kip}$$

Shear Causing End Moments due to Sway Left and Right

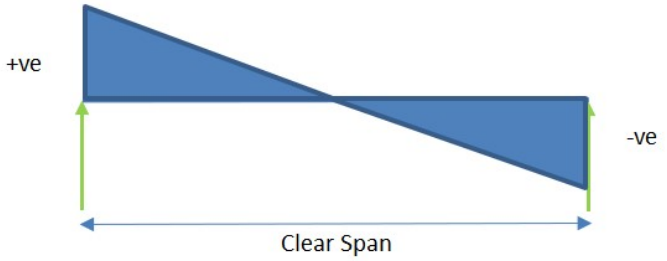




$$V\_SwayR := \frac{(Ms\_left - Mh\_right)}{L\_Clear} = -20.868 \ kip$$

$$V\_SwayL := \frac{(Mh\_left - Ms\_right)}{L\_Clear} = 16.786 \ kip$$

End Shear from Analysis Forces for Dead and Live load(See forces from analysis at end of document)



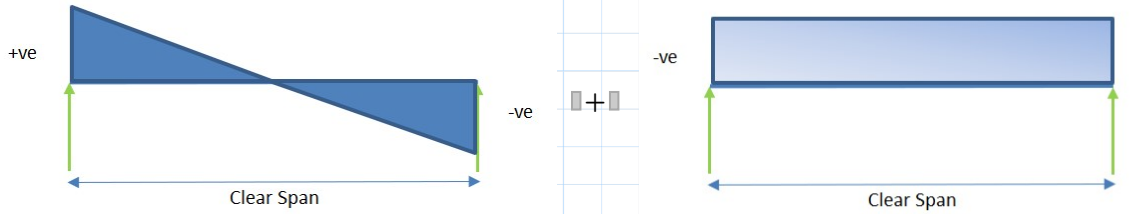
$$V\_DL\_L := 24.2 \ kip$$

$$V\_DL\_R := -24.59 \ kip$$

$$V\_LL\_L := 15.18 \ kip$$

$$V\_LL\_R := -15.43 \ kip$$

Net Shear from DL/LL and Moment



$$V\_DL\_L\_SS := V\_DL\_L - V\_DLMoment = 24.414 \ kip$$

$$V\_DL\_R\_SS := V\_DL\_R - V\_DLMoment = -24.376 \ kip$$

$$V\_LL\_L\_SS := V\_LL\_L - V\_LLMoment = 15.314 \ kip$$

$$V\_LL\_R\_SS := V\_LL\_R - V\_LLMoment = -15.296 \ kip$$

End Shear Due to Dead load+Live load and Sway (Fig R18.6.5)

$$DL\_LL\_L\_SwayR := 1.2 \cdot V\_DL\_L\_SS + V\_LL\_L\_SS + V\_SwayR = 23.743 \ kip$$

$$DL\_LL\_R\_SwayR := (1.2) \cdot (V\_DL\_R\_SS) + V\_LL\_R\_SS + V\_SwayR = -65.415 \ kip$$

$$DL\_LL\_L\_SwayL := 1.2 \cdot V\_DL\_L\_SS + V\_LL\_L\_SS + V\_SwayL = 61.396 \ kip$$

$$DL\_LL\_R\_SwayL := 1.2 \cdot V\_DL\_R\_SS + V\_LL\_R\_SS + V\_SwayL = -27.762 \ kip$$

Final Shear

$$Vu\_Sway\_L := \max\left(\left|DL\_LL\_L\_SwayR\right|, \left|DL\_LL\_L\_SwayL\right|\right) = 61.396 \ kip$$

$$Vu\_Sway\_R := \max\left(\left|DL\_LL\_R\_SwayR\right|, \left|DL\_LL\_R\_SwayL\right|\right) = 65.415 \ kip$$

RCDC Output - Design Calculation Report

Group	:	**G3**
Beam No	:	**B7**
Analysis Reference (Member)	:	33 (24 ft)
Beam Length	:	204 in
Breadth (B)	:	15 in
Depth (D)	:	30 in
Effective Depth (d)	:	27.32 in
Design Code	:	ACI 318 - 14
Beam Type	:	Ductile Beam (Special Frame)
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	:	708.61 kip-ft
As,min (flex) (B)	:	1.37 in^2
As,nominal (Bn)	:	0.53 in^2
As,min(user input)(B')	:	0.53 in^2
Maximum percentage steel (User Defined)	:	4 %
Maximum percentage steel (Special Frame)	:	Min (4 , 2.5)
	:	2.5 %
Strength Reduction Factor φ (Shear)	:	0.6

For Longitudinal Reinf						
	Beam Bottom			Beam Top		
	Left	Mid	Right	Left	Mid	Right
Critical L/C - Analysis	10	6	12	12	-	10
Critical L/C - RCDC	6	2	8	8	-	6
Mu (kip-ft)	57.41	152.15	53.6	81.23	-	85.75
As (flex) (in^2) (C)	0.47	1.29	0.44	0.67	-	0.71
Asc (flex) (in^2) (A)	-	-	-	-	-	-
Tu (kip-ft)	0.89	1.48	1.14	1.14	-	0.89
Tcr/4 (kip-ft)	7.7	7.7	7.7	7.7	-	7.7
Al, min(in^2)(Tor.) (D)	-	-	-	-	-	-
Al (in^2) (Tor.) (E)	-	-	-	-	-	-
Al (Dist) (in^2) (D)	-	-	-	-	-	-
Ast (in^2)	0.63	1.37	0.59	0.9	0.53	0.95
AstPrv (in^2)	0.98	1.37	0.59	0.98	0.55	0.98
Reinforcement Provided	5-#4	5-#4 2-#4	3-#4	5-#4	5-#3	5-#4

For Transverse Reinf			
	Left	Mid	Right
Critical L/C - RCDC	2	2	2
PtPrv (%)	0.24	0.335	0.24
Vu (kip)	53.33	18.35	54.19
Mu-Sect (kip-ft)	72.64	125.56	79.92
Φ Vc (kip)	0	0	0
Vs (kip)	88.89	30.58	90.32
Aoh (in^2)	-	-	-
At (in^2/ft)	-	-	-
Av (in^2/ft)	0.65	0.22	0.66
Tu (kip-ft)	1.48	1.48	1.48
At Torsion (in^2/ft)	0	0	0
Av Total Reqd (in^2/ft)	0.65	0.22	0.66
Asv Reqd (in^2/ft)	0.65	0.22	0.66
For Sway Shear			
V^{D+L} (kip)	44.61	14.83	44.54
Mh (kip-ft)	161.93	0	161.93
Ms (kip-ft)	161.93	0	98.56
Sway-Right (kip)	23.72	35.72	65.44
Sway-Left (kip)	61.42	1.98	27.74
Vu-Sway (kip)	61.42	35.72	65.44
Vud (kip)	61.42	35.72	65.44
Φ Vc Sway(kip)	0	0	0
Vs Sway(kip)	102.36	59.53	109.06
Asv Reqd Sway(in^2/ft)	0.75	0.44	0.8
Asv Reqd Final = max (Asv Reqd , Asv Reqd Sway) (in^2/ft)	0.75	0.44	0.8
Legs	2	2	2
Stirrup Rebar	3	3	3
SCalc (in)	2.5	5.5	2.5
SPrv (in)	2.5	5.5	2.5
Av Total Prv (in^2/ft)	1.05	0.48	1.05

Member Forces Table from RCDC

Beam	Analysis No	Load Case	Location	P	Mx	My	ShearX	ShearY	Torsion
			(ft)	(kip)	(kip-ft)	(kip-ft)	(kip)	(kip)	(kip-ft)
B7	33	LOAD 1: LOAD CASE 1	0	5.01	-0.01	32.95	0	24.2	0.67
		LOAD 1: LOAD CASE 1	1.41	5.01	-0.01	1.56	0	20.13	0.67
		LOAD 1: LOAD CASE 1	2.82	5.01	-0.01	-24.07	0	16.07	0.67
		LOAD 1: LOAD CASE 1	4.27	5.01	-0.01	-43.95	0	12	0.67
		LOAD 1: LOAD CASE 1	5.68	5.01	-0.01	-58.07	0	7.94	0.67
		LOAD 1: LOAD CASE 1	7.09	5.01	-0.01	-66.43	0	3.87	0.67
		LOAD 1: LOAD CASE 1	8.5	5.01	-0.01	-69.04	0	-0.2	0.67
		LOAD 1: LOAD CASE 1	9.91	5.01	-0.01	-65.88	0	-4.26	0.67
		LOAD 1: LOAD CASE 1	11.32	5.01	-0.01	-56.97	0	-8.33	0.67
		LOAD 1: LOAD CASE 1	12.76	5.01	-0.01	-42.3	0	-12.39	0.67
		LOAD 1: LOAD CASE 1	14.17	5.01	-0.01	-21.87	0	-16.46	0.67
		LOAD 1: LOAD CASE 1	15.58	5.01	-0.01	4.31	0	-20.52	0.67
		LOAD 1: LOAD CASE 1	16.99	5.01	-0.01	36.27	0	-24.59	0.67
		LOAD 2: LOAD CASE 2	0	3.14	-0.01	20.68	0	15.18	0.42
		LOAD 2: LOAD CASE 2	1.41	3.14	-0.01	0.98	0	12.63	0.42
		LOAD 2: LOAD CASE 2	2.82	3.14	-0.01	-15.11	0	10.08	0.42
		LOAD 2: LOAD CASE 2	4.27	3.14	-0.01	-27.58	0	7.53	0.42
		LOAD 2: LOAD CASE 2	5.68	3.14	-0.01	-36.44	0	4.98	0.42
		LOAD 2: LOAD CASE 2	7.09	3.14	-0.01	-41.69	0	2.43	0.42
		LOAD 2: LOAD CASE 2	8.5	3.14	-0.01	-43.32	0	-0.12	0.42
		LOAD 2: LOAD CASE 2	9.91	3.14	-0.01	-41.34	0	-2.67	0.42
		LOAD 2: LOAD CASE 2	11.32	3.14	-0.01	-35.74	0	-5.22	0.42
		LOAD 2: LOAD CASE 2	12.76	3.14	-0.01	-26.54	0	-7.78	0.42
		LOAD 2: LOAD CASE 2	14.17	3.14	-0.01	-13.72	0	-10.33	0.42
		LOAD 2: LOAD CASE 2	15.58	3.14	-0.01	2.71	0	-12.88	0.42
		LOAD 2: LOAD CASE 2	16.99	3.14	-0.01	22.75	0	-15.43	0.42