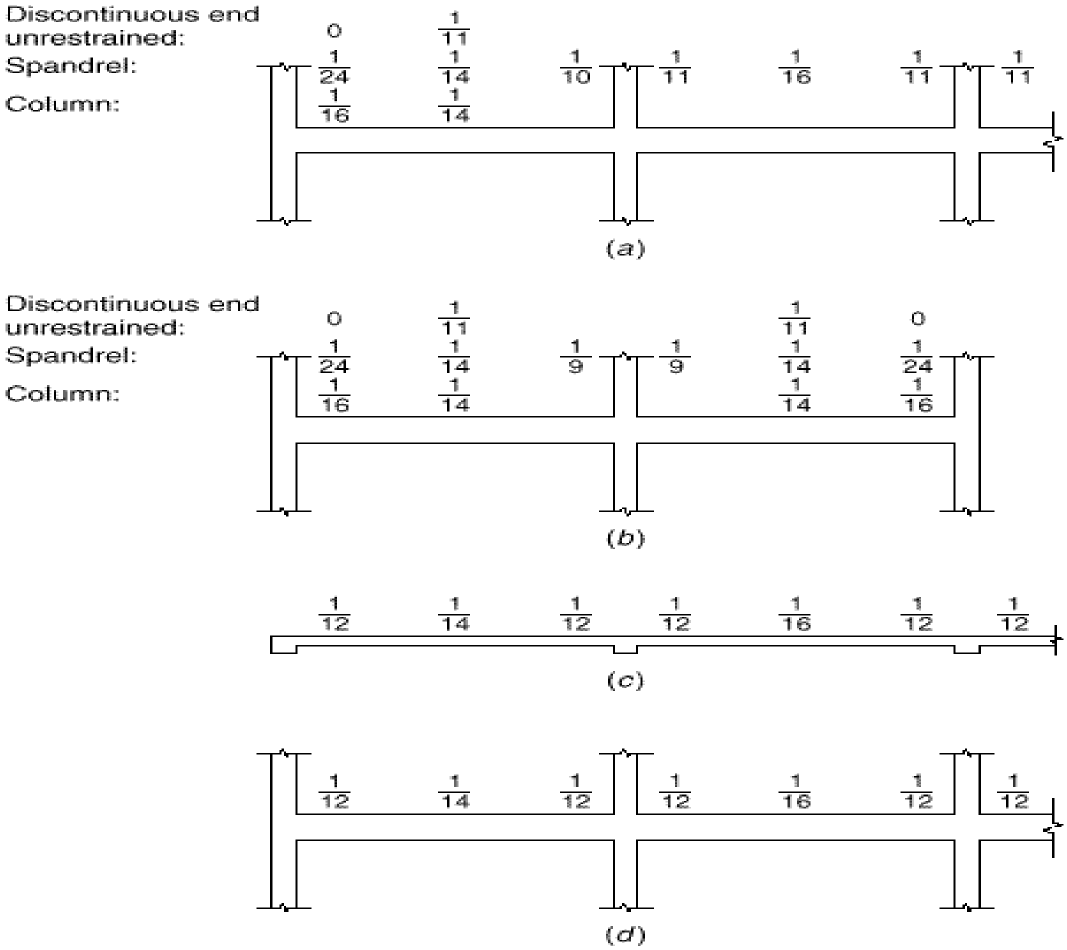
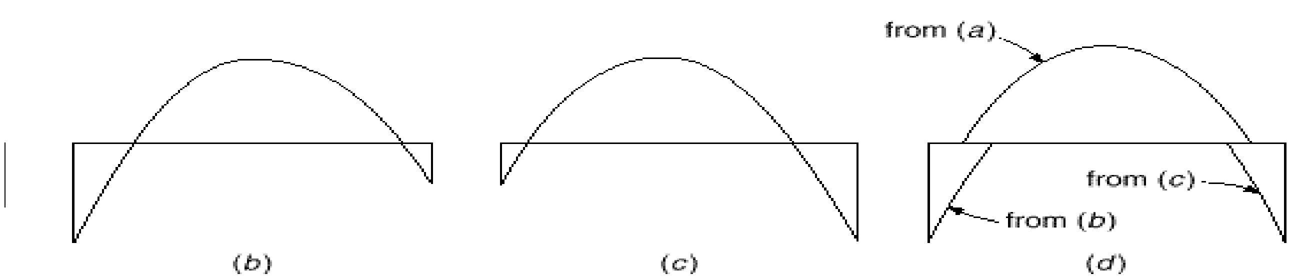




; and moment envelope for a continuous beam: (*a*) maximum positive moment; (*b*) maximum negative
mum negative moment at right end; (*d*) composite moment envelope.

One way joist Slab formula:

$$R_n = \frac{M_u/0.9}{b*d^2}*10^6 = Mpa \quad , \qquad d = h - 20 - \frac{d_b}{2} - d_s = \_\_mm$$

$$m = \frac{f_y}{0.85*f_c} = \_\, , \qquad \rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}\right) = \_$$

$$A_s = \rho*b*d = \_\,mm^2 \, , \qquad A_{s\,min} = max\begin{bmatrix} \frac{1.4}{420}*b_w*d \\ \frac{\sqrt{f_c}}{4*420}*b_w*d \end{bmatrix} = \_\,mm^2$$

$$n = \frac{A_s}{A_b} = real\ number \qquad\qquad for\ flexural\ \rightarrow n\ \emptyset d_b$$

$$A_{s\,shrinkage} = 0.0018*1000*h_f = \_\,mm^2$$

$$S_{max} = \min\left(\frac{A_b}{A_s}*1000 = \_mm\,, 300mm, 4*h_f\right)$$

$$V_u = \frac{C_v*w_u*L_n}{2} \qquad , \ \emptyset V_c = 1.1*0.75*\frac{\sqrt{f_c}}{6}*b_w*d*10^{-3} = \_\_kn$$

$$\emptyset V_c > V_u \qquad no\ need\ to\ shear\ reinforcment$$

Beam formula:-

$$R_n = \frac{M_u/0.9}{1000*d^2}*10^6 = \_\_Mpa$$

$$d = 600 - 40 - d_s - \frac{d_b}{2} = \_\_\,mm \ \ (one\ layer)$$

$$d = 600 - 40 - d_s - 25 - \frac{S}{2} = \_\_\,mm \ \ (two\ layer)$$

$$m = \frac{f_y}{0.85*f_c} = \_\_\, , \qquad \rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}\right) = \_\_$$

$$A_s = \rho*b*d = \_\,mm^2 \, ,$$

$$A_{s\,min} = \max\begin{bmatrix} \frac{1.4}{420}*b_w*d \\ \frac{\sqrt{f_c}}{4*420}*b_w*d \end{bmatrix} = \_\_\_\,mm^2$$

$$check \qquad A_s > A_{s\,min} \quad ok \quad , \qquad n = \frac{A_s}{A_b} = real\ number$$

$$check \quad b_{min} = 80 + 60 + (n-1)(d_b + 25) > b \qquad ok$$

$$if \ \ \frac{a_b}{d} = \beta_1 \left(\frac{600}{600 + f_y}\right) > \frac{a}{d} \qquad \therefore \ f_{s=fy}$$

$$if \ \ \frac{a_{TCL}}{d_t} = 0.375\,\beta_1 > \frac{a}{d_t} \quad \therefore \ Tension - controlled\ section$$

$$\emptyset V_c = 0.75 * \frac{\sqrt{f_c}}{6} * b_w * d * 10^{-3} = \_\_kn$$

$$V_s = \frac{V_u - \emptyset V_c}{0.75} = \_kn$$

$$A_v = 2 * \pi \frac{{d_s}^2}{4} = \_\_\ mm^2 \ \ (two\ leg)$$

$$S = \frac{A_v * f_y * d}{V_s} * 10^{-3}\_\_mm$$

$$if \ \ V_s \le 2V_c$$

$$S_{max} = \min(600\ , \frac{d}{2})$$

$$if \ \ 2V_c < V_s \le 4V_c$$

$$S_{max} = \min\left(300\ , \frac{d}{4}\right)$$

$$if \ \ V_s > 4V_c$$

$$need\ to\ increse\ the\ section$$

$$if \ \ V_u < \frac{1}{2}\emptyset V_c$$

$$no\ need\ for\ shear\ reinforcment$$

$$if \ \ \emptyset V_c > V_u > \frac{1}{2}\emptyset V_c$$

$$need\ to\ provide\ minmume$$

$$a_{v\,min} = \max\{\left(\frac{1}{16}\sqrt{f_c} * b_w * \frac{s}{f_y}\right), (\frac{b_w * s}{3f_y})\}$$

Example 1:

The figure shown below shows the architectural plan for 3-story building. The slab will be designed to carry super imposed dead load ($1.5 KN/m^2$) and Live load ($3 KN/ m^2$) by compressive strength 25 Mpa and steel yield strength 420 Mpa.

Given data:

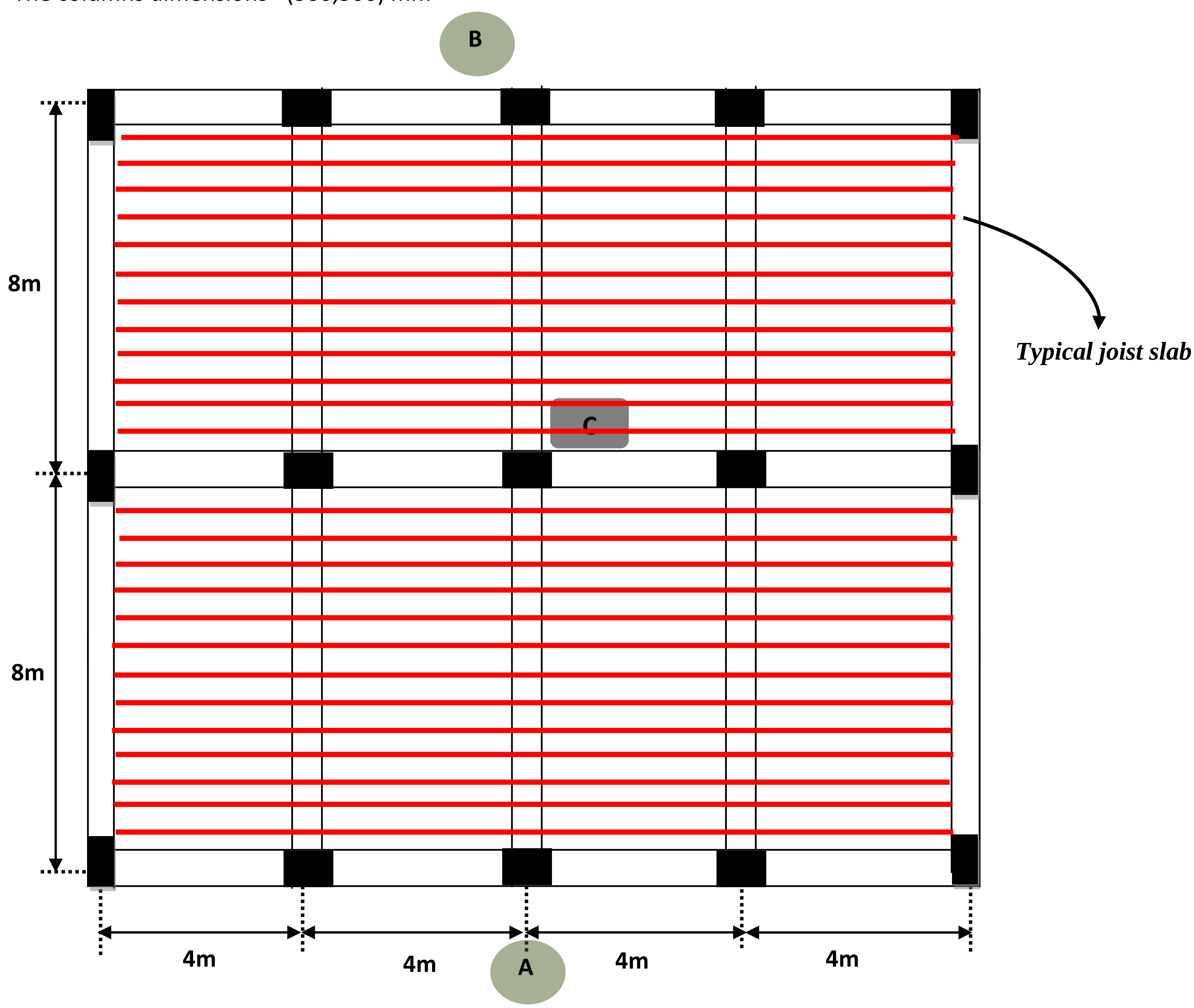
The one way joist slab is used.

Weight of block =$12 Kn/m^3$

$h_f = 50\ mm$, $h_w = 250\ mm$, $b_w = 120\ mm$, $S = 500\ mm$

The beams dimensions = (300,600) mm

The columns dimensions= (300,500) mm



Determine the following:

1- Check if Slab thickness meets SBC304.
2- Design the slab for Max +Ve moment.
3- Design the slab for Max -Ve moment.
4- Check the slab for Shear reinforcement.
5- Draw the details and show all value.
6- Design the beam (A-B) for flexure and shear.
7- Calculate the axial load acting on column C.

Solution:

$$h_{min} = \frac{l}{21} = \frac{4000}{21} = 190.5\ mm$$

$$h_{min} = \frac{l}{18.5} = \frac{4000}{18.5} = 216.2\ mm$$

$$h_{min} = \max(190.5\ , 216.2) = 216.2\ mm$$

$$h = 300\ mm > h_{min} \rightarrow ok$$

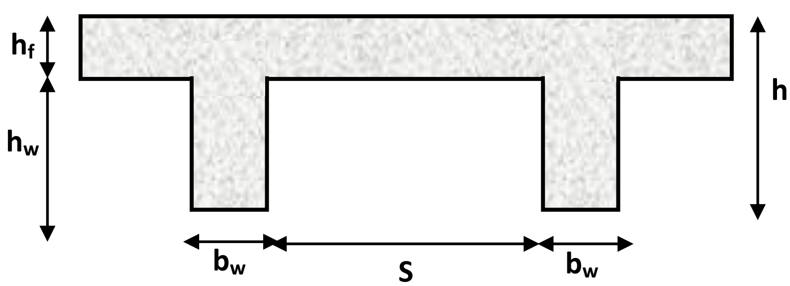
$$h_f \geq \left(50mm\ , \frac{500}{12} = 41,67\ mm\right) = 50\ mm \qquad h_f = 50\ mm \quad ok$$

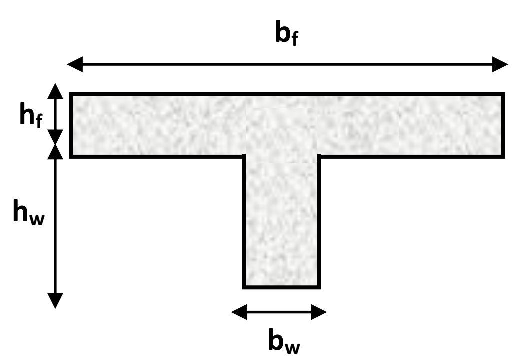
$$h_w \ngtr (3.5 * 120 = 4200mm) \qquad h_w = 250 \quad mm \quad ok$$

$$b_w \geq 100\ mm \qquad b_w = 120\ mm \quad ok$$

$$S \ngtr 800\ \text{mm} \qquad S = 500mm \quad ok$$

$$b_f = 500 + 120 = 620\ \text{mm}$$





$$DL = own\ weight + superimposed$$

$$DL = (0.05 * 25) + 1.5 = 2.75\ kn/m^2$$

$$LL = 3\ kn/m^2$$

$$Wu = 1.4DL + 1.7LL$$

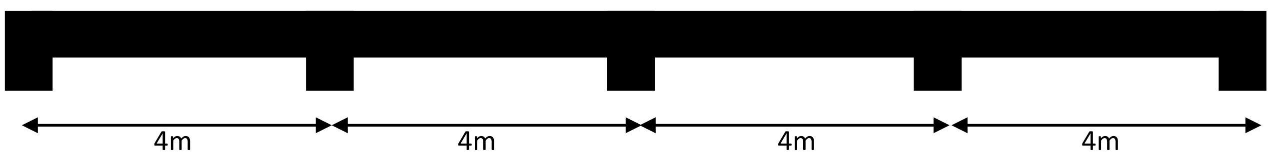
$$Wu = 1.4(2.75) + 1.7(3) = 8.95\ kn/m^2$$

Load on typical rip:

$$DL_{/rip} = (2.75 * 0.62) + (0.25 * 0.12 * 25) + (0.5 * 0.25 * 12) = 3.955\ kn/m$$

$$LL_{/rip} = (3 * 0.62) = 1.86\ kn/m$$

$$Wu_{/rip} = 1.4(3.955) + 1.7(1.86) = 8.7\ kn/m$$



Lu (m)	4m			4m			4m			4m		
Ln (m)	3.7m			3.7m			3.7m			3.7m		
Cm	1/24	1/14	1/10	1/11	1/16	1/11	1/11	1/16	1/11	1/10	1/14	1/24
Wu(kn/m^2)		8.7	8.7							8.7	8.7	
Mu(kn.m)		8.51	11.91							11.91	8.51	
d (mm)		267	267							267	267	
Rn (Mpa)		0.214	1.55							1.55	0.214	
P		0.00051	0.0038							0.0038	0.00051	
As (mm^2)		84.75	123							123	84.75	
As_{min}(mm^2)		106.8	106.8							106.8	106.8	
As (mm^2)		106.8	123							123	106.8	
N		1.36	1.57							1.57	1.36	
Use		2ϕ10	2ϕ10							2ϕ10	2ϕ10	
$As_{shrinkage}$(mm^2)		90	90							90	90	
S_{max}(mm)		200	200							200	200	
Cv			1.15							1.15		
Vu (kn)			18.51							18.51		
ϕVc (kn)			22.03							22.03		

sample of cacluations

$$L_u = 4m\,, \qquad L_n = 4 - 0.15 - 0.15 = 3.7m$$

$$C_m = \frac{1}{10}\,, \qquad M_u = \frac{1}{10} * 8.7 * 3.7^2 = 11.91\ kn.m$$

$$d = 300 - 20 - 8 - \frac{10}{2} = 267\ mm\ , \qquad R_n = \frac{11.91/0.9}{120 * 267^2} * 10^6 = 1.55\ Mpa$$

$$m = \frac{420}{0.85 * 25} = 19.765\,, \qquad \rho = \frac{1}{19.765}\left(1 - \sqrt{1 - \frac{2 * 1.55 * 19.765}{420}}\right) = 0.0038$$

$$A_s = 0.0038 * 120 * 267 = 123\ mm^2\,, \qquad A_{s\,min} = max\begin{bmatrix} \frac{1.4}{420} * 120 * 267 \\ \frac{\sqrt{f_c}}{4 * 420} * 100 * 225 \end{bmatrix} = 106.8\ mm^2$$

$$n = \frac{A_s}{A_b} = \frac{123}{78.5} = 1.57 \approx 2$$

$$for\ flexural\ \rightarrow use\ \ 2\ \emptyset 10$$

$$A_{s\ shrinkage} = 0.0018 * 1000 * 50 = 90\ mm^2$$

$$S_{max} = \min\left(\frac{78.5}{90} * 1000 = 872.2mm\,, 300mm, 4 * 50 = 200\right) = 200mm$$

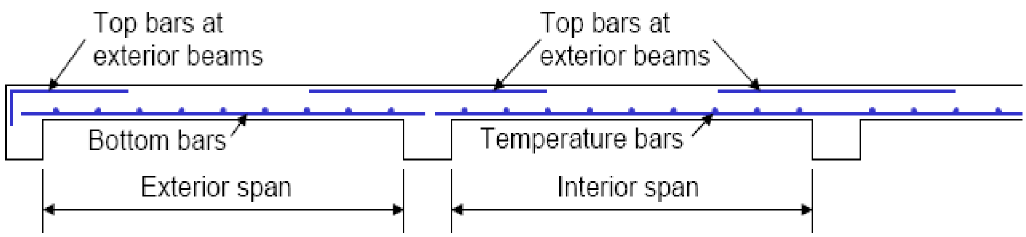
$$for\ shrinkage\ \rightarrow use\ \emptyset 10@200\ mm$$

$$C_v = 1.15\,, \qquad V_u = \frac{1.15 * 8.7 * 3.7}{2} = 18.51\ kn$$

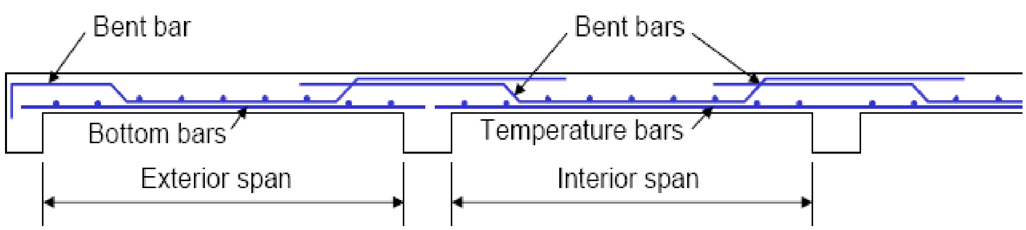
$$\emptyset V_c = (1.1)0.75 * \frac{\sqrt{25}}{6} * 120 * 267 * 10^{-3} = 22.03\ kn$$

$$\emptyset V_c > V_u \rightarrow\ shear\ reinforcment\ is\ not\ needed$$

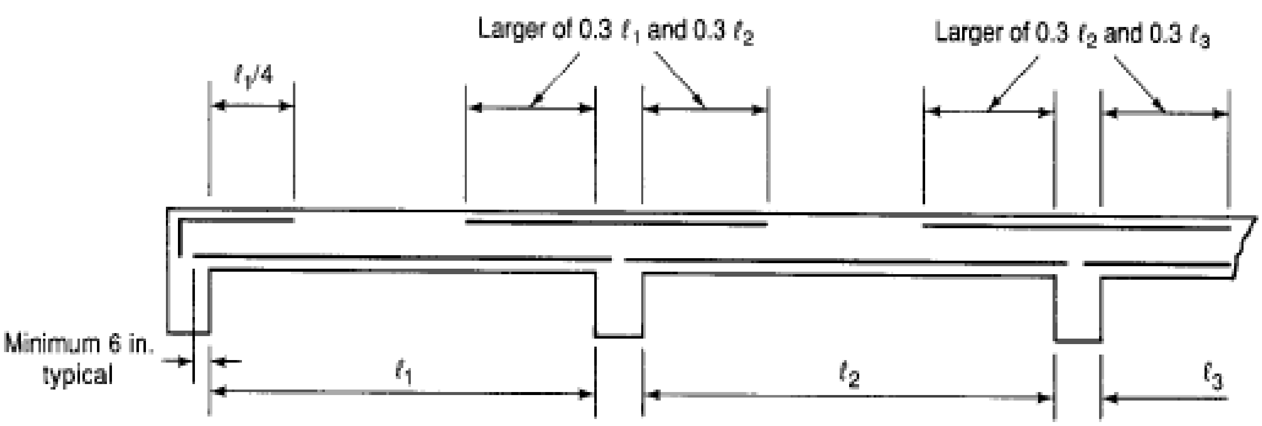
Typical reinforcement in a one-way slab



(a) Straight top and bottom bars

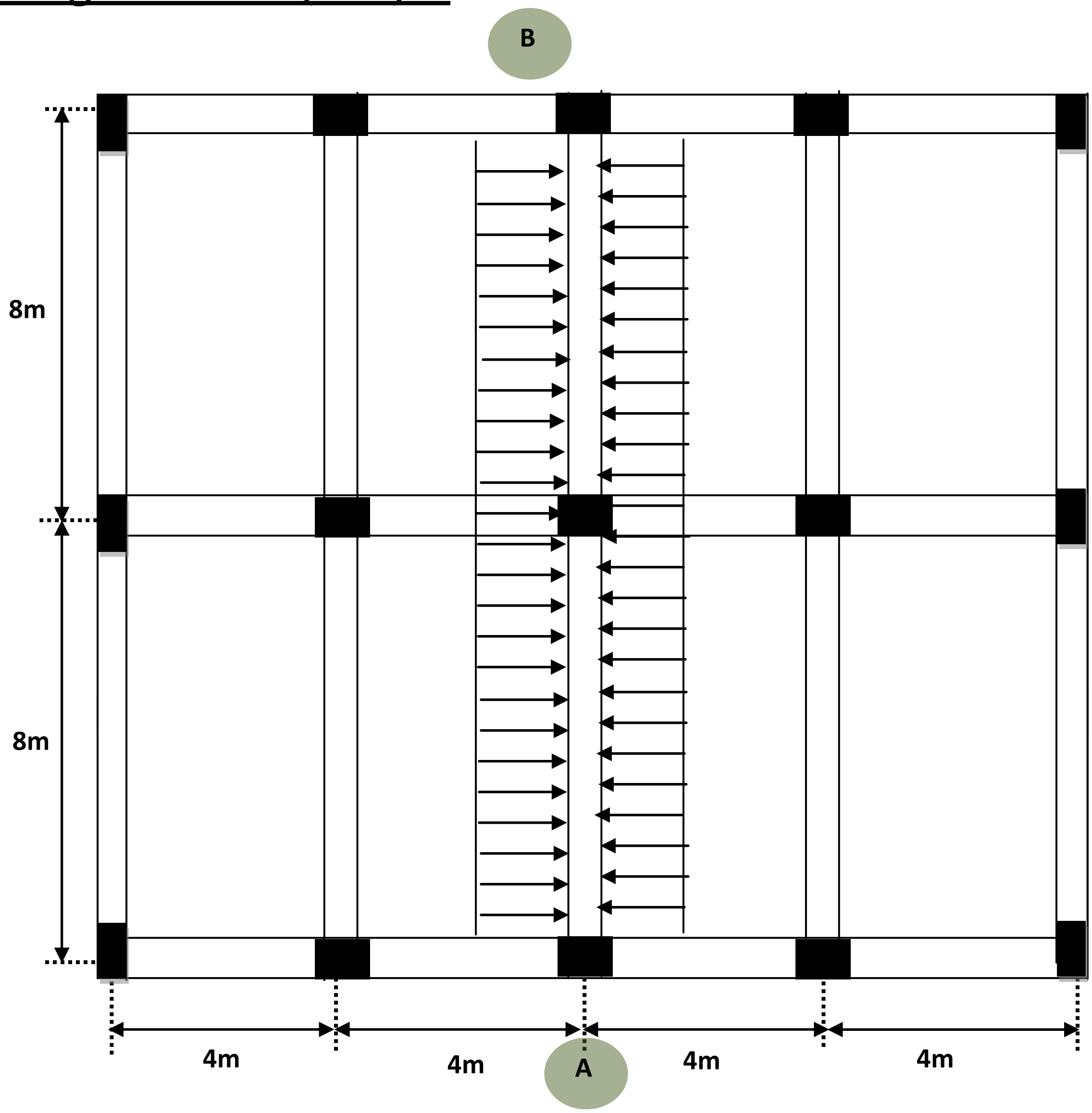


(b) Alternate straight and bent bars



(c) One-way slab

Design of beam (A-B) :-



Load acting on the beam (A-B)

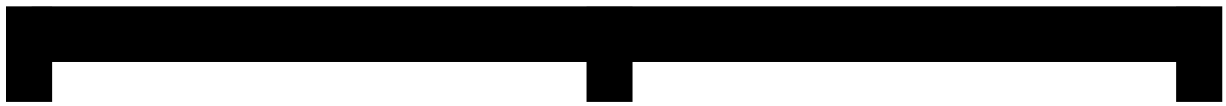
1- Dead load:

$$DL = \frac{3.955}{0.62} * (1.85 + 1.85) + (1.5 * 0.3) + (0.6 * 0.3 * 25) = 28.55\, kn/m$$

2- Live load

$$LL = \frac{1.86}{0.62} * (1.85 + 1.85) + (3 * 0.3) = 12\, kn/m$$

$$Wu = 1.4(28.55) + 1.7(12) = 60.37\ \ kn/m$$



Lu (m)	8m			8m		
Ln(m)	7.7m			7.7m		
Wu(kn/m)	**60.37**					
Cm	1/16	1/14	1/9	1/9	1/14	1/16
Mu (kn.m)		255.7	397.7	397.7	255.7	
d(mm)		517.5 (two layer)	517.5(two layer)	517.5(two layer)	517.5 (two layer)	
Rn(Mpa)		3.54	5.5	5.5	3.54	
P		0.0093	0.0155	0.0155	0.0093	
As(mm^2)		1443.825	2406.375	2406.375	1443.825	
As_{min} (mm^2)		517.5	517.5	517.5	517.5	
n		4.59≈5	7.66≈8	7.66≈8	4.59≈5	
Fs=Fy		Ok	Ok	Ok	Ok	
TCL		Ok	Ok	Ok	Ok	
b_{min} (mm)		0K	OK	OK	0K	
Use		5Ø20	8Ø20	8Ø20	5Ø20	
Cv	1		1.15	1.15		1
Vu (kn)	232.4		267.3	267.3		232.4
ϕVc (kn)	97.03		97.03	97.03		97.03
Vs (kn)	180.5		227.03	227.03		180.5
Av (mm^2)	157		157	157		157
S (mm)	189.1		150.31	150.31		189.1
S_{max} (mm)	258.75		258.75	258.75		258.75
Use	Ø10@185		Ø10@150	Ø10@150		Ø10@185

sample of cacluations

$$L_u = 8m\,, \qquad L_n = 8 - 0.15 - 0.15 = 7.7m$$

$$C_m = \frac{1}{9}\,, \qquad M_u = \frac{1}{9} * 60.37 * 7.7^2 = 397.7\ kn.m$$

$$d = 600 - 40 - 10 - 20 - \frac{25}{2} = 517.5\ mm\ \ (two\ layer)$$

$$R_n = \frac{397.7/0.9}{300 * 517.5^2} * 10^6 = 5.5\ Mpa$$

$$m = \frac{420}{0.85 * 25} = 19.765\,, \qquad \rho = \frac{1}{19.765}\left(1 - \sqrt{1 - \frac{2 * 5.5\ * 19.765}{420}}\right) = 0.0155$$

$$A_s = 0.0155 * 300 * 517.5 = 2406.375\ mm^2\,,$$

$$A_{s\,min} = \frac{1.4}{420} * 300 * 517.5 = 517\ mm^2$$

$$A_{s\,min} = \frac{\sqrt{25}}{4 * 420} * 300 * 517.5 = 462.1\ mm^2$$

$$A_{s\,min} = \max(517, 462.1) = 517 mm^2$$

$$n = \frac{2406.375}{314} = 7.66 \approx 8$$

$$a = \frac{8 * 314 * 420}{0.85 * 25 * 300} = 165.5\ mm$$

$$\frac{a_b}{d} = 0.5 > \frac{a}{d} = 0.32 \qquad \therefore\ f_{s=fy}$$

$$\frac{a_{TCL}}{d_t} = 0.31875 > \frac{a}{d_t} = 0.306 \qquad \therefore\ Tension - controlled\ section$$

$$for\ flexure\ use\ 8\emptyset 20$$

$$C_v = 1.15\ , \qquad V_u = \frac{1.15 * 60.3 * 7.7}{2} = 267.3\ kn$$

$$\emptyset V_c = 0.75 * \frac{\sqrt{25}}{6} * 300 * 517.5 * 10^{-3} = 97.03 kn$$

$$V_s = \frac{267.3 - 97.03}{0.75} = 227.03\ kn$$

$$A_v = 2 * \pi \frac{10^2}{4} = 157\ mm^2\ \ (two\ leg)$$

$$S = \frac{157 * 420 * 517.5}{227.03} * 10^{-3} = 150.31\ \ mm$$

$$V_s \le 2V_c$$

$$S_{max} = min\left(300, \frac{517.5}{2} = 258.75\right) = 258.75\ mm$$

$$use\ \emptyset 10@150mm$$

Axial load on column C:-

Beam s in x- direction:

$$DL = \left\{(0.3 * 0.6 * 25) * \frac{4}{2}\right\} + \left\{(0.3 * 0.6 * 25) * \frac{4}{2}\right\} = 18\ kn$$

$$LL = 0 + 0 = 0\ kn$$

Beams in y- direction:

$$DL = \left\{(0.3 * 0.6 * 25) + (1.5 * 0.3) + \left(\frac{3.955}{0.62} * 3.7\right)\right\} * \frac{8}{2} + \left\{(0.3 * 0.6 * 25) + (1.5 * 0.3) + \left(\frac{3.955}{0.62} * 3.7\right)\right\} * \frac{8}{2} = 228.42\ kn$$

$$LL = \left\{\frac{1.86}{0.62}(3.7) + (3 * 0.3)\right\} * \frac{8}{2} + \left\{\frac{1.86}{0.62}(3.7) + (3 * 0.3)\right\} * \frac{8}{2} = 96\ kn$$

$$Wu = 1.4(18 + 228.42) + 1.7(96) = 508.188\ kn$$

Example 2:

Given data:-

$f_c = 30\ Mpa \quad ,f_y = 420\ Mpa$

$super\ imposed = 2.5kn/m^2 \quad , \ LL = 3kn/m^2$

$h_f = 50\ mm \ , \quad h_w = 250\ mm \ , \quad b_w = 120\ mm \ , \quad S = 500\ mm$, Weight of block =12Kn/m^3

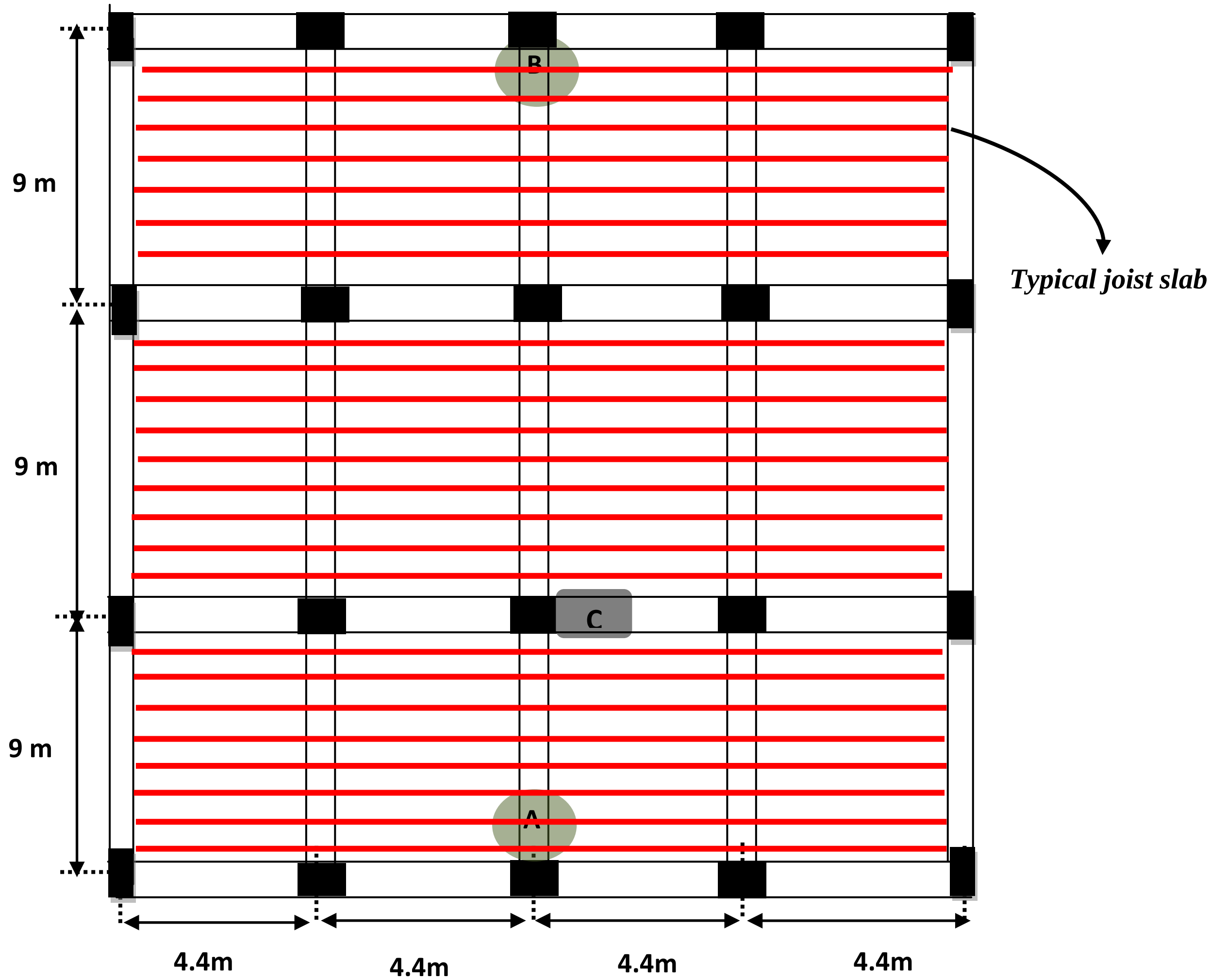
$beams\ size = (700{,}400) \quad , columns\ size\ (500{,}400) \quad , \qquad weight\ of\ wall = 15kn/m$

Required:-

Design the one way joist slab for flexure and shear.

Design the beam (A-D) for flexure and shear.

Compute the axial load on column C.



$$h_{min} = \frac{l}{28} = \frac{4400}{21} = 209.5\ mm$$

$$h_{min} = \frac{l}{24} = \frac{4400}{18.5} = 237.8\ mm$$

$$h_{min} = \max(209.5\ , 237.8) = 237.8\ mm$$

$$h > h_{min} \rightarrow ok$$

$$h = 300\ mm > h_{min} \rightarrow ok$$

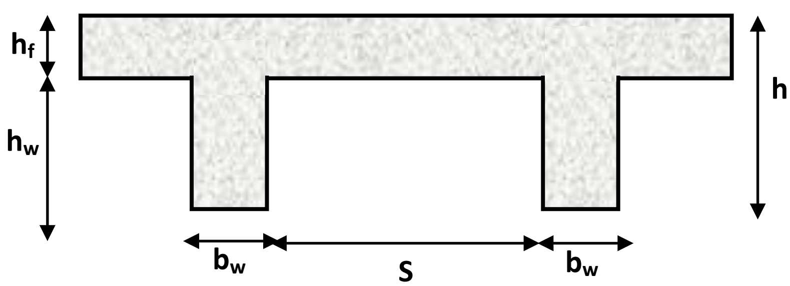
$$h_f \geq \left(50mm\ , \frac{500}{12} = 41{,}67\ mm\right) = 50\ mm \qquad h_f = 50\ mm \quad ok$$

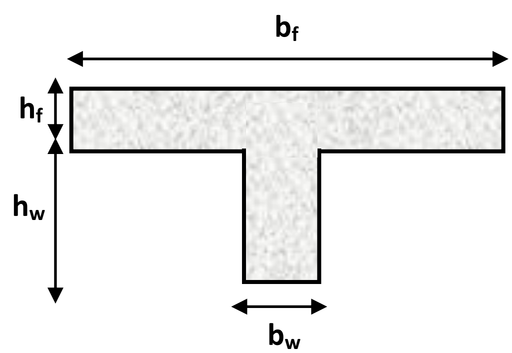
$$h_w \ngtr (3.5 * 100 = 350mm) \qquad h_w = 250 \quad mm \quad ok$$

$$b_w \geq 100\ mm \qquad b_w = 120\ mm \quad ok$$

$$S \ngtr 800\ \text{mm} \qquad S = 500mm \quad ok$$

$$b_f = 500 + 120 = 620\ \text{mm}$$





$$DL = own\ weight + superimposed$$

$$DL = (0.05 * 25) + 2.5 = 3.75\ \ kn/m^2$$

$$LL = 3\ \ kn/m^2$$

$$Wu = 1.4DL + 1.7LL$$

$$Wu = 1.4(3.75) + 1.7(3) = 10.35\ kn/m^2$$

Load on typical rip:

$$DL_{/rip} = (3.75 * 0.62) + (0.25 * 0.12 * 25) + (0.5 * 0.25 * 12) = 4.575\ kn/m$$

$$LL_{/rip} = (3 * 0.62) = 1.86\ kn/m$$

$$Wu_{/rip} = 1.4(4.575) + 1.7(1.86) = 9.567\ kn/m$$

Lu (m)	4.4m			4.4m			4.4m			4.4m		
Ln (m)	4m			4m			4m			4m		
Cm	1/24	1/14	1/10	1/11	1/16	1/11	1/11	1/16	1/11	1/10	1/14	1/24
Wu(kn/m^2)		9.567	9.567							9.567	9.567	
Mu(kn.m)		10.93	15.31							15.31	10.93	
d (mm)		267	267							267	267	
Rn (Mpa)		0.275	1.99							1.99	0.275	
P		0.00066	0.0049							0.0049	0.00066	
As (mm^2)		109.3	157							157	109.3	
As $_{min}$(mm^2)		106.8	106.8							106.8	106.8	
As (mm^2)		109.3	157							157	109.3	
N		1.39	1.999							1.999	1.39	
Use		2ϕ10	2ϕ10							2ϕ10	2ϕ10	
As $_{shrinkage}$(mm^2)		90	90							90	90	
S $_{max}$(mm)		200	200							200	200	
Cv			1.15							1.15		
Vu (kn)			22.0041							22.0041		
ϕVc (kn)			24.13							24.13		

$$\boldsymbol{sample\ of\ cacluations}$$

$$L_u = 4.4m\,, \qquad L_n = 4.4 - 0.2 - 0.2 = 4m$$

$$C_m = \frac{1}{10}\,, \qquad M_u = \frac{1}{10} * 9.567 * 4^2 = 15.31\ kn.m$$

$$d = 300 - 20 - 8 - \frac{10}{2} = 267\ mm\,, \qquad R_n = \frac{15.31/0.9}{120 * 267^2} * 10^6 = 1.99\ Mpa\,,$$

$$m = \frac{420}{0.85 * 30} = 16.471\,, \qquad \rho = \frac{1}{16.471}\left(1 - \sqrt{1 - \frac{2 * 1.99 * 16.471}{420}}\right) = 0.0049$$

$$A_s = 0.0049 * 120 * 267 = 157\ mm^2 \quad , \; A_{s\ min} = max\begin{bmatrix} \dfrac{1.4}{420} * 120 * 267 \\ \dfrac{\sqrt{f_c}}{4 * 420} * 100 * 225 \end{bmatrix} = 106.8\ mm^2$$

$$for\ flexural \ \rightarrow use\ 2\emptyset 110$$

$$A_{s\ shrinkage} = 0.0018 * 1000 * 50 = 90\ mm^2$$

$$S_{max} = \min\left(\frac{78.5}{90} * 1000 = 872.2mm\,, 300mm, 4 * 50 = 200\right) = 200mm$$

$$for\ shrinkage \ \rightarrow use\ \emptyset 10@200\ mm$$

$$C_v = 1.15\,, \qquad V_u = \frac{1.15 * 9.567 * 4}{2} = 22.0041\ kn$$

$$\emptyset V_c = (1.1)0.75 * \frac{\sqrt{30}}{6} * 120 * 267 * 10^{-3} = 24.13kn$$

$$\emptyset V_c > V_u \rightarrow \ shear\ reinforcment\ is\ not\ needed$$

Load acting on the beam (A-B)

1- Dead load:

$$DL = \frac{4.575}{0.62} * (2+2) + 15 + (2.5 * 0.4) + (0.7 * 0.4 * 25) = 52.52\, kn/m$$

2- Live load

$$LL = \frac{1.86}{0.62} * (2+2) + (3 * 0.4) = 13.2\, kn/m$$

$$Wu = 1.4(52.52) + 1.7(13.2) = 95.968\ kn/m$$

Lu (m)	9m			9m			9m		
Ln(m)	8.6m			8.6m			8.6m		
Wu(kn/m)	**95.968**								
Cm	1/16	1/14	1/10	1/11	1/16	1/11	1/10	1/14	1/16
Mu (kn.m)		507	710				710	507	
d(mm)		615.5	615.5				615.5	615.5	
Rn(Mpa)		3.72	5.21				5.21	3.72	
P		0. 00962	0.014				0.014	0. 00962	
As(mm^2)		2368.444	3446.8				3446.8	2368.444	
As_{min} (mm^2)		821	821				821	821	
N		7.54≈8	10.97≈11				10.97≈11	7.54≈8	
b_{min} (mm)									
Fs =Fy		Ok	Ok				Ok	Ok	
TCL		Ok	Ok				Ok	Ok	
Use		8ϕ20	11ϕ20				11ϕ20	8ϕ20	
Cv			1.15				1.15		
Vu (kn)			474.6				474.6		
ϕVc (kn)			168.56				168.56		
Vs (kn)			408.1				408.1		
Av (mm^2)			226.08				226.08		
S (mm)			143.21				143.21		
S_{max} (mm)			307.75				307.75		
Use			Φ12@140				Φ12@140		

sample of cacluations

$$L_u = 9m\,, \qquad L_n = 9 - 0.2 - 0.2 = 8.6m$$

$$C_m = \frac{1}{10}\,, \qquad M_u = \frac{1}{10} * 95.968 * 8.6^2 = 710\ kn.m$$

$$d = 600 - 40 - 12 - 20 - \frac{25}{2} = 615.5\ mm\ \ (two\ layer)$$

$$R_n = \frac{710/0.9}{400 * 615.5^2} * 10^6 = 5.21\ Mpa$$

$$m = \frac{420}{0.85 * 30} = 16.471\,, \qquad \rho = \frac{1}{16.471}\left(1 - \sqrt{1 - \frac{2 * 5.21 * 16.471}{420}}\right) = 0.014$$

$$A_s = 0.014 * 400 * 615.5 = 3446.8\ mm^2\,,$$

$$A_{s\ min} = \frac{1.4}{420} * 400 * 615.5 = 821\ mm^2$$

$$A_{s\ min} = \frac{\sqrt{30}}{4 * 420} * 400 * 615 = 803\ mm^2$$

$$A_{s\ min} = \max(821{,}803\ ) = 821 mm^2$$

$$n = \frac{3151.4}{314} = 10.97 \approx 11$$

$$a = \frac{11 * 314 * 420}{0.85 * 30 * 400} = 142.22\ mm$$

$$\frac{a_b}{d} = 0.5 > \frac{a}{d} = \ 0.23 \qquad \therefore\ f_{s=fy}$$

$$\frac{a_{TCL}}{d_t} = 0.31875\ > \frac{a}{d_t} = 0.222 \qquad \therefore\ Tension - controlled\ section$$

$$for\ flexure\ use\ \ 11\emptyset 20$$

$$C_v = 1.15\,, \qquad V_u = \frac{1.15 * 95{,}968 * 8.6}{2} = 474.6\ kn$$

$$\emptyset V_c = 0.75 * \frac{\sqrt{30}}{6} * 400 * 615.5 * 10^{-3} = 168.56 kn$$

$$V_s = \frac{474.6 - 168.56}{0.75} = 408.1 kn$$

$$A_v = 2 * \pi \frac{12^2}{4} = 226.08mm^2 \ \ (two\ leg)$$

$$S = \frac{226.08 * 420 * 615.5}{408.1} * 10^{-3} = 142.21mm$$

$$V_s < 2V_c$$

$$S_{max} = min\left(300, \frac{615.5}{2} = 307.75\right) = 300\ mm$$

$$use\ \emptyset 12@140mm$$

Axial load on column C:-

Beams in x- direction:

$$DL = \left\{\left((0.4 * 0.7 * 25) + 15\right) * \frac{4.4}{2}\right\} + \left\{\left((0.4 * 0.7 * 25) + 15\right) * \frac{4.4}{2}\right\} = 96.8\ kn$$

$$LL = 0 + 0 = 0\ kn$$

Beams in y- direction:

$$DL = \left\{\left(\frac{4.575}{0.62} * (2 + 2) + 15 + (2.5 * 0.4) + (0.7 * 0.4 * 25)\right) * \frac{9}{2}\right\} + \left\{\left(\frac{4.575}{0.62} * (2 + 2) + 15 + (2.5 * 0.4) + (0.7 * 0.4 * 25)\right) * \frac{9}{2}\right\} = 472.68\ kn$$

$$LL = \left\{\left(\frac{1.86}{0.62} * (2 + 2) + (3 * 0.4)\right) * \frac{9}{2}\right\} + \left\{\left(\frac{1.86}{0.62} * (2 + 2) + (3 * 0.4)\right) * \frac{9}{2}\right\} = 118.8\ kn$$

$$Wu = 1.4(96.8 + 472.68) + 1.7(118.8) = 999.232\ kn$$