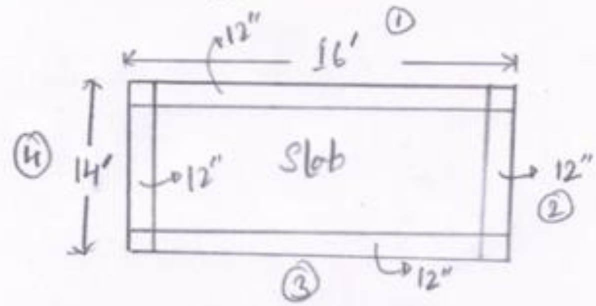
Two Way Beam Supported Slab

Part 2

The following example was done by Mr. Naim Hassan, 3rd Year 2nd Semester Student of CE Dept., AUST

Given a slab of 16 feet by 14 feet and supported on all four edges by beams width of 12 inches on all four sides , beams' depth 12 inches below the slab. The slab is a typical interior slab.

f_y=60 ksi , f'_c=3 ksi ;



Solution:

$h_f = \frac{(16+14)\times12\times2}{160} = 4.5$ inch

now, $\alpha_f = \frac{E_{cb}I_b}{E_{cs}I_s}$

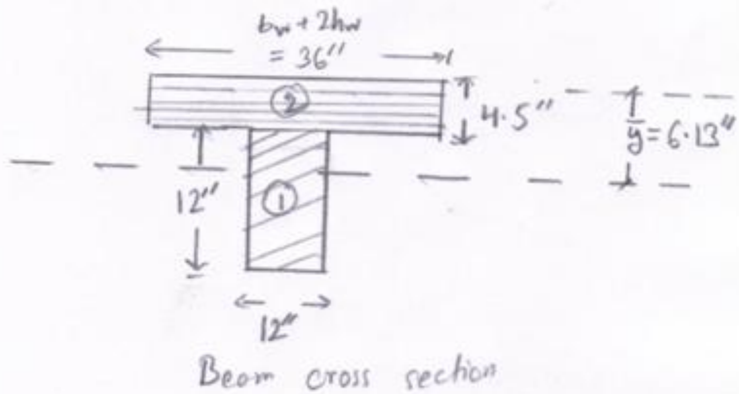
$I_{S1,3} = \frac{16\times12\times4.5^3}{12} = 1458$ in^4

$I_{S2,4} = \frac{14\times12\times4.5^3}{12} = 1275.75$ in^4

$b_w+2h_w \le b_w+8h_f \rightarrow 12+2\times12 \le 12+8\times4.5$

$b_w+2h_w = 36$ in

for beam the centroid is,



$y = \frac{36\times4.5\times\frac{4.5}{2}+12\times12\times(4.5+\frac{12}{2})}{36\times4.5+12\times12} = 6.13$ in

$I_b = \frac{12\times12^3}{12} + 12\times12\times((4.5+12/2)-6.13)^2 + \frac{36\times4.5^3}{12} + 36\times4.5(4.5/2-6.13)^2 = 7190.14$ in^4

$\alpha_{m1,3} = \frac{I_b}{I_{s1,3}} = \frac{7190.14}{1458} = 4.93$

$\alpha_{m2,4} = \frac{I_b}{I_{s2,4}} = \frac{7190.14}{1275.75} = 5.64$

$\alpha_{mavg} = \frac{4.93+5.64+4.93+5.64}{4} = 5.29$

Since $\alpha_{mavg} > 2$; $h_{min} = \frac{l_n(0.8+\frac{f_y}{200000})}{36+9\beta} = \frac{14\times12(0.8+\frac{60000}{200000})}{36+9\times\frac{14}{12}}$ =3.97 inch=4.0 inch

h_{min}= 4.0 inch

The following Example was done by Md. Mahmudun Nobe, ID - 12.01.03.078, AUST Batch no. 28

Determination of minimum thickness of a slab

A two-way reinforced concrete building floor system is composed of slab panels measuring 20x25 ft in plan, supported by shallow column-line beams cast monolithically with the slab as shown in Fig. 02. Using concrete with f'_c=4000 psi and steel with f_y= 60,000 psi, determine the minimum thickness of the slab.

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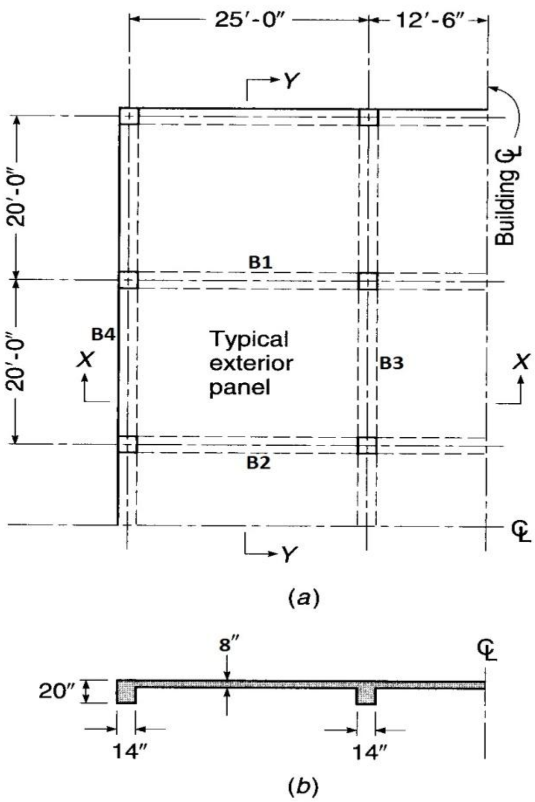


Figure 02: Two-way slab floor with beams on column lines:

(a) Partial floor plan;

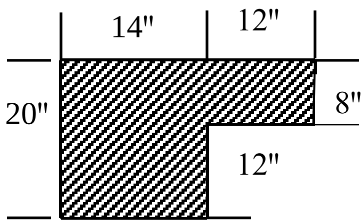
(b) Section *X*-*X* (section *Y*-*Y* similar).

Solution: At first select the largest slab panel from floor slab plan. In this example, dimension of the slab panel is 20'×25'. Primarily, now we determining thickness of slab using the following formula: thickness (in)= $\frac{\text{Perimeter}}{145}$

Here, Perimeter= 2×(20+25)×12= 1080 in

So thickness= $\frac{1080}{145}$= 7.45 in≈ 8 in (say)

<u>Moment of Inertia for beam B4 (Exterior beam):</u>



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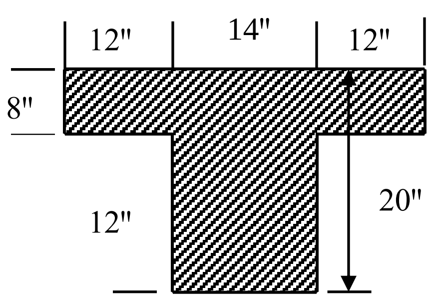
$\bar{Y}_4 = \frac{(20\times14\times10)+(12\times8\times4)}{(20\times14)+(12\times8)}$= 8.47 in

$I_{b4} = \frac{14\times20^3}{12} + (20\times14)\times(10-8.47)^2 + \frac{12\times8^3}{12} + (12\times8)\times(8.47-4)^2$= 12418.95 in^4

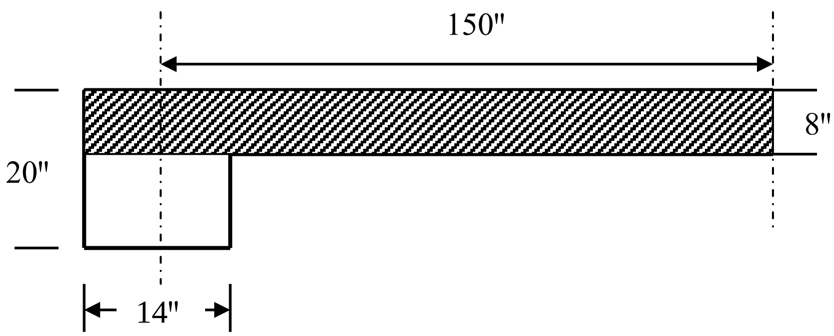
<u>Moment of Inertia for Beam B1, B2, and B3 (Interior beam):</u> In this case, those three beam's dimension is same and those are interior beam. So here moment of inertia for beam B1, B2, B3 is same.



$\bar{Y}_1 = \bar{Y}_2 = \bar{Y}_3 = \frac{(20\times14\times10)+(12\times8\times4)\times2}{(20\times14)+(12\times8)\times2}$= 7.56 in

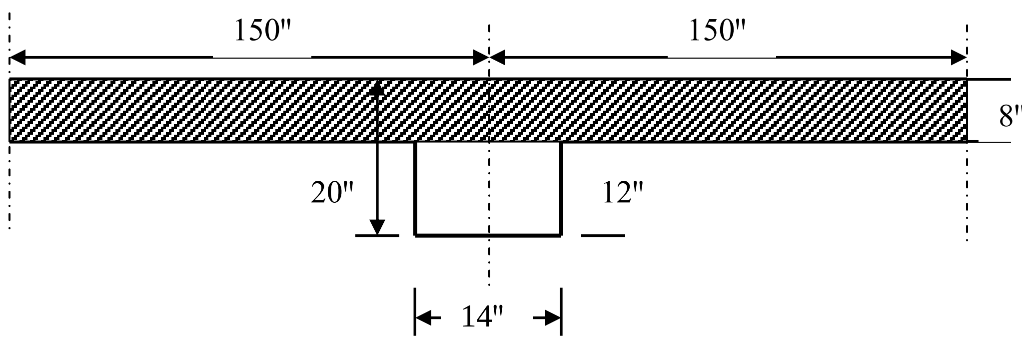
$I_{b1} = I_{b2} = I_{b3} = \frac{14\times20^3}{12} + (20\times14)\times(10-7.56)^2 + (\frac{12\times8^3}{12} + (12\times8)\times(7.56-4)^2)\times2$= 14457.67 in^4

Calculation of I_{s4}:



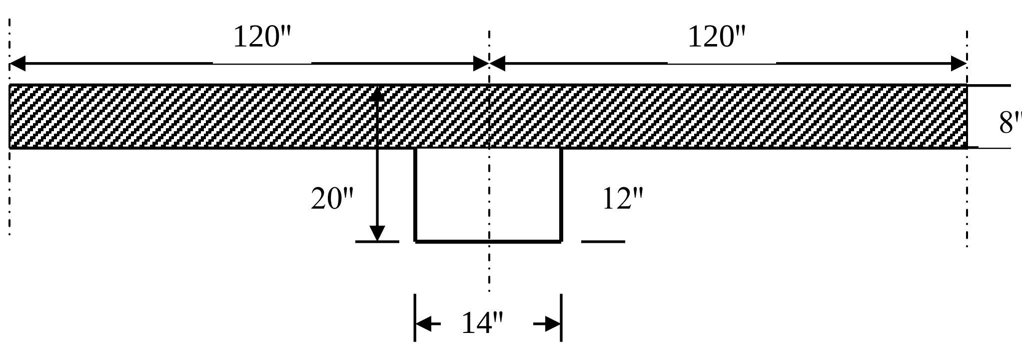
$I_{s4} = \frac{(150+7)\times 8^3}{12} = 6698.67$ in^4

Calculation of I_{s3}:



$I_{s3} = \frac{(150+150)\times 8^3}{12} = 12800$ in^4

Calculation of I_{s1} and I_{s2}: Value of I_{s1} and I_{s2} is same. Because B1 and B2 both are interior beam and for both cases, clear span on both side transverse to the beam B1 and B2 are same.



$I_{s1}= I_{s2}= \frac{(120+120)\times 8^3}{12}= 10240\ in^4$

Calculation of α: We know $\alpha= \frac{E_{cb}\, I_b}{E_{cs}\, I_s}$. Here $E_{cb}= E_{cs}$. Because of beam and slab concrete is same. So we can write $\alpha= \frac{I_b}{I_s}$.

For this example $\alpha_1= \frac{I_{b1}}{I_{s1}}= \frac{14457.67}{10240}= 1.41$

$\alpha_2= \frac{I_{b2}}{I_{s2}}= \frac{14457.67}{10240}= 1.41$

$\alpha_3= \frac{I_{b3}}{I_{s3}}= \frac{14457.67}{12800}= 1.13$

$\alpha_4= \frac{I_{b4}}{I_{s4}}= \frac{12418.95}{6698.67}= 1.85$

Average value of α, $\alpha_{avg}= \frac{1.41+1.41+1.13+1.85}{4} = 1.45$

The ratio of long to short clear spans is $\beta= {}^{286}/_{226} = 1.27$. Then the minimum thickness is not to be less than that given by Eq. (13.8a):

$$h= \frac{286(0.8+\left(\frac{60000}{200,000}\right))}{36+5\times 1.27(1.45-0.2)} = 7.16\ in$$

The following Example was done by Md. Mahmudun Nobe, ID - 12.01.03.078, AUST Batch no. 28

Determination of minimum thickness of a slab

Design of two-way edge supported slab by using moment coefficients.

Beam-column supported floor slab of a 93'-6"×75'-6" (center to center distance of extreme columns) "cyclone shelter" is to carry service live load of 100 psf in addition to its own weight, 1/2" thick plaster and 3/2" thick floor finish. Supporting columns of 14 in square are spaced orthogonally at an interval at 31'-2" and 25'-2" on centers along longitudinal and transverse directions respectively. Width of each beam is 14 in. Using BNBC/ACI code of moment coefficients design the slab by USD method, if f'_c= 3000 psi and f_y= 60000 psi.

Solution:

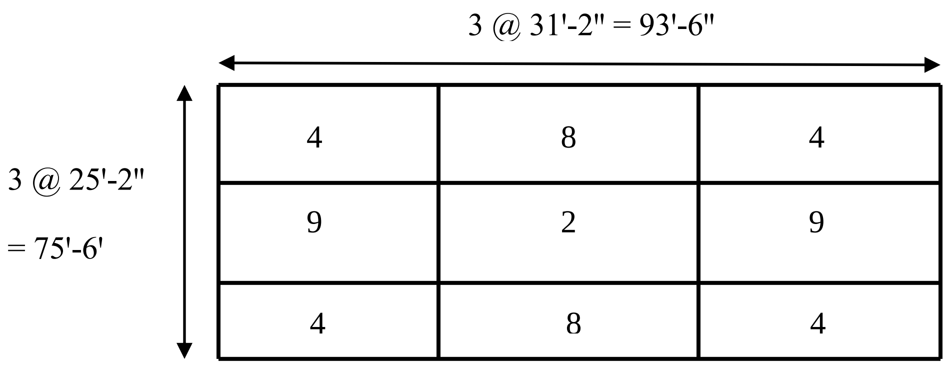


Figure 03: Slab panel orientation and case type, e.g., case 9 is typical exterior, 4 is corner slab etc.

Here A= 25'2"-1'2"= 24' and B= 31'2"-1'2"= 30'= l_n.

$$t = \frac{l_n (0.8+\left(\frac{fy}{200000}\right))}{36+9\beta} = \frac{30*(0.8+\left(\frac{60000}{200000}\right))}{36+9*\frac{30}{24}} = 8.38" \approx 8.5" \text{ say.}$$

So d= 8.5"-1"= 7.5'

W_{DL}= (8.5+0.5+1.5)*12.5*1.2= 157.5 psf

W_{LL}= 100*1.6= 160 psf

W_u = 317.5 psf

m= A/B= 24/30= 0.8

	2	4	8	9
$-C_A$	0.065	0.071	0.055	0.075
$-C_B$	0.027.	0.029	0.041	0.017
$C_{A\ DL}$	0.026	0.039	0.032	0.029
$C_{B\ DL}$	0.011	0.016	0.015	0.010
$C_{A\ LL}$	0.041	0.048	0.044	0.042
$C_{B\ LL}$	0.017	0.020	0.019	0.017

(circle) Controlling coefficient.

[Note: In this slab, there are four different types of cases among all panels. We take the maximum value of moment coefficient from four cases.]

$+M_A = C_{A\ DL}*W_{DL}*A^2 + C_{A\ LL}*W_{LL}*A^2$

$= 0.039*157.5*24^2 + 0.048*160*24^2$

= 7961.76l lb-ft/ft

= 7.69 k-ft/ft

$-M_A = C_A*W_u*A^2$

$= 0.075*317.5*24^2$

= 13716 lb-ft/ft

= 13.6 k-ft/ft

$+M_B = C_{B\ DL}*W_{DL}*B^2 + C_{B\ LL}*W_{LL}*B^2$

$= 0.016*157.5*30^2 + 0.020*160*30^2$

= 5148 lb-ft/ft

= 5.148 k-ft/ft

$-M_B = C_B*W_u*B^2$

$= 0.041*317.5*30^2$

= 11716 lb-ft/ft

= 11.716 k-ft/ft

Rebar for short direction/transverse direction:

$+A_{S\ A} = \frac{M*12}{0.9*f_y*\left(d-\frac{a}{2}\right)} = \frac{M*12}{0.9*60*\left(d-\frac{a}{2}\right)} = \frac{M}{4.5*\left(d-\frac{a}{2}\right)} = \frac{7.96}{4.5*(7.5-0.24)} = 0.244\ in^2/ft$

and $a = \frac{A_s f_y}{0.85 f_c' b} = \frac{A_s*60}{0.85*3*12} = 1.96*A_S = 1.96*0.244 = 0.478$ in.

$A_{min} = 0.0018*b*t*1.5 = 0.0018*12*8.5*1.5 = 0.275\ in^2/ft$ (Controlling).

Using φ10 bar

$S = \frac{\text{dia of bar used} * \text{width of strip}}{\text{requried } A_s} = \frac{0.121*12}{0.275} = 5.28'' \approx 5''$c/c at bottom along short direction crank 50% bar to negative zone.

$-A_{S\ A} = \frac{M}{4.5*\left(d-\frac{a}{2}\right)} = \frac{13.61}{4.5*(7.5-0.42)}$ = 0.427 in^2/ft (Controlling).

$a = 1.96 * A_s$ = 0.838 in

A_{min}= 0.275 in^2/ft.

Already provided $A_{s1} = \frac{0.121*12}{10}$= 0.1452 in^2/ft

Extra top required, A_{s2}= (0.4275-0.1452) = 0.2823 in^2/ft.

Using Φ10 bar S= 5.14" ≈ 5" c/c extra top.

Rebar along long direction:

$+A_{S\ B} = \frac{5.148}{4.5*(7.5-0.15)}$ = 0.155 in^2/ft

A_{min}= 0.275 in^2/ft (Controlling).

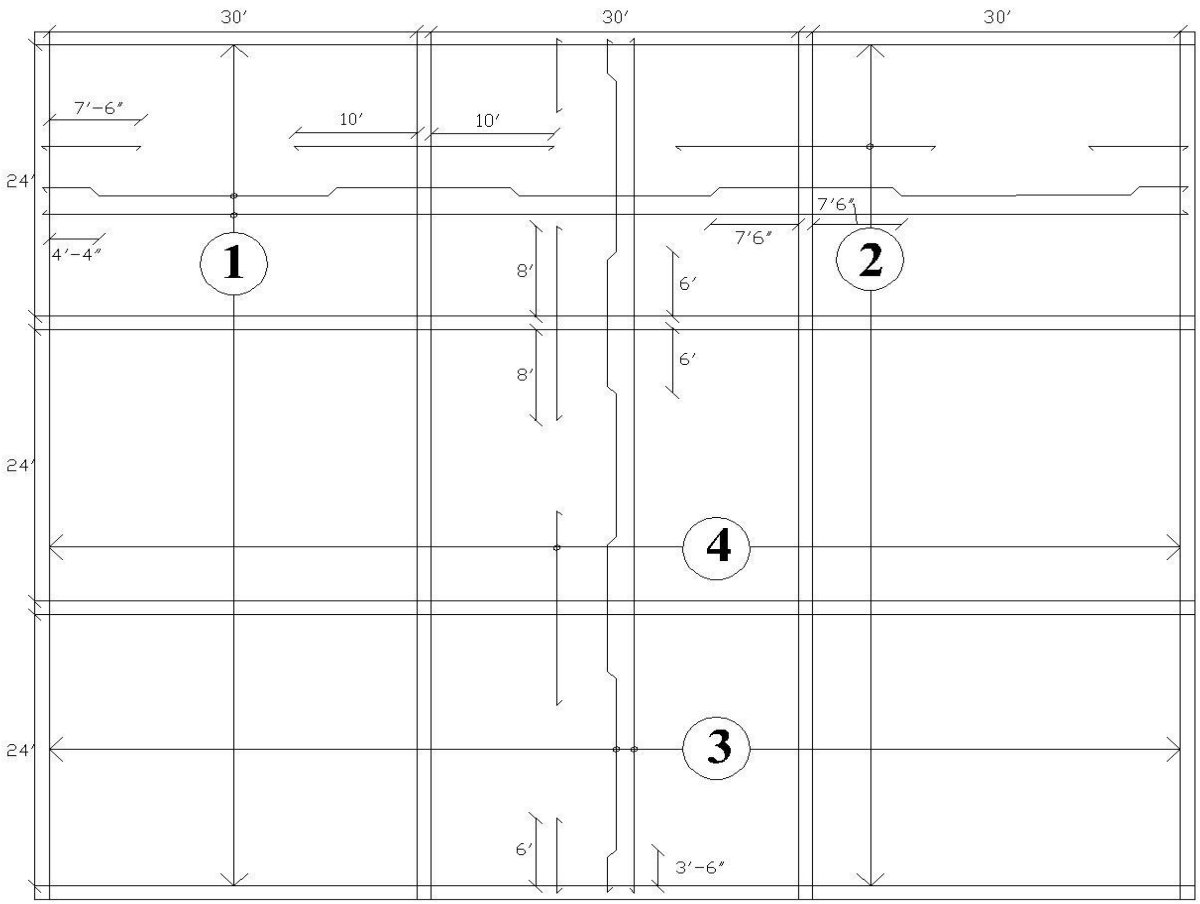
Using Φ10 bar @ 5.27' '≈ 5" c/c at bottom along long direction crank 50% bar to negative zone.

$-A_{S\ B} = \frac{11.716}{4.5*(7.5-0.36)}$ = 0.365 in^2/ft

Already provided $A_{s1} = \frac{0.121*12}{10}$ = 0.145 in^2/ft

Extra top required, A_{s2}= (0.365-0.1452) in^2/ft = 0.2198 in^2/ft

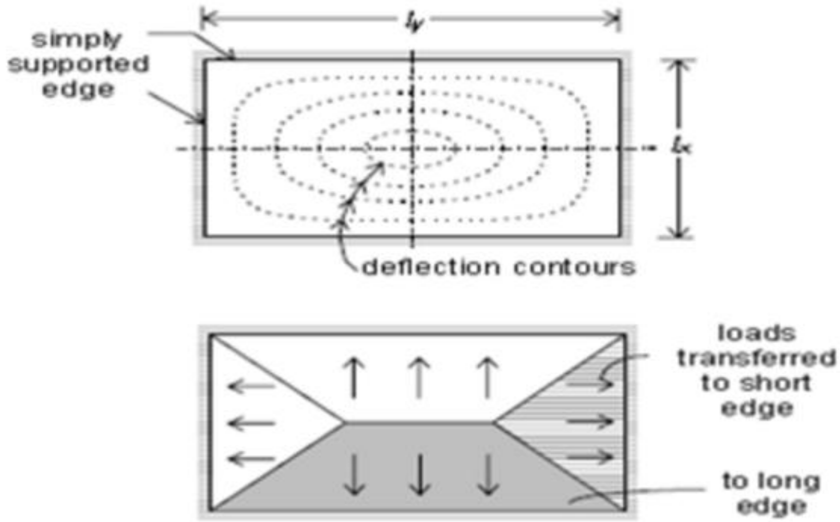
Using Φ10 bar @ 6.6" ≈ 6.5" c/c extra top.



Legends:

(**1**) Ø 10 @ 5" c/c althrough cranked alternatively.
(**2**) Ø 10 @ 6.5" c/c extra top.
(**3**) Ø 10 @ 5" c/c althrough cranked alternatively.
(**4**) Ø 10 @ 5" c/c extra top.
All beams are 14"×14"
Slab Thickness= 8.5"

Figure: Reinforcement details of slab in plan.



(b) two-way slab action