Finding the slab thickness for two way slab with edge beams

Note:

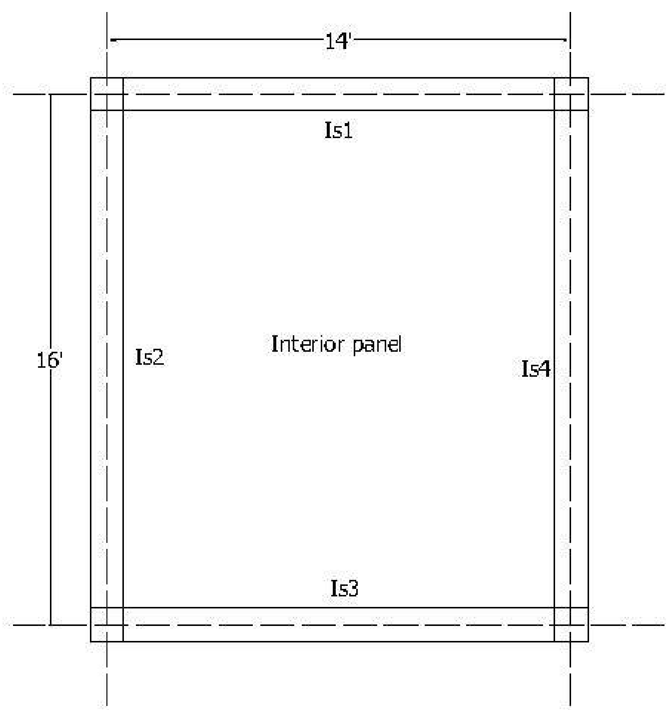
Preliminary slab thickness may be taken as, h, inches = P /160 (for less than 19 ft longer span), or P /145 (for more than 19 ft longer span) where, P = Perimeter, inches

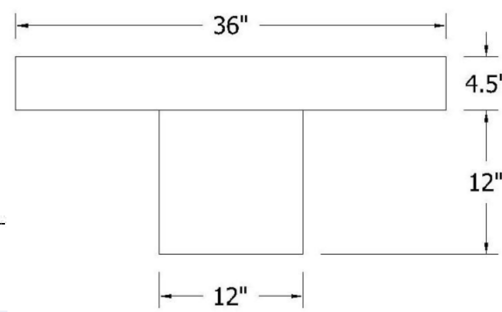
Example 1:

The following example was done by Mr. Naim Hassan (13.02.03.048), AUST Batch 31, Student of CE Dept., AUST

A two-way reinforced concrete building floor system is composed of slab panels measuring 16 x14 feet and supported by shallow column line 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 ; Determine the minimum thickness of the slab.

Solution:





Here,

Perimeter = (16+14) x 12 x2 = 720 inch

So, Thickness of the slab, $h_f = \frac{720}{160}$= 4.5 inch

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

Calculation of I_{s1} and I_{s3}:

Value of I_{s1} and I_{s3} is same. Because B1 and B3 both are interior beam and for both cases, clear span on transverse to the beam B1 and B3 are same

$I_{S1}, I_{S3} = \frac{16ft \times 12 inches \times 4.5 inches^3}{12} = 1458 \text{ in}^4$

Calculation of I_{s2} and I_{s4}:

Value of I_{s2} and I_{s4} is same. Because B2 and B4 both are interior beam and for both cases, clear span on transverse to the beam B2 and B4 are same.

$I_{S2}, I_{s4} = \frac{14ft \times 12in. \times 4.5in.^3}{12} = 1275.75 \text{ in}^4$

$b_w+2h_w \leq b_w+8h_f \rightarrow 12+2x12 \leq 12+8x4.5$

$b_w+2h_w = 36$ in (ok)

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

$I_b = \frac{12\times12^3}{12} + 12x12x((4.5+12/2)-6.13)^2 + \frac{36\times4.5^3}{12} + 36x4.5(4.5/2-6.13)^2 = 7190.14 \text{ in}^4$

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

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

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

Since $\alpha_{mavg} > 2$; $h_{min} = \frac{l_n(0.8+\frac{fy}{200000})}{36+9\beta} = \frac{(16-\frac{12}{12})\times12(0.8+\frac{60000}{200000})}{36+9\times\frac{15}{13}}$ =4.27 inch say, 4.50 inch.

Selected, Slab Thickness, $h_{minimum}$ = 4.50 inch

Example 2: Determination of minimum thickness of a slab

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

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. below. Using concrete with f'_c=4000 psi and steel with f_y= 60,000 psi, determine the minimum thickness of the slab.

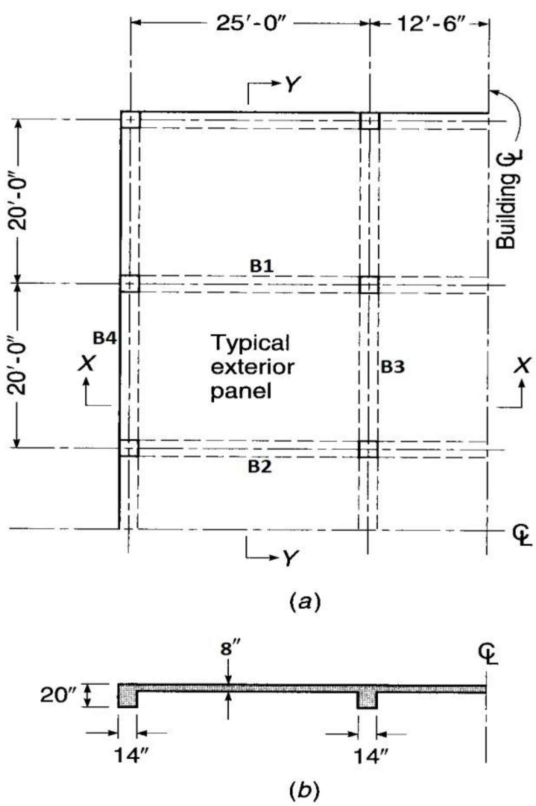
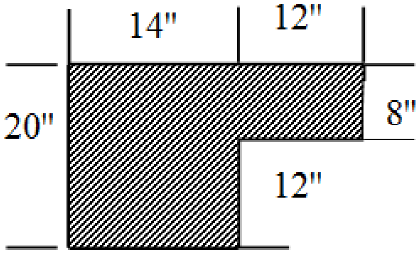


Figure: Two-way slab floor with beams on column lines:
(a) Partial floor plan;
(b) Section *X*-*X* (section *Y*-*Y* similar).

Solution: At first select the largest slab panel from floor slab plan. In this example, dimension of the slab panel is 20'×25'. Here, Perimeter= 2×(20+25)×12= 1080 in

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

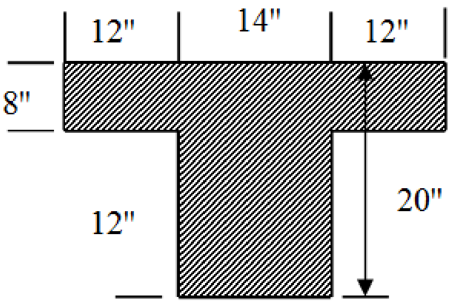
Moment of Inertia for beam B4 (Exterior beam):



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

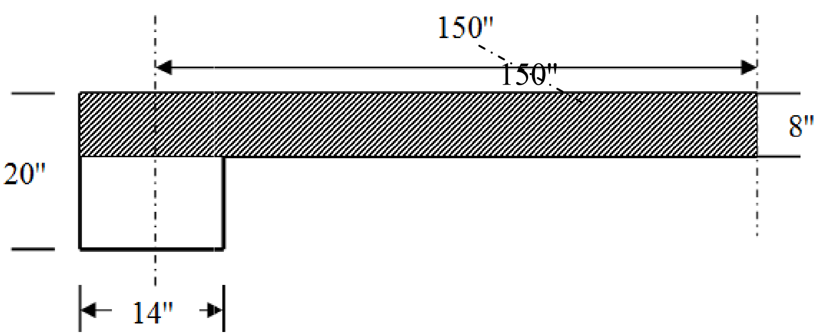
Moment of Inertia for Beam B1, B2, and B3 (Interior beam): In this case, those three beam's dimension is same and those are interior beam. So here moment of inertia for beam B1, B2, B3 is same.



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

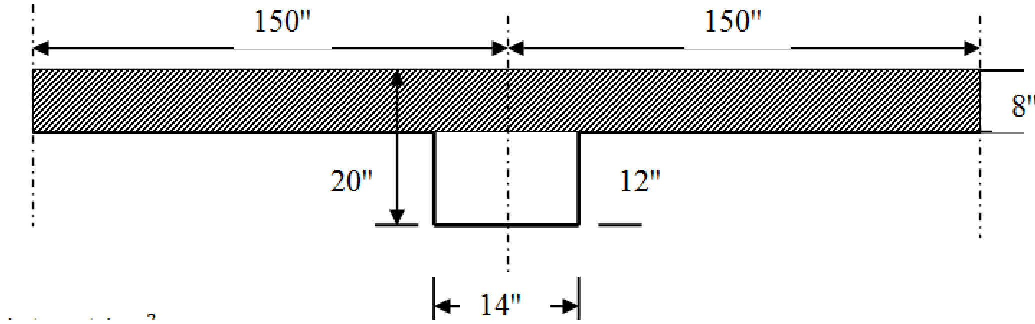
$I_{b1} = I_{b2} = I_{b3} = \frac{14\times20^3}{12} + (20\times14)\times(10-7.56)^2 + (\frac{12\times8^3}{12} + (12\times8)\times(7.56-4)^2)\times2 =$ 14457.67 in^4

Calculation of I_{s4}:



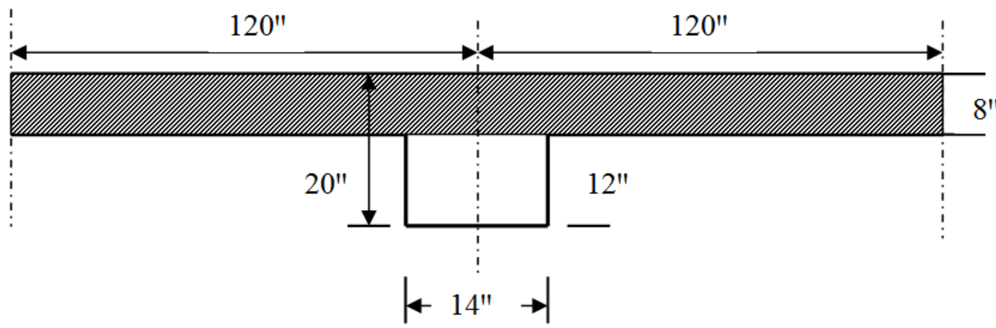
$I_{s4} = \frac{(150+7)\times8^3}{12} = 6698.67$ in^4

Calculation of I_{s3}:



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

<u>Calculation of I_{s1} and I_{s2}:</u> 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.



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

<u>Calculation of α:</u> We know $\alpha = \frac{\mathbf{E_{cb}\, I_b}}{\mathbf{E_{cs}\, I_s}}$. Here $E_{cb} = E_{cs}$. Because of beam and slab concrete is same.

So we can write $\alpha = \frac{\mathbf{I_b}}{\mathbf{I_s}}$.

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

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

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

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

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):

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

Selected, Slab Thickness, $h_{minimum}$ = 7.50 inch