ALMUSTAQBAL UNIVERSITY COLLEGE

DEPARTMENT OF BUILDING & CONSTRUCTION ENGINEERING TECHNOLOGY

ANALYSIS & DESIGN OF REINFORCED CONCRETE STRUCTURES (II)

SLAB THICKNESS II

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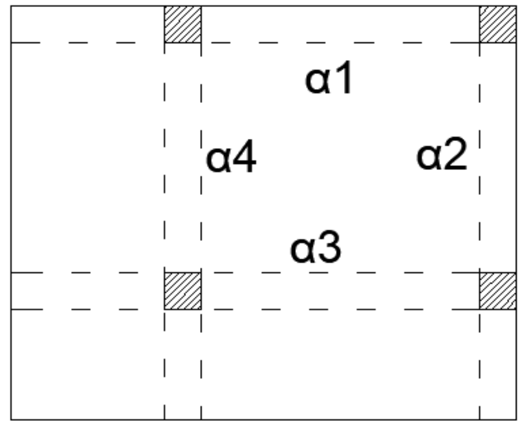
SLAB WITH BEAMS IN DETAIL:

$$\alpha_{fm} = \frac{\alpha_1+\alpha_2+\alpha_3+\alpha_4}{4}$$



Where:

α_{fm}: *average value of* α *for all beams on the edge of the panel*

$$\alpha = \frac{E_{c\,beam}.I_{beam}}{E_{c\,slab}\,.I_{slab}} = \frac{I_{beam}}{I_{slab}}$$

DETERMINING I_{BEAM}

$$I_{BEAM} = f.\frac{b_w h^3}{12}$$

EDGE BEAM DETAILS:

$b_f = b_w + a$

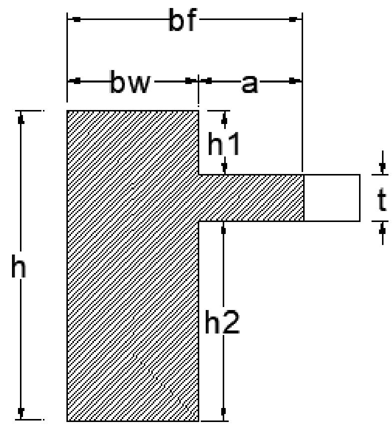
$a = \min val.[4t\ or\ \max(h1, h2)]$

$$I_b = f.\frac{b_w.h^3}{12}$$

$$f = 1 + 0.2\frac{b_f}{b_w}$$

$$0.2 \le \frac{t}{h} \le 0.5$$

$$2 \le \frac{b_f}{b_w} \le 4$$



Or approximately $\boldsymbol{f = 1.5}$

INTERIOR BEAM DETAILS:

$a = \min val.[4t\ or\ \max(h1, h2)]$

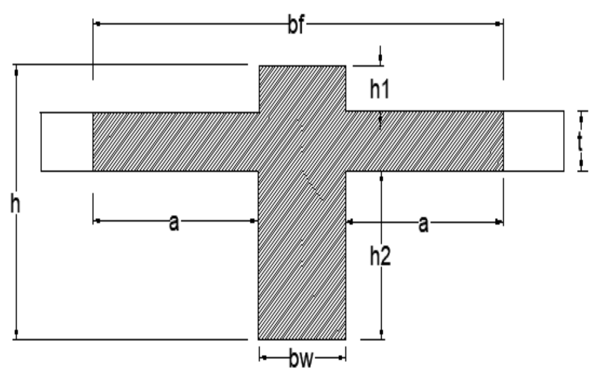
$bf = 2a + bw$

$$f = 1 + 0.2\frac{b_f}{b_w}$$

$$0.2 \le \frac{t}{h} \le 0.5$$

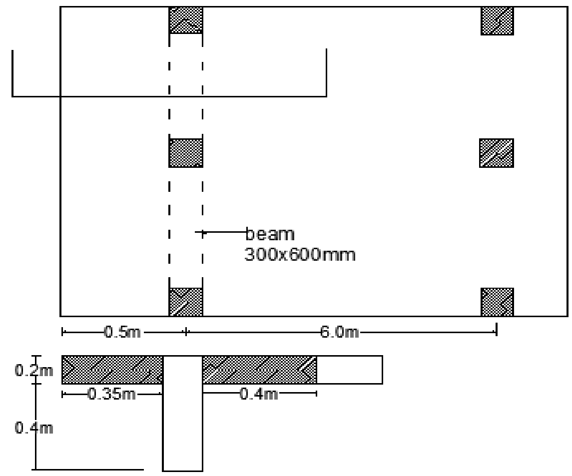
$$2 \le \frac{b_f}{b_w} \le 4$$

$$I_b = f.\frac{b_w.h^3}{12}$$



Or approximately $\boldsymbol{f = 2.0}$

Example Six: find a & b_f.



Solution:

$$a = \min[4t \text{ or } max.(h_1, h_2)$$
$$= \min[4 \times 0.2, max.(0.4m)]$$

$$\therefore a = 0.4m$$

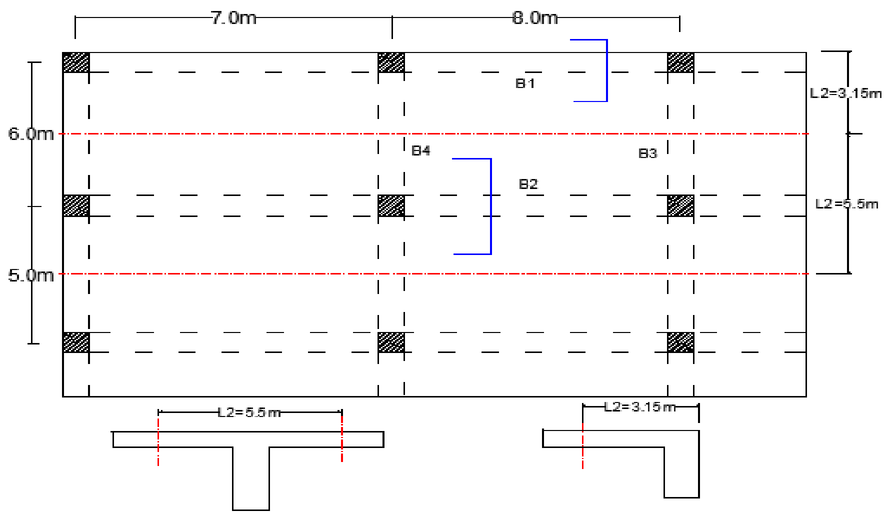
$$b_f = 0.35 + 0.3 + 0.4 = 1.05m$$

DETERMINING I_{SLAB}

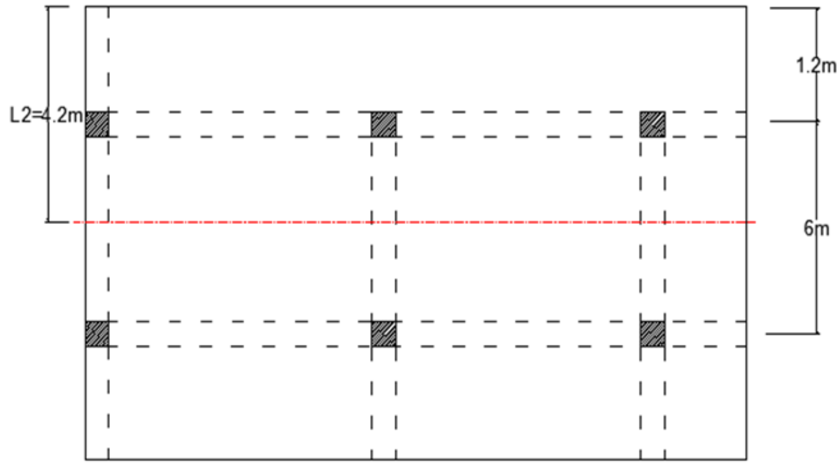
$$I_{SLAB} = \frac{l_2 . t^3}{12}$$

Where:

$l_2 = length\ of\ span\ perpindicular\ to\ the\ beam's\ direction$



- In the case of a cantilever parallel to the outside beam



Note:

- If a panel has one edge without a beam, the (α) for that beam is (0).

$$\therefore \alpha_{fm} = \frac{\alpha_1 + \alpha_2 + \alpha_3 + 0}{4}$$

- In the case of an exterior panel with an exterior edge that has no beam or a weak beam $\alpha \leq 0.8$, it is a must to increase the determined slab thickness by 10%.

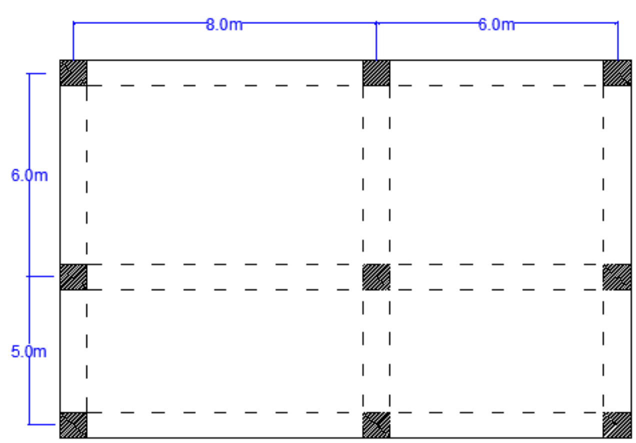
- If slab thickness was given and it is required to check the slab thickness

$$slab\ thickness_{calculated} \leq slab\ thickness_{given}$$

- the largest panel area should be considered, and the largest span should be taken when calculating l_n.

Example Seven: find l_n, s_n for the slab shown in the figure. All column sizes are $(300 \times 300mm)$

Solution:

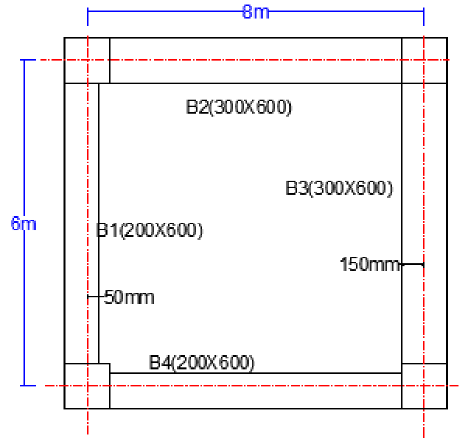


$$l_n = 8000 - 300 = 7700mm$$

$$s_n = 6000 - 300 = 5700mm$$

Example Eight: find l_n, s_n for the slab shown in the figure. All column sizes are $(300 \times 300mm)$

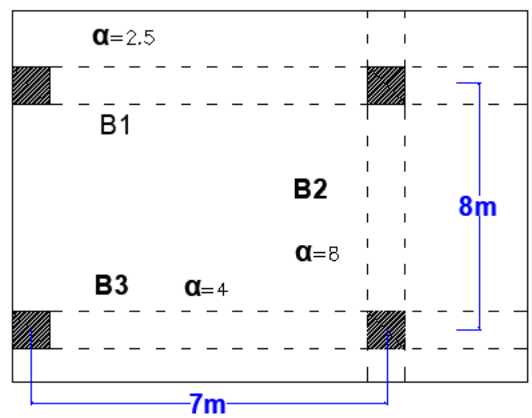
Solution:



$$l_n = 8000 - 150 - 50 = 7800mm$$

$$s_n = 6000 - 150 - 50 = 5800mm$$

Example Nine: Find slab thickness. Use $f_y = 400MPa$, Beam size (300x600) mm and column size (300x300) mm.



Solution:

$$\alpha_{fm} = \frac{\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4}{4}$$

$$= \frac{2.5 + 8 + 4 + 0}{4} = 3.625$$

Since the slab has beams → we use table 8.3.1.2

$$\therefore \alpha_{fm} > 2$$

$$\beta = \frac{l_n}{s_n} = \frac{8 - 0.3}{7 - 0.3} = 1.15$$

Table 8.3.1.2—Minimum thickness of nonprestressed two-way slabs with beams spanning between supports on all sides

α_{fm}[1]	Minimum h, mm		
$\alpha_{fm} \le 0.2$	8.3.1.1 applies		(a)
$0.2 < \alpha_{fm} \le 2.0$	Greater of:	$\dfrac{\ell_n\left(0.8 + \frac{f_y}{1400}\right)}{36 + 5\beta(\alpha_{fm} - 0.2)}$	(b)[2],[3]
		125	(c)
$\alpha_{fm} > 2.0$	Greater of:	$\dfrac{\ell_n\left(0.8 + \frac{f_y}{1400}\right)}{36 + 9\beta}$	(d)[2],[3]
		90	(e)

[1]α_{fm} is the average value of α_f for all beams on edges of a panel and α_f shall be calculated in accordance with 8.10.2.7.

[2]ℓ_n is the clear span in the long direction, measured face-to-face of beams (mm).

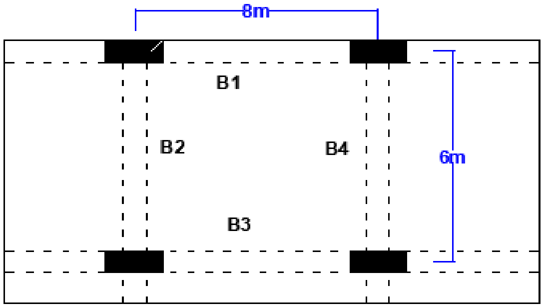
[3]β is the ratio of clear spans in long to short directions of slab.

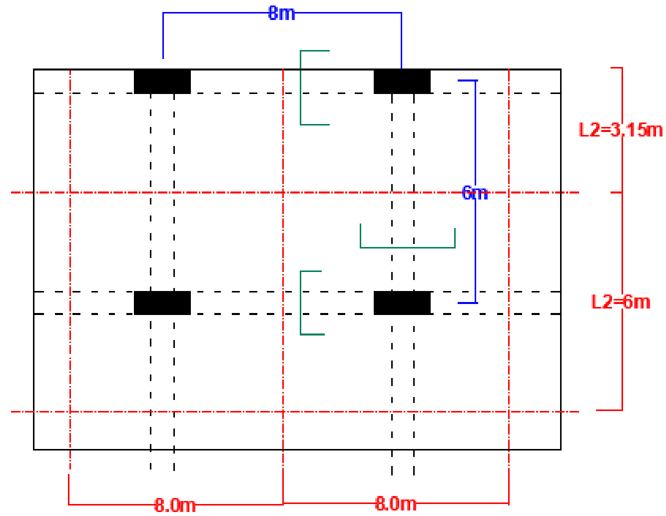
Since the panel is an exterior panel and the exterior edge has no beam, then increase the thickness by 10%.

$$h = 1.1 \times \frac{l_n(0.8 + \frac{f_y}{1400})}{36 + 9(1.15)} = 1.1 \times \frac{7700(0.8 + \frac{400}{1400})}{36 + 9(1.15)} = 0.198m \quad > 90mm \quad ok$$

$$\therefore h = 198mm \approx 200mm.$$

Example Ten: check the slab thickness. All columns are of (300x600mm), all beams are (300x700mm), slab thickness ($h = 200mm$), and $f_y = 350MPa$.

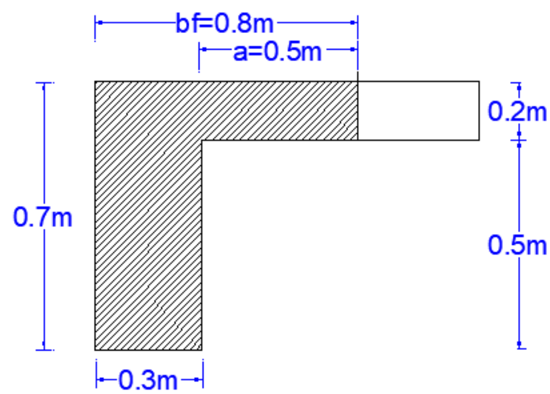




Solution:

Find α for the beams:

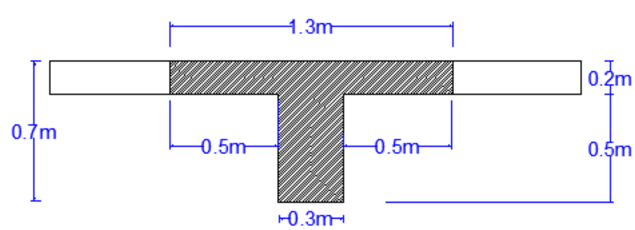
B1:



$$a = min.[4t \; or \; h_2] = min.[4 \times 0.2 = 0.8 \; or \; 0.5]$$
$$\therefore a = 0.5m$$
$$\frac{b_f}{b_w} = \frac{0.5+0.3}{0.3} = 2.667 \qquad 2 \le \frac{b_f}{b_w} \le 4$$
$$\frac{t}{h_{beam}} = \frac{0.2}{0.7} = 0.29 \qquad 0.2 < \frac{t}{h_{beam}} < 0.5$$

$$f = 1 + 0.2\frac{b_f}{b_w} = 1 + 0.2 \times 2.667 = 1.53$$
$$I_{beam} = f.\frac{bh^3}{12} = 1.53 \times \frac{0.3(0.7)^3}{12} = 0.01315m^4$$
$$I_{slab} = \frac{l_2.t^3}{12} = \frac{3.15(0.2)^3}{12} = 0.0021m^4$$
$$\therefore \alpha_{B1} = \frac{0.0135}{0.0021} = 6.26 > 0.8 \quad \text{ok.}$$

B2:



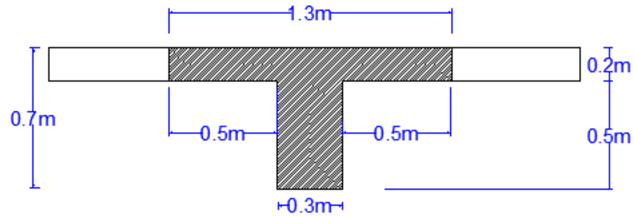
$\frac{b_f}{b_w} = \frac{0.5+0.3+0.5}{0.3} = 4.3 > 4$ although the condition is not satisfied, however, the difference isn't large.

$$\frac{t}{h_{beam}} = \frac{0.2}{0.7} = 0.29 \rightarrow 0.2 < \frac{t}{h_{beam}} < 0.5 \quad ok$$
$$f = 1 + 0.2 \times 4.3 = 1.87$$
$$I_{beam} = f.\frac{bh^3}{12} = 1.87 \times \frac{0.3(0.7)^3}{12} = 0.016m^4$$

$$I_{slab} = \frac{l_2 . t^3}{12} = \frac{8(0.2)^3}{12} = 0.00533 m^4$$

$$\therefore \alpha_{B2} = \frac{0.016}{0.0053} = 3 \ > 0.8 \quad ok.$$

B3:



$$I_{beam} = I_{B2} = 0.016 m^4$$
$$I_{slab} = \frac{l_2 . t^3}{12} = \frac{6(0.2)^3}{12} = 0.4 m^4$$
$$\alpha_{B3} = \frac{0.016}{0.4} = 4.01$$

B4:

$$\alpha_{B4} = \alpha_{B2} = 3.0$$
$$\therefore \alpha_{fm} = \frac{6.26 + 3 + 4.01 + 3}{4} = 4.07 \ > 2.0$$

Table 8.3.1.2—Minimum thickness of nonprestressed two-way slabs with beams spanning between supports on all sides

α_{fm}[1]	Minimum h, mm		
$\alpha_{fm} \le 0.2$	8.3.1.1 applies		(a)
$0.2 < \alpha_{fm} \le 2.0$	Greater of:	$\frac{\ell_n\left(0.8 + \frac{f_y}{1400}\right)}{36 + 5\beta(\alpha_{fm} - 0.2)}$	(b)[2],[3]
		125	(c)
$\alpha_{fm} > 2.0$	Greater of:	$\frac{\ell_n\left(0.8 + \frac{f_y}{1400}\right)}{36 + 9\beta}$	(d)[2],[3]
		90	(e)

[1]α_{fm} is the average value of α_f for all beams on edges of a panel and α_f shall be calculated in accordance with 8.10.2.7.

[2]ℓ_n is the clear span in the long direction, measured face-to-face of beams (mm).

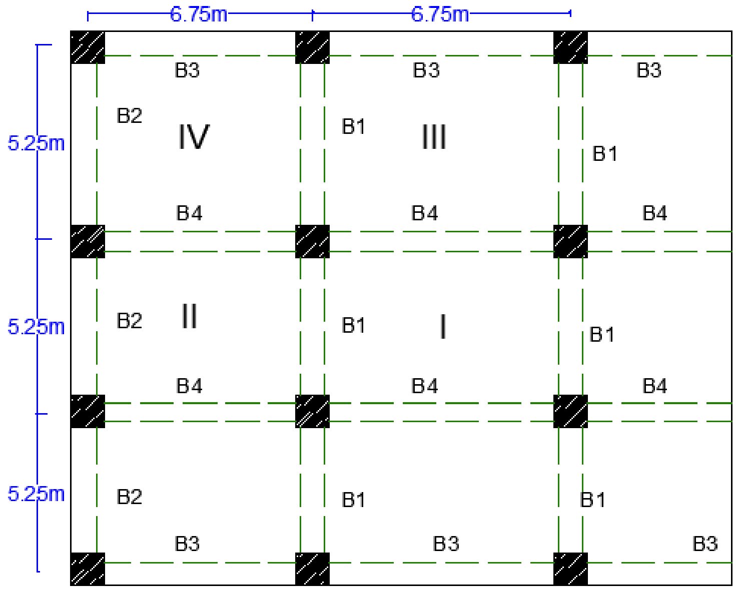
[3]β is the ratio of clear spans in long to short directions of slab.

$$l_n = 8000 - 300 = 7700 mm$$
$$\beta = \frac{7700}{5700} = 1.35$$

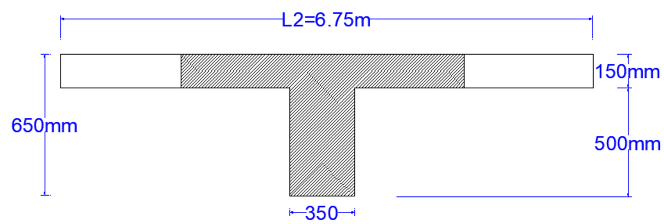
$$h = \frac{7700(0.8 + \frac{400}{1400}}{36 + 9(1.35)} = 173.6 mm \quad > 90 mm \qquad ok.$$
$$\therefore h = 180 mm$$
$$h_{calculated} = 180 mm \ < h_{given} = 200 mm$$

$$\therefore slab\ thickness\ is\ okay.$$

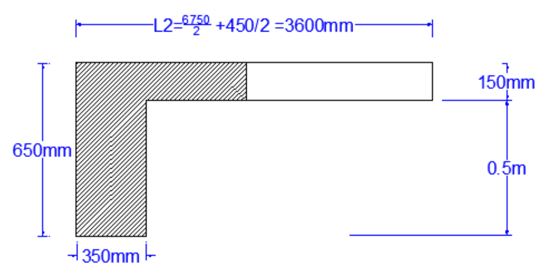
Example Eleven: estimate the slab thickness for the following slab beam given. Dimensions of all beams are $(350 \times 650mm)$, and all column sizes $(450 \times 450mm)$. $f'_c = 30MPa, f_y = 420MPa,$ $and\ use\ f_{L\ beam} = 1.5\ and\ f_{T\ beam} = 2.0$. Assume slab thickness =150mm.



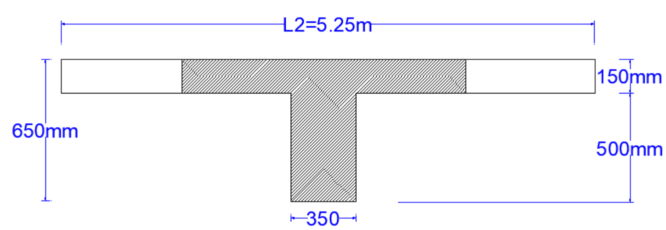
SOLUTION:



$$\alpha_{B1} = \left(\frac{2 \times 350 \times 650^3}{12}\right) \Big/ \left(\frac{6750 \times 150^3}{12}\right) = 8.43$$

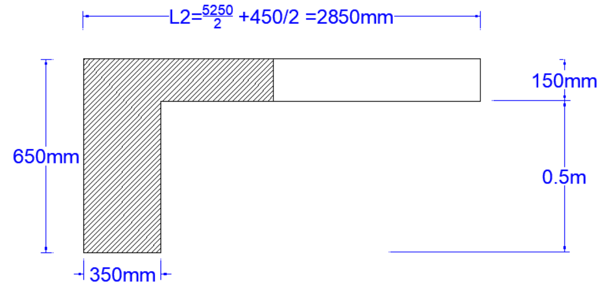


$$\alpha_{B2} = \left(\frac{1.5 \times 350 \times 650^3}{12}\right) \Big/ \left(\frac{3600 \times 150^3}{12}\right) = 11.6$$



$$\alpha_{B3} = \left(\frac{1.5 \times 350 \times 650^3}{12}\right) \Big/ \left(\frac{2850 \times 150^3}{12}\right) = 14.9$$

$$\alpha_{B4} = \left(\frac{2 \times 350 \times 650^3}{12}\right) \Big/ \left(\frac{5250 \times 150^3}{12}\right) = 10.8$$



$$\therefore\ panel\ I: \alpha_{fm} = \frac{2 \times 8.43 + 2 \times 10.8}{4} = 9.6 > 2$$

$$panel\ II: \alpha_{fm} = \frac{8.43 + 11.6 + 2 \times 10.8}{4} = 10.9 > 2$$

$$panel\ III: \alpha_{fm} = \frac{2 \times 8.43 + 14.9 + 10.8}{4} = 10.6 > 2$$

$$panel\ IV: \alpha_{fm} = \frac{8.43 + 11.6 + +14.9 + 10.8}{4} = 11.4 > 2$$

Use Table 8.3.1.2:

For panel II & IV: $l_n = 6750 - 125 - \frac{350}{2} = 6450mm$
For panel III & IV: $S_n = 5250 - 125 - \frac{350}{2} = 4950mm$
For panel I & III: $l_n = 6750 - 350 = 6400mm$
For panel I & II: $S_n = 5250 - 350 = 4900mm$

Panel I: $\beta = \frac{l_n}{S_n} = \frac{6400}{4900} = 1.3$ Panel II: $\beta = \frac{l_n}{S_n} = \frac{6450}{4900} = 1.31$
Panel III: $\beta = \frac{l_n}{S_n} = \frac{6400}{4950} = 1.293$ Panel IV: $\beta = \frac{l_n}{S_n} = \frac{6450}{4950} = 1.3$

Panel I: $h = \frac{6400(0.8+\frac{420}{1400})}{36+9(1.3)} = 147.5mm \quad > 90mm$
Panel II: $h = 148.4mm \quad > 90mm$
Panel III: $h = 147.7mm \quad > 90mm$
Panel IV: $h = 148.7mm \quad > 90mm$

$$\therefore all\ h < \ h_{slab\ given} = 150mm$$

$$\therefore h = 150mm$$