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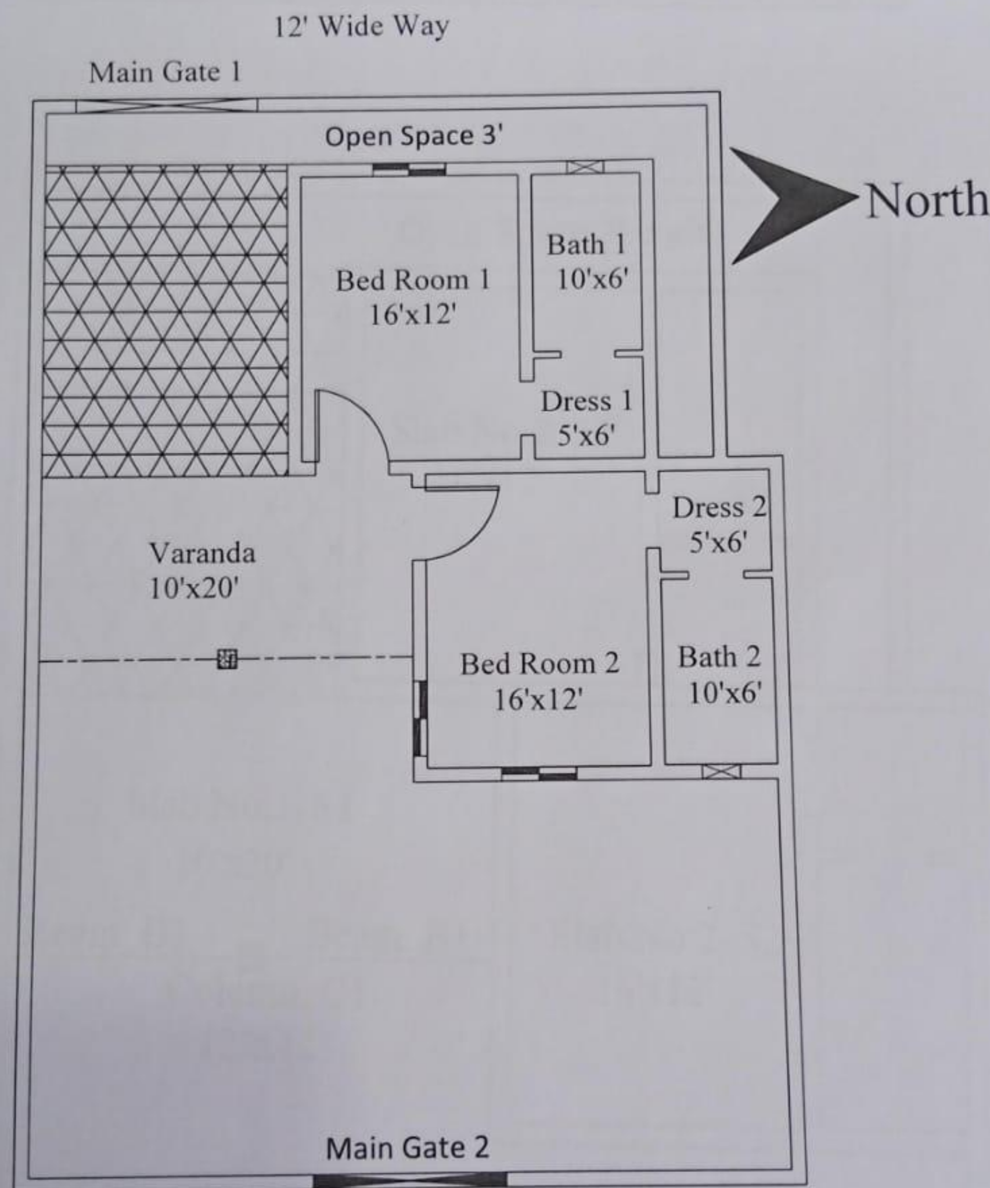
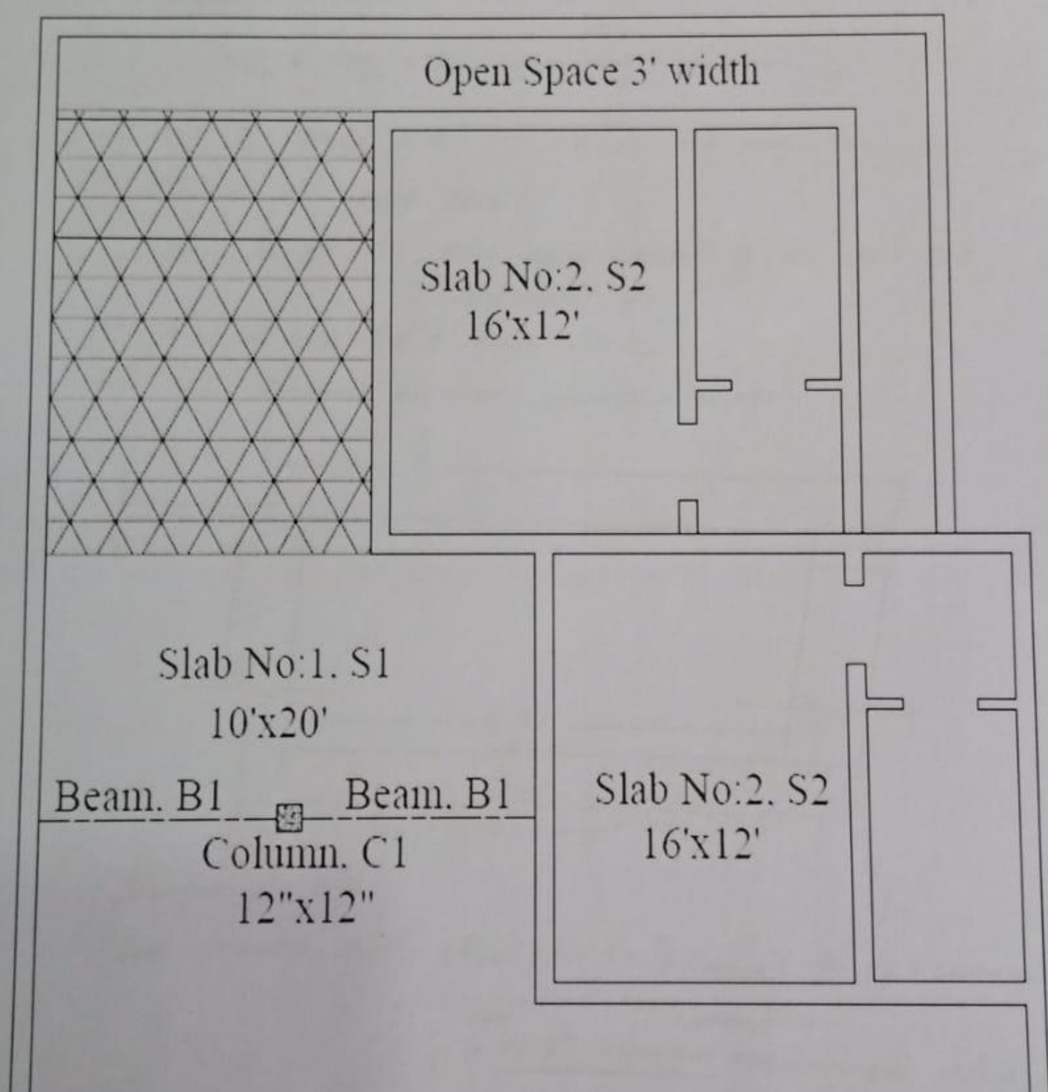
MS Transportation Engineering

Paper Reinforced Design Concrete

Plan of House



<u>Drawing Showing Slabs, Beams and Columns</u>



1. Design of Slab1, S1:

1

Solution:

(1) Design of Slab, S_1;

Step. 1

Sizes:

$l_b/l_a = 20/10 = 2$ one way Slab.

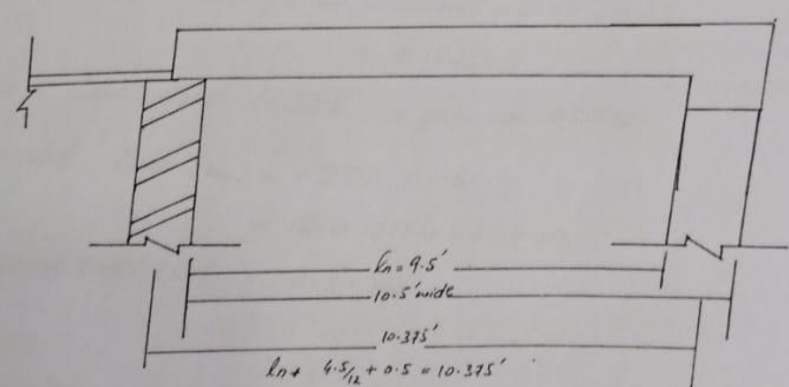
As $l_b/l_a \geq 2$ then it is one way Slab.

Assume 5" depth Slab.

Span length for end span according to ACI 8.7 is minimum of;

(i) $l = l_n + h_f = 9.5' + 5/12) = 9.92'$

(ii) c/c distance between supports = 10.375'



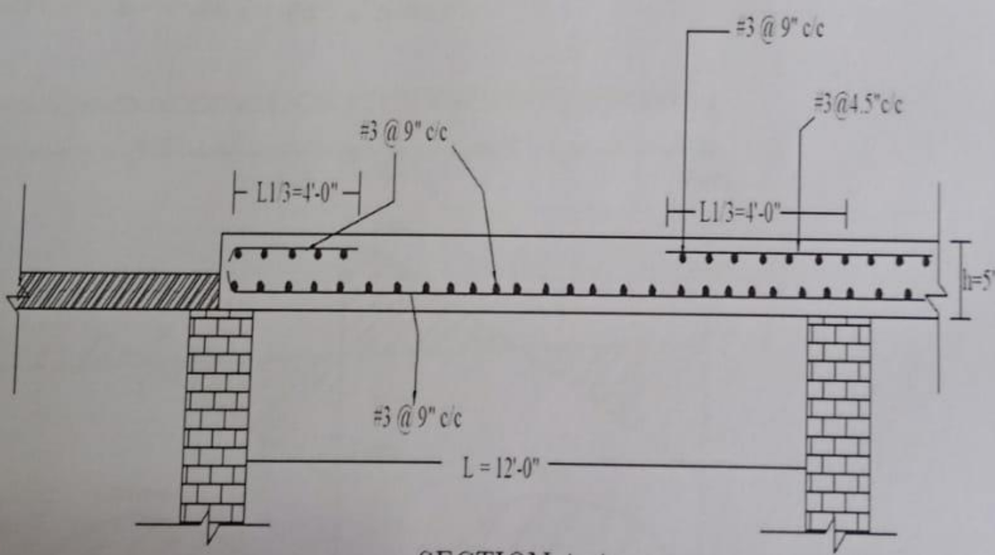
Therefore $l = 9.92'$

Slab thickness $(h_f) = (l/20) \times (0.4 + f_y/100000)$ for $f_y < 60000$ psi

$= 9.92/20 \times (0.4 + 40000/100000) \times 12$

$= 4.7616''$ Minimum requirement. ACI 9.5.2.1

Panel	Depth (in)	Mark	Bottom Reinforcement	Mark	Top reinforcement	
S2	5"	M1	3/8" φ @ 9" c/c	MT1	3/8" φ @ 4.5" c/c	Continuous End
				MT2	3/8" φ @ 9" c/c	Non continuous Ends
S1	5"	M2	3/8" φ @ 6" c/c	MT2	3/8" φ @ 9" c/c	Non Continuous End
		M1	3/8" φ @ 9" c/c			



SECTION A-A

2 At MID Span:

Positive moment (M_{pos}) = Coefficient × ($w_u l_n^2$)

$$= (1/11) \times \{1.25 \times (9.5)^2\}$$

$$= 10.255 \text{ ft·K} \times 12$$

$$= 123 \text{ in·K}.$$

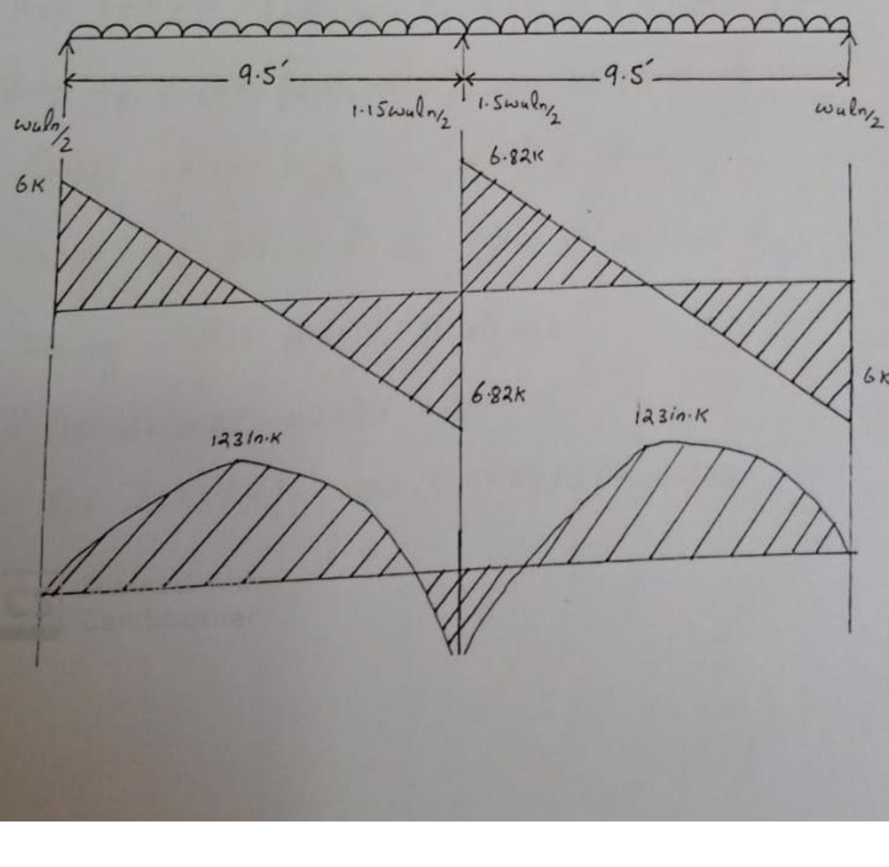
$$V_{int} = 1.15 w_u l_n / 2$$

$$= 1.15 \times 1.25 \times 9.5 / 2 = 6.82K$$

$$V_{u(int)} = 6.82 - 1.25 \times 1.25 = 6.97K$$

$$V_{ext} = w_u l_n / 2 = 1.25 \times 9.5 / 2 = 5.9 \approx 6K$$

$$V_{u(ext)} = 6 - 1.25 \times 1.25 = 5.93K$$



Finally use #3 @ 9" c/c (#10 @ 225mm c/c).

"Provide #3 @ 9" c/c as negative reinforcement along the longer direction."

$M_{a,pos,(d1+11)} = 1.53$ ft·K $= 18.36$ in·K $> \phi M_n$

Let $a = 0.2d$

$a = 0.2 \times 4$

$a = 0.8$ in

$A_s = 1.53 \times 12 / \{0.9 \times 40 \times (4 - (0.8/2))\} = 0.146 in^2$

$a = 0.146 \times 40 / (0.85 \times 3 \times 12) = 0.191$ in

$A_s = 1.53 \times 12 / \{0.9 \times 40 \times (4 - 0.191/2)\} = 0.131 in^2$

$a = 0.131 \times 40 / (0.85 \times 3 \times 12) = 0.171$ in

$A_s = 1.53 \times 12 / \{0.9 \times 40 \times (4 - 0.30/2)\} = 0.131 in^2$. OK.

Using $3/8"$ ϕ (#3) {#10, 10mm}, with bar area $A_b = 0.11 in^2$

Spacing $= 0.11 \times 12 / 0.131 = 10.07" \approx 9"$ c/c

Finally use #3 @ 9" c/c (#10 @ 225 mm c/c).

$M_{a,neg} = 2.67$ ft·K $= 32.04$ in·K

Let $a = 0.2d = 0.2 \times 4 = 0.8$ in

$A_s = 2.67 \times 12 / \{0.9 \times 40 \times (4 - (0.8/2))\} = 0.24 in^2$

Step No: 4

Design:

$A_{s\,min} = 0.002\, b h_f = 0.002 \times 12 \times 5 = 0.12 in^2$

$a = A_{s\,min}\, f_y / (0.85 f'_c b)$

$= 0.12 \times 40 / (0.85 \times 3 \times 12) = 0.156 in$

$\phi M_{n(min)} = \phi A_{s\,min} f_y (d - a/2)$

$= 0.9 \times 0.12 \times 40 \times (4 - 0.156/2) = 16.94$ in.K

(capacity provided by A_{smin}).

$\phi M_{n(min)}$ is greater than $M_{b,pos,(d1+11)}$ but less than $M_{a,neg}$ and $M_{a,pos,(d1+11)}$.

$M_{b,pos,(d1+11)} = 0.712$ ft-K $= 8.544$ in.K $< \phi M_{n(min)}$

Therefore, $A_{smin} = 0.12 in^2$ governs

Using 3/8" ϕ (#3) {#10, 10mm}, with bar area

$A_b = 0.11 in^2$

Spacing $= (0.11/0.12) \times 12 = 11''$

Maximum spacing according to ACI 13.3.2 for two way slab is;

$2h_f = 2 \times 5 = 10''$

Therefore maximum spacing of 10" governs.

$$M_{a,neg} = C_{a,neg} \times w_u \times l_a^2$$
$$= 0.088 \times 0.211 \times 12^2 = 2.67 \text{ ft}\cdot\text{K} = 32.04 \text{ in}\cdot\text{K}$$

$$M_{b,neg} = C_{b,neg} \times w_u \times l_b^2 =$$
$$= 0 \times 0.211 \times 16^2 = 0 \text{ ft}\cdot\text{K}$$

$$M_{a,pos,dl} = C_{a,pos,dl} \times w_{u,dl} \times l_a^2$$
$$= 0.048 \times 0.147 \times 12^2 = 1.016 \text{ ft}\cdot\text{K} = 12.19 \text{ in}\cdot\text{K}$$

$$M_{b,pos,dl} = C_{b,pos,dl} \times w_{u,dl} \times l_b^2$$
$$= 0.012 \times 0.147 \times 16^2 = 0.45 \text{ ft}\cdot\text{K} = 5.42 \text{ in}\cdot\text{K}.$$

$$M_{a,pos,ll} = C_{a,pos,ll} \times w_{u,ll} \times l_a^2$$
$$= 0.055 \times 0.064 \times 12^2 = 0.51 \text{ ft}\cdot\text{K} = 6.12 \text{ in}\cdot\text{K}$$

$$M_{b,pos,ll} = C_{b,pos,ll} \times w_{u,ll} \times l_b^2$$
$$= 0.016 \times 0.064 \times 16^2$$
$$= 0.262 \text{ ft}\cdot\text{K} = 3.144 \text{ in}\cdot\text{K}.$$

Therefore finally we have;

$$M_{a,neg} = 2.67 \text{ ft}\cdot\text{K} = 32.04 \text{ in}\cdot\text{K}$$

$$M_{b,neg} = 0 \text{ ft}\cdot\text{K}$$

$$M_{a,pos,(dl+ll)} = 1.016 + 0.51 = 1.53 \text{ ft}\cdot\text{K} = 18.36 \text{ in}\cdot\text{K}$$

$$M_{b,pos\,(dl+ll)} = 0.45 + 0.262 = 0.712 \text{ ft}\cdot\text{K} = 8.544 \text{ in}\cdot\text{K}$$

Where C_a, C_b = tabulated moment co-efficients as given in Appendix, A.

W_u = Ultimate uniform load, psf

l_a, l_b = length of clear spans in short and long directions respectively.

Therefore, for the design problem under discussion.

$m = l_a / l_b$

$m = 12/16 = 0.75$

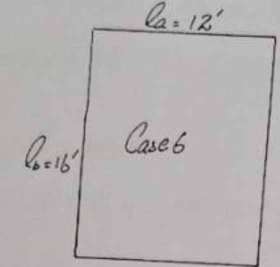


Figure 3: Two way slab (S_1)

Table 1.2: Moment coefficients for slab					
Case #6 [m = 0.75]					
Coefficients for negative moments in slabs		Coefficients for dead load positive moments in slabs		Coefficients for live load positive moments in slabs	
$C_{a,neg}$		$C_{b,dl}$	$C_{b,dl}$	$C_{a,ll}$	$C_{b,ll}$
0.088	0	0.048	0.012	0.055	0.016

Refer to tables 12.3 to 12.6 of Nilson 12th Ed.

2. Design of Slab2, S2:

2. Design of Slab, S_2:

Step No. 1 : Sizes

$l_b/l_a = 16/12 = 1.33 < 2$

Hence Two way slab

Formula for Minimum depth of two way slab:

$h_{min} = \text{Perimeter}/180$

$h_{min} = 2 \times (16+12) \times 12/180 = 3.73in$

Assume $h = 5''$

Step No: 2 :

Loads

Factored Load $(w_u) = w_u\,dl + w_u\,ll$

$w_u = 1.2D.L + 1.6L.L$

From previous data;

$D.L = 0.1225$

$L.L = 0.04$

$w_u = (1.2 \times 0.1225) + (1.6 \times 0.04)$

$w_u = 0.211\ Ksf$

Step No: 3

Analysis:

$M_{a,pos,(dl+ll)} = M_{a,pos,dl} + M_{a,pos,ll} = C_{a,pos,dl} \times w_{u,dl} \times l_a^2 + C_{a,pos,ll} \times w_{u,ll} \times l_a^2$

$M_{b,pos,(dl,ll)} = M_{b,pos,dl} + M_{b,pos,ll} = C_{b,pos,dl} \times w_{u,dl} \times l_a^2$

$M_{a.neg} = C_{a,neg}\,w_u l_a^2$

$M_{.neg} = C_{n.neg}\,W_u l_a^2$

Therefore 6" spacing is OK.

⇒ Maximum spacing for shrinkage steel in one way slab according to ACI. 7.12.2 is minimum of;

(i) $5h_f = 5 \times 5 = 25"$

(ii) 18"

Therefore 9" spacing is OK.

Using $\frac{1}{2}'' \phi$ (#4) {#13, 13 mm}, with bar area $A_b = 0.20 in^2$.

Spacing = area of one bar = A_b/A_s

$= \left[0.20\ in^2 / 0.160\ (in^2/ft)\right] \times 12 = 15 in.$

Using $\frac{3}{8}'' \phi$ (#3) {#10, 10 mm} with bar area $A_b = 0.11 in^2$

Spacing = Area of one bar A_b/A_s

$= \left[0.11\ in^2/0.160\ (in^2/ft)\right] \times 12 = 7.5'' \approx 6''$

Finally use #3 @ 6" c/c (#10 @ 150 mm c/c).

Shrinkage steel or temperature steel (A_{st}).

$A_{st} = 0.002 bh_f$.

$A_{st} = 0.002 \times 12 \times 5 = 0.12 in^2$

Using $\frac{3}{8}'' \phi$ (#3) {#10, 10mm}, with bar area, $A_b = 0.11 in^2$

Spacing = Area of one bar (A_b/A_{smin})

$= (0.11/0.12) \times 12 = 11''$ c/c.

Finally use #3 @ 9" c/c (#10 @ 225mm c/c).

⇒ Maximum spacing for main steel in one way slab according to ACI 7.6.5 is minimum of

(i) $3h_f = 3 \times 5 = 15''$

Step No: 4

Design

$A_{smin} = 0.002\, b h_f$ (for f_y 40 ksi, ACI 10.5.4).

$= 0.002 \times 12 \times 5 = 0.12 in^2$

$a = A_{smin} f_y / (0.85 f_c' b)$

$= 0.12 \times 40 / (0.85 \times 3 \times 12) = 0.156 in$

$\phi M_n (min) = \phi A_{smin} f_y (d - a/2)$

$= 0.9 \times 0.12 \times 40 \times (4 - 0.156/2)$

$= 16.94$ in k $< M_u$

Therefore,

$\Rightarrow A_s = M_u / \{\phi f_y (d - a/2)\}$

Take $a = 0.2d$

$A_s = 22.44 / \{0.9 \times 40 \times (4 - (0.2 \times 4)/2\}$

$A_s = 0.173 in^2$

$\Rightarrow a = 0.173 \times 40 / (0.85 \times 3 \times 12) = 0.226 in$

$A_s = 22.44 / \{0.9 \times 40 \times (4 - 0.226/2)\}$

$= 0.160 in^2$

$\Rightarrow a = 0.160 \times 40 / (0.85 \times 3 \times 12) = 0.209 in$

$A_s = 22.44 / \{0.9 \times 40 \times (4 - (0.209/2)\}$

$A_s = 0.160 in^2$ ok.

Therefore take $h_f = 5''$

for finding 'd':

$d = h_f - 0.75 - (3/8)/2 = 4''$

Step No: 2 Loading:

Table: 1.1 Dead loads			
Material	Thickness (in)	γ (kcf)	Load = γ x thickness (ksf)
Slab	5	0.15	$0.15 \times (5/12) = 0.0625$
Mud	4	0.12	$0.12 \times (4 \times 12) = 0.04$
Brick Tile	2	0.12	$0.12 \times (2/12) = 0.02$

Service Dead Load (D.L) $= 0.0625 + 0.04 + 0.02$

$= 0.1225$ ksf

Service Live Load (L.L) = 40 psf or 0.04 ksf

Factored Load (w_u) $= 1.2\,D.L + 1.6\,L.L$

$= 1.2 \times 0.1225 + 1.6 \times 0.04$

Factord Load (w_u) $= 0.211$ ksf.

Step No: 3

Analysis:

$M_u = w_u l^2/8$ (l = span length of slab)

$M_u = 0.211 \times 9.9^2/8 = 2.59$ ft.k/ft

$= 31$ in.k/ft.