Department of Civil Engineering
Katihar Engineering College, Katihar

Subject: Design of Concrete Structure-I
Topic: Design of Slab
Lecture: 05
Course Instructor: Prof. Rashid Mustafa

Q-2. Design a simply supported roof slab for a room 8m x 3.5 m clear in size, if the superimposed load is 5 kN/m². Use M15 grade of concrete & Fe 415 steel. Slab is supported on wall of size 230 mm thick.

Soln. Simply supported roof slab

$$\frac{L}{d} = 20$$

$$d = \text{span}/20$$

$$= \frac{3500}{20} = 175 \text{ mm}$$

Provide clear cover = 20 mm and dia of bar = 10 mm.

Overall depth (D) = d + clear cover + $\frac{\phi}{2}$

$$= 175 + 20 + \frac{10}{2}$$

$$= 200 \text{ mm}$$

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(ii) Effective span

$L_{eff\,x} = \left.\begin{matrix} L_c + d \\ L_c + W \end{matrix}\right\}$ whichever is less

$= \left.\begin{matrix} 3.5 + 0.175 \\ 3.5 + 0.23 \end{matrix}\right\}$ whichever is less

$L_{eff\,x} = 3.675$ mm

$L_{eff\,y} = \left.\begin{matrix} 8 + 0.175 \\ 8 + 0.23 \end{matrix}\right\}$ whichever is less

$L_{eff\,y} = 8.175$ m

$\dfrac{L_{eff\,y}}{L_{eff\,x}} = \dfrac{8.175}{3.675} = 2.2 > 2$ (One way slab)

(iii) Calculation of load.

Dead load = $B \times D \times \gamma$

$= 1 \times 0.2 \times 25 = 5$ kN/m

superimposed load = $1 \times 5 = 5$ kN/m

Total Load = $5 + 5 = 10$ kN/m

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factored B.M (Mu) = $\frac{1.5 w L_{eff}^2}{8}$

$= \frac{1.5 \times 10 \times 3.675^2}{8}$

= 25.32 kN-m

Effective depth = $\sqrt{\frac{BMU}{Q \cdot B}}$

$= \sqrt{\frac{25.32 \times 10^6}{0.138 \times 15 \times 1000}}$

= 110.61 mm

$D = 110.61 + 20 + \frac{10}{2} = 135.61$ mm

Adopt D = 150 mm

Effective depth (d) = $150 - 20 - \frac{10}{2} = 125$ mm

Area of steel (Ast).

$M_u = 0.87 f_y A_{st} (d - 0.42 x_u)$

$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} B}$.

$25.32 \times 10^6 = 0.87 \times 415 \times A_{st} \left(125 - \frac{0.42 \times 0.87 \times 415 \times A_{st}}{0.36 \times 15 \times 1000}\right)$

$A_{st} = 659 \text{ mm}^2$

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For Fe415

$A_{st\,min} = 0.12\%$ of BD

$= \left(\frac{0.12}{100}\right) \times 1000 \times 150$

$= 180\ mm^2$

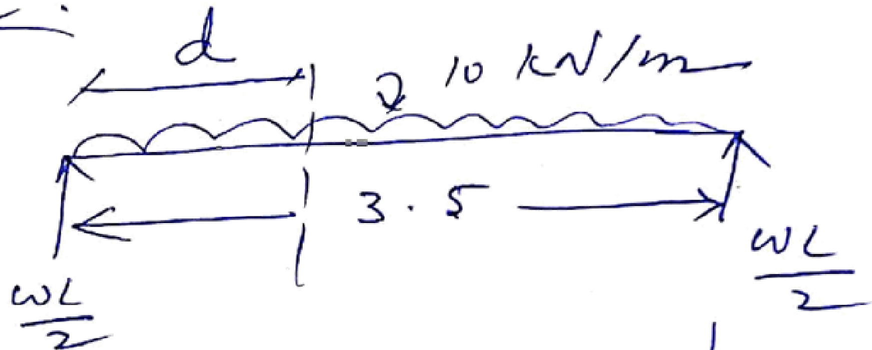
$A_{st} > A_{st\,min}$ OK.

Spacing $(S) = \frac{\frac{\pi}{4} \times 10^2}{658.3} \times 1000$

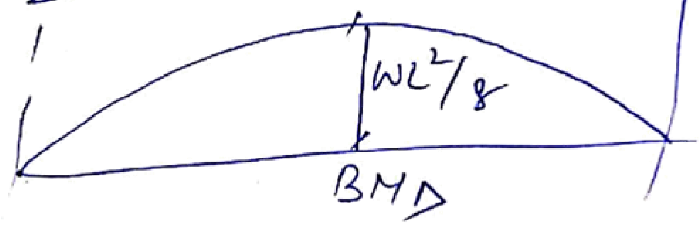
$= 120\ mm$

Provide 10 mm bar @ 120 mm c/c

Check for Shear:



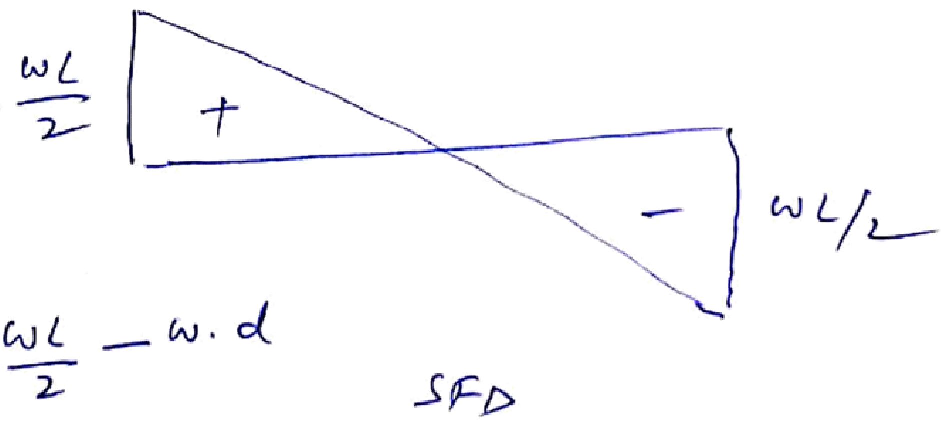
Nominal shear stress $(\tau_v) = \frac{V_u}{B.d}$



$V_u = 1.5\ \frac{wL}{2}$

$= 1.5 \times \frac{10 \times 3.5}{2}$

$= 26.25\ kN$



V_u at d distance from the support $= \frac{wL}{2} - w.d$

$= (17.5 - 10 \times 0.125) \times 1.5$

$= 24.375\ kN$

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Nominal Shear stress (τ_v) = $\frac{24.375 \times 10^3}{1000 \times 125}$

= $0.195 \ N/mm^2$

For M15 $\quad \tau_{cmax} = 2.43 \ N/mm^2$

$\tau_v < 0.5 \ \tau_{cmax}$

$0.5 \times \tau_{cmax} = 0.5 \times 2.43 = 1.21 \ N/mm^2$

$\tau_v < 1.21 \ N/mm^2$ ok.

Check for development length

$L_d \leq 1.3 \frac{M_1}{V} + L_0$

$L_d = \frac{0.87 f_y \phi}{4 \tau_{bd}} = \frac{0.87 \times 415 \times 10}{4 \times 1.6}$

$= 564.14 \ mm$

$M_1 = 0.87 f_y \frac{A_{st}}{2} (d - 0.42 x_u)$

$= 0.87 \times 415 \times \frac{A_{st}}{2} \left(d - 0.42 \times \frac{0.87 f_y A_{st}}{0.36 f_{ck} B}\right)$

$= 14.82 \ kN\text{-}m$

$\frac{M_1}{V} = \left(\frac{14.82 \times 10^6}{24.375 \times 10^3}\right) = 608.12 \ mm$

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$L_0 = 125\ mm$

$$L_d \leq 1.3\frac{M_1}{V} + L_0$$

$= 1.3 \times 608.12 + 125$

$= \sout{195}\ 915.55$

$L_d < 915.55$ **ok**.

Safe in bond.

Here $L_0 \rightarrow$ Maxm of d or 12ϕ

⇒ Design of two way slab.

A two way slab is

(i) ~~The~~ supported on all four sides (support may be simply support, continious or fixed)

(ii) Beam is also a support.

→ The span ratio

$$\boxed{\frac{L_y}{L_x} \leq 2}$$

Where $L_y \rightarrow$ longer span

$L_x \rightarrow$ shorter span

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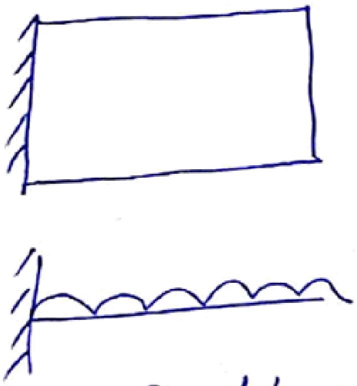
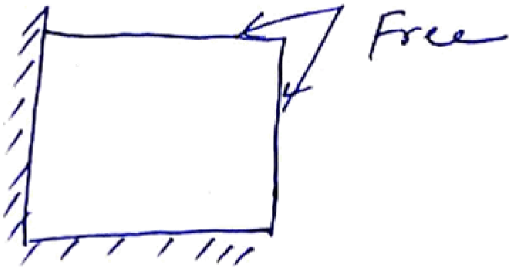
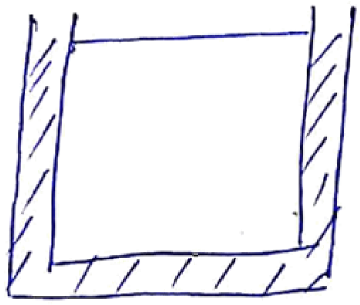
These slab are not two way slab.



Cantilever



Two side supported slab

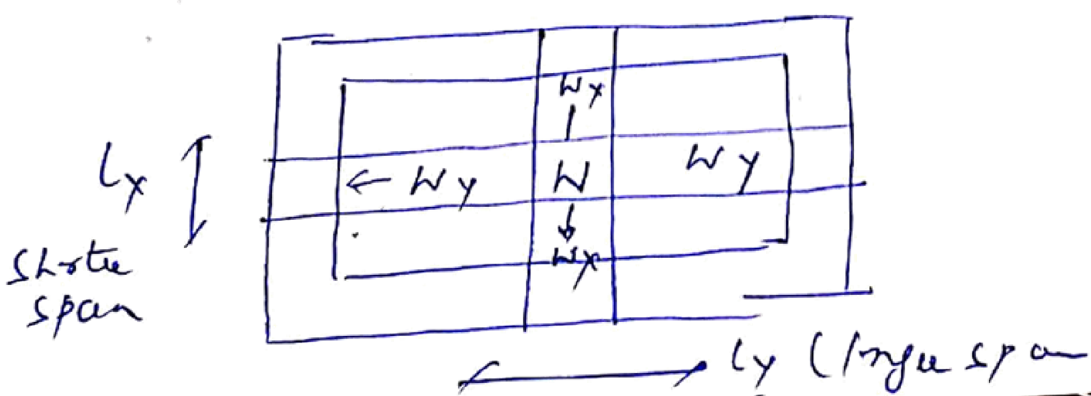


Three side supported slab

→ In the design of two way slab

- Rankine-Grashoff Theory
- Marcus Method

⇒ **Rankine Grashoff Theory:**



Deflection is same at any point in two direction

$$\delta_x = \delta_y$$

$$\frac{5}{384EI} w_x l_x^4 = \frac{5}{384EI} \cdot w_y l_y^4$$

$$w_x l_x^4 = w_y l_y^4$$

$$\boxed{w_x = \left(\frac{l_y}{l_x}\right)^4 \cdot w_y}$$

$$\boxed{w_x = r^4 \cdot w_y}$$

Where r = span ratio = $\frac{l_y}{l_x}$.

$$\text{Total load } (w) = w_x + w_y$$

$$= w_y \cdot r^4 + w_y$$

$$= w_y (1 + r^4)$$

$$w_y = \frac{w}{1 + r^4}$$

$$\boxed{w_y = \left(\frac{1}{1+r^4}\right) w}$$

$$\boxed{w_x = \left(\frac{r^4}{1+r^4}\right) w}$$

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Moment

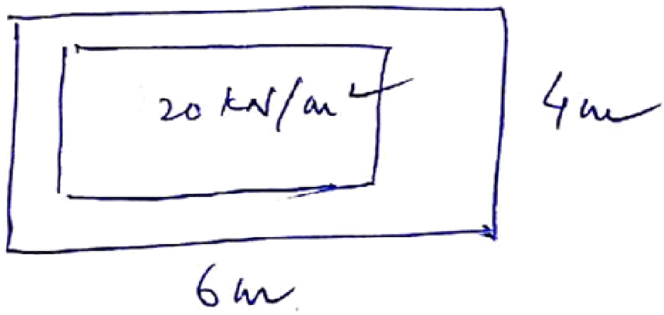
$$M_x = w_x \frac{L_x^2}{8}$$

$$\boxed{M_x = \left(\frac{r^4}{1+r^4}\right) \cdot w \cdot \frac{L_x^2}{8}}$$

$$M_y = w_y \cdot \frac{L_y^2}{8}$$

$$\boxed{M_y = \left(\frac{1}{1+r^4}\right) w \cdot \frac{L_y^2}{8}}$$

Ex.



$$\frac{L_y}{L_x} = \frac{6}{4} = 1.5 < 2 \quad \text{(Two way slab)}$$

$$w_x = \left(\frac{r^4}{1+r^4}\right) \cdot w = \left(\frac{1.5^4}{1+1.5^4}\right) \cdot 20$$

$$= 16.7 \text{ kN/m}^2$$

$$w_y = \left(\frac{1}{1+r^4}\right) \cdot w = \left(\frac{1}{1+1.5^4}\right) \times 20$$

$$= 3.3 \text{ kN/m}^2$$

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$$M_x = \frac{w_x \cdot l_x^2}{8}$$

$$= \frac{16.7 \times 4^2}{8} = 33.4 \text{ kN-m}$$

$$M_y = \frac{w_y \cdot l_x^2}{8} = \frac{3.3 \times 6^2}{8}$$

$$= 14.85 \text{ kN-m}$$

HAPPY LEARNING

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