Sin

Reinforced Concrete

Book - ~~7~~, 13th edition, 7th edition

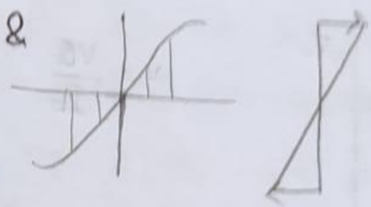
08.09.22

Design of concrete structure - Nilson

Flexural Analysis beam & Design of beams

Bending of homogeneous beam

* Fundamental assumptions according to flexure & flexural shear



1. A cross section that was plane before loading remains plane under load.
2. - Bending stress ~~f~~ at any point depends in a manner given by the stress-strain diagram of the material.
3. The distribution of shear stress over the depth of the section depends on the shape of the cross section and of the stress-strain diagram.

4. Way to combined action of shear and flexural stresses at any point in a beam there are inclined cases of tension and compression.

$$t = \frac{f}{2} \pm \sqrt{\frac{f^2}{4} + v}$$

v = intensity of tangential
f = intensity of normal fiber stress

5. Since the horizontal and vertical shear stresses are equal and the flexural stresses are zero at neutral. The inclined and tensile and compressive stresses ~~are zero at the neu~~ in that plane from angle 45° with the horizontal, the intensity of each being equal to the unit shear at the point.

6. Bending stress at a distance y from neutral axis = f

External bending moment at section = M

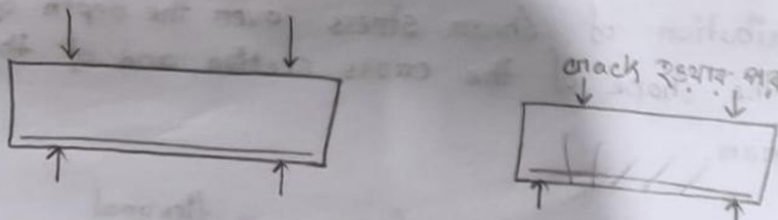
Moment of inertia = I

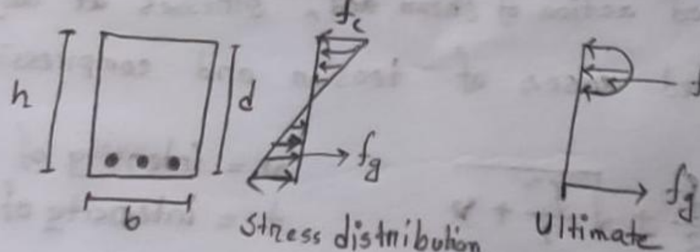
$$M_{max} = \frac{Mc}{I} = \frac{M}{S}$$

Shear stress = $\frac{VQ}{Ib}$

7. $$v = \frac{VQ}{Ib}$$

Reinforced Concrete Behaviour



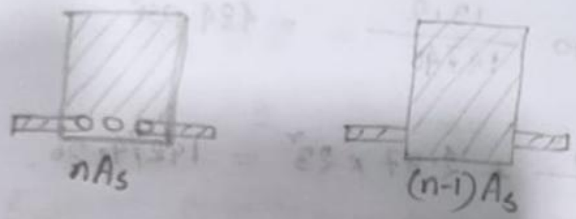


$f_g = f_s$

Chapter 1, 1.16.
Elastic behaviour
22-23 Page

05.04.22

Stresses elastic in crack & uncrack section



n = number of reinforcement bars

Problem 3.1 Book

A rectangular beam has the dimension $b = 10''$, $h = 25''$ & $d = 23''$. Its reinforce #8 bars. So, the bar area, A_s = ~~23.7~~ 3.27. The concrete cylinder strength 4000 Psi. The tensile strength in bending (ε_s) = ~~470~~ 475 psi. The yield point of steel f_y = 60,000 psi. ~~The~~ Stress-strain curve of the material is follow. Determine the stress caused by bending moment 45 kip-ft.

$$\epsilon_c = \frac{f_c}{E_s}. \qquad \epsilon_s = \frac{f_s}{E_s} \qquad f_s = \frac{E_s}{E_c} \times f_c = n f_c.$$

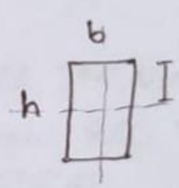
$f_c' = 4000$ psi

1.20 = 1.50
1.69 = 2.00

f_c = design strength $\qquad f_c'$ = crashing strength in 28 days

$$n = \frac{E_s}{E_c} \text{ (from s-s diagram)}$$

$$= \frac{29\times10^6}{3.6\times10^6} = 8$$



$(n-1)A_s = 7 \times$ ~~23.7~~ $3.27 = 22.89$

~~moment of inertia, $I = \frac{bh^3}{12} = \frac{10\times25^3}{12} = 13020.83$~~

$M = 45$ kip-ft $= 45\times12000 = 540000$ lb-in

$\bar{y} = 13.2$, $\bar{y} = 11.84$

$$f_c = \frac{M\bar{y}}{I} = 540000 \frac{13.2}{14740} = 484 \text{ psi}$$

$$I = \frac{bh^3}{12} + (A * d^2) = \frac{10 \times 25^3}{12} + 2.37 \times 23^2 = 14274.56$$

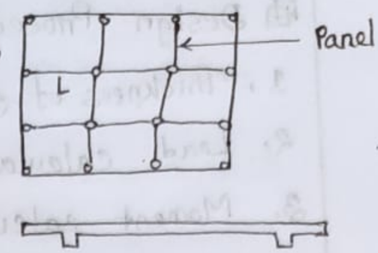
$= 25$

Similarly, the concrete tension stress at the bottom fibers.

$$f_{ct} = 540000 \times \frac{25 - 13.2}{14740}$$

22.05.22

13.2 Design of one-way slab



$L/B \leq 2$ -

$L/B \geq 2$ - One way slab

Support condition — support যদি 4 side এ না থেকে 2 side থাকে, তখন সেটা one way slab.

Support 4 side এই থাকলে, $L/B \leq 2$, তখন two way slab.

main Reinforcement shorter distance/direction এ থাকে। one side'এ থাকে।

↳ one way slab এ

Temperature shrinkage reinforcement ~~perpendicular~~ RCC কেন use হয়?

↳ To reduce heat

main reinforcement RCC তে কেন perpendicular থাকে না।

Causes and effect of slab -

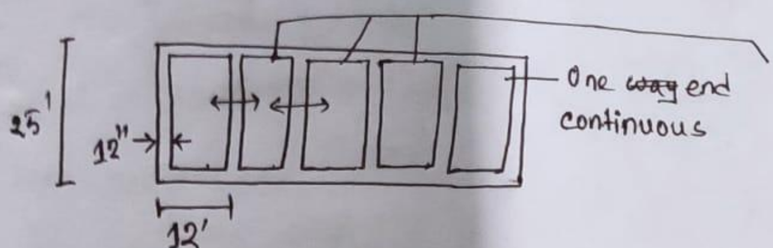
One way slab এর condition,

Temperature shrinkage reinforcement one way

Chapter 13 Table 13.1

Minimum thickness of nonprestressed one-way slabs:

Simply supported	$l/20$
One end continuous	$l/24$
Both end continuous	$l/28$
Cantilever	$l/10$



both end continuous কারণ পাশাপাশি beam গুলো আছে।

span length নিয়ে হিসাব করবো। এখানে 12' নিয়ে calculation করতে হবে।

thickness

Load calculation:

WSD = DL + LL

USD = 1.2D + 1.6LL

Table 13.2

Minimum ratios of temperature and shrinkage reinforcement in slabs based on gross concrete area:

Slab where Grade 40 or 50 deformed bars are used	0.0020

Design Procedure :

1. Thickness of slab
2. Load calculation
3. Moment calculation
4. Depth check
5. Shear check
6. Bond check

Temperature shrinkage কেন use করি?

To reduce expansion and contraction due to the change of heat, we provide temperature shrinkage RCC are provided, crack produce থেকে protect করে।

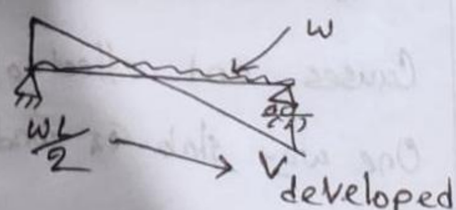
WSD → $d = \sqrt{\frac{M}{Rb}}$ $\qquad R = \frac{1}{2} f_c j k$

depth check:

USD → $M_u = \phi f_y \rho b d^2 \left(1 - \frac{\beta}{\alpha} \cdot \frac{\rho f_y}{f_c'}\right)$

$A_s = \frac{M_u}{\phi f_y (d - a/2)}$ $\qquad$ WSD → $A_s = \frac{M}{f_s j d}$

Shear check:



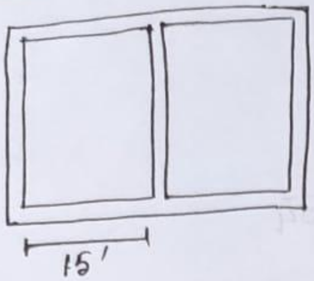
WSD, $V_{allowable} = 1.1 \sqrt{f_c'}$ psi

USD, $V_{allowable} = 2\phi \sqrt{f_c'}$ psi

check করতে হবে যেন, $V_{developed} < V_{allowable}$ হয়।

Slabs where Grade 60 deformed bars or welded wire fabric (smooth or deformed) are used	0.0018
Slabs where reinforcement with yield strength exceeding 60000 psi measured at yield strain of 0.35 percent is used	$\frac{0.0018 \times 60000}{f_y}$

29.05.22



LL = 100 psf

$f_c' = 4000$ psi

$f_y = 60,000$ psi

design a one way slab.

Soln: $t = \frac{l}{28} = \frac{15 \times 12}{28}$ [Assuming both end continuous]

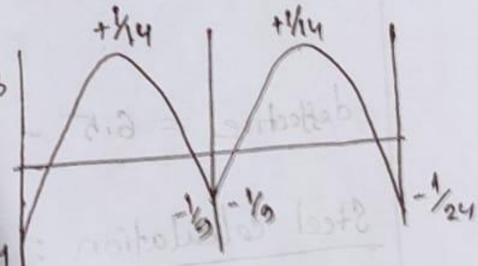
$= 6.43 = 6.5''$

load calculation :

$DL = \frac{6.5}{12} \times 150 = 81.25''$

LL = 100 psf

$W_u = 1.2 DL + 1.6 LL = 1.2 \times 81.25 + 1.6 \times 100 = 257.5$



$M_A = -\frac{w_u l^2}{24} = \frac{257.5 \times 15^2}{24} = -2414.063$

$M_B = +\frac{w_u l^2}{14} = \frac{257.5 \times 15^2}{14} = 4138.39$

$M_c = -\frac{w_u l^2}{9} = -\frac{257.5 \times 15^2}{9} = -6437.5$

Depth check:

$M_u = \phi f_y \rho b d^2 (1 - \frac{\beta}{\alpha} - \frac{f_y \rho}{f_c'})$

$\rho = \rho_{max}$

$$\rho_{max} = 0.85\beta_1 \frac{f_c'}{f_y} \cdot \frac{\epsilon_u}{\epsilon_u+\epsilon_y}$$

$$= 0.85 \times 0.85 \frac{4}{60} \cdot \frac{0.003}{0.003+0.004}$$

$$= 0.0206$$

$$M_u = \phi f_y \rho b d^2 \left(1 - \frac{\beta}{\alpha} \cdot \frac{f_y \rho}{f_c'}\right)$$

$$\Rightarrow 6437.5 \times 12 = 0.9 \times 60000 \times 0.206 \times 12 \times d^2 \left(1 - 0.59 \frac{60 \times 0.206}{4}\right)$$ (k-ft to lb-in)

$d = 2.69 = 3''$

$t = 3 + cc + \phi/2$

$= 3 + 0.75 + 0.25 = 4'' < 6.5$

okay.

$d_{effective} = 6.5 - 1 = 5.5''$

Steel calculation :

at point A,

$$A_s = \frac{M_A}{\phi f_y (d - a/2)}$$

$$= \frac{2414.06 \times 12}{0.9 \times 60000 \left(5.5 - \frac{1.47}{2} A_s\right)}$$

$$a = \frac{A_s f_y}{0.85 f_c' b}$$

$$= \frac{A_s \times 60}{0.85 \times 4 \times 12}$$

$\Rightarrow a = 1.47 A_s$

$\Rightarrow 2.97\times10^5 A_s - 3.97\times10^4 A_s^2 = 2.89\times10^4$.

$A_s = 0.0995 \; in^2$ or $7.38 \; in^2$

$\therefore A_s = 0.1 \; in^2$.

At point B,

$$A_s = \frac{M_B}{\phi f_y (d - a/2)}$$

$$= \frac{4138.39 \times 12}{0.9 \times 60000 \times (5.5 - \frac{1.47}{2} A_s)}$$

$$A_s = \frac{49660.68}{2.97\times10^5 - 3.97\times10^4 A_s}$$

$$\Rightarrow A_s = 0.17$$

At point C,

$$A_s = \frac{6437.5 \times 12}{0.9\times60000 \times (5.5 - \frac{1.47}{2} A_s)}$$

$$A_s = 0.27$$

Distribution reinforcement $= 0.0018 \, bt$ $[b = 1' = 12'']$ $d = 6.5$

$= 0.14 \; in^2$

psf × 1 = plf

~~Depth~~ check:

Shear

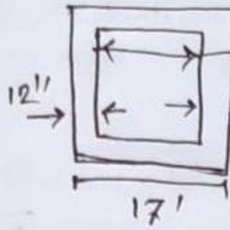
Stress = Area = bd = 12 × 6.5

$v_{allowable} = 2\phi\sqrt{f_c'}$

$= 2 \times 0.75 \times \sqrt{4000}$

=

$\therefore V_{all} > V_{check}$.



Clear distance
↳ 17 − 2 = 15'

[Clear distance এ সবসময় হিসাব করতে হবে]

Clear slab.

Same Problem by WSD method — 30.5.22

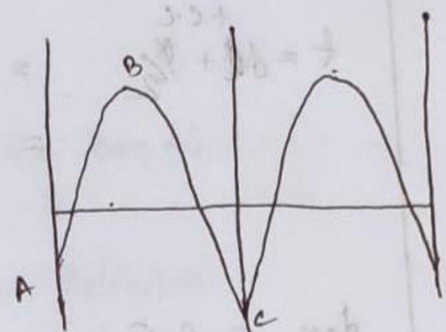
$t = \frac{l}{28} = \frac{15 \times 12}{28} = 6.5'$

load calculation:

$DL = \frac{6.5}{12} \times 150 = 81.25$

$LL = 100$ psf

$w = 100 + 81.25 = 181.25$



$M_A = -\frac{wl^2}{24} =$ ~~−2575~~ $= -1699.22$

$M_B = +\frac{wl^2}{14} = 2912.95$

$M_C = -\frac{1}{9} \cdot wl^2 = -4531.25$

Depth check: $d = \sqrt{\frac{M}{Rb}} =$

$n = \frac{E_s}{E_c} = \frac{29 \times 10^6}{57000 \times \sqrt{4000}} =$

$r = \frac{f_s}{f_c} = \frac{0.40 \times 60000}{0.45 \times 4000} =$

$$K = \frac{n}{n+r} = \qquad = 0.375$$

$$J = 1 - \frac{K}{3} = 1 - \frac{0.375}{3} = 0.875$$

$$R = \frac{1}{2} f_c J K = \frac{1}{2} \times \overset{0.45}{4000} \times 0.875 \times 0.375$$

$$= 295.31$$

$f_c = f'_c \times .45$

$f_s = 0.4 \times f_y$

$$d = \sqrt{\frac{M}{Rb}} = \sqrt{\frac{4531.25 \times 12}{295.31 \times 12}} = 3.92$$

$$t = d + c.c + \phi/2 = 3.92 + cc + \frac{\phi}{2} = 3.92 + \frac{0.5}{2} + 0.75$$

$= \sout{4.37}$, $\sout{5.12}$ $4.92 < 6.5$ ok

$d_{eff} = 6.5 - 1 = 5.5$] USD ✓

$d_{eff} = 6.5 - cc - \phi/2$] WSD ϕ

$= 5.3$

$$A_s = \frac{M_A \times 12}{f_s J d} = \frac{1699.22 \times 12}{24000 \times 0.875 \times 5.5} = 0.18$$

$$A_s = 0.0018\,bt$$

$$= 0.0018 \times 12 \times 6.5$$

$$= 0.14$$

Distribution reinforcement = 0.0018 bt

Shear Check :

Developed shear, $V = \frac{wl}{2}$

$= \frac{181.25 \times 15}{2} = 1360 \text{ lb}.$

$v = \frac{1360}{bd} = \frac{1360}{12 \times 5.5} = 20.6$

$v_d = \frac{V_{max}}{\Sigma_0 \cdot Jd} =$

$\Sigma_0 = n\pi d$, d = Bar dia

Top bar, $v_{all} = \frac{1.3\sqrt{f_c'}}{D}$ → deffective.

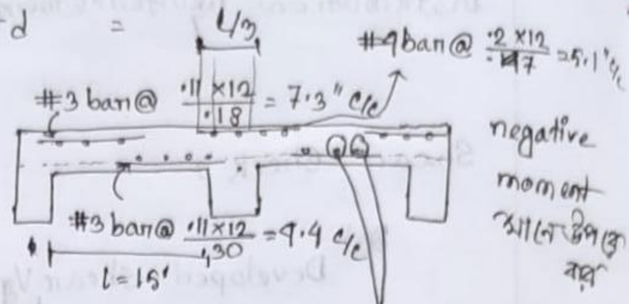
bottom, $v_{all} = \frac{2.4\sqrt{f_c'}}{D}$.

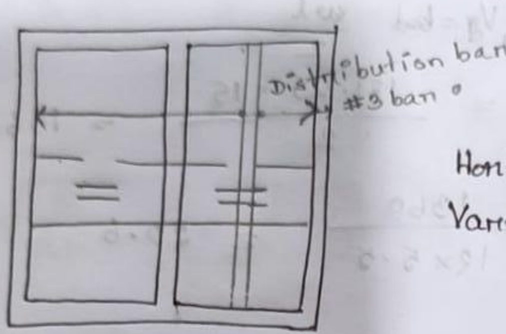
05.06.2022

$U_d = \frac{V_{max}}{\Sigma_o jd}$

$= \frac{1359.375}{\quad}$

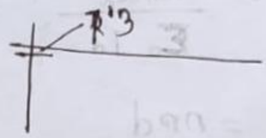
$\Sigma_o = n\pi d$





Horizontally – Top bar
Vartically – Distribution bar

Fig: Reinforcement details



$\frac{V_{max}}{\Sigma jd} = \frac{1359.375}{1.18 \times 0.875 \times 5.5}$

$= 229.38$ psi

$\Sigma_o = 1 \times 3.14 \times 0.375$

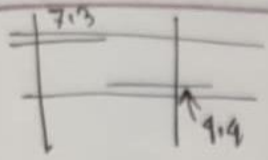
$= 1.18$

$V_{allowable} = \frac{3.4\sqrt{f_c'}}{D} \leq 350$

$= \frac{3.4\sqrt{4000}}{0.375} \leq 350 = 573.43 \leq 350$ [350 থেকে বড় হলে 350 ই ধরতে হবে]

$V_{allawable} = 350 > 229.38$ psi.

Okay. [Allowable বড় হলে তবে okay]



$$\Sigma_o = 3 \times 3.14 \times 0.375 = 3.54$$

$$U_d = \frac{V_{max}}{\Sigma_o j d} = \frac{1359.375}{3.54 \times 0.875 \times 5.5} = 76.$$

Check করার দরকার নাই।