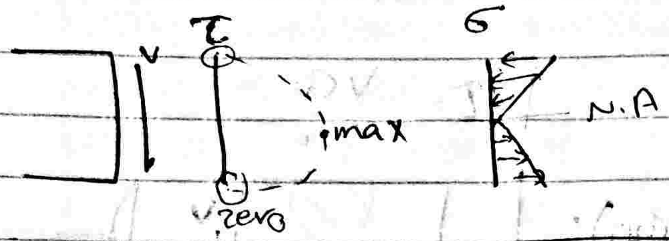
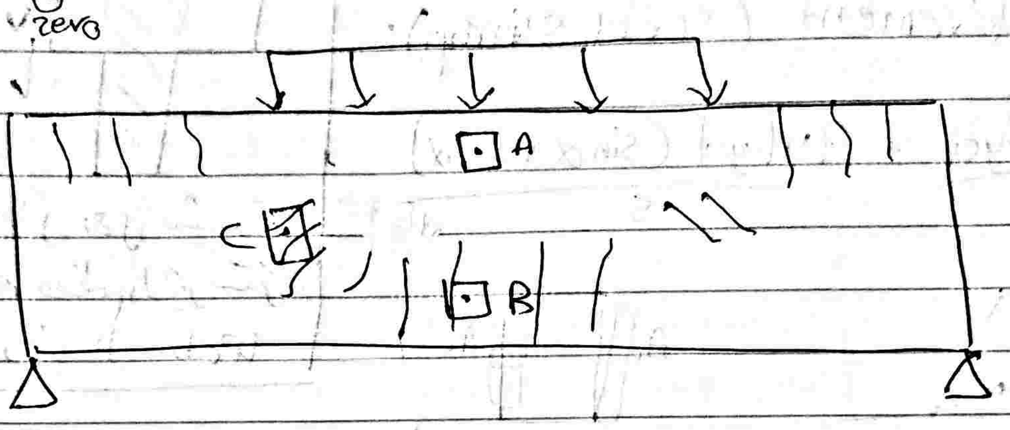
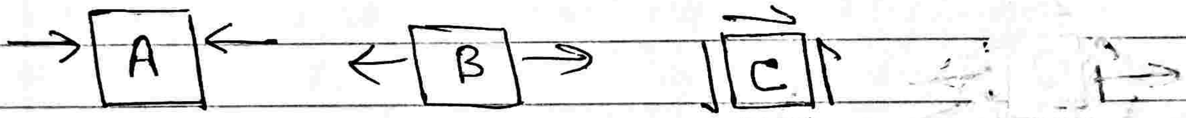
Shear

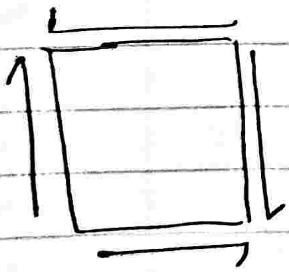
• المناطق الي بكون عندها ماكسيمم مومنت ، بكون الشير عندها صفر





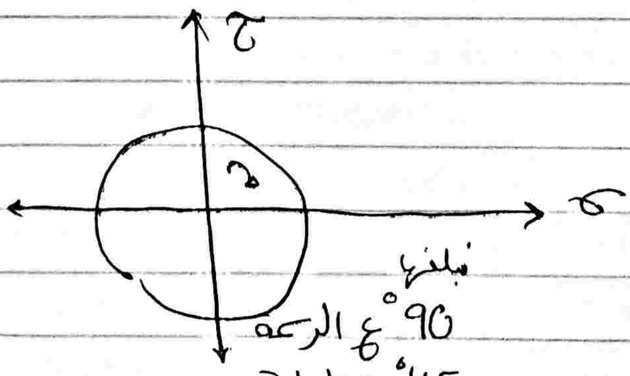


compression stress — tension stress — pure shear stress

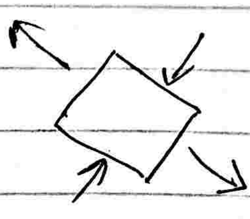


→ maximum tension ⇒ لانه الكونكريت ضعيف بالتنشن بنوجد مكانه لحتى نسلح عليه

→ mohr circle



بنلفها 90° ع الرسمة
و 45° ع الواقع ←

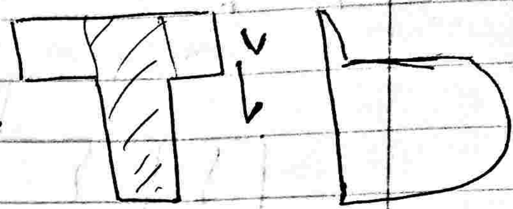


. Shear reinforcement → Stirrups (legs) / Bent Bars → حتى لو قمنا بثني الحسل ما بتتغير الـ strength (منه مخاضعه).

* Concrete resistance for shear:-

. $V_c = 0.17 \sqrt{f'_c}\ b_w d$ ← MPa

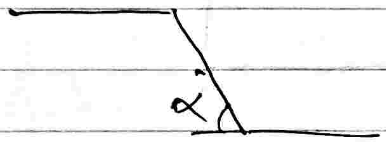
$* \tau = \frac{VQ}{It}$

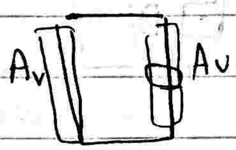


العرض الأقل يعمل شير سترس أكبر ⇐ معظم الشير سترس موجود في الـ web

* Shear reinforcement (Steel Stirrup):

. $V_s = \frac{A_v f_y d}{S} = \frac{A_v f_y d (\sin\alpha + \cos\alpha)}{S}$





Av → one leges

$$\underbrace{\phi V_n}_{\text{Shear strength from concreter, Steel}} > V_u$$

. ACI Code requirements :-

$S < S_{max}$

No need	min reinforcement	special design (S)

$V_u < \frac{\phi V_c}{2}$ $\qquad$ $V_u < \phi V_c$

$$\bullet\ S_{max} = \min \begin{cases} \rightarrow \dfrac{A_v f_y}{0.062\sqrt{f'_c}\, b_w} \leq \dfrac{A_v f_y}{0.35\, b_w} \\ \rightarrow \dfrac{d}{2} \ \ldots \left(\dfrac{3}{4} d \text{ for bent bars}\right) \\ \rightarrow 600 \text{ mm} \end{cases}$$

effective depth

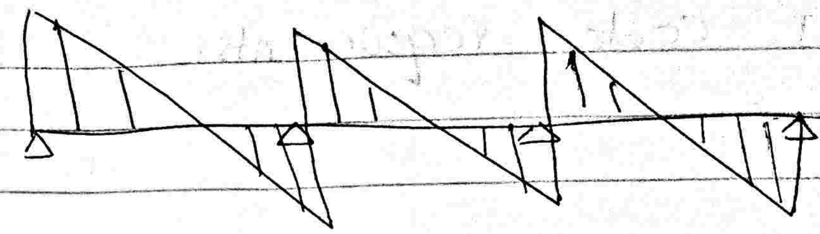
. $V_s > 2V_c = 0.33\sqrt{f'_c}\, b_w d$ → The max spacing is divided by 2.

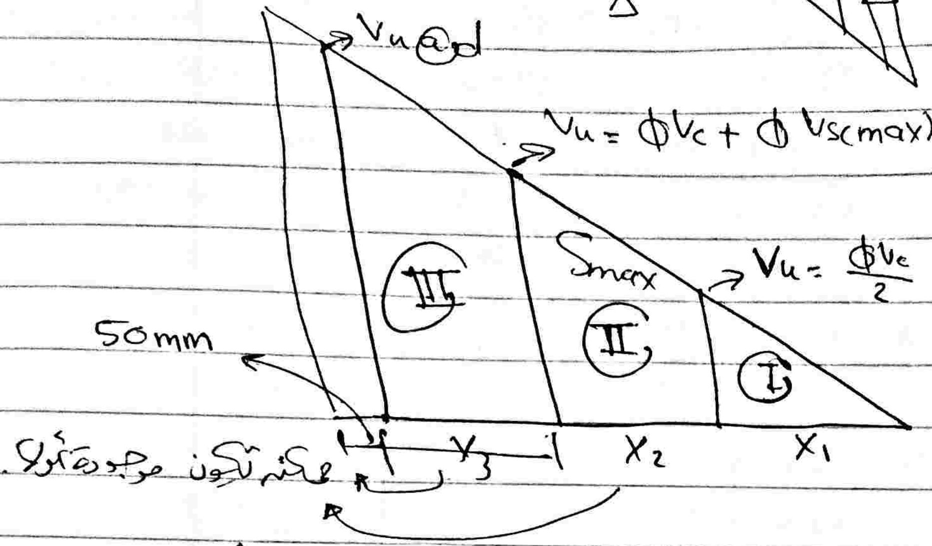
. $V_s > 4V_c = 0.66\sqrt{f'_c}\, b_w d$ → Section geometry must be increasing.

. $S_{min} \geq 100$ mm

. strength reduction factor : $\phi = 0.75$

. V_u : shear at distance d from the face of support $V_u @ d$.





• $\underset{\uparrow \text{ Structral Analysis}}{V_{u@d}} = \underset{\uparrow \text{ geometry}}{\phi V_c} + V_s \Longrightarrow V_s = \dfrac{V_{u@d} - \phi V_c}{\phi}$

• Compare V_s with $2V_c = 0.33\sqrt{f'_c}\, b_w d$

→ $V_s < 2V_s$ → The max spacing remains the same

→ $V_s > 2V_c$ ⇒ The max spacing is divided by 2

→ $V_s > 4V_c$ → Change section geometry

• $\phi V_{smax} = \dfrac{\phi A_v f_y d}{S_{max}}$

stirrups $= \dfrac{X_3}{S} + \dfrac{X_2}{S_{max}} + 1$

Example:

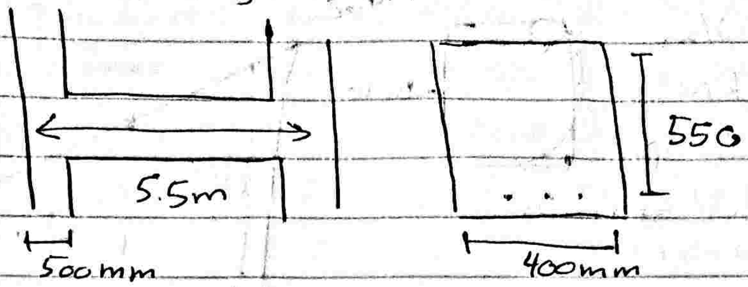
$w_D = 60\ kN/m$

$W_L = 60\ kN/m$

$f'_c = 28\ MPa$

$f_y = 420\ MPa$

Simply Supported

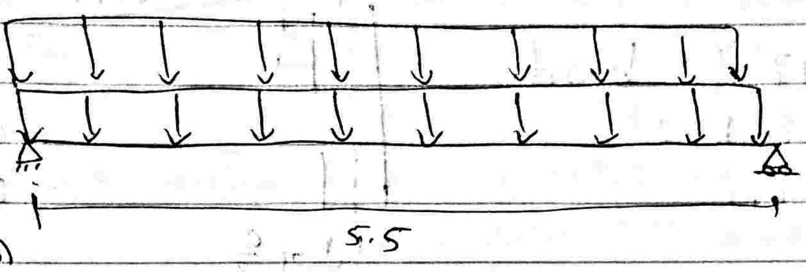


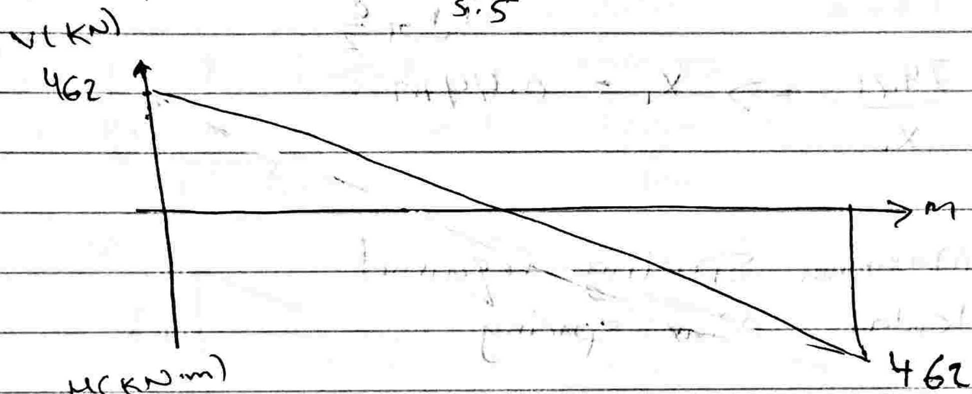
$W_u = 1.2D + 1.6L$

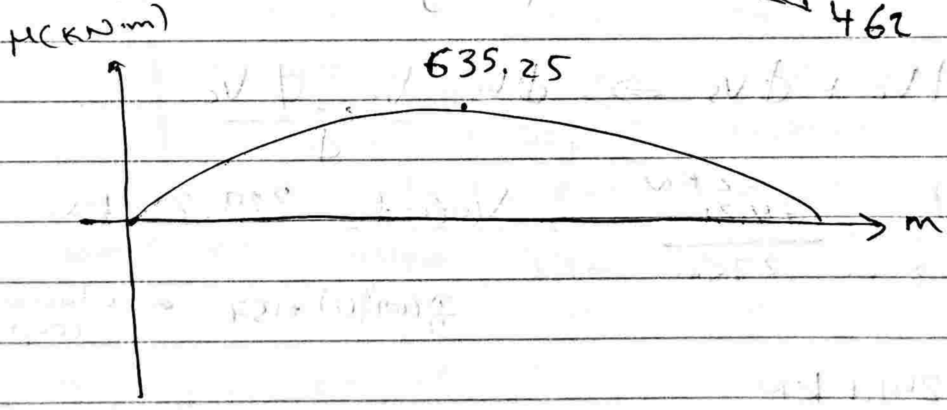
$= 168\ kN/m$

$R = \frac{wL}{2}$

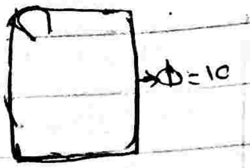
$= 462\ kN$

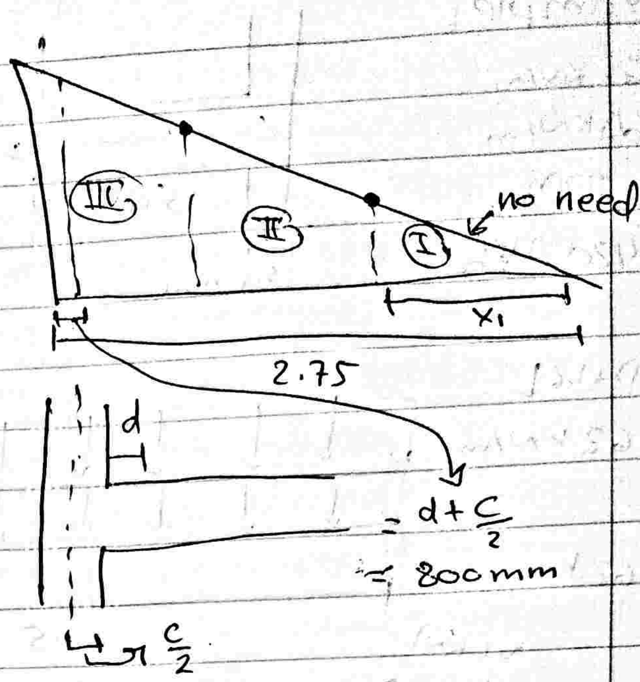






- $w_u = 168$ KN/m
- $V_u = 462$ KN
- $f_y = 420$ MPa, $f'_c = 28$ MPa





Region (I) : No Stirrups

$\frac{\phi V_c}{2}$? on Shear diagram

$\rightarrow \phi V_c = \phi \; 0.17 \sqrt{f'_c} \, b w d$
$= 148.42$ KN

$\rightarrow \frac{\phi V_c}{2} = 74.21$ KN

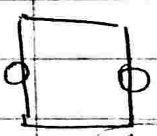
$$\frac{462}{2.75} = \frac{74.21}{X_1} \Rightarrow X_1 = 0.44\,m$$

Region (II) : Maximum Spacing required
⇒ To calculat Max spacing

$$V_{u@d} = \phi V_c + \phi V_s \Rightarrow V_s = \frac{V_{u@d} - \phi V_c}{\phi}$$

$$\rightarrow \frac{V_{u@d}}{2.75 - 0.8 \; m} = \frac{462 \text{ KN}}{2.75 m} \longrightarrow V_{u@d} = 329.28 \text{ KN}$$

$\frac{\pi}{4}(10)^2(2) = 157$ ← closed loop ←



$\rightarrow V_s = 241.1$ KN
$\rightarrow V_c = 198$ KN , $2V_c = 396$ KN
$V_s < 2V_c \rightarrow$ max Spacing → min =

$$\left\{ \begin{array}{l} \frac{A_v f_y}{0.062\sqrt{f'_c}\, b_w} \overset{503}{} \le \frac{A_v f_y}{0.35 b_w} \overset{471}{} \\ \frac{d}{2} = 275 \text{mm} \\ 600 \end{array} \right.$$

$S_{max} = 275$ mm
$= 27.5$ cm pratical ??
No
250mm أو بنزلها العامل

$$\phi V_{s(max)} = \frac{\phi A_v f_y d}{S_{max}} = 109 \text{ KN}$$

When we use max Spacing $\Rightarrow V_u = \phi V_c + \phi V_{smax}$

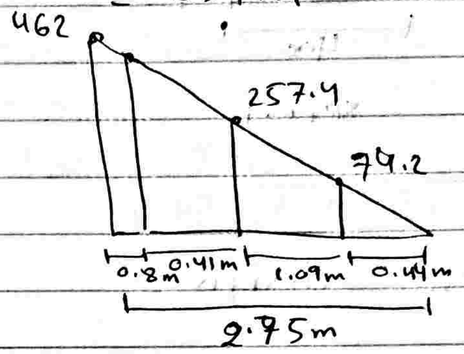
$= 148.4 + 109$

$= 257.4$ KN

$\frac{462}{2.75} = \frac{275.4}{x}$

$x = 1.639$ m

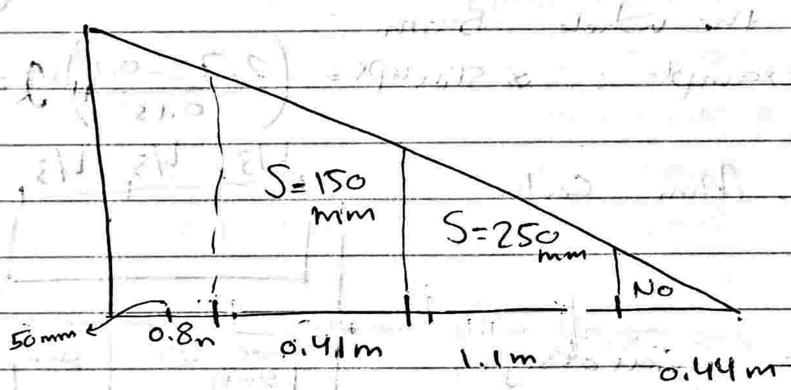
$x_2 = 0.1$ m



Region (III): special design:

$$S = \frac{A_v f_y d}{V_s} = 150.4 \text{mm} \approx 150 \text{mm}$$

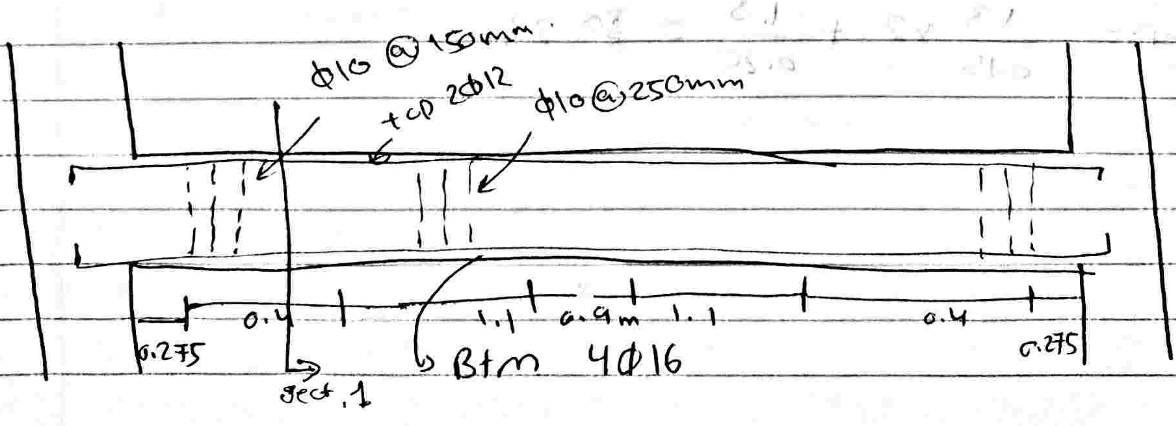
$V_s \leftarrow 241.2$

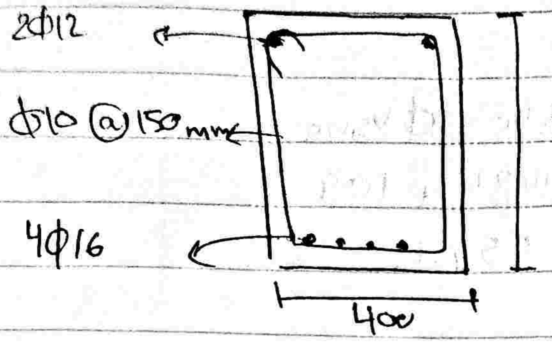


\# of stirrups =

$$\Rightarrow \frac{1.1}{0.25} + \frac{0.41}{0.15} + 1 = 4.4 + 2.73 + 1 = 8.13$$

* for the hole Beam $2 \times (8.13) = 17$

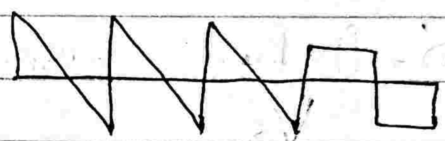




sect. 1

• practical design:-

Approach 1: least Calc.

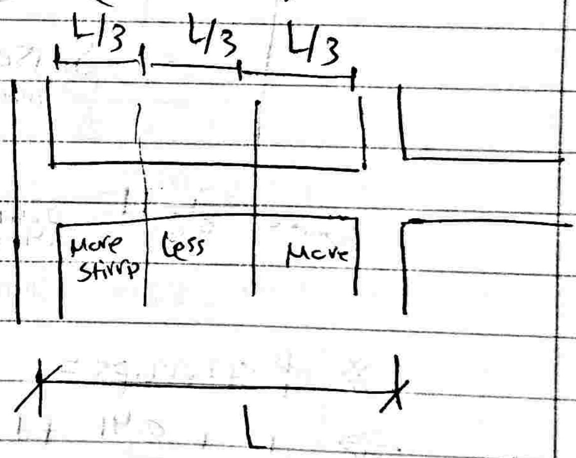


required spacing
↳ Apply for the whole Beam

Max V_u @ d → ϕV_c → S
V_s

for the example: # stirrups = $\left(\frac{2.75-0.8}{0.15}+1\right) \times 2 = 26$

Approach 2:- Mini Calc.



more spacing → Special design
less spacing → Max spacing

For our Ex:-

$\frac{5.5-1.6}{3} = 1.3$

stirrups = $\frac{1.3}{0.15} \times 2 + \frac{1.3}{0.25} = 23$