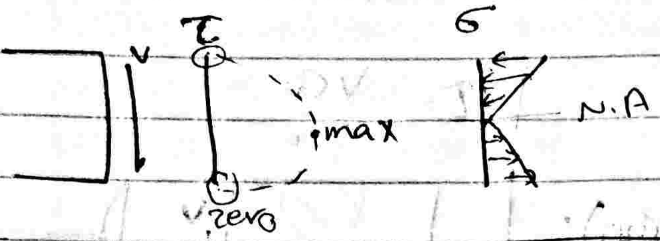
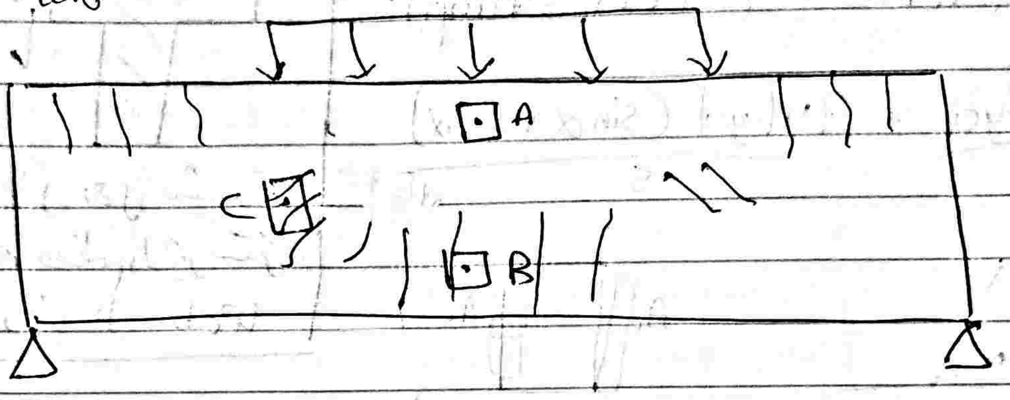
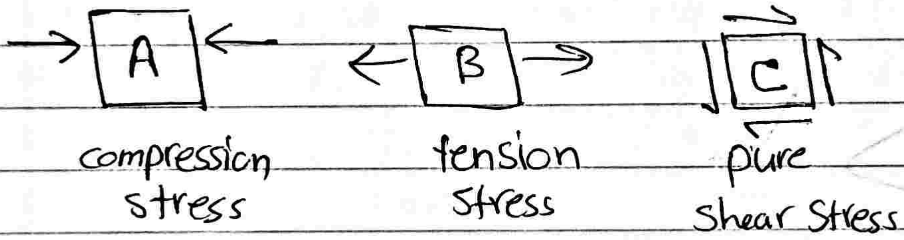
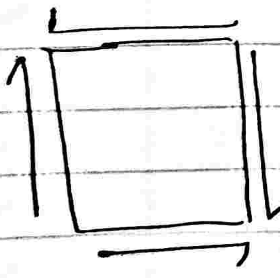
Shear

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



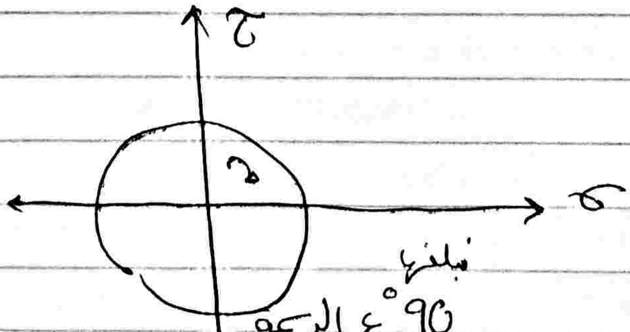


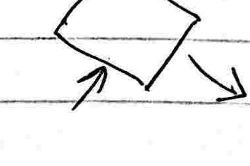




→ maximum tension ⇒ لانه الكونكريت ضعيف بالتنشن بنوجد مكانه كثير نافع عليه

→ mohr circle



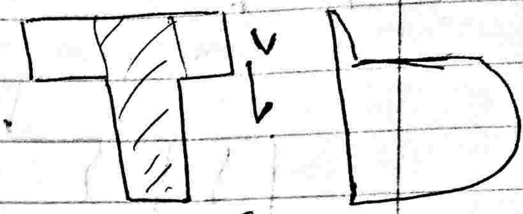


. Shear reinforcement → Stirrups (legs)
→ Bent Bars ← حتى لو قمنا بثني الحديد مابتتغير
الـ strength (مو مضاعفة).

* Concrete resistance for shear:-

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

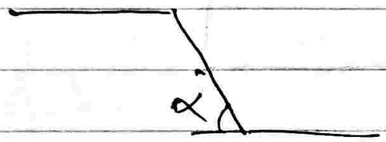
* $\tau = \frac{VQ}{It}$

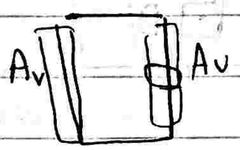


العرض الأقل يحمل شير ستريس أكبر ⇐ معظم الشير ستريس موجود في ال web

* Shear reinforcment (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

$\phi V_n > V_u$

Shear strength from concrete / Steel

- ACI code requirements:-

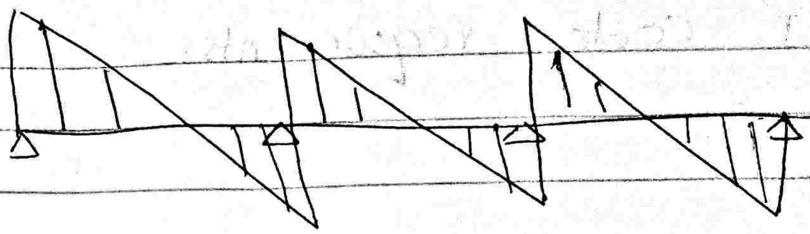
$S < S_{max}$ ↑ (S)

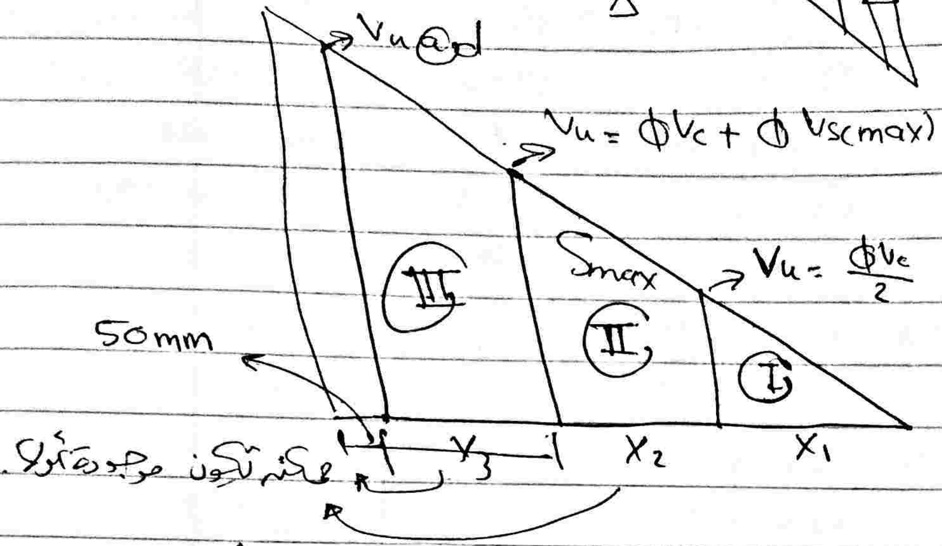
No need	min reinforcement	special design (S)
	$V_u < \frac{\phi V_c}{2}$	$V_u < \phi V_c$

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

  (d: 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 $V_u @ d$.





- $V_u@d = \phi V_c + V_s \Longrightarrow V_s = \dfrac{V_u@d - \phi V_c}{\phi}$

  ($V_u@d$ ↑ Structural Analysis; ϕV_c ↑ geometry)

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

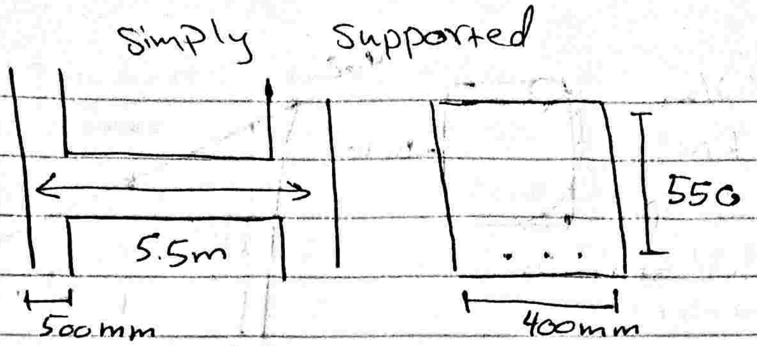
Example:

$w_D = 60\ kN/m$

$w_L = 60\ kN/m$

$f'_c = 28\ MPa$

$f_y = 420\ MPa$

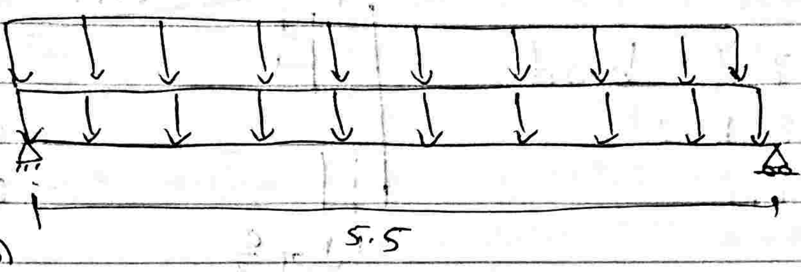


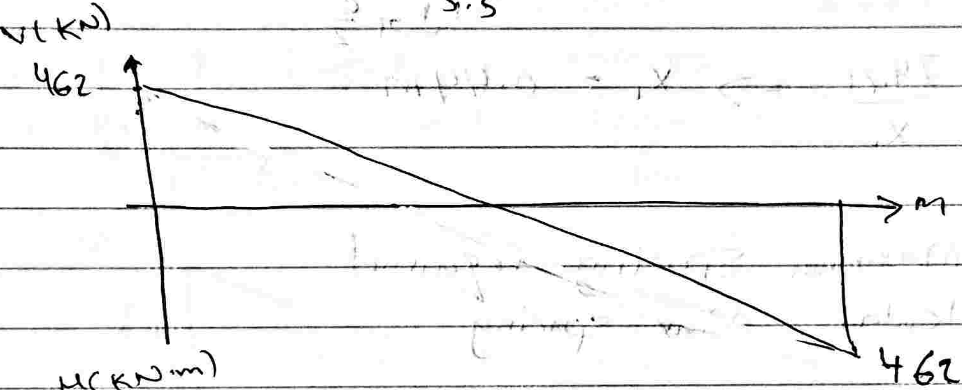
$W_u = 1.2D + 1.6L$

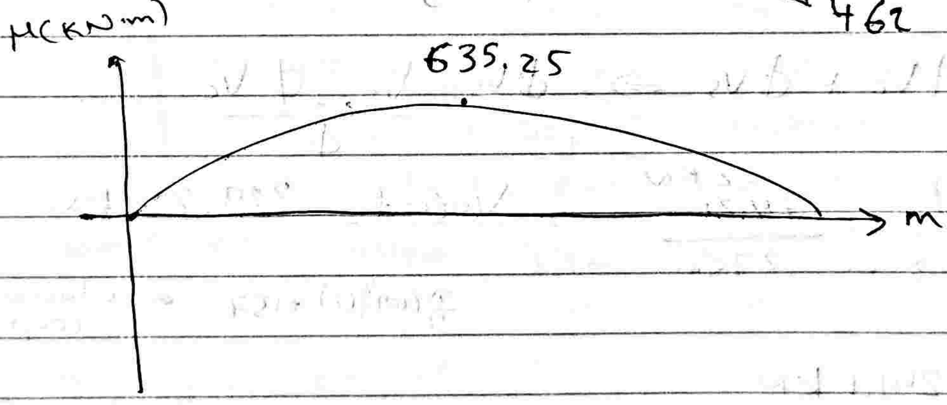
$= 168\ kN/m$

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

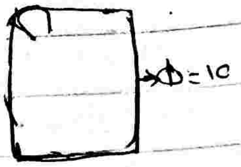
$= 462\ kN$

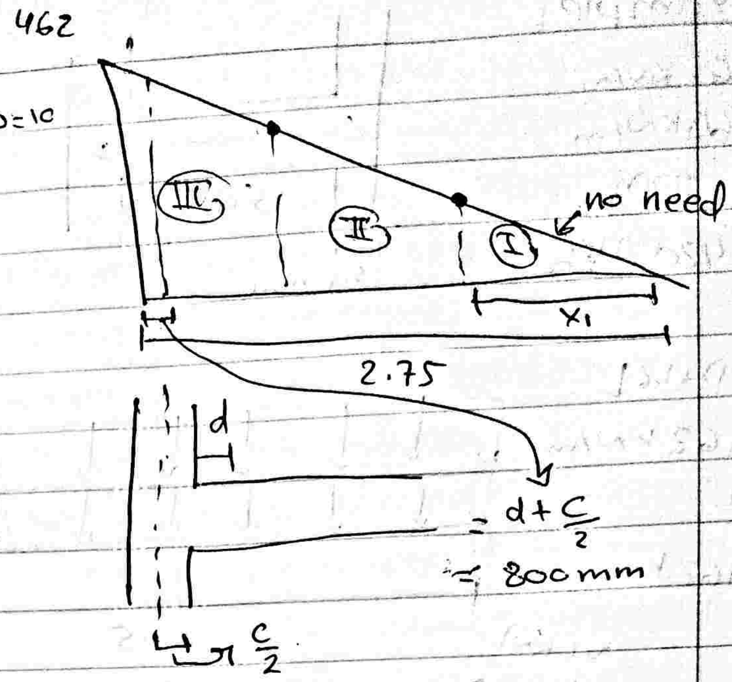






- $w_u = 168$ KN/m
- $V_u = 462$ KN
- $f_y = 420$ MPa, $f_c' = 28$ MPa





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

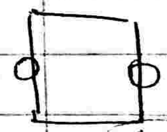
$\frac{462}{2.75} = \frac{74.21}{x_1} \Rightarrow x_1 = 0.44$ m

Region (II) : Maximum Spacing required
$\Rightarrow$ To calculat Max spacing

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

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

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



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

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

$S_{max} = 275$ mm
$= 27.5$ cm pratical ??

No
نريحها العامل ن 250mm

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

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

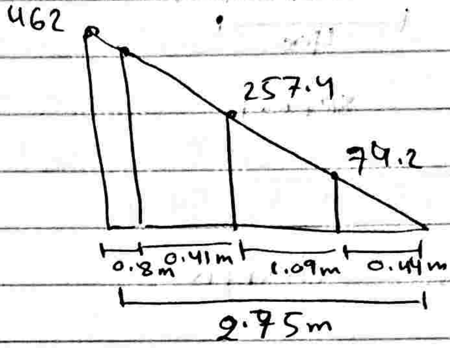
$= 148.4 + 109$

$= 257.4 \text{ KN}$

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

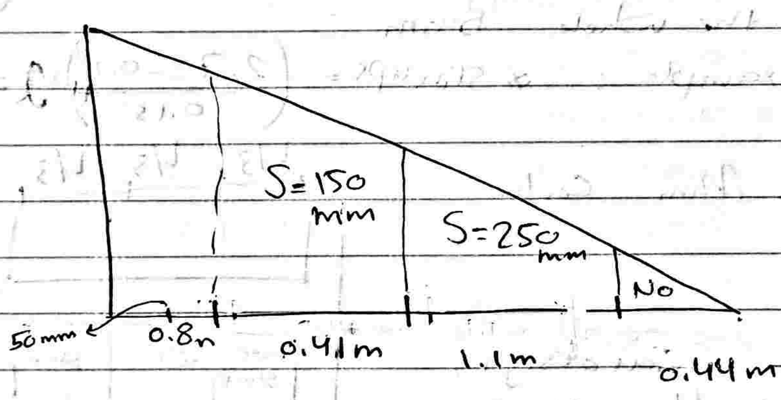
$x = 1.539 \text{ m}$

$x_2 = 0.1 \text{ m}$



Region (III): special design:

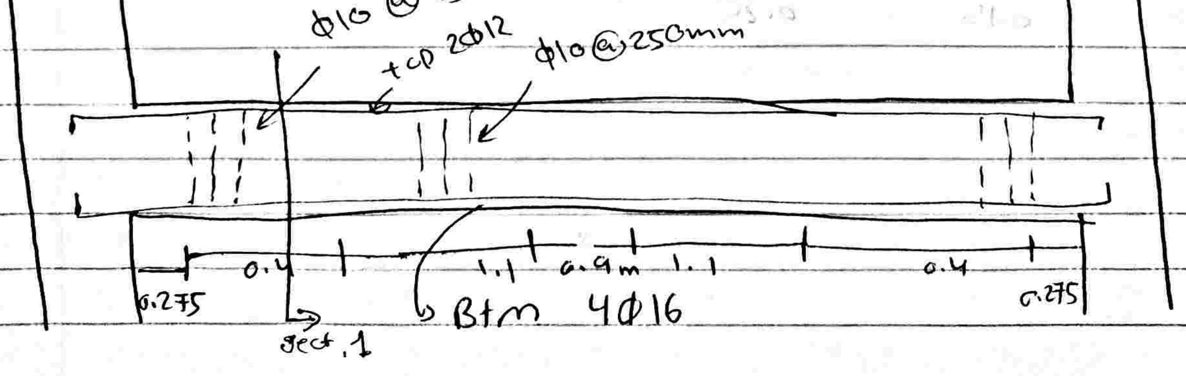
$S = \dfrac{A_v f_y d}{V_s} = 150.4 \text{mm} \approx 150 \text{mm}$ (V_s ← 241.2)

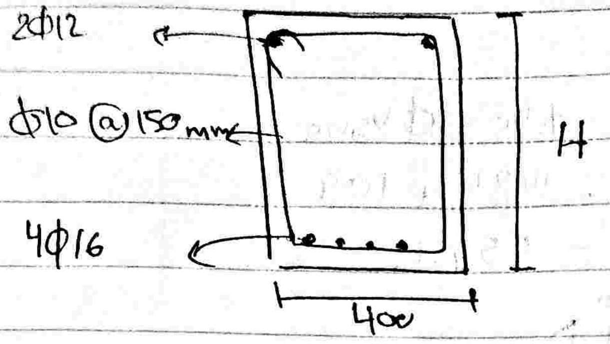


\# of stirrups =

⇒ $\dfrac{1.1}{0.25} + \dfrac{0.41}{0.15} + 1 = 4.4 + 2.73 + 1 = 8.13$

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

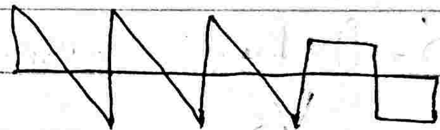




sect. 1

• practical design:-

Approach 1: least Calc.

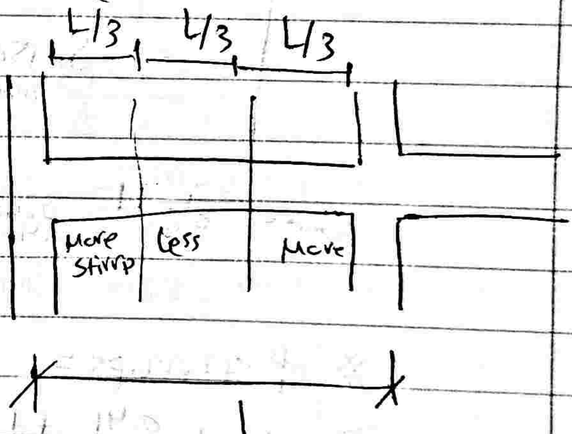


required spacing
↳ Apply for the whole Beam

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