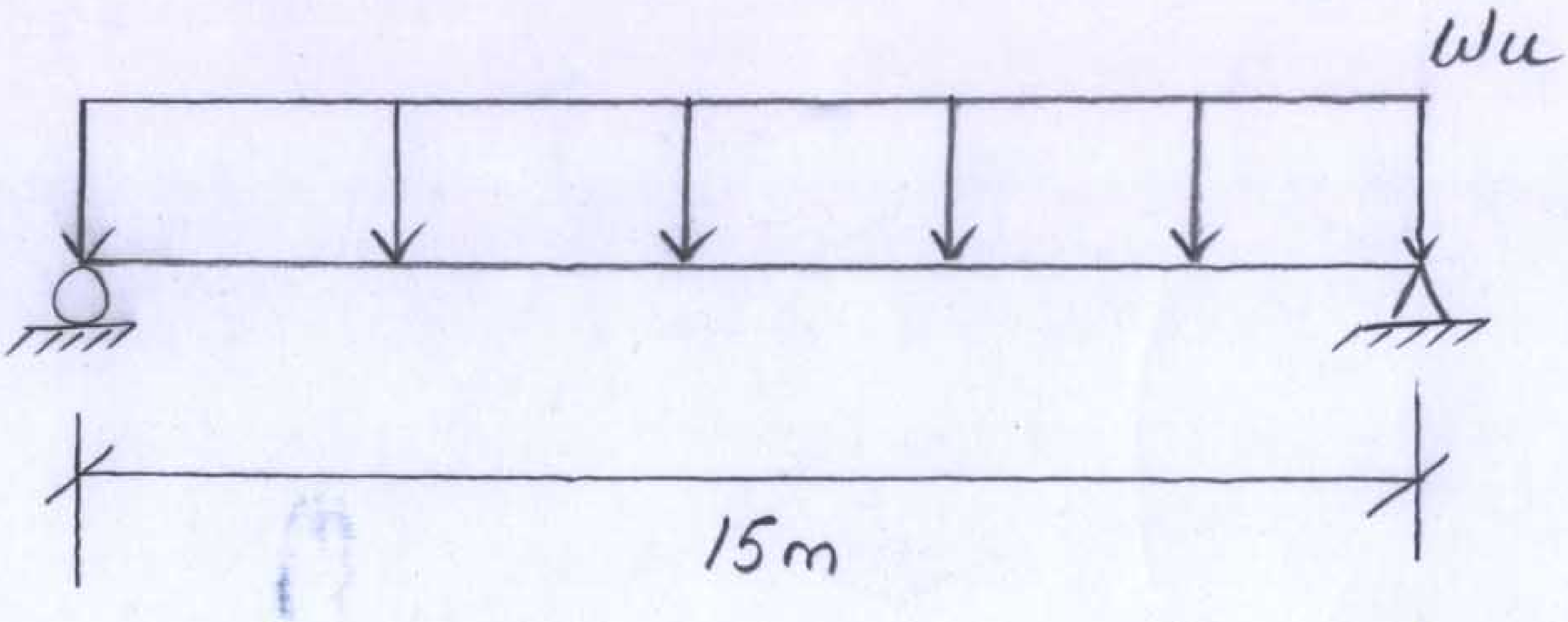
Assignment V

① $\varnothing = 1$



$As = (8.04)(12) = 96.5 cm^2$
$A's = 19.63 cm^2$

- **T = Cc**

$Asfy = 0.85 f'c\, b \times a + A'sfy$

$\Rightarrow a = \frac{Asfy - A'sfy}{0.85 f'c \times b} = 22.61 cm \Rightarrow C = \frac{a}{0.85} = 26.6 cm$

- **Check if Tension steel yielded:**

$\varepsilon s = \frac{d-c}{c} \times 0.003 = 0.0094 > 0.002$

$\Rightarrow$ Tension steel yielded as assumed

- **Check if Compression steel yielded:**

$\varepsilon' s = \frac{c-d'}{c} \times 0.003 = 0.0023 > 0.002$

$\Rightarrow$ compression steel also yielded as assumed

- **Nominal Flexural capacity of Section:**

$Mn = 1 \cdot Mu = (As - A's) fy (d - \frac{a}{2}) + A'sfy (d-d')$
$= 31219981.8 + 8574384$
$= 39794365.8$ kg-cm = **397 T-m**

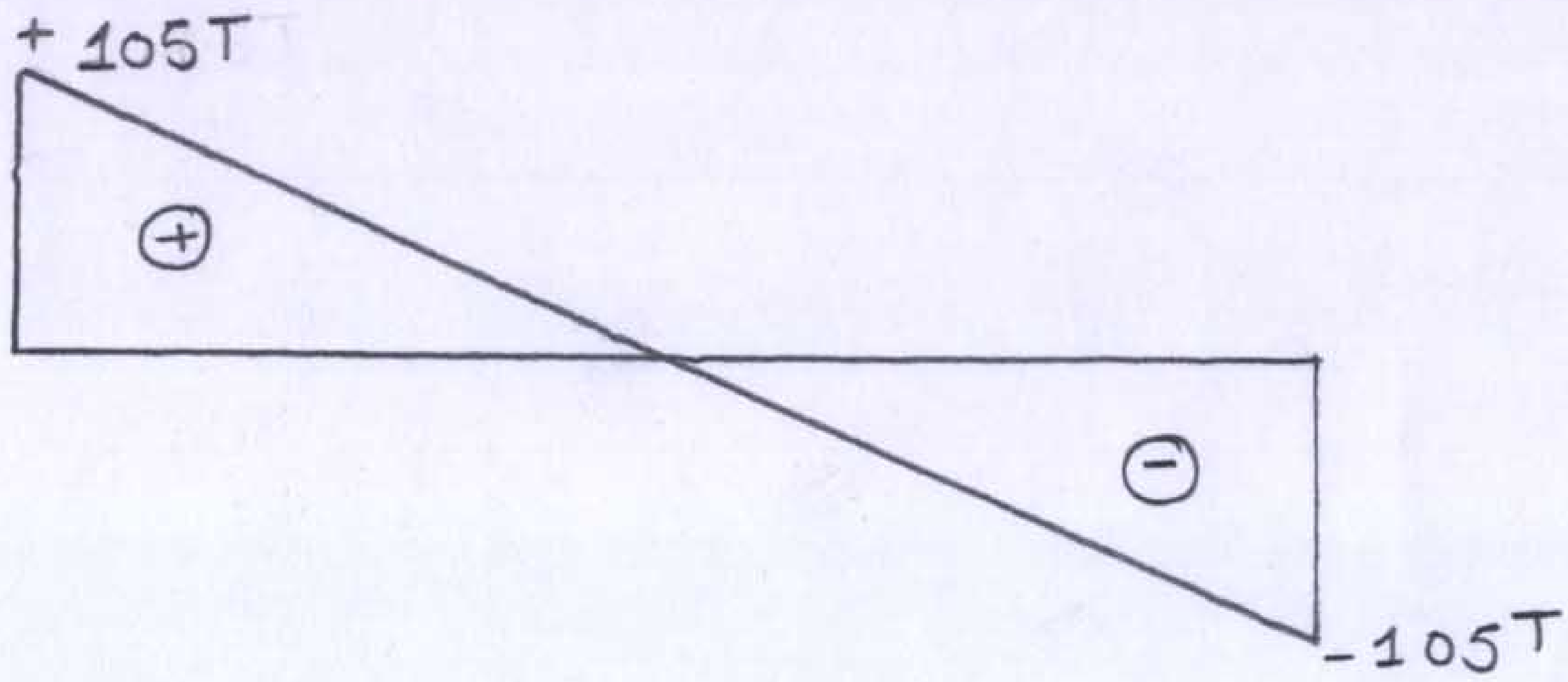
$Mu = \frac{WuL^2}{8}$ (since beam is simply supported)

$\Rightarrow Wu = \frac{(397)(8)}{(15)^2} = 14.11 T/m$

Take **Wu = 14 T/m**

(2)

Shear Diagram:



i) Use simplified Approach :

$V_c = 2\sqrt{f'_c}\ b_w \cdot d = \dfrac{2\sqrt{4000}}{14.22} \times 60 \times 110 = 58.7\,T$

$@\ x = d = 1.1m \longrightarrow V_u = 90^T$

$@\ x = \frac{L}{4} \approx 3m \longrightarrow V_u = 63^T$

$@\ x = 6m \longrightarrow V_u = 21^T$

Zone 1: ($< x \leq 3$)

$V_u = 90^T$

$\dfrac{A_v}{S} = \dfrac{V_u/\phi - V_c}{f_y \cdot d} = \dfrac{[(90/0.85) - (58.7)] \times 10^3}{(4200)(110)} = 0.102$

$\left(\dfrac{A_v}{S}\right)_{min} = \dfrac{3.5\, b_w}{f_y} = 0.05$

$\left(\dfrac{A_v}{S}\right) > 0.05 \Rightarrow$ o.k

$\dfrac{V_u}{\phi} - V_c = 47.2^T$

$4\sqrt{f'_c} \cdot b_w \cdot d = \dfrac{4\sqrt{4000}}{14.22} \times 60 \times 110 = 117.4^T$

Since $\dfrac{V_u}{\phi} - V_c < 4\sqrt{f'_c} \cdot b_w \cdot d$

$\Rightarrow S_{max} = \dfrac{d}{2} = 55\,cm$ OR $24'' = 60\,cm$

$\Rightarrow S_{max} = 55\,cm$ (smaller)

Use 2Leg T_{10} stirrups:

$\Rightarrow A_v = 1.57\ cm^2$

$$\frac{A_v}{S} = 0.102 \Rightarrow S = \frac{1.57}{0.102} = 15.4\ cm$$

Take $S = 15\ cm < S_{max} = 55\ cm$

Zone 2: $(3 < x < 6m)$

$V_u = 63^T > \phi V_c \Rightarrow$ we need shear Reinforcement.

$$\frac{A_v}{S} = \frac{(63/0.85 - 58.7) \times 10^3}{(4200)(110)} = 0.033 < \left(\frac{A_v}{S}\right)_{min} = 0.05$$

$\Rightarrow$ Use $\left(\frac{A_v}{S}\right)_{min}$

$$\frac{V_u}{\phi} - V_c = 15.42 < 4\sqrt{f'c} \cdot b_w \cdot d = 117.4$$

$\Rightarrow S_{max} = \frac{d}{2} = 55\ cm$ (smaller than $24'' = 60cm$)

Use 2Leg T_{10} stirrups $\longrightarrow$ $A_v = 1.57\ cm^2$

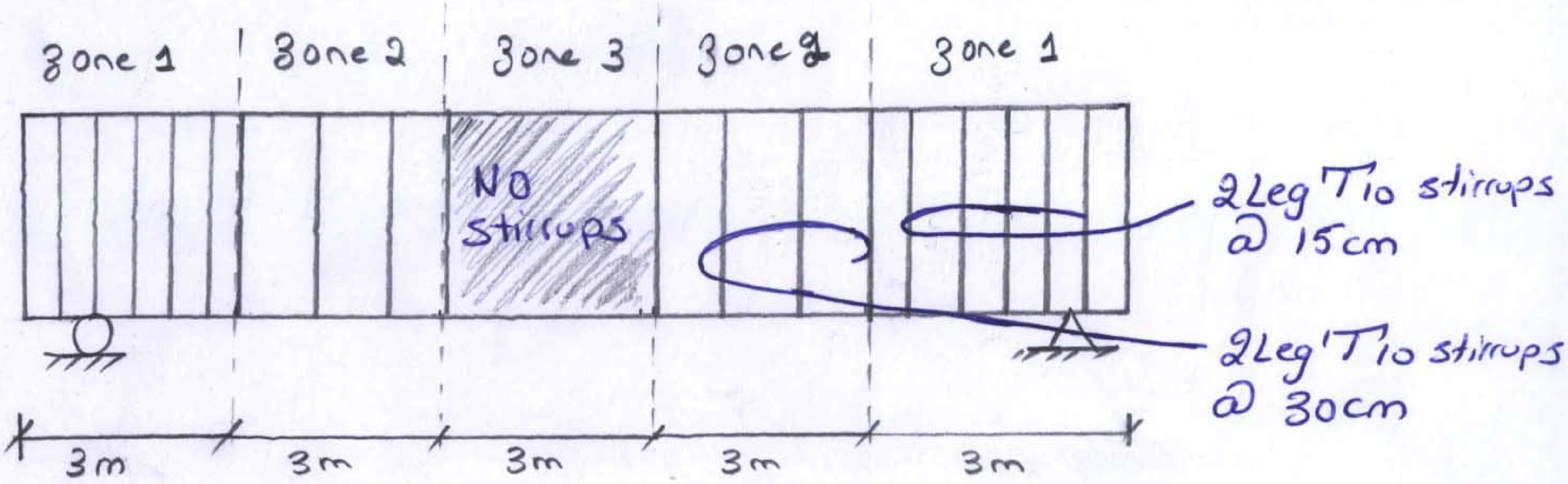
$$\Rightarrow S = \frac{1.57}{0.05} = 31.4\ cm < S_{max} = 55\ cm$$

$\Rightarrow$ Take $S = 30\ cm$

Zone 3: $(6 < x < 9)$

$V_u = 21^T < \frac{\phi V_c}{2} = 25^T$

$\Rightarrow$ No shear Reinforcement is needed.



ii) Use Exact Approach:

$$V_c = \left[1.9\sqrt{f'_c} + 2500_{psi}\, \rho_w \frac{V_u \cdot d}{M_u}\right] b_w \times d$$

where $\rho_w = \frac{A_s}{b_w \cdot d} = \frac{96.5}{(60)(110)} = 0.0146$

Conditions: $\longrightarrow$ • $\frac{V_u \cdot d}{M_u} \ngtr 1.0$

and • $V_c \ngtr 3.5\sqrt{f'_c}\, b_w \cdot d = 102.7\,T$

Zone: 1 $(0 < x < 3m)$

$@\, x = d = 1.1m \longrightarrow V_u = \boxed{90\,T}$

$$M_u = \frac{w_u l}{2} x - \frac{w_u x^2}{2}$$

$$= \frac{(14)(15)}{2}(1.1) - \frac{(14)(1.1)^2}{2}$$

$$= 115.5 - 8.47 = \boxed{107\,T\text{-}m}$$

$$\Rightarrow V_c = \left[\frac{1.9\sqrt{4000}}{14.22} + \frac{(2500)(0.0146)}{14.22}\frac{(90)(1.1)}{(107)}\right](60)(110)$$

$\frac{(90)(1.1)}{(107)} \rightarrow 0.9 < 1.0$

$$= \boxed{71.4\,T} < 102.7$$

$$\frac{A_v}{s} = \frac{V_u/\phi - V_c}{f_y \cdot d} = \frac{(90/0.85 - 71.4)\times 10^3}{(4200)(110)} = 0.075 > \left(\frac{A_v}{s}\right)_{min} = 0.05$$

$$\frac{V_u}{\phi} - V_c = 34.5\,T$$

$$4\sqrt{f'_c}\, b_w \cdot d = \frac{4\sqrt{4000}}{14.22}(60)(110) = 117.4\,T$$

Since $\frac{V_u}{\phi} - V_c < 4\sqrt{f'_c}\, b_w \cdot d \Rightarrow s_{max} = \frac{d}{2} = 55cm$

Use 2 Leg T10 stirrups $\rightarrow A_v = 1.57\,cm^2$

$\Rightarrow s = \frac{1.57}{0.075} = 20.933\,cm \Rightarrow$ take $\boxed{s = 20\,cm} < s_{max} = 55\,cm$

Zone 2: $(3 < x < 6m)$

@ $x = 3m \longrightarrow V_u = 63T$

$M_u = 252\ T\text{-}m$

$V_c = 50.43\ T$

$V_u > \frac{\phi V_c}{2} \Rightarrow$ shear reinforcement is required.

$$\frac{A_v}{S} = \frac{V_u/\phi - V_c}{f_y d} = \frac{(63/0.85 - 50.43)(1000)}{(4200)(110)} = 0.0513 > \left(\frac{A_v}{S}\right)_{min} = 0.05$$

$$\frac{V_u}{\phi} - V_c = 23.7T < 4\sqrt{f'_c}\, b_w \cdot d = 117.4T$$

$\Rightarrow S_{max} = \frac{d}{2} = 55cm$

Use 2Leg T10 stirrups $\longrightarrow A_v = 1.57 cm^2$

$\Rightarrow S = \frac{1.57}{0.0513} = 30.6\ cm \Rightarrow$ **Use $S = 30cm$** $< S_{max} = 55cm$

Zone 3: $(6 < x < 9)$

@ $x = 6m \longrightarrow V_u = 21T$

$M_u = 378\ T\text{-}m$

$V_c = 56.8T$

$V_u < \phi \frac{V_c}{2} = 24T$

$\Rightarrow$ No shear Reinforcement is Required In This Zone.