Reinforced Concrete Design 1

HW 2

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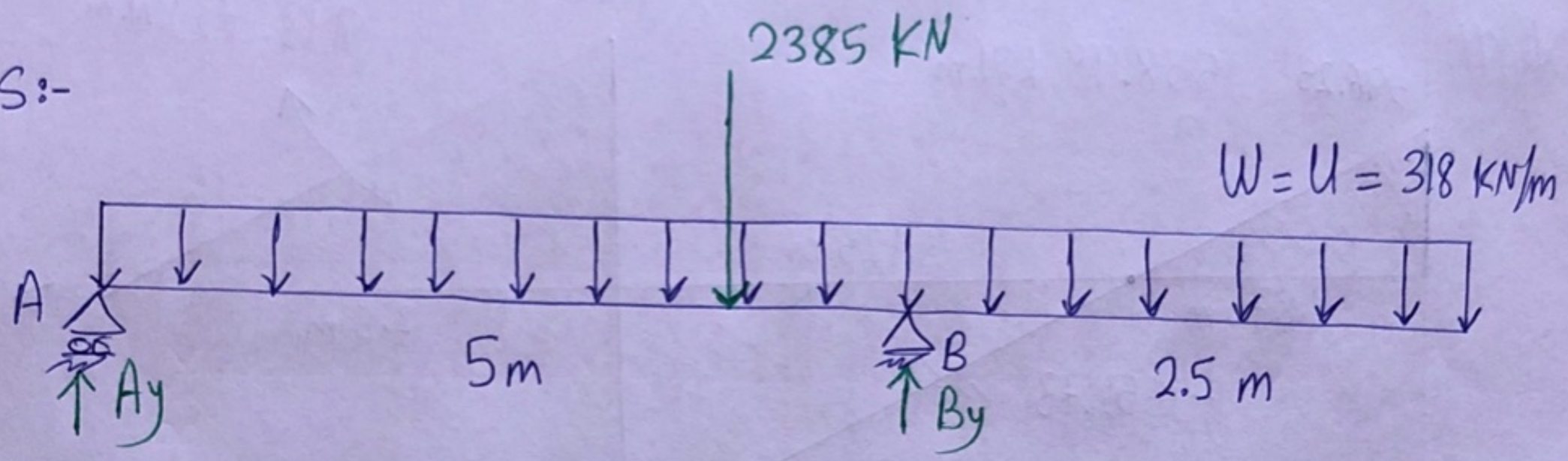
Ans:-



Assumptions: min. depth = $\frac{2.5}{8} = 0.3125 \approx 0.35 = 350$ mm

B = 200 m

SW = 1 * 0.35 * 0.2 * γ_c = 24 K/m³

= 1.68 KN/m

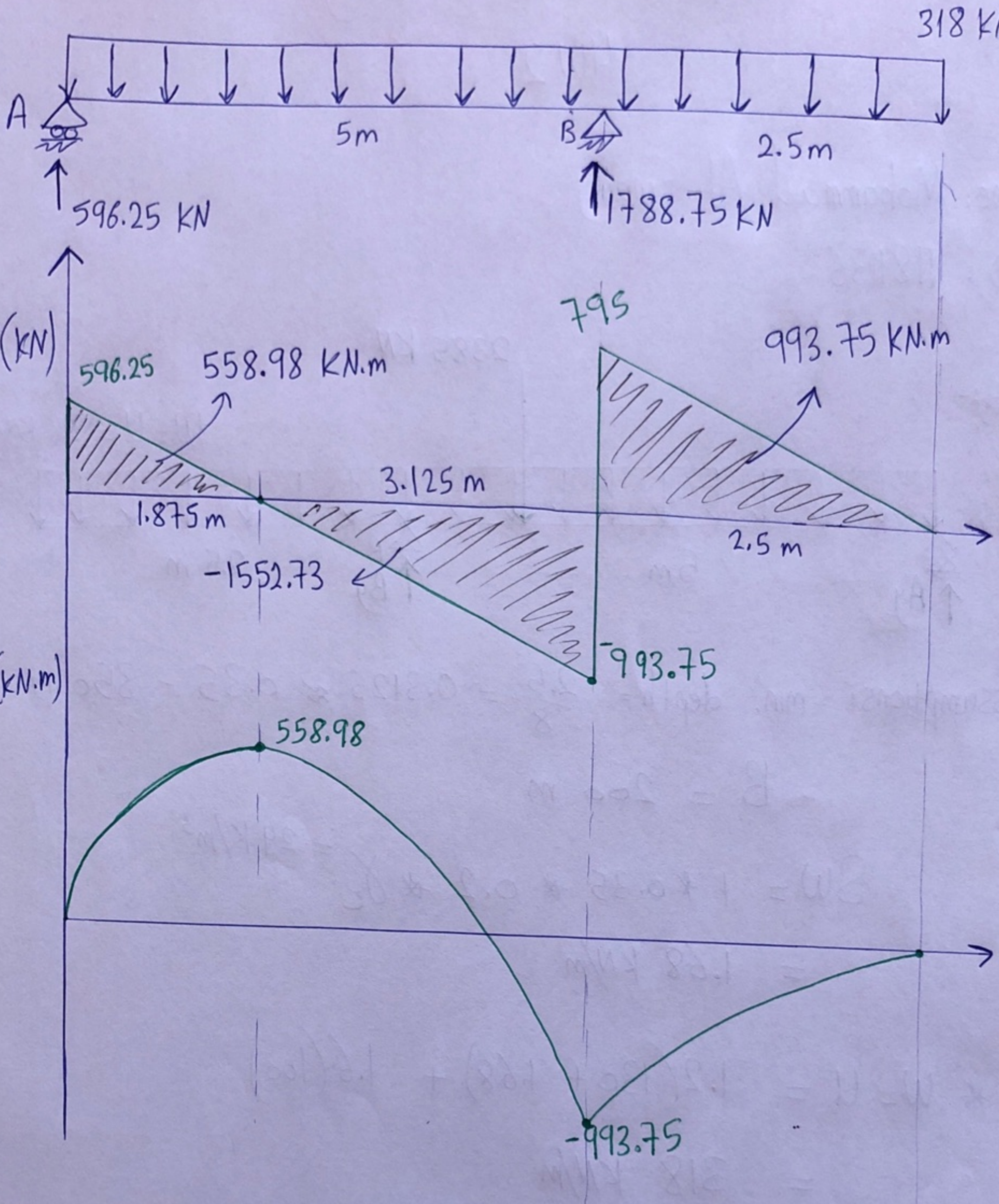
* W = U = 1.2(130 + 1.68) + 1.6(100)

= 318 KN/m

* $\Sigma M_A = 0$: $5\,By = \frac{2385\,(7.5)}{2}$ → By = 1788.75 KN↑

ΣFy: 1788.75 + Ay = 2385

Ay = 596.25 KN↑



Max negative moment = 993.75 KN.m

" positive " = 558.98 KN.m

* take $m_u = 993.75$ KN.m

let $\rho = 0.5\,\rho_{max} = 0.0103$

To find R:

$$\frac{0.0105 - 0.1000}{4 - 3.83} = \frac{0.0103 - 0.1000}{R - 3.83}$$

$$R = 3.93 \text{ mpa}$$

$$R = \frac{M_u}{\phi b d^2} \longrightarrow 3.93 = \frac{993.75 * 10^6}{0.9\, bd^2}$$

$$\longrightarrow bd^2 = 281 * 10^6 \text{ mm}^3$$

$$(1.5 - 3)\, b = d$$

	b	d
X	200	1185 → 5.925b
✓	400	838 → 2.095b

$\therefore b = 400$ mm

$H = 900$ mm

newd = 840 mm

$\longrightarrow$ new $SW = 1 * 0.4 * 0.9 * 24$

$= 8.64 \approx 9 \ KN/m$

new $W = 1.2(130 + 9) + 1.6(100)$

$= 327 \ KN/m$

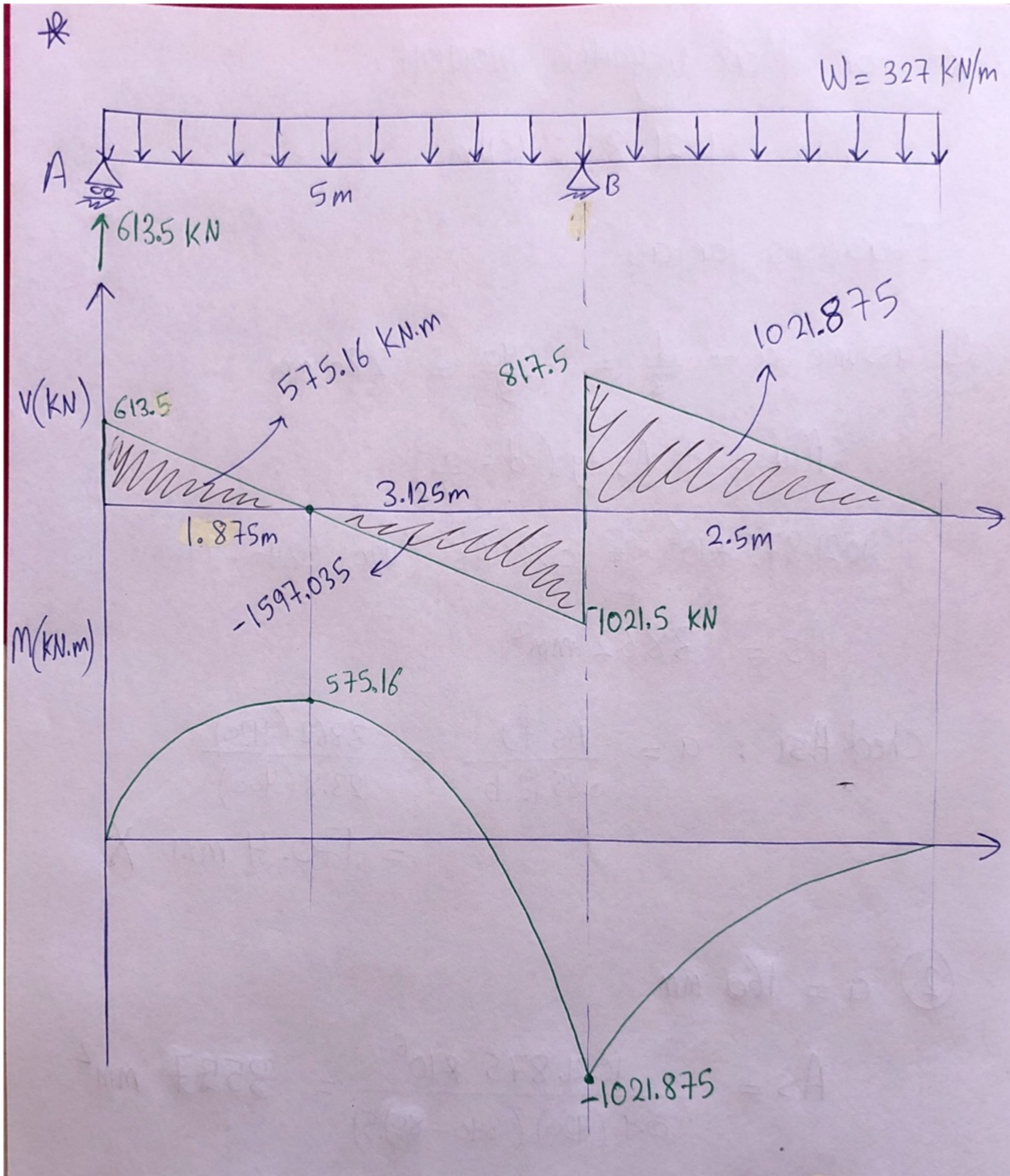
$* \ \Sigma M_A = 0: \quad 5By = \dfrac{327(7.5)^2}{2}$

$By = 1839 \ KN \uparrow$

$\Sigma Fy = 0: \quad 1839 + Ay = 2452.5$

$Ay = 613.5 \ KN \uparrow$

New Shear-Moment Diagram $\longrightarrow$



new Max negative moment = 1021.875 KN.m

// // positive // = 575.16 KN.m

* For Max negative moment:

$$Mu = 1021.875 \text{ kN.m}$$

Iterations for a:

① assume $a = \frac{d}{3} = \frac{840}{3} = 280$ mm

$$Mu = \phi As\, fy \left(d - \frac{a}{2}\right)$$

$$1021.875 * 10^6 = 0.9\, As\, (420)\left(840 - 140\right)$$

$$As = 3862 \text{ mm}^2$$

check a : $a = \frac{As\, fy}{0.85\, fc'\, b} = \frac{3862\,(420)}{23.8\,(400)}$

$= 170.4$ mm X

② $a = 155$ mm

$$As = \frac{1021.875 * 10^6}{0.9\,(420)\,(840 - 77.5)} = 3545 \text{ mm}^2$$

Check: $a = \frac{3545\,(420)}{(23.8)\,(400)} = 156.4$ mm

$\therefore$ $a = 155$ mm

$\longrightarrow$ $A_s = 3545\ mm^2$

from Design Aid Table A.2:-

take : ① $6 \phi 29$

$$5S = 400 - 6(29) - 100$$

$$S = 25.2\ mm$$

② $5 \phi 32$

$$4S = 400 - 5(32) - 100$$

$$S = 35\ mm$$

$\longrightarrow$ take $5 \phi 32$

$A_s = 4095\ mm^2$

Checks : ① check on ϕ :

$$\rho = \frac{4095}{840(400)} = 0.0122$$

$\rho_{min} < \rho < \rho_{max}$ ✓

(0.0033) (0.0206)

② check on M_n :

$$\phi M_n = \phi f_y A_s \left(d - \frac{a}{2}\right)$$

* $$a = \frac{A_s f_y}{0.85 f'_c B} = \frac{4095\,(420)}{23.8\,(400)} = 180.7 \text{ mm}$$

$$\rightarrow \phi M_n = 0.9\,(420)(4095)\left(840 - \frac{180.7}{2}\right)$$

$$\longrightarrow \phi M_n = 1160.4 \text{ KN.m} > M_u \quad \checkmark$$

* For Max positive moment:

$$M_u = 575.16 \text{ KN.m}$$

Iterations for a :

① $a = 140$

$$A_s = \frac{575.16 * 10^6}{0.9(420)(840-70)} = 1976 \text{ mm}^2$$

Check a : $$a = \frac{1976\,(420)}{(400)(23.8)} = 87.2 \text{ mm}$$

X

② $a = 85$ mm

$$A_s = \frac{575.16 * 10^6}{0.9(420)(840 - \frac{85}{2})} = 1908 \text{ mm}^2$$

Check a: $a = \frac{1908(420)}{(23.8)(400)} = 84.2$ mm

$\longrightarrow$ $a = 85$ mm / $A_s = 1908$ mm²

from Design Aid Table A.2:-

take 5 ∅ 22 " $A_s = 1935$ mm² ~

$4S = 400 - 5(22) - 80 - 20$

$S = 47.5$ mm ✓

∴ take 5∅22 $\longrightarrow A_s = 1935$ mm²

Checks: ① Check on ϕ :

$$\rho = \frac{1935}{840\,(400)} = 0.00576$$

$$\rho_{min} < \rho < \rho_{max} \quad \checkmark$$

② Check on M_n :

$$a = \frac{1935\,(420)}{23.8\,(400)} = 85.4\ mm$$

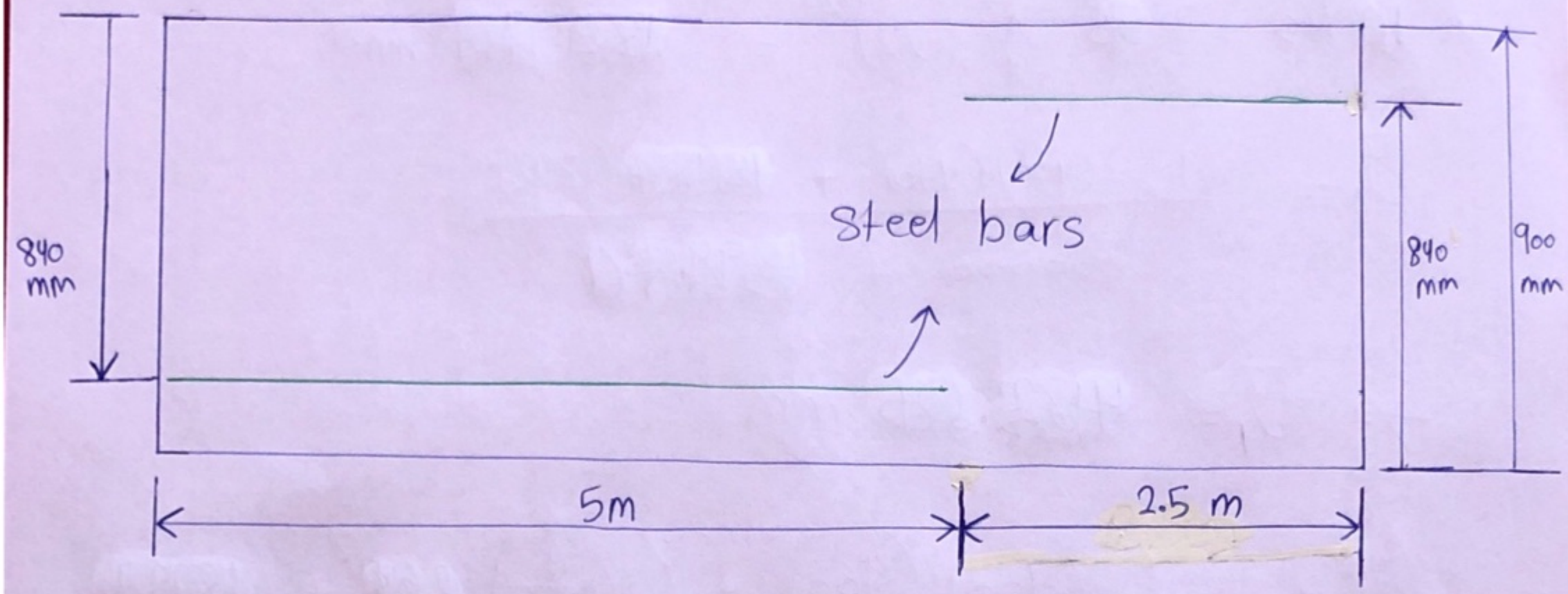
$$\phi M_n = 0.9\,(1935)\,(420)\left(840 - \frac{85.4}{2}\right)$$

$$\longrightarrow \phi M_n = 583.17\ kN.m > M_u$$

$\checkmark$

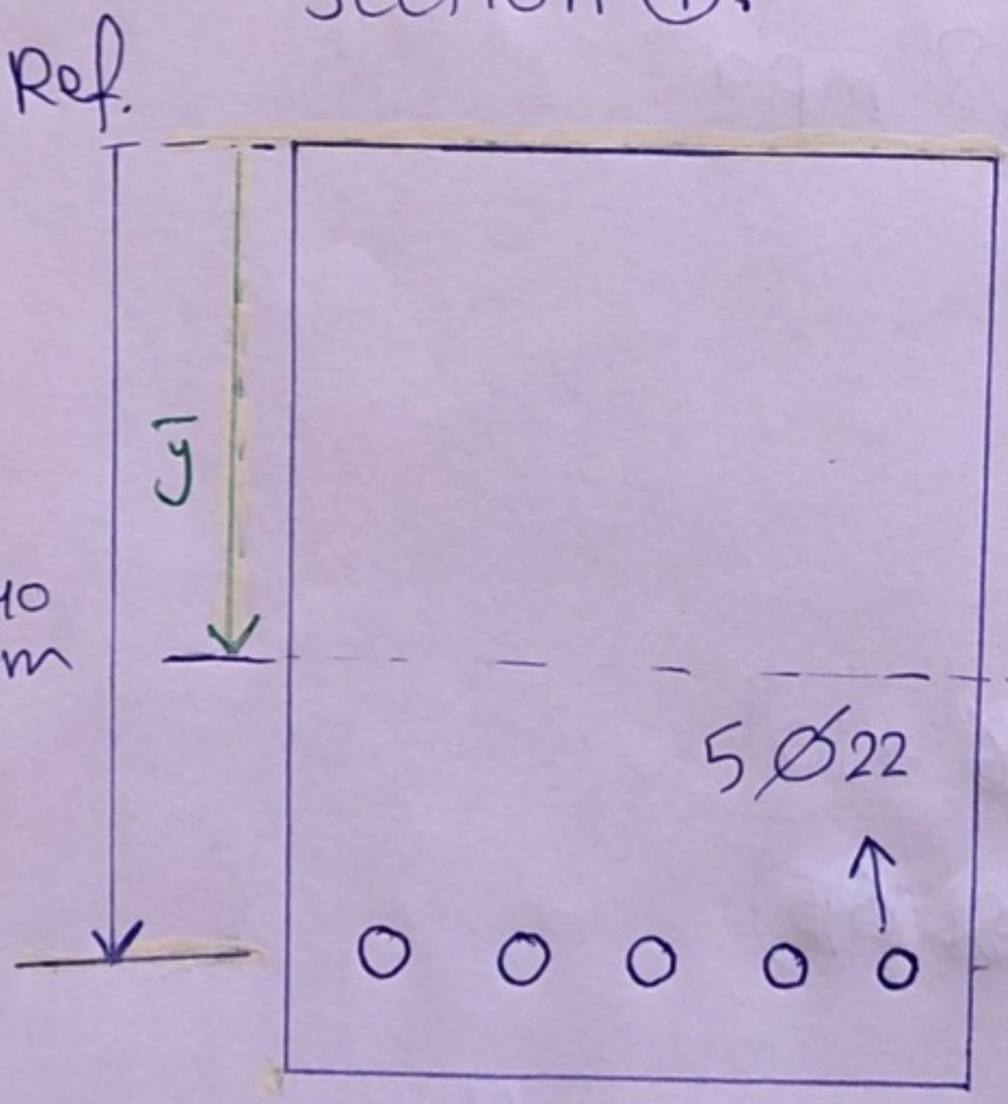
(4)

Side View

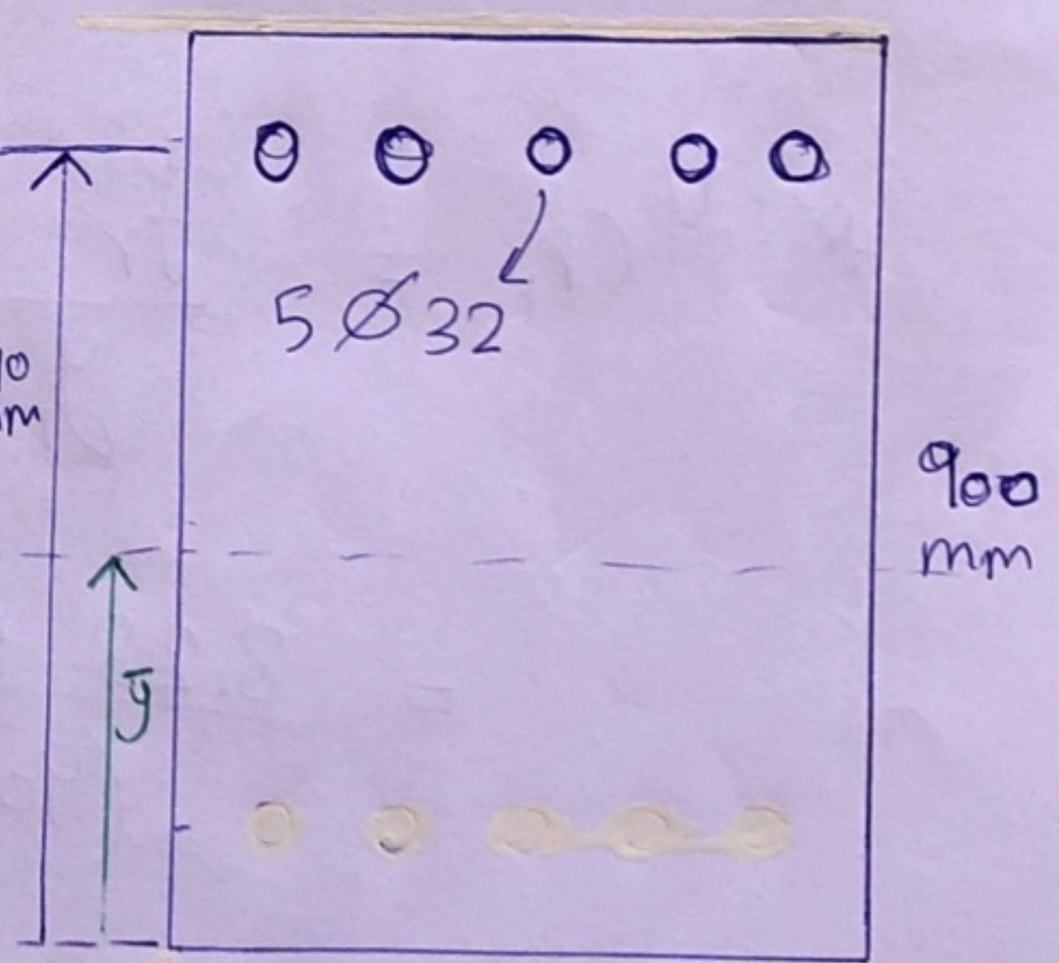


* Sections :-

Section (1):



Section (2):



(5) for section (1) "$M_u = 575.16$ KN.m"

$$(n-1)\,A_s = 7 * 5\,\frac{\pi}{4}(22)^2 = 13297.9 \text{ mm}^2$$

$$\bar{y}_1 = \frac{(900)(400)(450) + 13297.9(840)}{360000 + 13297.9}$$

$$\rightarrow \bar{y}_1 = 463.89 \text{ mm}$$

$$I_1 = \frac{1}{12}(400)(900)^3 + (360000)(13.89)^2 + (13297.9)(840-463.89)^2$$

$$I_1 = 26.25 * 10^9 \text{ mm}^4$$

$$* f_r = 0.62\sqrt{28} = 3.28 \text{ mpa}$$

$$* M_{cr_1} = \frac{f_r\, I_1}{y_1}$$

$$= \frac{3.28 * 26.25 * 10^9}{(900 - 463.89)}$$

$$= 197.43 \text{ KN.m} << M_4$$

* For Section 2 "$M_u = 1021.875$ KN.m"

$$(n-1)A_s = 7 * 5 \frac{\pi}{4}(32)^2 = 28134.4 \text{ mm}^2$$

$$\overline{y}_2 = \frac{360000\,(450) + 28134.4\,(840)}{360000 + 28134.4}$$

$$\longrightarrow \overline{y}_2 = 478.27 \text{ mm}$$

$$I_2 = \frac{1}{12}(400)(900)^3 + (360000)(28.27)^2 + (28134.4)(840 - 478.27)^2$$

$$= 28.27 * 10^9 \text{ mm}^4$$

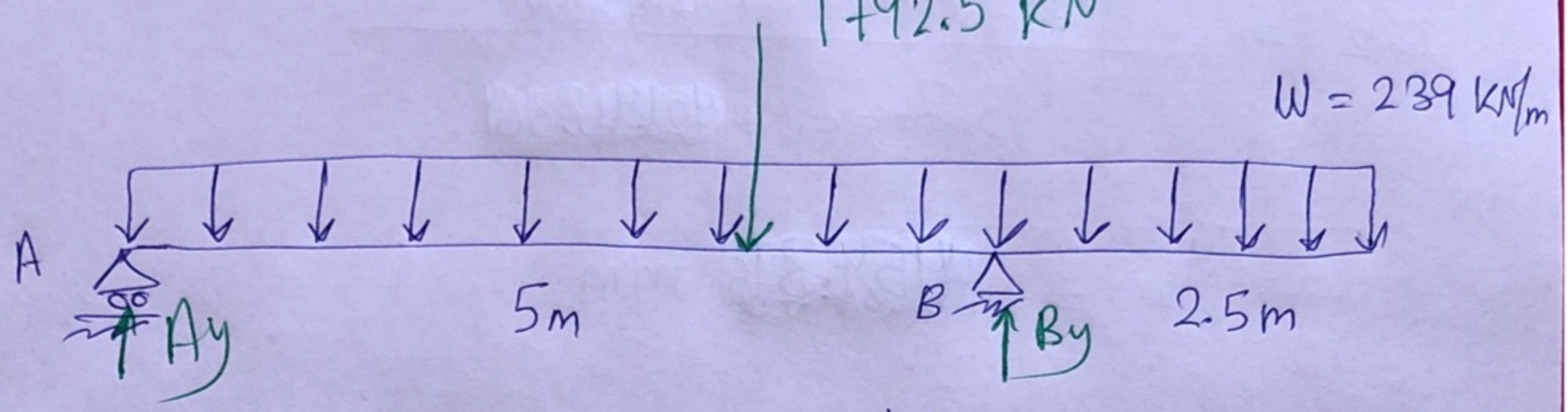
$$* M_{cr_2} = \frac{3.28\,(28.27 * 10^9)}{(900 - 478.27)}$$

$$\longrightarrow M_{cr_2} = 219.87 \text{ KN.m} <<< M_u$$

⑥ $W = D + L$

$= 130 + 9 + 100$

$= 239 \text{ KN/m}$

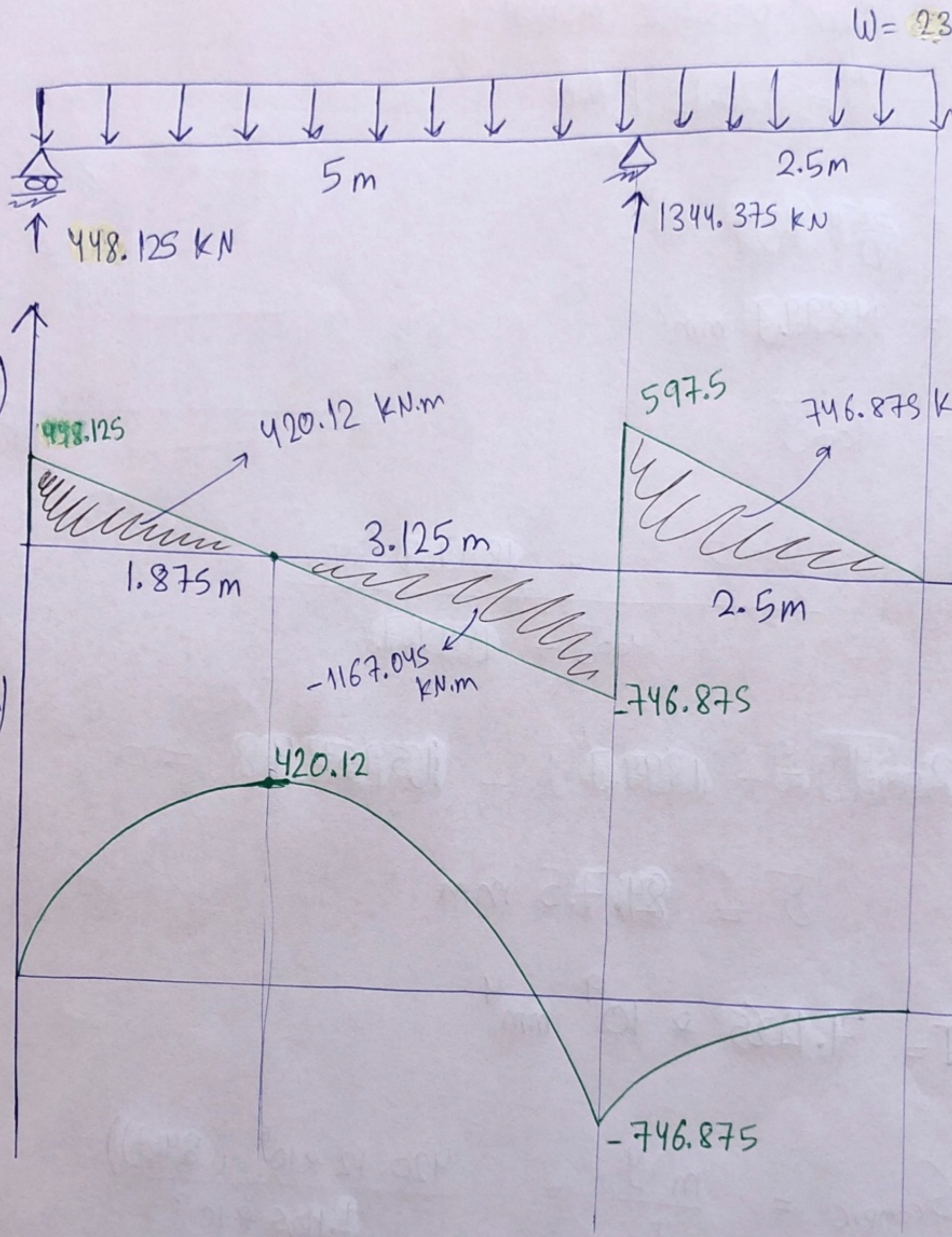


$\Sigma M_A = 0: \quad 5By = 239\left(\frac{7.5}{2}\right)(7.5)$

$By = 1344.375 \text{ KN} \uparrow$

$\Sigma Fy = 0: \quad By + Ay = 1792.5$

$Ay = 448.125 \text{ KN} \uparrow$



Max negative moment = 746.875 KN.m

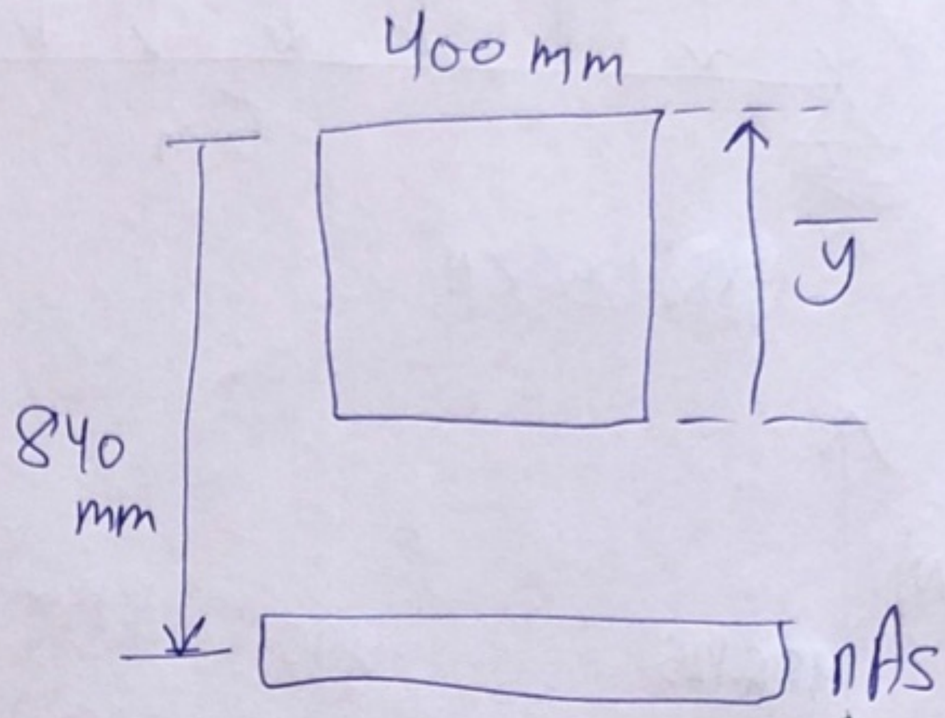
// positive // = 420.12 KN.m

for Max positive moment:

$$M = 420.12 \text{ KN.m}$$

$$nAs = 8 * 5 \frac{\pi}{4} (22)^2$$

$$= 15197.6 \text{ mm}^2$$



$$Ac = 400\bar{y}$$

$$\bar{y} = \frac{400\bar{y}\,\frac{\bar{y}}{2} + 15197.6(840)}{400\bar{y} + 15197.6}$$

$$200(\bar{y})^2 + 15197.6\,\bar{y} - 12765984 = 0$$

$$\bar{y} = 217.5 \text{ mm}$$

$$I = 7.26 * 10^9 \text{ mm}^4$$

$$\sigma_{comp,c} = \frac{m\,y}{I} = \frac{420.12 * 10^6 (217.5)}{7.26 * 10^9}$$

$$\longrightarrow \sigma_{comp,c} = 12.59 \text{ mpa}$$

$$f_{st} = n\frac{m\,y}{I} = \frac{8\,(420.12) * 10^6 * (840 - 217.5)}{7.26 * 10^9}$$

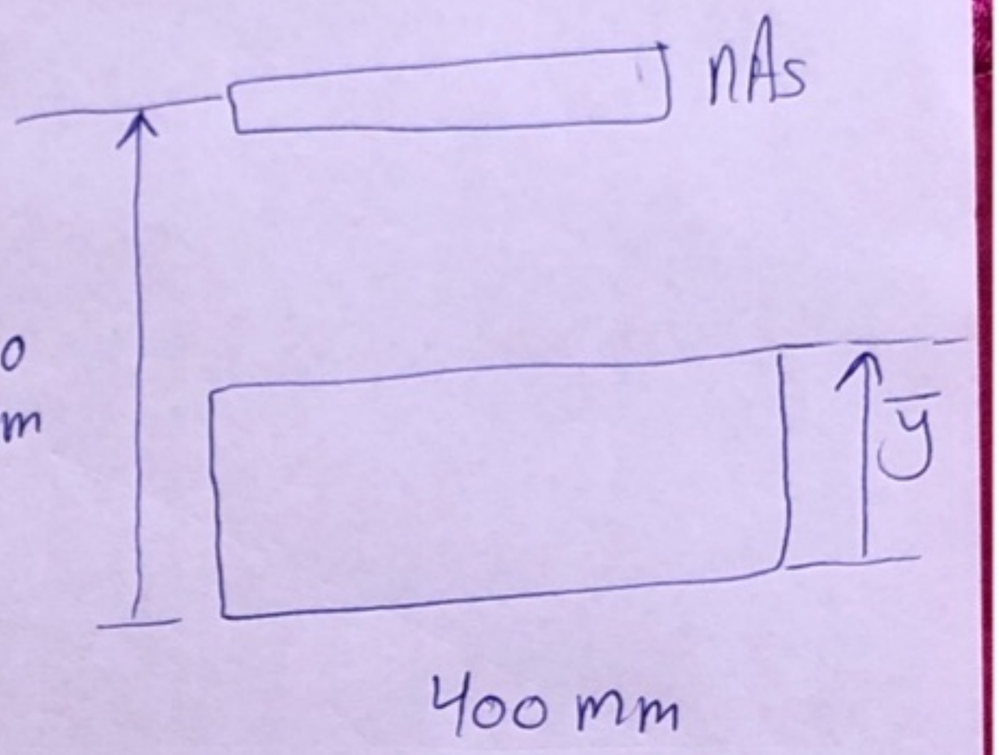
$$\longrightarrow f_{st} = 288.18 \text{ mpa}$$

→ for max negative moment :

$$M = 746.875 \text{ KN.m}$$

$$nAs = 8 \frac{\pi}{4} * 5(32)^2$$

$$= 32153.6 \text{ mm}^2$$



$$\bar{y} = \frac{400\,\bar{y}\left(\frac{\bar{y}}{2}\right) + 32153.6(840)}{400\,\bar{y} + 32153.6}$$

$$200\,\bar{y}^2 + 32153.6\,\bar{y} - 27009024 = 0$$

$$\bar{y} = 295.79 \text{ mm}$$

$$I = 12.97 * 10^9 \text{ mm}^4$$

$$\rightarrow \sigma_{comp,c} = \frac{746.875 * 10^6 \ (295.79)}{12.97 * 10^9}$$

$$= 17.03 \text{ mpa}$$

$$\rightarrow f_s = 8\frac{(746.875 * 10^6 \ (840 - 295.79))}{12.97 * 10^9}$$

$$\rightarrow f_s = 250.71 \text{ mpa}$$

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