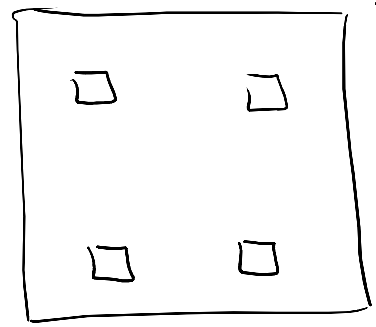
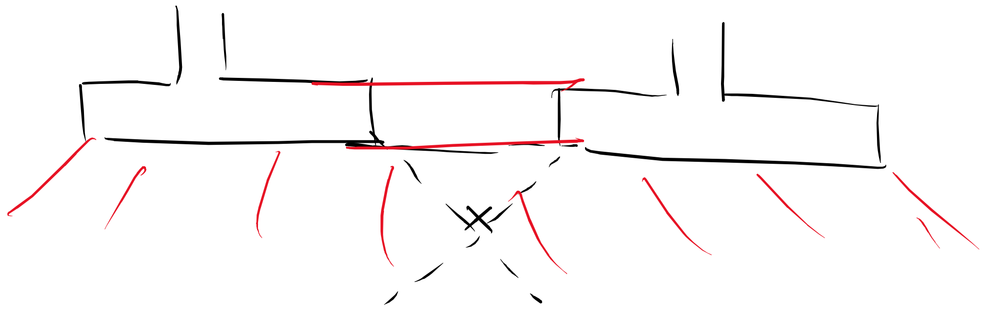
Mat Foundation



- if $\frac{\Sigma P}{q_{all}} > 60\%$ of Building Area.

- if $\frac{\Sigma P}{q_{all}} < 50 \rightarrow$ Isolated or Combined or Strap.

- $\frac{\Sigma P}{q_{all}} > 100\% \longrightarrow$ Piles.

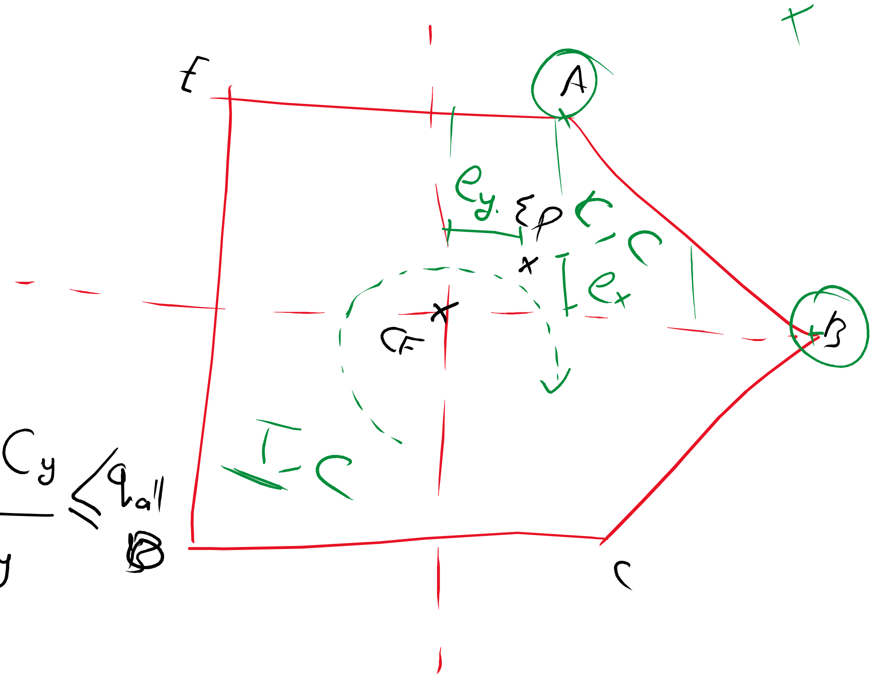


$\rightarrow$ eccentricity $\rightarrow$ moment

Center of Load $\neq$ Center of Mat

Cases

1. M_x
2. M_y
3. M_y and M_x



$$\sigma_{max} = \frac{\Sigma P}{A} + \frac{M_x C_x}{I_x} + \frac{M_{yx} C_y}{I_y} \leq q_{all}$$

B

$$M_x = P \times e_x$$

$$M_y = P_x \, e_y$$

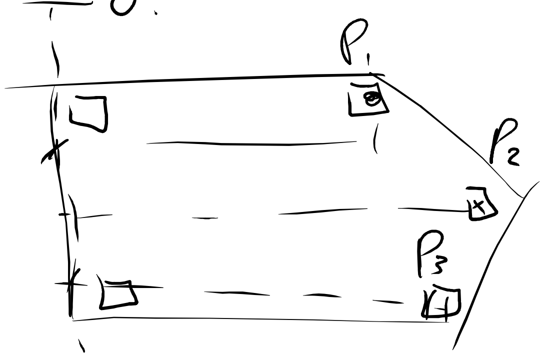
① $\sigma_{max} \rightarrow$ at A or B
(at the quarter where (P) found.

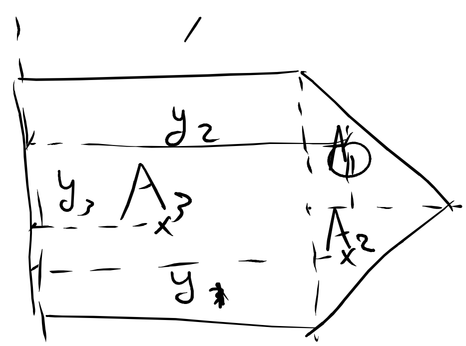
② σ_{min} is at the farther distance from P $\rightarrow$ at D

$$\sigma_{min} \geq 0$$
$$\sigma_{max} \leq q_{all}$$

$$y_p = \frac{\sum P_i \times y_i}{\sum P_i} \quad , \quad y_G = \frac{\sum A_i \times y_i}{\sum A_i}$$

Load LR y.
Foot RL y





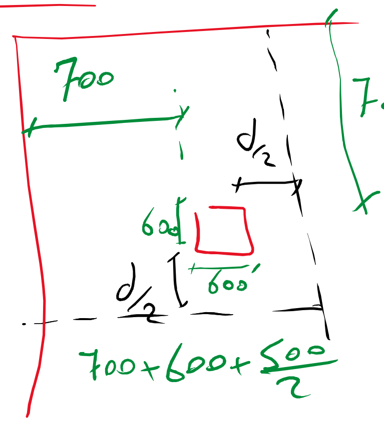
$$X_p = \frac{\sum P_i \times X_i}{\sum P_i} \quad , \quad X_G = \frac{\sum A_i \times X_i}{\sum A_i}$$

thickness

① mostly thickness controled by Punching.

interior or edge or Corner $d = 500\,mm$.

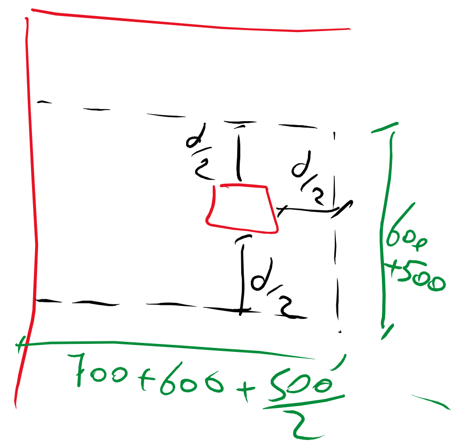
Corner



$b_o = \left(600 + \frac{500}{2} + 700\right) \times 2$

$= 3100\,mm$

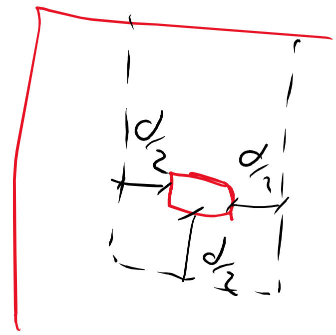
edge



$b_o = 1550 \times 2 + 600 + 500$

$= 4200\,mm$

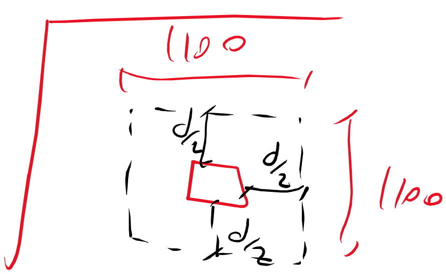
edge.



$b_o = 1550 \times 2 + 600 + 500$

$= 4200$

interior



$b_o = 1100 \times 2 + 1100 \times 2$

$= 4400\,m$

$b_o \downarrow \quad \phi V_c \downarrow$

Critical Case at the lowest $b_o \longrightarrow$ at Corner Case

Design the mat foundation shown

$f'_c : 20$ MPa | $q_{all} : 60$ kN/m^2

$f_y : 420$ MPa | all Columns 50x50 cm

Ultimate load Factor 1.4

Loads given are service loads

① thickness (hint: Controled by Punching)

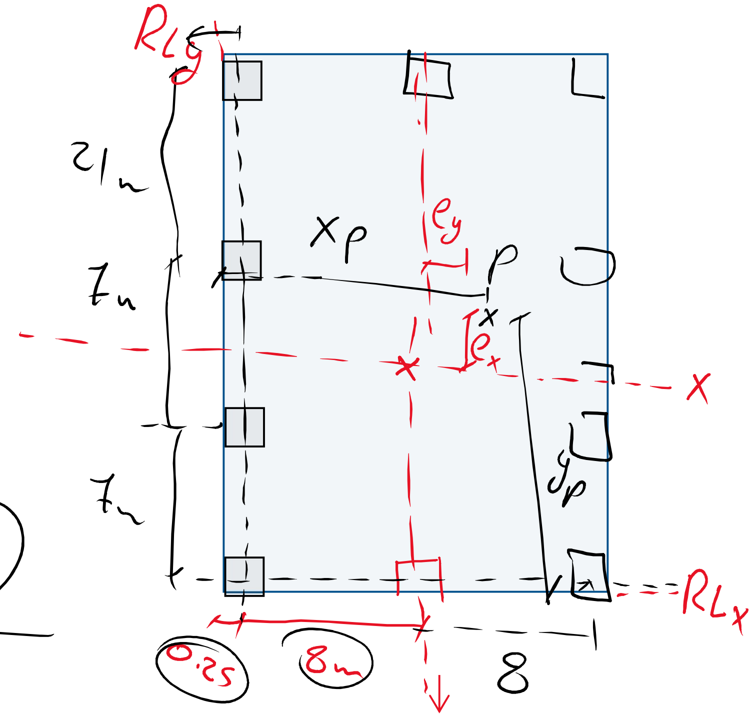
② Draw SFD, BMD for strip H-I

Solution

$$\sigma_{max} = \frac{P}{A} + \frac{M_x C_x}{I_x} + \frac{M_y C_y}{I_y} \leq q_{all} : 60 \text{ kN/m}^2$$

ⓐ Center of load and Center of footing

$$x_p = \frac{\sum P_i \, x_i}{\sum P_i}$$



$$= \frac{\left((400+1500+1500+400)\times 0 + (500+1500+1500+500)\times 8 + (450+1200+1200+350)\times 16\right)}{\sum P_i = 11000\ \text{kN}}$$

$$X_p = 7.56\ \text{m}$$

$$X_f = \frac{16}{2} = 8\ \text{m}$$

$$y_p = \frac{\left(\overset{②}{4200} \times 7\text{m} + (\overset{③}{4200} \times 14) + 1350 \times 21\text{m}\right)}{11000}$$

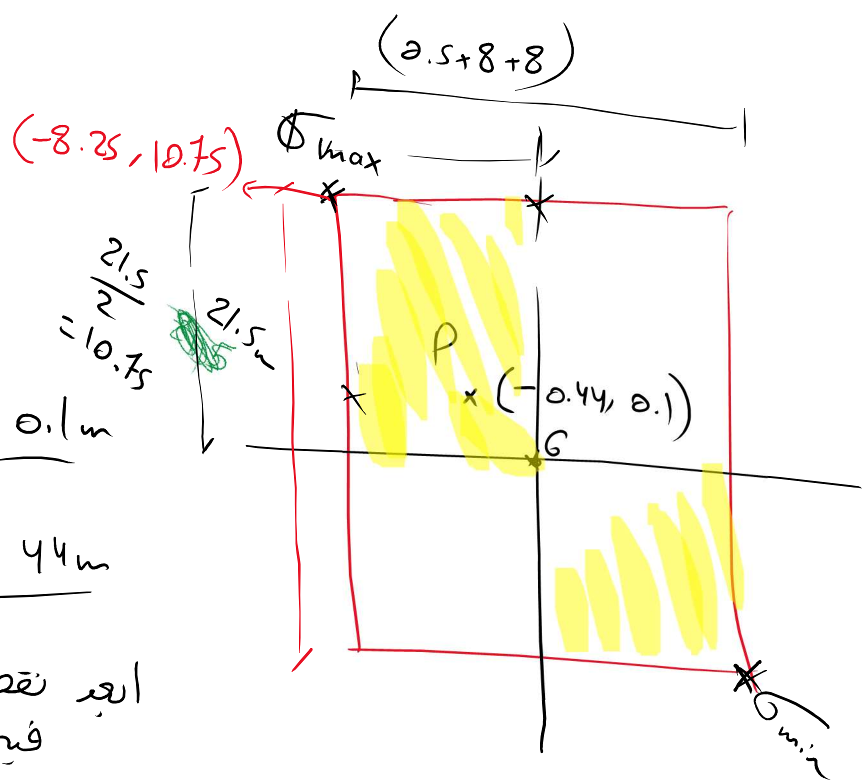
$$y_p = 10.6\ \text{m}$$

$$y_f = \frac{21}{2} = 10.5\ \text{m}$$

$$e_x = y_p - y_f = 10.6 - 10.5\text{m} = 0.1\ \text{m}$$

$$e_y = X_p - X_f = 7.56 - 8\text{m} = \bar{0}.44\ \text{m}$$

ابعد نقطه عن الحمل في الربع الذي يتواجد فيه الحمل



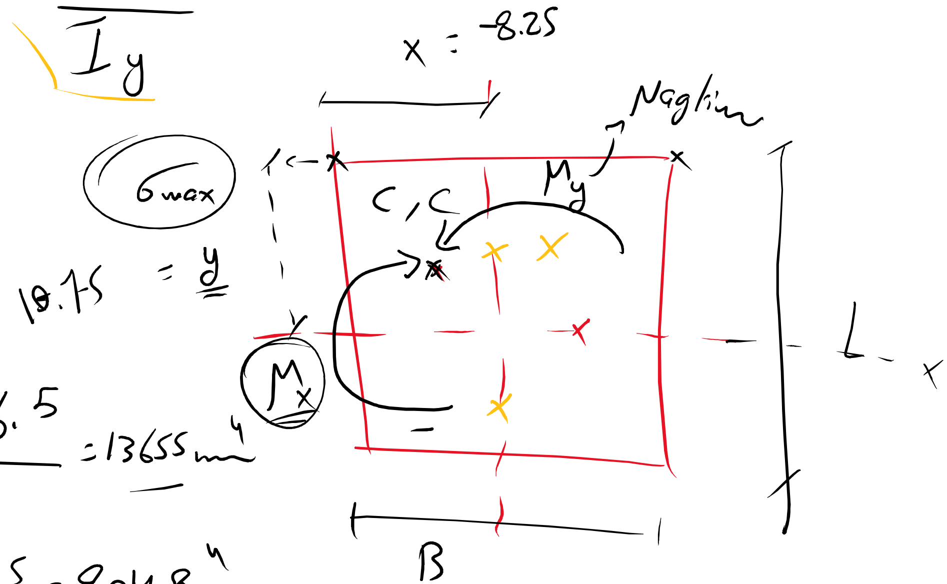
$$\sigma_{max} \leq q_{all} = 60\ kN/m^2$$

Servic

$$\sigma_{max} = \frac{P}{A} + \frac{M_x \times \overset{\underline{y}}{C_x}}{I_x} + \frac{M_y\ \overset{x}{C_y}}{I_y}$$

$$M_x = P_x e_x$$

$$M_y = P_x e_y$$



$$I_x = \frac{L^3 \times B}{12} = \frac{21.5^3 \times 16.5}{12} = 13655\ m^4$$

$$I_y = \frac{B^3 \times L}{12} = \frac{16.5^3 \times 12.5}{12} = 8048\ m^4$$

Stress

$$\sigma_{max} = \frac{11000}{355} + \frac{(11000 \times 0.1) \times 10.75}{13655} + \frac{(11000 \times \overset{e_y}{-0.44}) \times \overset{X\text{-coor.}}{-8.25}}{8048}$$

$$= 36.8\ kN/m^2 \ll q_{all} = 60\ kN/m^2 \quad \underline{ok}$$

thickness

using approximate method

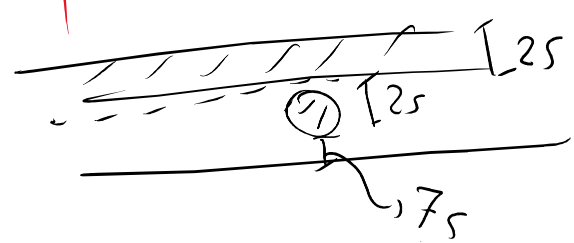
Column	P_u	d (mm)
Corner	$1.4 \times 450 = 630$	$20\sqrt{630} = 502$ mm
edge	$1.4 \times 1500 = 2100$ kN	$15\sqrt{2100} = 687$ mm Control
interior	$1.4 \times 1500 = 2100$	$10\sqrt{2100} = 458$ m

(moment from e → use P_u)

take $d = 700$ →

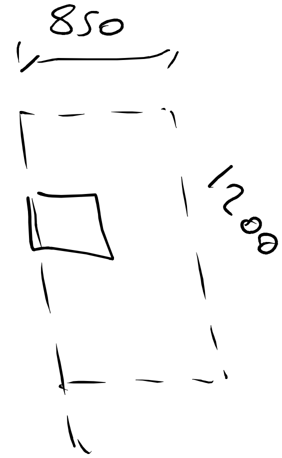
$H = 700 + 75 +$ distance to bar center (25mm)

$\boxed{H = 700 + 75 + 25 = 800\text{mm}}$



Check assumed Section H

→ edge Column



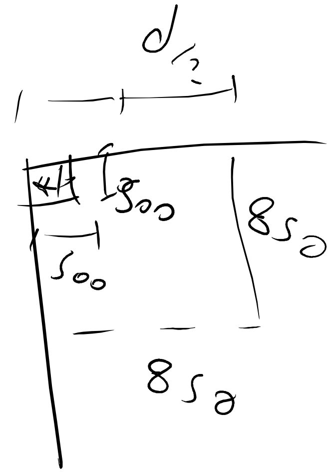
$$\phi V_c = 0.75 \times \frac{1}{3}\sqrt{20} \times \left(\frac{1200 + 2\times 850}{1000}\right)$$

$$= 2247 \text{ kN}$$

$$V_u = P_u - (\underbrace{\sigma}_{\text{non uniform}} \times \cancel{A})$$

$V_u = P_u = 2100$ KN $< \phi V_c$ ok

→ Corner Column



$$\phi V_c = 0.75 \times \frac{1}{3}\sqrt{20} \times \frac{\overset{b_o}{(1700)} \times \overset{d}{700}}{1000}$$

$= 1330$ kN $> P_u$ ok

→ check interior Colu

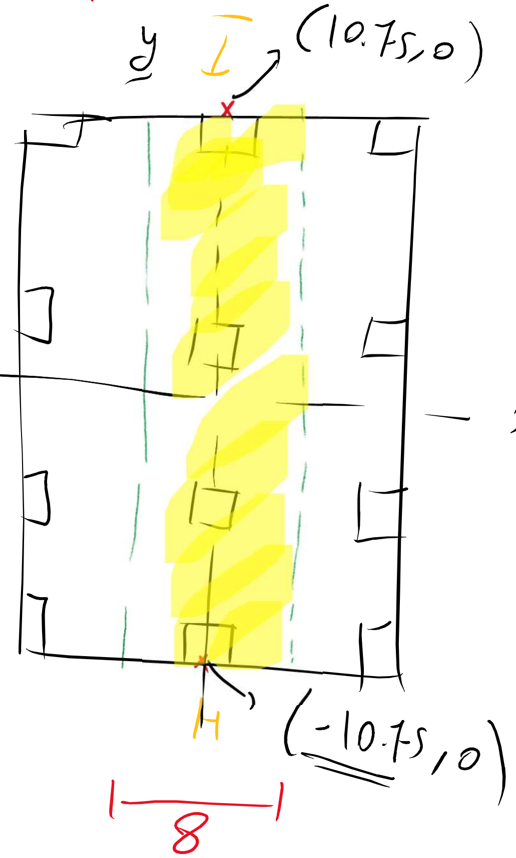
③ Draw SFD + BMD for Strip I–H

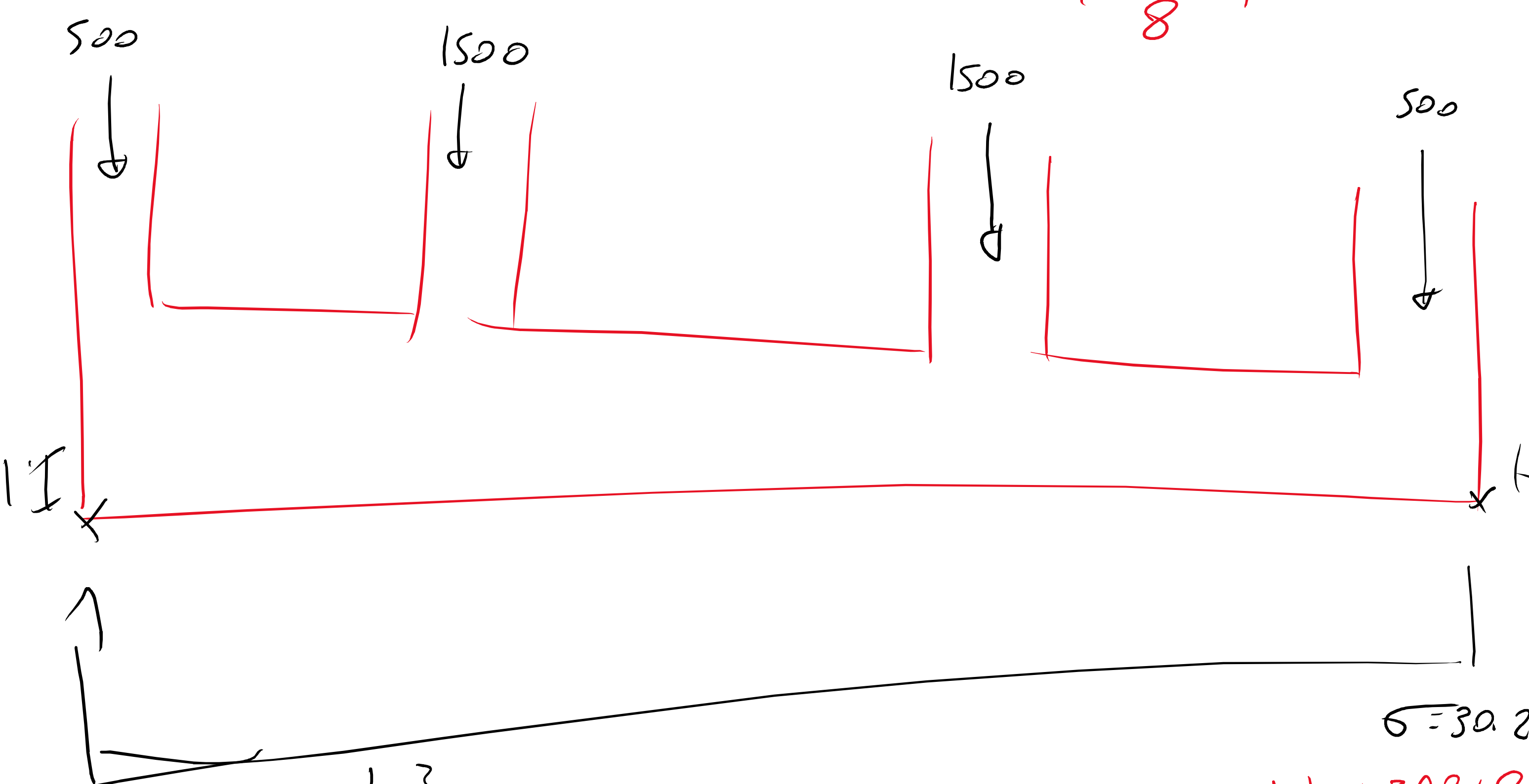
$$\sigma_{at\,I} = \frac{1100}{355} + \frac{(1100)\times 10.75}{13655} + \cancel{\frac{--\times 0}{I_y}}$$

$$= 31.8\ kN/m^2$$

$$\sigma_{at\,H} = \frac{1100}{355} + \frac{(1100)\times -10.75}{13655} + 0$$

$$= 30.2\ kN/m^2$$





$\sigma = 31.8\ kN/m^2$

$\sigma = 30.2\ kN/m^2$

$W_I = 31.8 \times 8m = 256.4\ kN/m$

$W_H = 30.2 \times 8$

$= 241.6\ kN/m^2$

→ Load at Strip = 500 + 1500 + 1500 + 500 = 4000 kN.

→ Total Reaction = $\left(\frac{256.4 + 241.6}{2}\right) \times 21.5 = \underline{5350}$ kN

<u>Differ</u>

5350 − 4000 = $\underline{\underline{1350}}$ kN

→ Reaction (modified) = $5350 - \frac{1350}{2} = 4675$ kN.

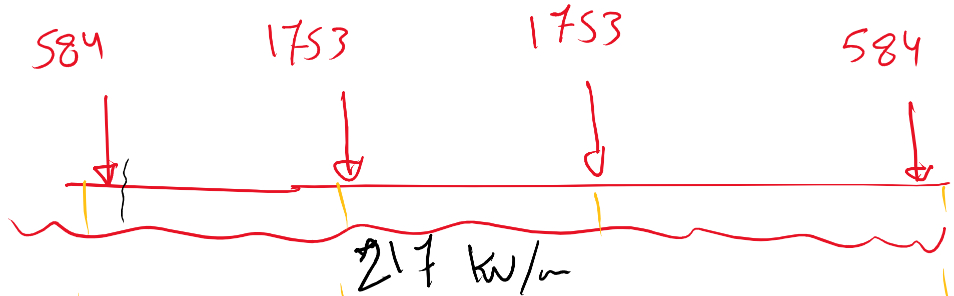
→ Load (modified)

$\frac{1350}{2} + 4000 = 4675$ kN (Total Load)

4000 → 4675

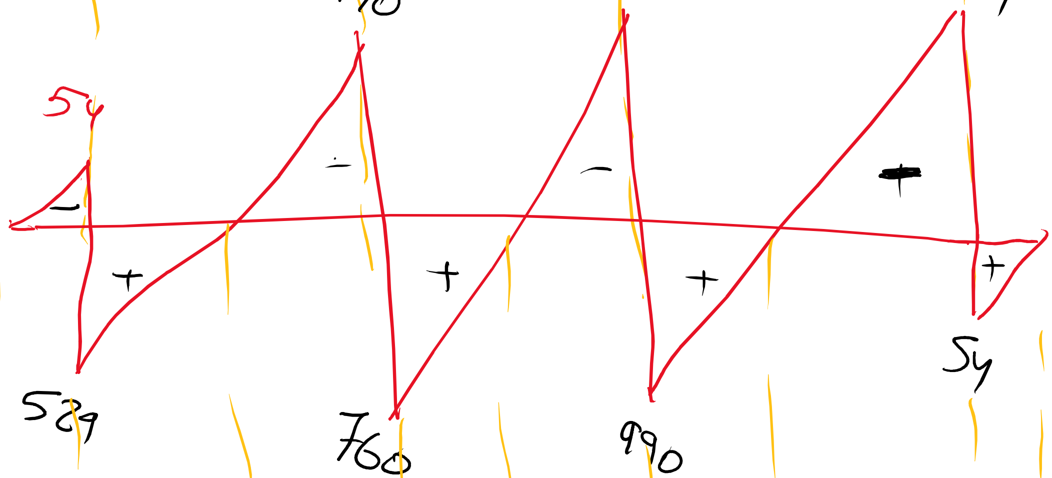
500 → $\underline{X_1}$ → $X_1 = 584$ kN

1500 → $\underline{X_2}$ → $X_2 = 1753$ kN

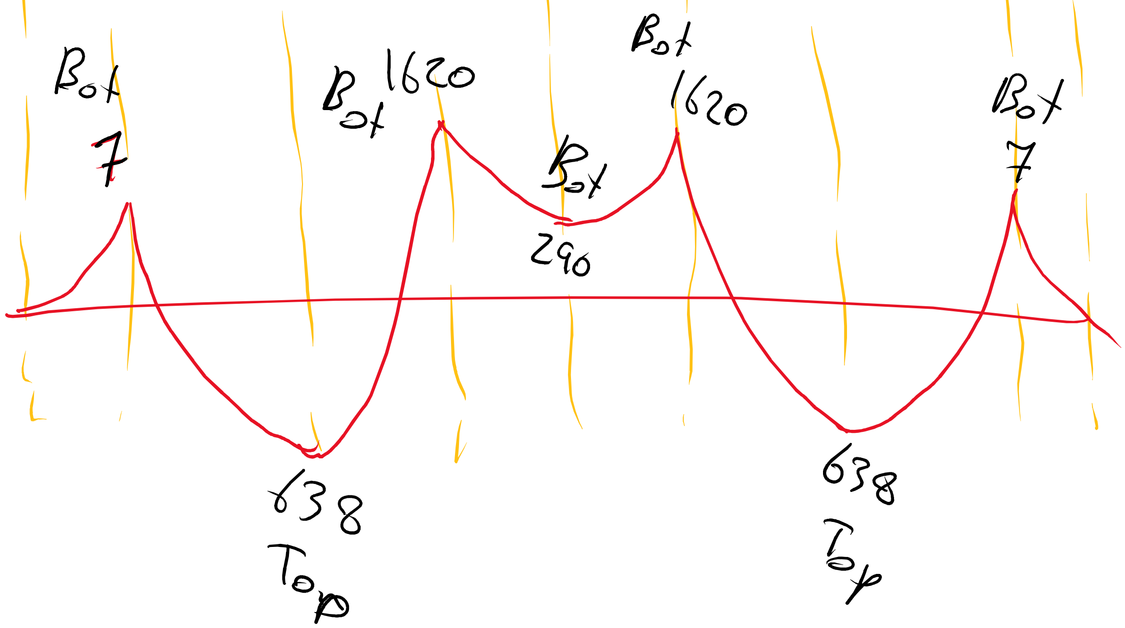


$$\text{Reaction} = \frac{4675}{21.5\,m} = 217\,kN/m$$

Service SFD →

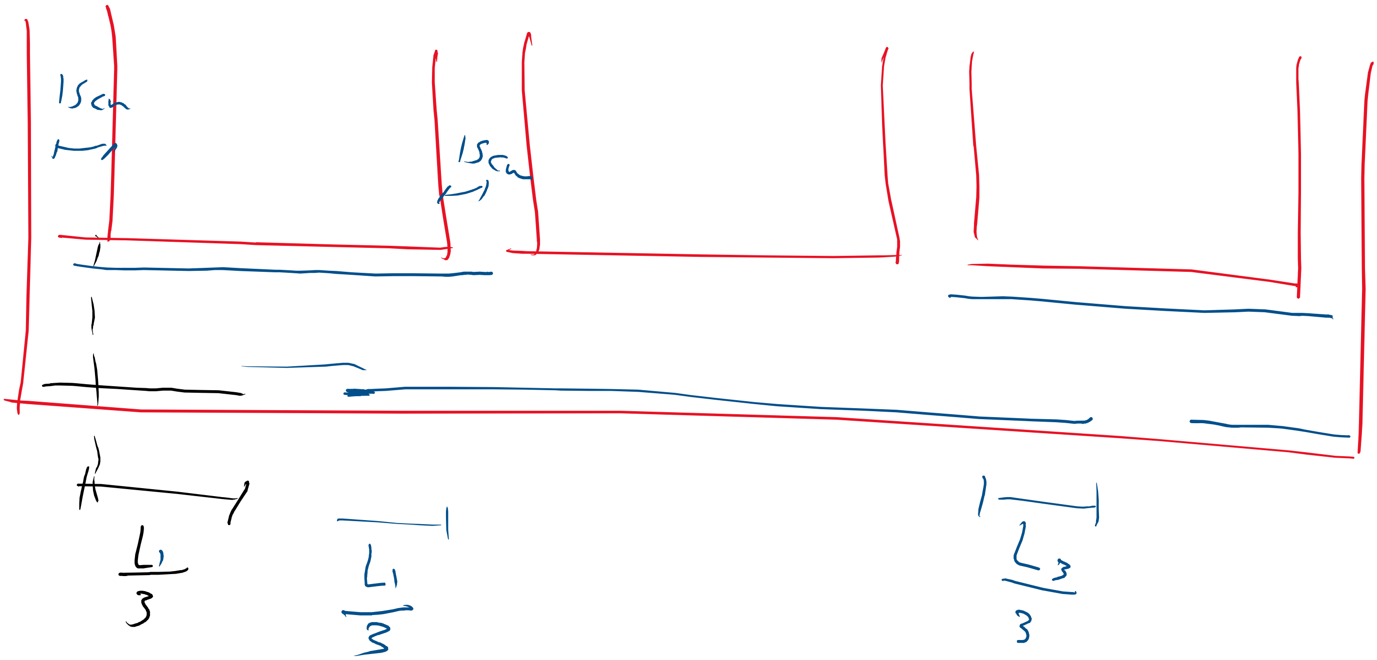


Service Load BMD



$V_u = 1.4 \times V_{service}$ → Check one way shear at Max $\underline{\underline{V_u}}$

$M_u = 1.4 \times M_{service}$ → find reinforcement



Use As shrinkage where no Reinforcement used.