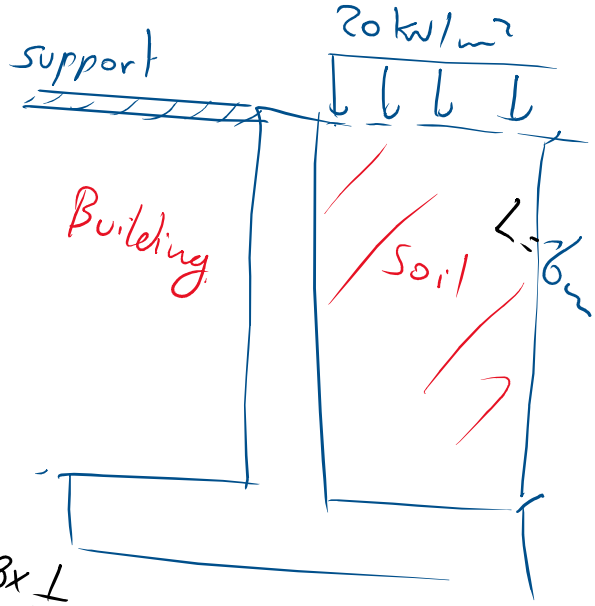
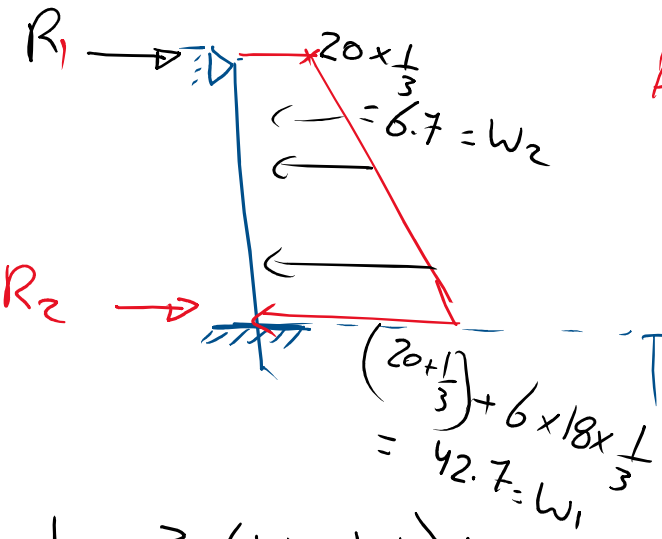
Example Basement Wall

Design the Basement Wall shown, assume $f'_c = 28$ MPa.

$f_y = 420$ MPa $\quad \gamma_s = 18$ kN/m^3

$q_{wall} = 240$ kN/m $\quad k_o = \frac{1}{3}$





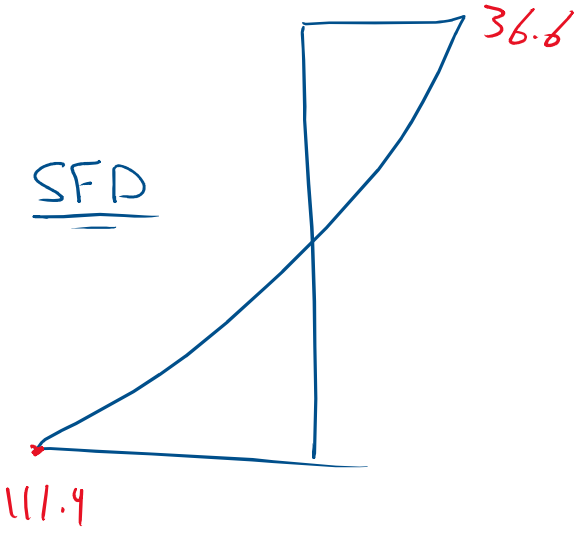
For 1 story.

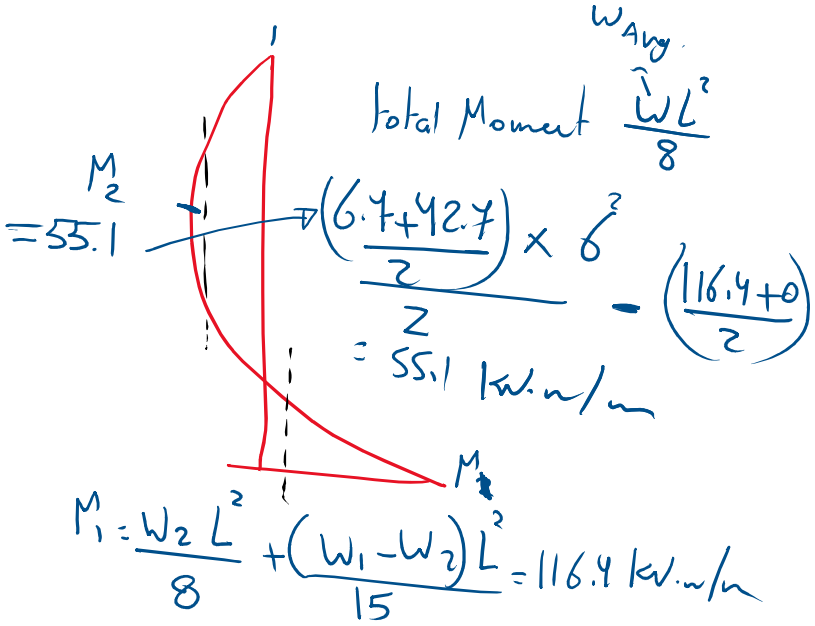
$$R_1 = 0.1 W_2 L + \frac{3}{8}(W_1 - W_2)L$$

$$R_1 = (42.7 - 6.7)\,0.1 \times 6 + 6.7 \times 6 \times \frac{3}{8} = 36.6 \text{ kN/m}$$

$$\Sigma F_y = 0 \rightarrow R_2 = \frac{42.7 + 6.7}{2} \times 6 - 36.6 = 111.4 \text{ kN/m}$$

SFD





$$M_1 = \frac{W_2 L^2}{8} + \frac{(W_1 - W_2)L^2}{15} = 116.4 \text{ kN.m/m}$$

$\Rightarrow \underbrace{V_u = P_u}_{\text{assume.}} = 111.4 \times \underline{\underline{1.6}}_{F.S} =$

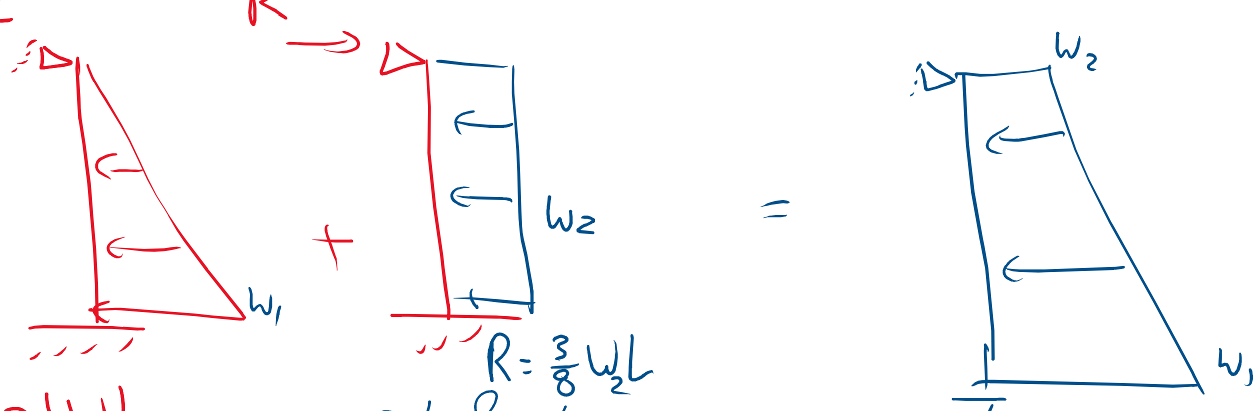
$\phi V_c = V_u$

$$0.75 \times (0.166)\sqrt{28} \times \frac{\overset{b}{1000} \times d}{1000} = \overset{V_u}{1.6 \times 111.4}$$

$d = 269$ mm $\rightarrow$ $h = 350$ mm

d 270 mm

*Notes



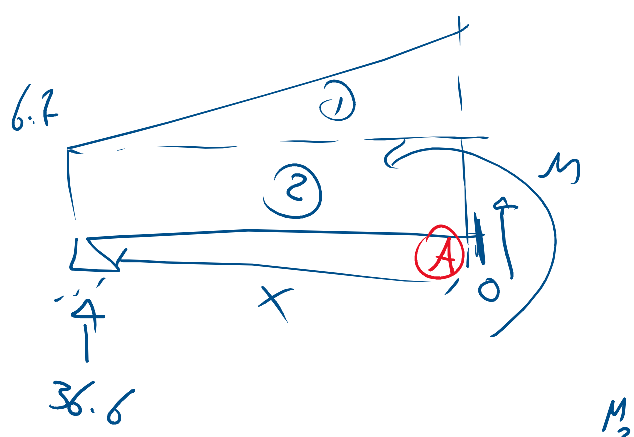
$R = 0.1 w L$ — no surcharge load

$R = \frac{3}{8} W_2 L$ — only surcharge load. Or liquid load.

$R = 0.1 w L + \frac{3}{8} W_2 L$, $w \to (w_1 - w_2)$

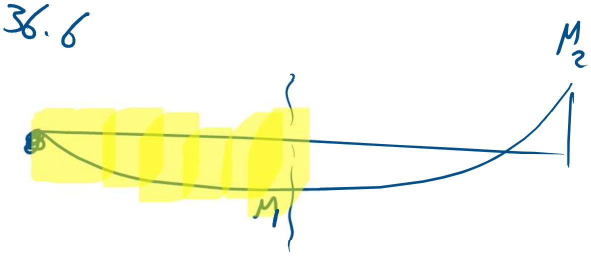
$\Sigma F_x = 0$

$$36.6 = \left(\frac{\left(\frac{42.7 - 6.7}{6}\right)x + 6.7}{2} + 6.7\right)x$$



$X = 2.55$

$\Sigma M_A = 0 \rightarrow \underline{\underline{M_1 = 55.1}}$



$$\frac{wL^2}{8} = M_1 + \left(\frac{M_2}{2}\right)$$

$$M_2 = 2\left(\frac{wL^2}{8} - M_1\right)$$

$M = 116.4$

$M_u = 1.6 \times 116.4 \Rightarrow 186.24 \text{ kN.m/m}$

$\rho = 7.21 \times 10^{-3} \rightarrow A_s = 1945 \text{ mm}^2 > A_{s\min} = 900 \text{ mm}^2/\text{m}$

$\hookrightarrow d = 270$ $\quad$ $\rightarrow$ use $8\phi 18/\text{m}$

$b = 1000$

$0.0033 \times 1000 \times 270 = 900$

$\rightarrow M_2 = 55.1$

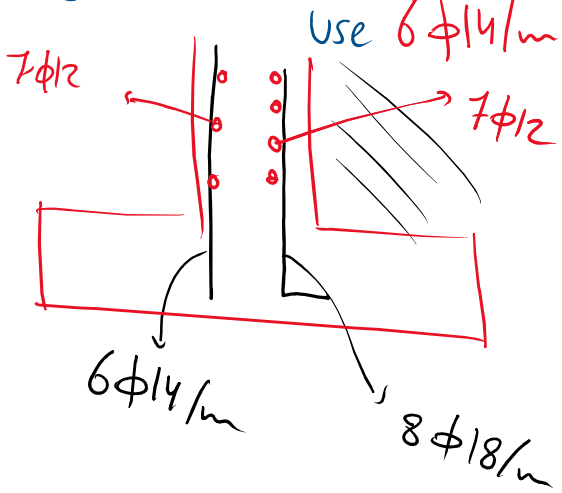
$M_u = 1.6 \times 55.1 = 89.1 \rightarrow A_s = \frac{89.1}{186.24} \times 1945 \rightarrow 920 \text{ mm}^2/\text{m} > A_{s\min}$ (ratio)

horizontal Steel

$A_{s\min} = 0.002 \times 350 \times 1000$

$= 700 \text{ mm}^2/\text{m}$

$\rightarrow 7\phi 12/\text{m}$

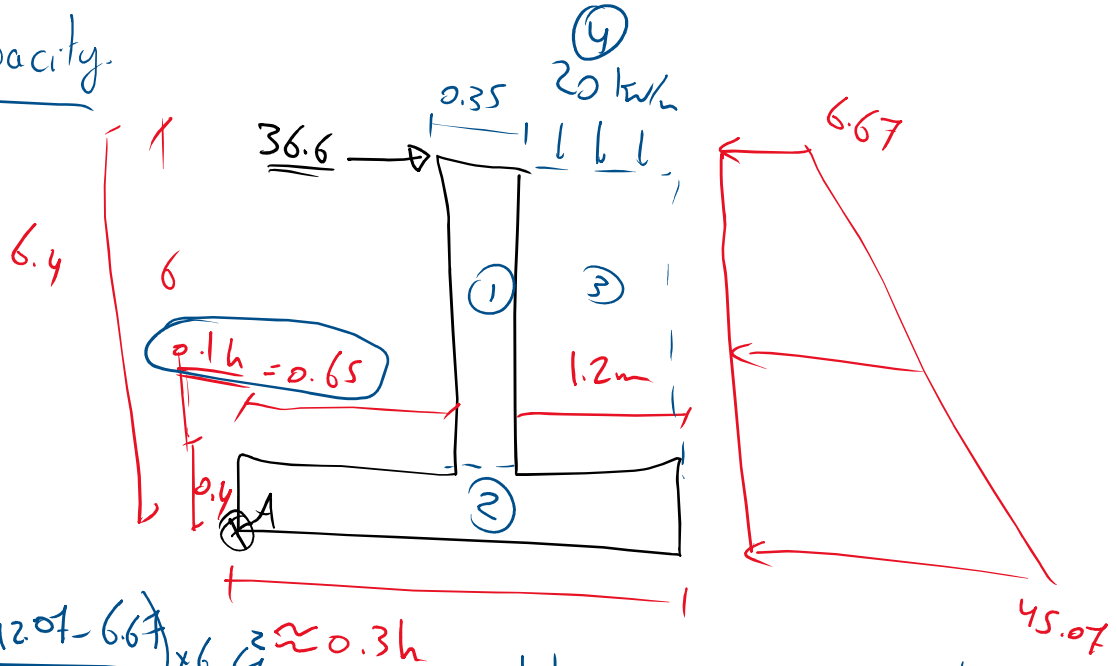


Stability Check

① O.T ✓

② Sliding ✓

③ Bearing Capacity.



$$M_{OT} = 6.67 \times \frac{6.4^2}{2} + \frac{(42.07 - 6.67)}{2} \times 6.67^2 \approx 0.3h$$

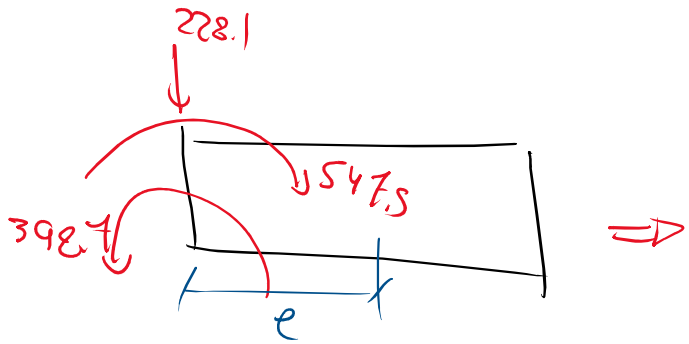
$$= 398.7 \text{ kN.m/m}$$

$$M_R = 313.3 + 6.4 \times 36.6$$

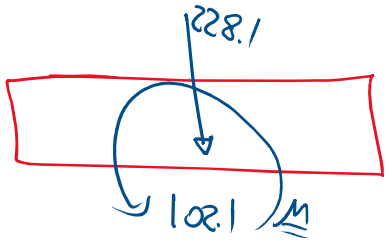
$$= 547.5 \text{ kN.m/m}$$

$$P_V = 228.1 \text{ kN.m}$$

	W	arm	Moment
①	52.5	0.825	43.3
②	129.6	1.6	207.4
③	22	1.1	24.2
④	24	1.6	38.4
	228.1		313.3



⇒

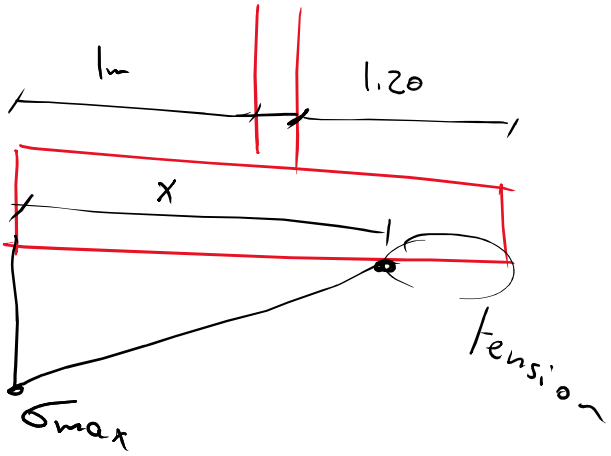


$$e = \frac{M}{P} = \frac{102.1}{228.1} = 0.448 > \frac{b}{6} = \frac{2.2}{6} = 0.36$$ Large Eccnt

$$X = \left(\frac{L}{2} - e\right) \times 3 = \left(\frac{2.2}{2} - 0.448\right) \times 3 = 1.96\,m$$

$$\sigma_{max} = \frac{P}{B \times L}\left(1 + \frac{6e}{L}\right)$$

$$\frac{228.1}{1 \times 2.2}\left(1 + \frac{6 \times 0.448}{2.2}\right) = 230.1\ kN/m^2$$

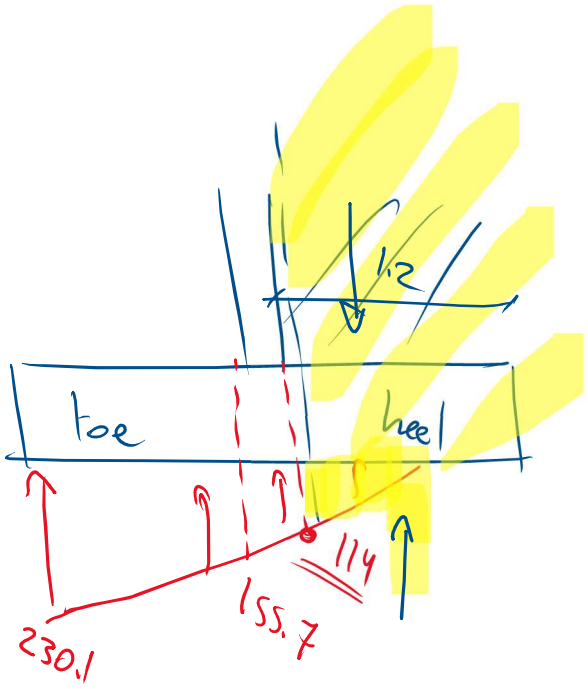


$\sigma_{max} < q_{all} = 240\ kN/m^2$ ok

Bearing Check ok

Heel Design

$$V_u = 1.6\left(128 \times 1.2\right) + \left(0.4 \times 25 \times 1.2\right) \times 1.2$$
$$- 114\,\frac{(1.96 - 1)}{2} \times 1.6$$
$$= 149.6\ kN/m$$



$$\phi V_c = 0.75\left(\frac{1}{6}\right)\sqrt{28} \times \frac{b}{1000} \times 320 = 211.7\ kN > V_u\ ok.$$

$$M_u = 1.6 \times 128 \times \frac{1.2^2}{2} + \left(0.4 \times 25 \times \frac{1.2^2}{2}\right) \times 1.2 - 114 \frac{(1.96-1)^2}{6} \times 1.6$$

$$= 114 \text{ kN.m/m}$$

$A_s = 1025 \text{ mm}^2/\text{m} > A_{s\,min} = 720 \text{ mm}^2/\text{m} \Rightarrow 7\phi 14/\text{m}$

Toe Design

$$V_u < P_u = 0.65 \times 1.6 \times \frac{(230 + 155.7)}{2} = 202.2 \text{ kN} < \phi V_c$$

$$M_u = \left(\frac{155.7(0.65)^2}{2} + (230.1 - 155.7)\frac{0.65}{2} \times \frac{2}{3} \times 0.65\right) 1.6$$

$$= 70.1 \text{ kN.m/m}$$

$A_s = 600 \text{ mm}^2/\text{m} < A_{s\,min} \Rightarrow$ use $A_{s\,min}$ $6\phi 12$.

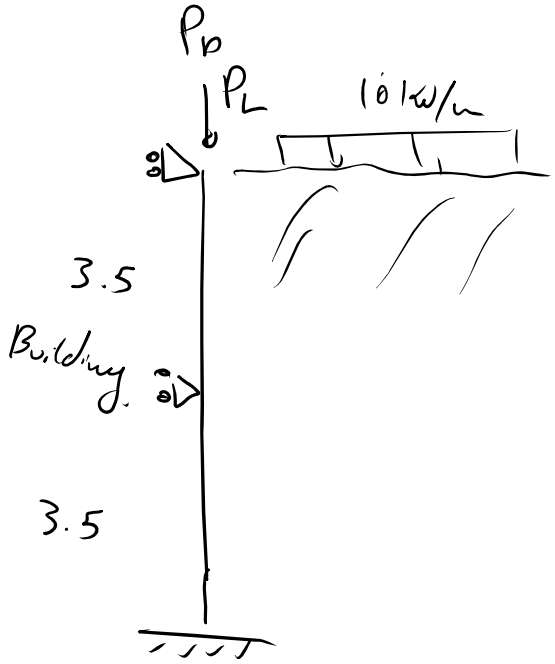
Basement Wall of Double Slab

Basement Wall of two floors is a part of building which consist of eight floors, tributaray from Slab is 3m (distance to adjucent beem is 6m), the load on Slab are $W_d = 10\ kN/m^2$, $W_L = 4\ kN/m^2$, $h = 3.5\ m$ height

$q_{wall} = 280\ kN/m^2$, Wall Top weight $= 22\ kN/m$ on each floor.

$\phi = 30°$, surchange live load $= 10\ kN/m$

$f'_c = 24\ MPa$, $\gamma_s = 20\ kN/m^3$



Line Load $= 8 \times 4 \times 3 = 96\ kN/m$

Dead Load/slab $= 8 \times 10 \times 3 = 240\ kN/m$

Dead Load/wall $= 8 \times 22 = 176\ kN/m$

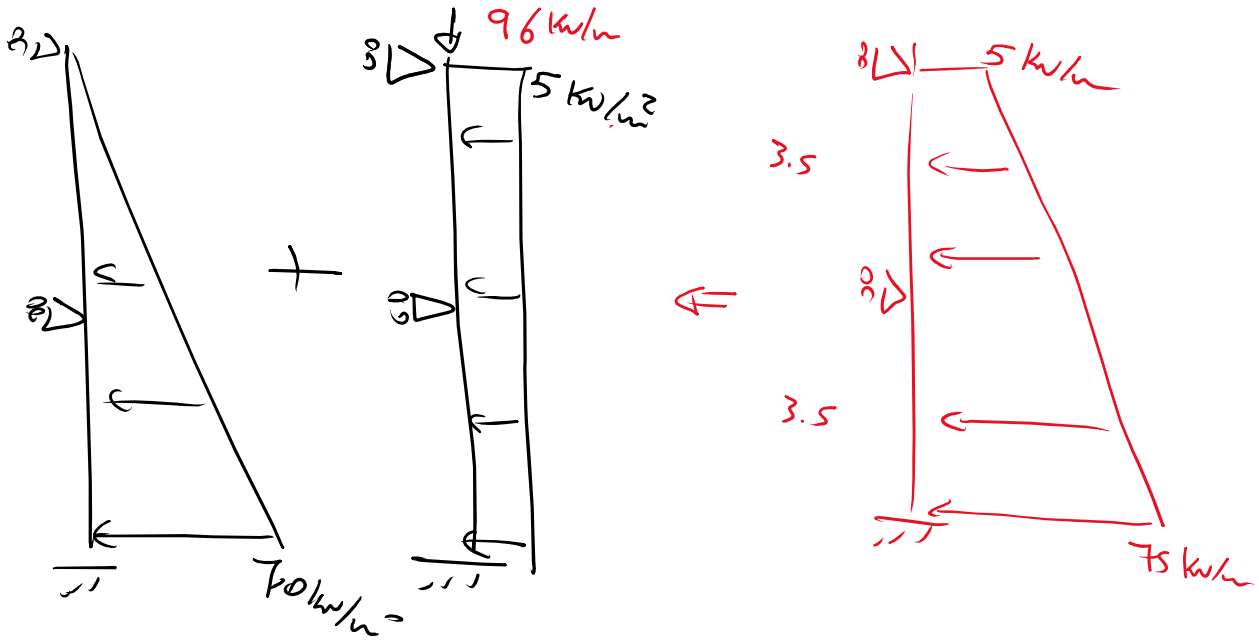
Total DL $= 416\ kN/m$

$K_o = 1 - \sin\phi$

$= 1 - \sin 30 = 0.5$

$q_1 = 0.5 \times 10 = 5\ kN/m$

$q_2 = q_1 + \gamma_o h K_o = 5 + 20 \times 7 \times \frac{1}{2} = 75\ kN/m^2$

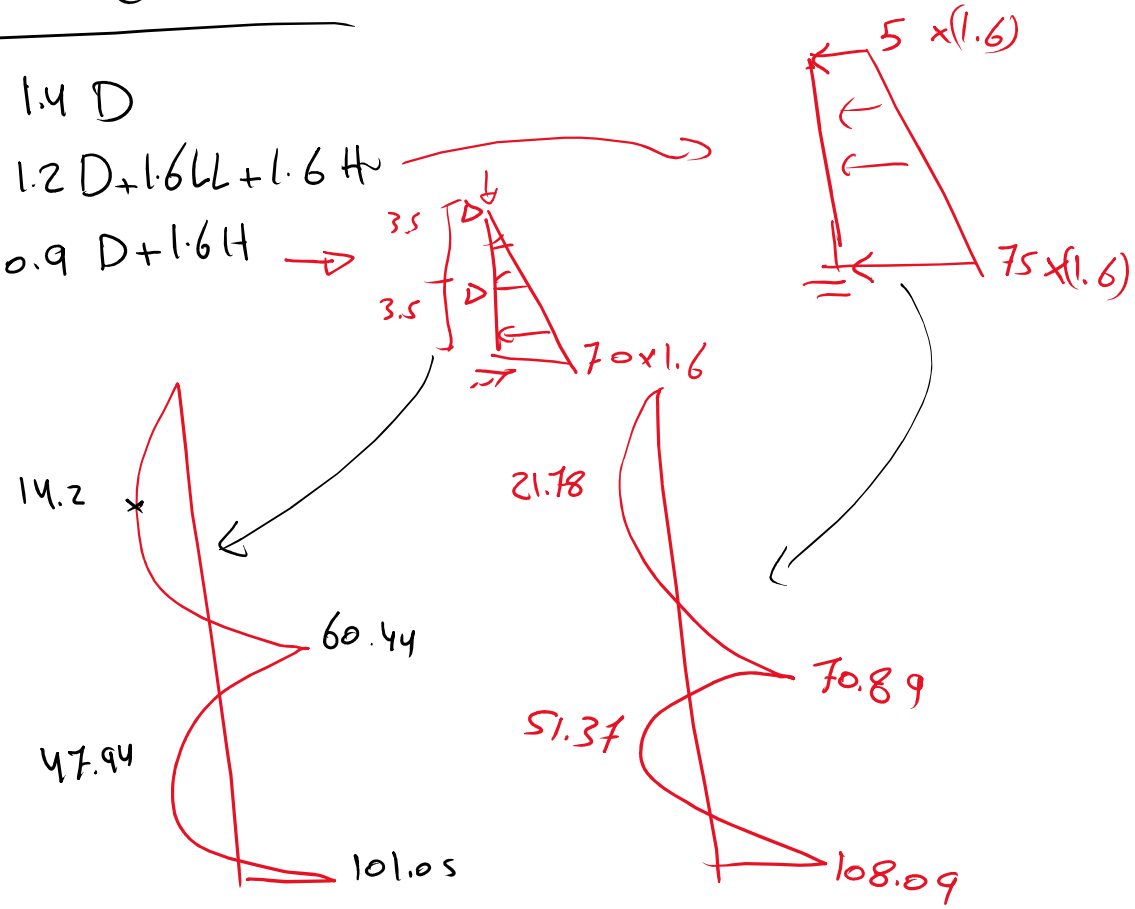


Load Combination

① 1.4 D

② 1.2 D + 1.6 LL + 1.6 H

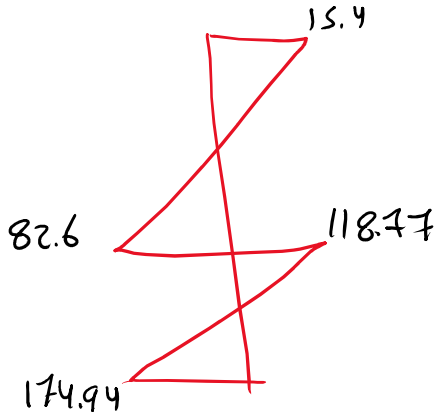
③ 0.9 D + 1.6 H



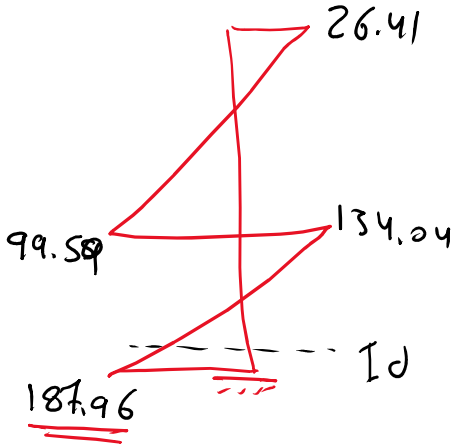
③ Comb

② Comb.

③ SFD



② SF

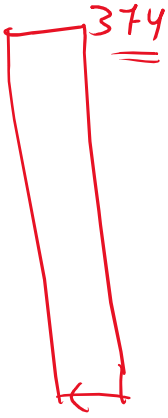


Axial load

Comb ③

0.9 x 416

+1.6 x 0



Comb ②

1.2 x 416 + 1.6 x 96

slab LL

Comb ①

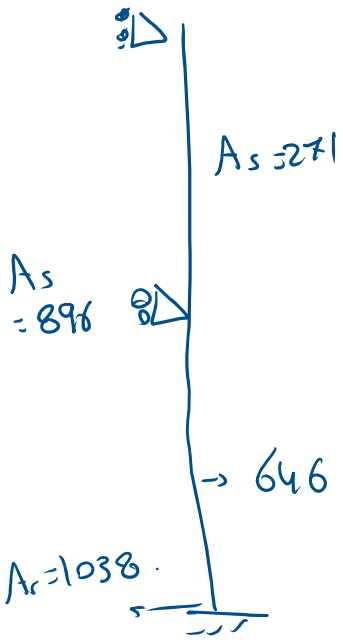
1.4 x 416

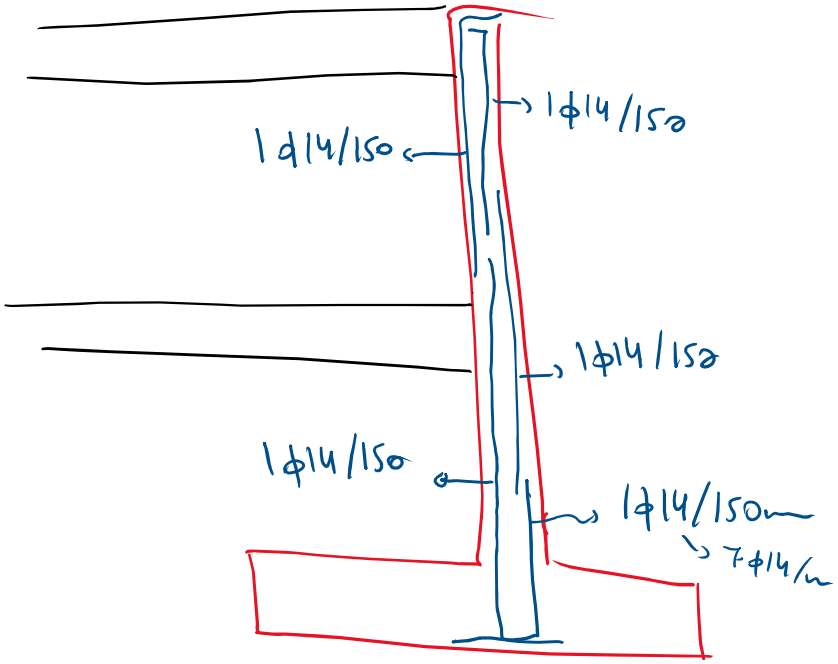
Check Shear / Wall thickness

For 350 wall

$$\phi V_c = 0.75 \times \frac{1}{6}\left(\sqrt{24} \times \frac{(1000) \times (290)}{1000}\right) = 177.6 \text{ kN}$$

$$V_u\Big|_d = 153.9 < \phi V_c \quad \text{ok.}$$


As =271
As
=898
→ 646
Ar=1038


1ϕ14/150
→ 1ϕ14/150
→ 1ϕ14/150
1ϕ14/150
→ 1ϕ14/150m
↘ 7ϕ14/m