LØSNINGSFORSLAG H18

Oppgave 1 - Jordskjelv, bære- og avstivningssystemer (5 %)

a) Hvilke parametere bestemmer størrelsene på jordskjelvkreftene?
    1. Geografi (byggeplassens lokasjon).
    2. Grunnforhold
    3. Byggets brukskategori
    4. Avstivningssystem og fundamentering
    5. Konstruksjonens masse (egenvekt) og nyttelaster.

b) Beskriv kort og presist begrepet "soft story".

    1. Stivhetsfordelingen vertikalt i bygget får en brå endring som gir konsentrasjon av ikke-elastiske deformasjoner. Dvs. at man får en eller flere svake etasjer som kan kunne kollapse ved påvirkning av horisontalkrefter. (Nøkkelord: Stivhetsfordeling/endring i stivhet).

c) Beskriv hovedforskjellen på en skive og en plate. Forklar kort hvorfor vi ønsker å bruke skivevirkning til avstivning. Bruk gjerne figurer.

    1. Plate: Flateelement som belastes tvers/normalt av planet, som kan bære last i en eller begge retninger.
    2. Skive: Flateelement som belastes i sitt eget plan.
    3. Man ønsker å nytte skivevirkning da flateelementet er desidert stivest og sterkest i planet. Ofte har man dekker som kan virke som skiver, slik at man kan fordele kreftene ut til yttervegg. Vegger benyttes også gjerne som avstivende elementer i stedet for vindkryss. (Nøkkelord: Stivhet, normalt på planet/i planet)

d) Forklart kort og presist hvorfor avstivning i montasjefasen er viktig.
    1. Avstiving i montasjefasen er viktig, fordi man har beregnet det ferdige bygget. Under montasje vil f.eks. avstivende elementer mangle, slik at forutsetningene for beregningene ikke lengre er gjeldende. Dette kan f.eks. være manglende dekker for å hindre vipping av bjelker, manglende dekker/bjelker inn på en søyle, som gir en lengre knekklengde.

Oppgave 2

a)

Lillehammer kommune tab. NA. 4.1 (901)

$s_{k,0} = 4.5\ kN/m^2$ $H = 350\ m$

$H_0 = 250\ m$ $\Delta s = 1.0\ kN/m^2$

Karakteristisk snølast på mark

$s_k = s_{k,0} + h\,\Delta s_k$ NA. 4.1

$h = \frac{(H - H_0)}{100} = \frac{(350 - 250)\,m}{100} = \underline{1}$

$s_k = 4.5\ kN/m^2 + 1 \cdot 1.0\ kN/m^2 = 5.5\ kN/m^2$

Snølast på flatt tak

$s = \mu_1 \cdot C_e \cdot C_t \cdot s_k$ 5.2(3) (5.1)

$C_t = 1$ $C_e = 1$ (tab. 5.1)

$\mu_1 = 0.8$ (Tab. 5.2)

$s = 0.8 \cdot 1 \cdot 1 \cdot 5.5\,kN/m^2 = \underline{4.4\ kN/m^2}$

b)

Fra flatelast til linjelast

$G_{takk} = 0.6\ kN/m^2 \cdot 5\ m = 3.0\ kN/m$

$G_{kjelle} = 1.0\ kN/m$

$Q_{nytte} = 1.0\ kN/m^2 \cdot 5\ m = 5.0\ kN/m$

$Q_{snø} = 4.4\ kN/m^2 \cdot 5\ m = 22\ kN/m$ ← Dominerende nyttelast.

6.10 a)

$$q_{Ed} = \gamma_G \cdot G_k + \gamma_{Q,1} \psi_{0,1} Q_k + \sum \gamma_{Q,i} \psi_{0,i} Q_{k,i}$$

$$= 1.35(3,0\ kN/m + 1.0\ kN/m) + (1.5 \cdot 0,7 \cdot 5.0\ kN/m) +$$

$$(1.5 \cdot 0,7 \cdot 22\ kN/m^2) = \underline{33.75\ kN/m}$$

6.10b)

$$q_{Ed} = \sum \gamma_G \cdot G_k + \gamma_{Q,1} \cdot Q_{k,1} + \sum \gamma_{Q,i} \cdot \psi_{0,i} Q_{k,i}$$

$$= 0.89 \cdot 1.35(3.0\ kN/m + 1,0\ kN/m) + 1.5 \cdot 22\ kN/m +$$

$$1.5 \cdot 0.7 \cdot 5\ kN/m = \underline{43.05\ kN/m}$$

6.10b) er dim. lasthombinasjon.

c)

Utvendig vindtrykk på flate:

$$w_e = q_p(z_e) \cdot c_{pe} \qquad (5.1)$$

$$v_{b,0} = 22 \text{ m/s} \qquad (\text{tab. NA.4(901.1)})$$

Benytter kurvediagram a) for 22 m/s og kurve for terrengkategori II.

$z_e = 12$ m.

$q_{p0}(12\text{ m}) = 750 \text{ N/m}^2 = 0.75 \text{ kN/m}^2$

$c_{pe\,10}$:

Sone D: $+0.8$ $\quad h/d = \frac{12}{24} = 0.6 \Rightarrow 1$

Sone E: -0.5 $\quad$ (tabell 7.1)

$w_{e(D)} = 0.75 \text{ kN/m}^2 \cdot +0.8 = +0.6 \text{ kN/m}^2$ (trykk)

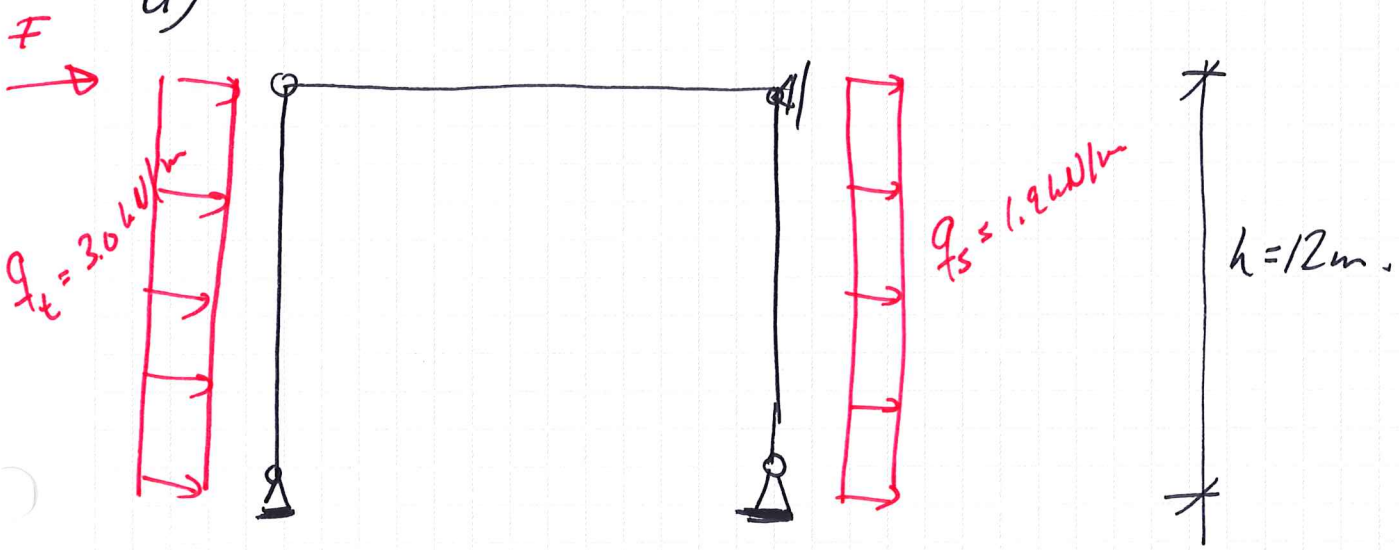
$w_{e(E)} = 0.75 \text{ kN/m}^2 \cdot -0.5 = -0.375 \text{ kN/m}^2$ (~~SUG~~ Sug).

Rammeavstand 5 m:

Sone D = $0.6 \text{ kN/m}^2 \cdot 5\text{ m} = 3.0 \text{ kN/m}$

Sone E = $0.375 \text{ kN/m}^2 \cdot 5\text{ m} = 1.9 \text{ kN/m}$

d)



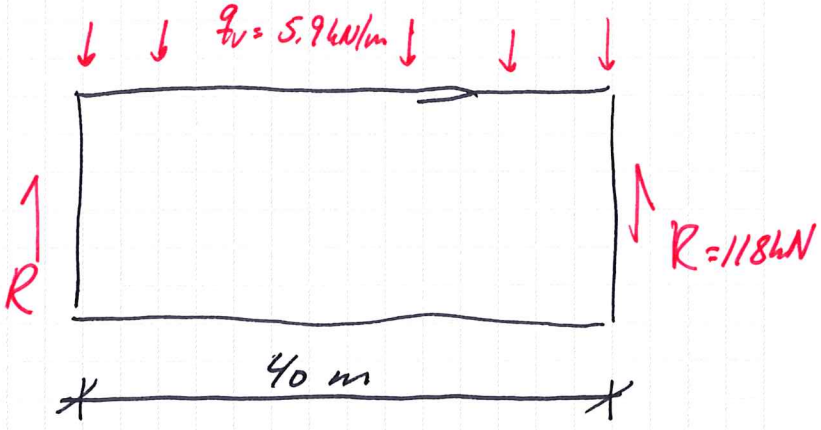
$$F = (q_t + q_s) \cdot \frac{h}{2} = (3.0\,kN/m + 1.9\,kN/m)\,\frac{12m}{2}$$

$$= \underline{29.4\,kN}$$

Fordeler lasten på rammeavstanden 5 m.

$$q_v = \frac{29.4\,kN}{5m}$$

$$q_v = \underline{5.9\,kN/m}$$



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

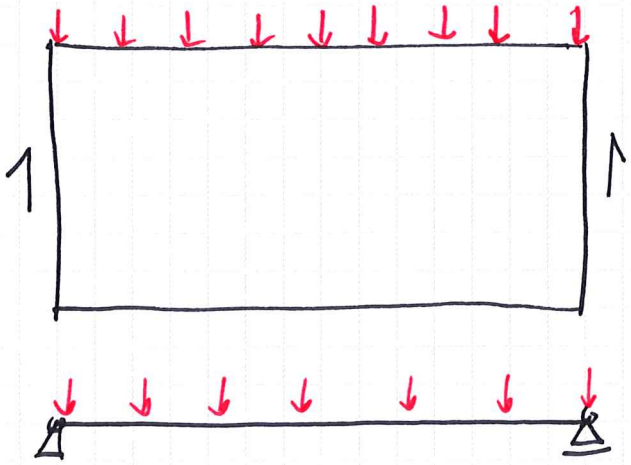
$$= \frac{5.9\,kN/m \cdot 40m}{2} = \underline{\underline{118\,kN}}$$

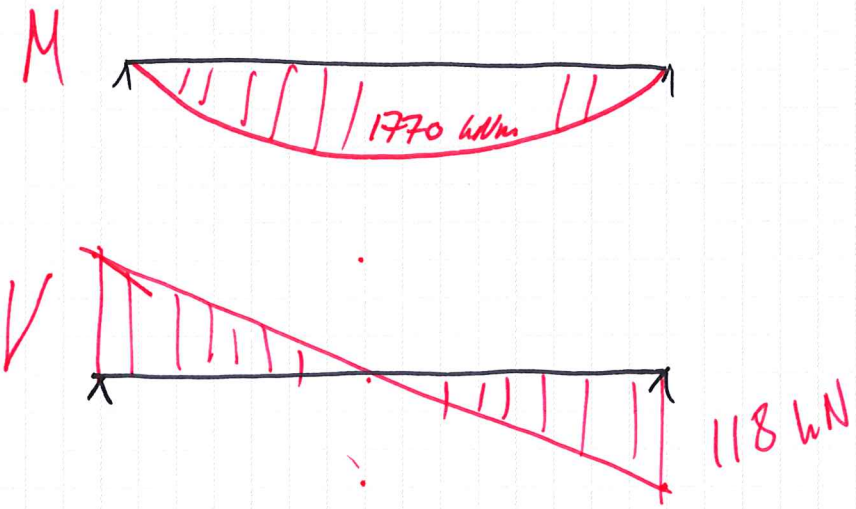
e)

$$M_{max} = \frac{q_{Ed} \cdot l^2}{8} \qquad q_{Ed} = q_v \cdot \gamma_Q =$$

$$M_{max} = \frac{\gamma_Q \cdot q_v \cdot l^2}{8} = \frac{1.5 \cdot 5.9\,kN/m \cdot 40^2\,m}{8}$$

$$M_{max} = 1770\ kNm.$$



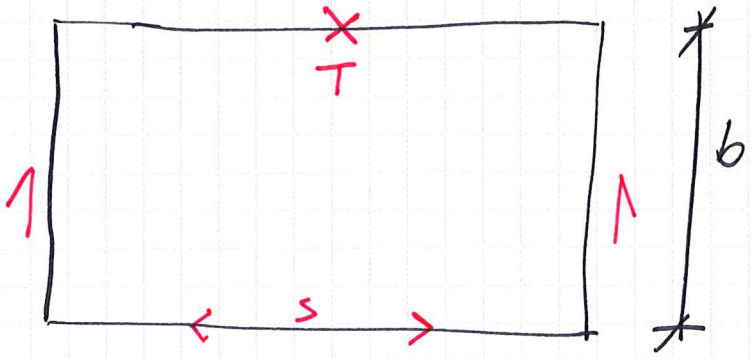


f)

$$s_{max} = \frac{M_{max}}{b}$$

$$s_{max} = \frac{1770\ kNm}{20\ m}$$

$$s_{max} = \underline{\underline{88.5\ kN}}$$



g)

$q_{p0}(z_e)$ fra oppgave c) gir $q_{p0}(12) = 0.75 kN/m^2$

c_{pe} for flatt tak

$c_{pe,1} = \div 2.5$ (tabell 7.2)

$$w_{e(F)} = q_{p0}(z_e) \cdot c_{pe}$$

$$= 0.75\ kN/m^2 \cdot \div 2.5 = \underline{\underline{\div 1.875\ kN/m^2}}\ (sug)$$

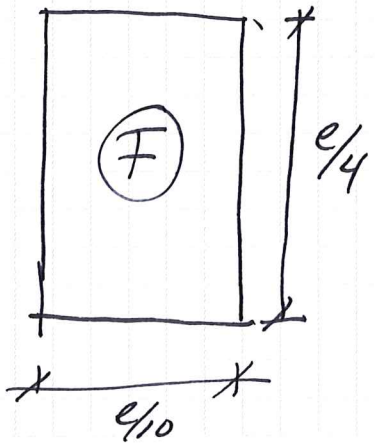
Sone F

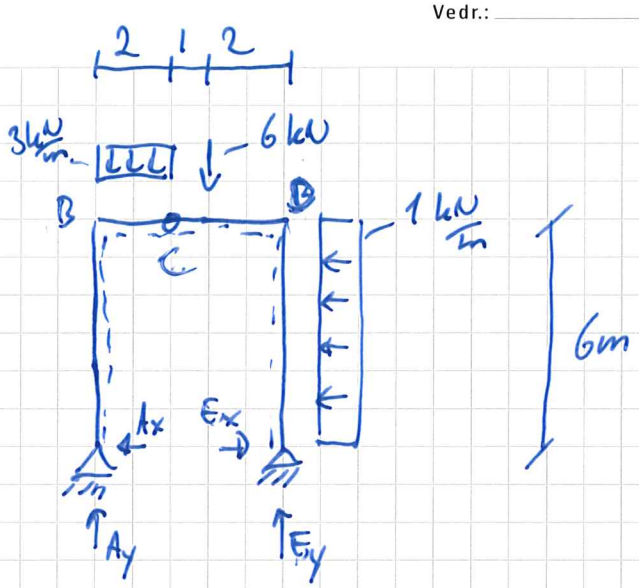
$$e = \min \begin{cases} 2 \cdot h = 2 \cdot 12m = 24m \\ b = 40m \end{cases} \} = 24m$$

$e/10 = 24/10 = 2.4\ m$

$e/4 = 24/4 = 6\ m$

$A_F = 6 \cdot 2.4\ m = \underline{\underline{14.4\ m^2}}$





4 opplagerbetingelser

3+1 lysning

$\overset{+}{\rightarrow}\ \Sigma F_x = 0 \Rightarrow -A_x + E_x - 6\cdot 1 \Rightarrow A_x = E_x - 6\,kN$

$+\uparrow\ \Sigma F_y = 0 \Rightarrow A_y + E_y - 2\cdot 3 - 6 \Rightarrow A_y = 12\,kN - E_y$

$+\circlearrowleft_{\text{om A}}\ \Sigma M = 0 \Rightarrow -5E_y + 1\cdot 6 + 3\cdot 6 - 3\cdot 6$

$\Rightarrow 5E_y = 6\,kNm \Rightarrow E_y = \frac{6\,kN}{5} = 1{,}2\,kN$

$\Rightarrow A_y = 12\,kN - \frac{6}{5}\,kN = \frac{54}{5}\,kN = 10{,}8\,kN$

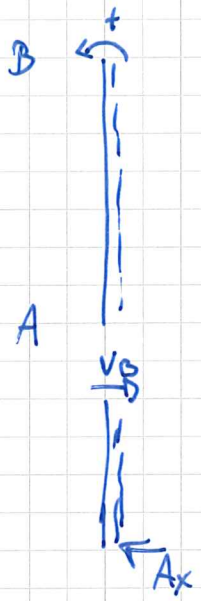
$+\circlearrowleft_{\text{C om}}\ \Sigma M = 0 \Rightarrow 2A_y + 6A_x - 1\cdot 6 = 0$

(venstre side)

$6A_x = 6 - 2\cdot 10{,}8 = -15{,}6$

$A_x = -2{,}6$

$\Rightarrow E_x = -2{,}6 + 6 = 3{,}4\,kN$

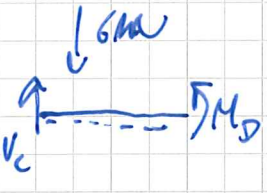


$\curvearrowleft^{+} \sum M_{om B} = 0 \Rightarrow M_B - 6A_x = 0 \Rightarrow M_B = 6A_x = 6 \cdot -2{,}6 = -15{,}6$

$V_B = A_x = -2{,}6$

$\sum F_y = 0 \Rightarrow -V_C + A_y - 6kN \Rightarrow V_C = A_y - 6kN = 4{,}8kN$

$M_C = 0$



$+\circlearrowleft \sum M_{om D} = 0 \quad -V_C \cdot 3 + 2 \cdot 6 + M_D$

$\Rightarrow M_D = 3 \cdot 4{,}8 - 12 = 2{,}4 \; kNm$

$+\uparrow \sum F_y = 0 \quad V_C - 6kN - V_D \Rightarrow V_D = V_C - 6 = -1{,}2kN$

Multiconsult

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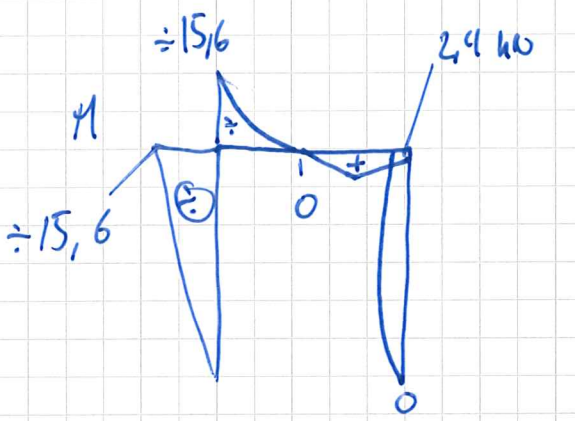
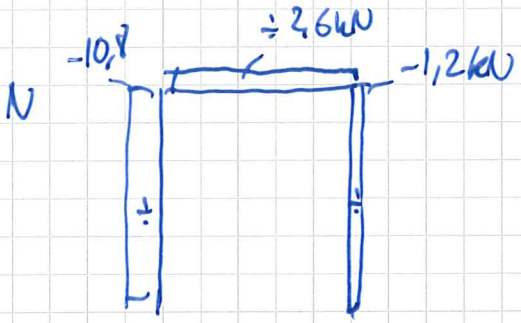
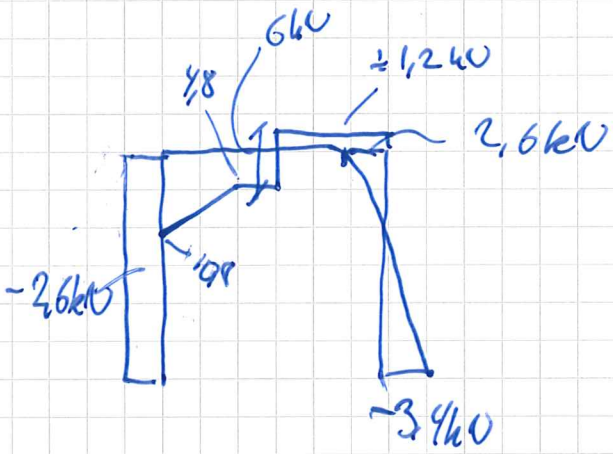


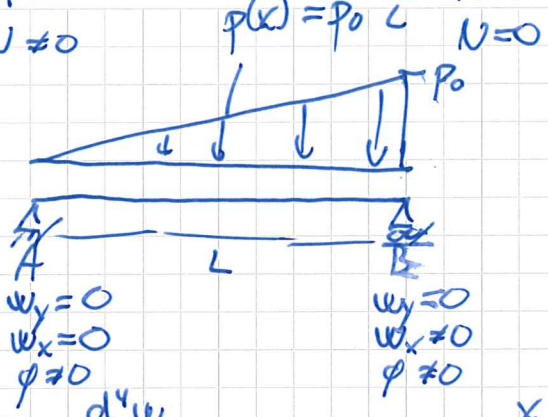




20 min

$V \neq 0$
$M = 0$
$N \neq 0$

$N \neq 0$
$M = 0$
$N = 0$



Bernulis hjelke
Linær elastisk

$$EI \frac{d^4w}{dx^4} = p(x) = p_0 \frac{x}{L}$$

$$EI \frac{d^3w}{dx^3} = \frac{1}{2}\frac{p_0}{L}x^2 + C_1 = -V(x)$$

$$EI \frac{d^2w}{dx^2} = \frac{1}{6}\frac{p_0}{L}x^3 + C_1 x + C_2 = -M(x)$$

$$EI \frac{dw}{dx} = \frac{1}{24}\frac{p_0}{L}x^4 + \frac{1}{2}C_1 x^2 + C_2 x + C_3 = EI\,\varphi_y$$

$$EI\, w = \frac{1}{120}\frac{p_0}{L}x^5 + \frac{1}{6}C_1 x^3 + \frac{1}{2}C_2 x^2 + C_3 x + C_4$$

$w(0) = 0 \Rightarrow C_4 = 0$

$M(0) = 0 \Rightarrow C_2 = 0$

$M(L) = 0 \Rightarrow \frac{1}{6}\frac{p_0}{L}L^3 + C_1 L + 0 = 0$

$\Rightarrow C_1 = -\frac{1}{6}p_0 L$

$w(L) = 0 \Rightarrow \frac{1}{120}\frac{p_0}{L}L^5 - \frac{1}{36}p_0 L L^3 + 0 + C_3 L + 0 = 0$

$\Rightarrow \frac{1}{120}p_0 L^4 - \frac{1}{36}p_0 L^4 = -C_3 L$

$\Rightarrow C_3 = -\left(\frac{1}{120} - \frac{1}{36}\right)p_0 L^3$

$= -\frac{36-120}{4320}p_0 L^3 = \frac{84}{4320}p_0 L^3$

$= \frac{7}{360}p_0 L^3$

$$w_y(x) = \frac{1}{120}\frac{p_0}{L}x^5 - \frac{1}{36}p_0 L x^3 + \frac{7}{360}p_0 L^3 x$$

$$\varphi_y(x) = \frac{1}{EI}\left(\frac{1}{24}\frac{p_0}{L}x^4 - \frac{1}{12}p_0 L x^2 + \frac{7}{360}p_0 L^3\right)$$

$$\varphi_y(0) = \frac{1}{EI}\left(0 - 0 + \frac{7}{360}p_0 L^3\right)$$

$$= \frac{7}{360}\frac{p_0 L^3}{EI}$$

$$M(x) = -\frac{1}{6}\frac{p_0}{L}x^3 + \frac{1}{6}p_0 L x + 0 = \frac{p_0 x}{6}\left(L - \frac{x^2}{L}\right)$$

$$\max\ V(x) = 0 = -\frac{1}{2}\frac{p_0}{L}x^2 + \frac{1}{6}p_0 L = \frac{p_0}{2}\left(\frac{L}{3} - \frac{x^2}{L}\right)$$

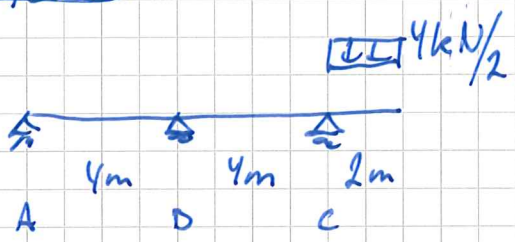
$$\Rightarrow x^2 = \frac{1}{6}p_0 L \cdot 2\frac{L}{p_0} = \frac{1}{3}L^2$$

$$x = \frac{1}{\sqrt{3}}L$$

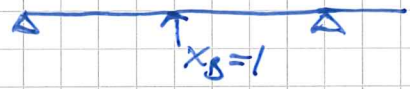
Kraftmetoden

Oppløsningsligningen 4

Ligning 3



SBG:



$\curvearrowright \Sigma M_A = 0 \Rightarrow 9m \cdot 2m \cdot 4kN/m - 8m \cdot C_y = 0$

$\Rightarrow C_y = 9kN$

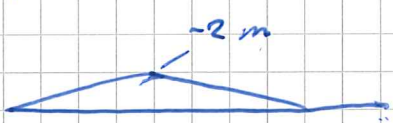
$A_y = \frac{X_B}{2}$ $C_y = \frac{X_B}{2}$

$\Sigma F_y = 0 \Rightarrow A_y + C_y - 2m \cdot 4kN/m = 0$

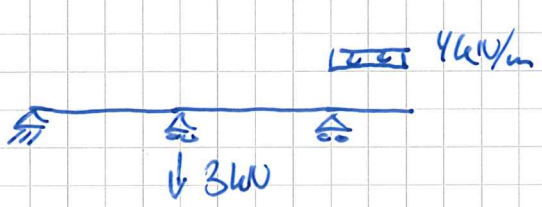
$\Rightarrow A_y = -1kN$

$M_0(x)$

$M_V(x)$



$$X_B = -\frac{\delta_{B0}}{\delta_{BB}} = -\frac{\int M_0 M_V \, dx}{\int M_V^2 \, dx} = \frac{\frac{1}{4}(-8)\cdot(-2)\cdot 8m}{\frac{1}{3}(-2)^2 \cdot 8m} = -3kN$$

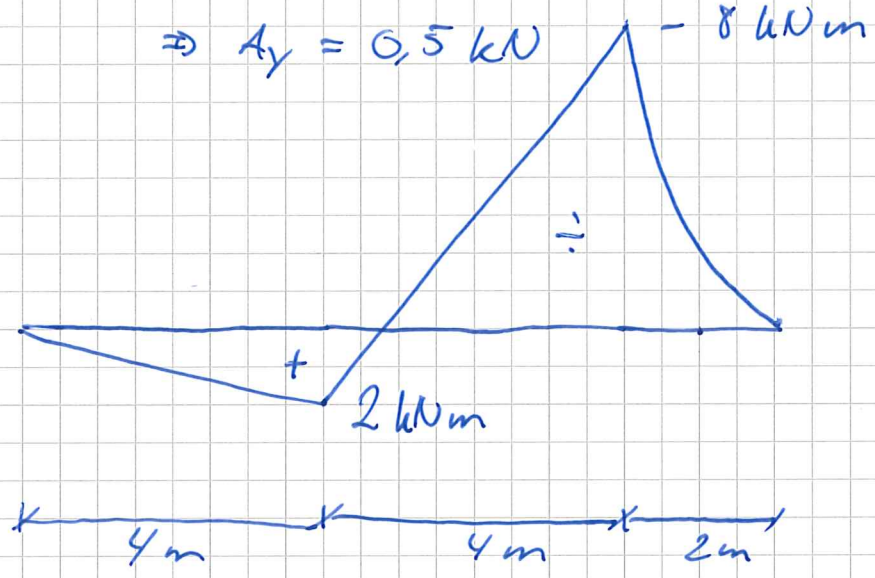


$+\circlearrowleft \quad \Sigma M = 0 \Rightarrow 4m \cdot 3kN + 9m \cdot 2m \cdot 4kN/m - 8m \cdot C_y$

$\Rightarrow C_y = 10{,}5\,kN$

$\Sigma F_y = 0 \Rightarrow A_y - 3kN + 10{,}5kN - 8kN = 0$

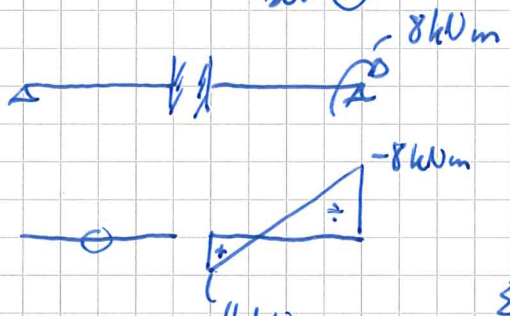
$\Rightarrow A_y = 0{,}5\,kN$

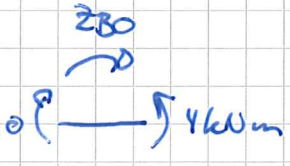


Forskyvningsmetoden

Ytre last

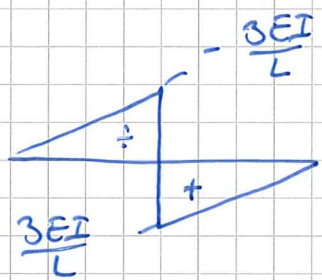
Ball (20)

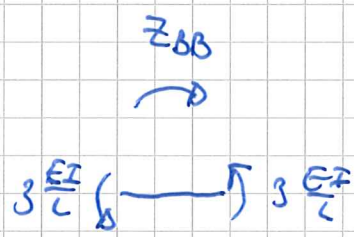




$$\Sigma M = 0 = z_{B0} - 4\,kNm \Rightarrow z_{B0} = 4\,kNm$$

Ball (13) $\gamma_B = 1$





$$\Sigma M = 0 = z_{BB} - (3+3)\frac{EI}{L} \Rightarrow z_{BB} = 6\frac{EI}{L}$$

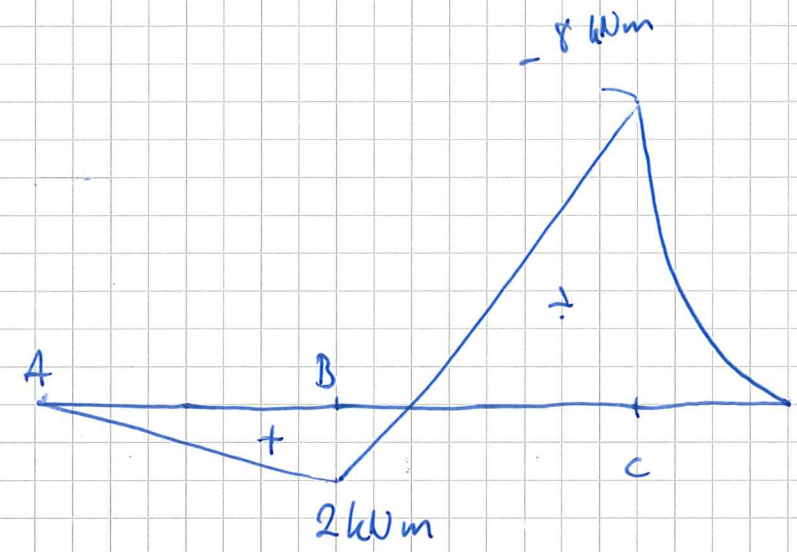
↑ 4m

$$z_B = 0 = z_{B0} + z_{BB} \cdot \gamma_B \Rightarrow \gamma_B = -\frac{z_{B0}}{z_{BB}}$$

$$\gamma_B = -\frac{4\,kNm}{6\frac{EI}{4m}} = -\frac{8}{3}\frac{kNm^2}{EI}$$

$M_{B,venstre} = 0 - \frac{3EI}{L} \cdot \frac{-8}{3} \frac{kNm^2}{EI} = 2\,kNm$ ✓ OK

$M_{B,høyre} = 4\,kNm + \frac{3EI}{L} \cdot \frac{-8}{3} \frac{kNm^2}{EI} = 2\,kNm$ ✓

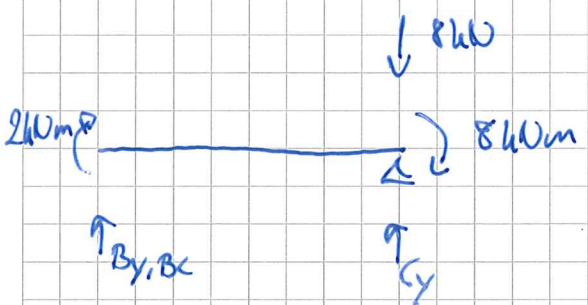


$\sum M = 0$ om B $\Rightarrow 4m \cdot A_y - 2\,kNm = 0$

$\Rightarrow A_y = \frac{1}{2}\,kN$

$\sum F_y = 0 \Rightarrow A_y + B_{y,AB} = 0$

$\Rightarrow B_{y,AB} = -\frac{1}{2}\,kN$



$\sum M = 0$ om C $\Rightarrow 4m \cdot B_{y,BC} + 8\,kNm + 2\,kNm$

$\Rightarrow B_{y,BC} = -2{,}5\,kN$

$\sum F_y = 0 \Rightarrow B_{y,BC} + C_y - 8\,kN = 0$

$\Rightarrow C_y = 10{,}5\,kN$

$B_y = B_{y,AB} + B_{y,BC} = -3\,kN$