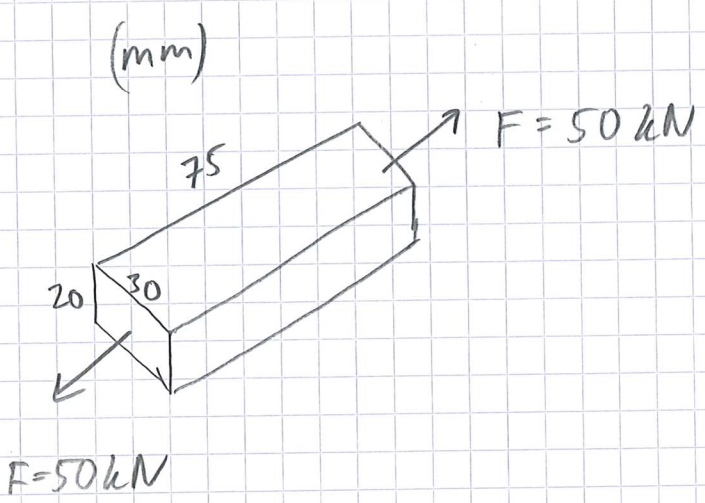
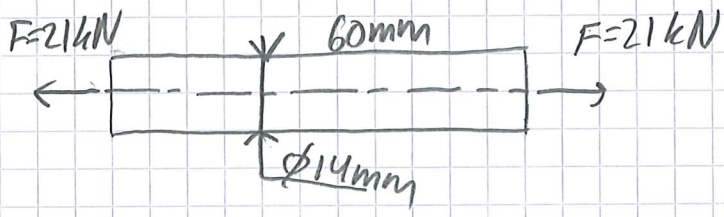
①



$$\sigma_{max} = \frac{F}{A} = \frac{50\,000}{20 \cdot 30} \approx 83{,}3 \text{ MPa}$$

$$\delta = \frac{FL}{EA} = \frac{50\,000 \cdot 75}{200\,000 \cdot (20 \cdot 30)} \approx 0{,}031 \text{ mm}$$

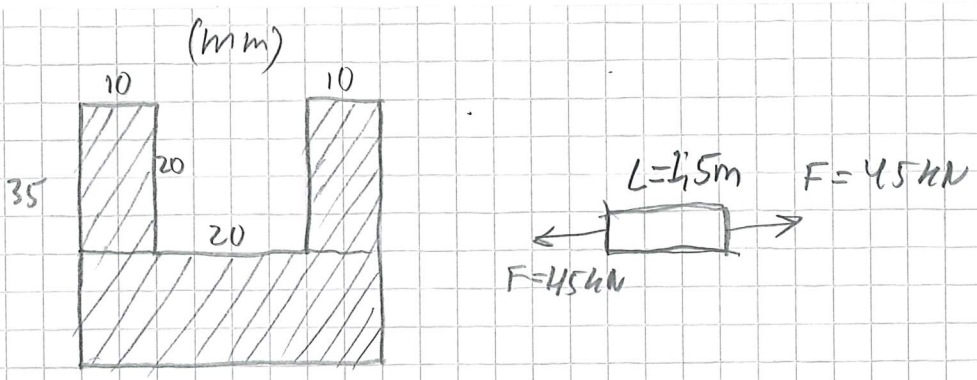
(2)



$$\sigma_{max} = \frac{F}{A} = \frac{21000}{\frac{\pi \cdot 14^2}{4}} \approx 136{,}4 \text{ MPa}$$

$$\delta = \frac{FL}{EA} = \frac{21000 \cdot 60}{200000 \cdot \frac{\pi \cdot 14^2}{4}} \approx 0{,}04 \text{ mm}$$

(3)



$A = 2 \cdot (10 \cdot 20) + 15 \cdot 40 = 1000\,mm^2$

Spänning

$$\sigma = \frac{F}{A} = \frac{50000}{1000} = \underline{\underline{50\,MPa}}$$

Förlängning

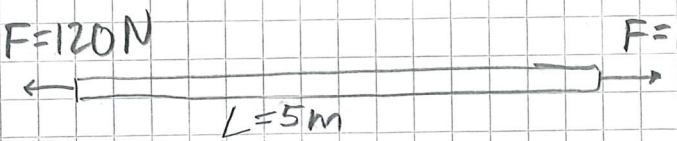
$$\delta = \frac{FL}{EA} = \frac{50000 \cdot 1500}{70000 \cdot 1000} \approx \underline{\underline{1,07\,mm}}$$

$E_{al} = 70\,000\,MPa$

Töjning

$$\varepsilon = \frac{\delta}{L} = \frac{1,07}{1500} \approx 0,000713\ mm/mm$$

(4)



$F = 12 \cdot 10 = 120N$

Tøjning

$$\varepsilon = \frac{10}{5000} = 0,002 \quad mm/mm$$

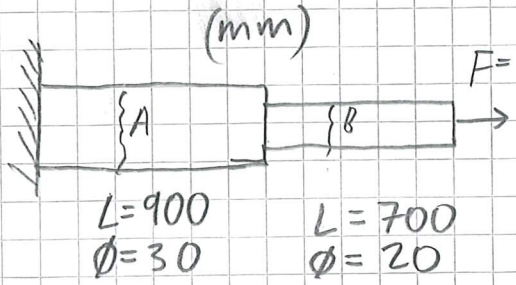
Spænding

$$\sigma = \frac{F}{A} = \frac{120}{\frac{\pi 5^2}{4}} \approx 6,11 \; MPa$$

E-modul

$$\sigma = E \cdot \varepsilon \quad \Rightarrow \quad E = \frac{\sigma}{\varepsilon} = \frac{6,11}{0,002} = 3055 \; MPa$$

⑤



$E = 200\,000$ MPa

Spänning

$$\sigma_A = \frac{F}{A} = \frac{50000}{\frac{\pi 30^2}{4}} \approx 70{,}74 \text{ MPa} \quad (\text{Snitt A})$$

$$\sigma_B = \frac{F}{A} = \frac{50\,000}{\frac{\pi \cdot 20^2}{4}} \approx 159{,}2 \text{ MPa} \quad (\text{Snitt B})$$

Förlängning

$$\delta_{tot} = \delta_A + \delta_B = \frac{F \cdot L_A}{E \cdot A_A} + \frac{F \cdot L_B}{E \cdot A_B} = \frac{F}{E}\left(\frac{L_A}{A_A} + \frac{L_B}{A_B}\right) =$$

$$= \frac{50\,000}{200\,000}\left(\frac{900}{\frac{\pi \cdot 30^2}{4}} + \frac{700}{\frac{\pi \cdot 20^2}{4}}\right) \approx 0{,}875 \text{ mm}$$

⑥

Ø10mm
L=100mm
V=0,30
E=70000 MPa (aluminium)

$$\varepsilon_x = \frac{\sigma}{E} = \frac{\frac{12\,000 \cdot 4}{\pi \cdot 10^2}}{70000} \approx 0{,}0022 \text{ mm/mm}$$

$$\varepsilon_{tvär} = -V \cdot \varepsilon_x = -0{,}30 \cdot 0{,}0022 \approx -0{,}000655 \text{ mm/mm}$$

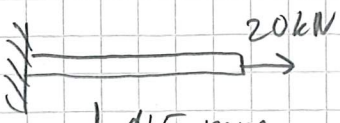
Diameterminskning

$$\Delta d = \varepsilon_{tvär} \cdot d = -0{,}000655 \cdot 10 \approx -0{,}0066 \text{ mm}$$

Förlängning

$$\delta = \frac{FL}{EA} = \frac{12000 \cdot 100}{70000 \cdot \frac{\pi \cdot 10^2}{4}} \approx 0{,}218 \text{ mm}$$

(7)



$d = \emptyset 15$ mm
$L = 600$ mm

$\delta = 500\,\mu m = 0{,}500$ mm
$\Delta d = 4{,}0\,\mu m = 0{,}0040$ mm

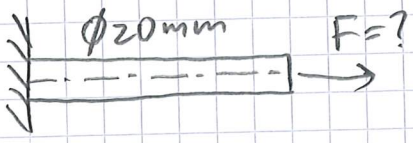
$$\varepsilon_{tvar} = \frac{\Delta d}{d} = \frac{-0{,}0040}{15} \approx -0{,}000267 \text{ mm/mm}$$

$$\nu = -\frac{\varepsilon_{tvar}}{\varepsilon_x} = -\frac{\frac{-\Delta d}{d}}{\frac{\delta}{L}} = -\frac{\frac{-0{,}0040}{15}}{\frac{0{,}500}{600}} = 0{,}32$$

$$E = \frac{\sigma}{\varepsilon_x} = \frac{\frac{F}{A}}{\frac{\delta}{L}} = \frac{\frac{20\,000 \cdot 4}{\pi \cdot 15^2}}{\frac{0{,}500}{600}} \approx 135\,812 \text{ MPa}$$

Svar: $\nu = 0{,}32$ och $E \approx 136$ GPa

(8)



$R_e = 355\ MPa$

$n_s = 2,0$

$$\left.\begin{aligned} \sigma_{adm} &= \frac{R_e}{n_s} \\ \sigma_{adm} &= \frac{F}{A} \end{aligned}\right\} \quad \frac{R_e}{n_s} = \frac{F}{A} \quad \Rightarrow \quad F = \frac{R_e}{n_s} \cdot A$$

$$F = \frac{355}{2,0} \cdot \frac{\pi \cdot 20^2}{4} \approx 55\,763\ N$$

(9)

$$\sigma_{max} = \frac{F}{A} = \frac{60\,000}{25 \cdot 25} = 96 \text{ MPa}$$

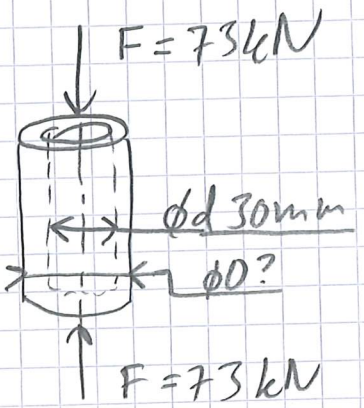
$$n_s = \frac{R_e}{\sigma_{max}} = \frac{355}{96} \approx 3,7$$

(10)

$$\sigma_{max} = \frac{F}{A} = \frac{1200}{\frac{\pi \cdot 5^2}{4}} \approx 61,1\ MPa$$

$$n_s = \frac{Re}{\sigma_{max}} \Rightarrow Re = n_s \cdot \sigma_{max} = 2,0 \cdot 61,1 \approx \underline{122,3\ MPa}$$

(11)



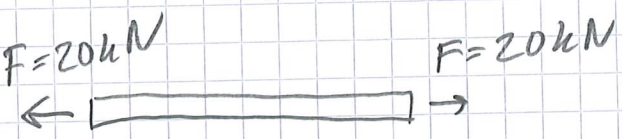
$$\sigma_{till} = \frac{R_e}{n_s} = \frac{355}{2,0} = 177,5 \text{ MPa}$$

$$\sigma_{till} = \frac{F}{A} \quad \text{där } A = \frac{\pi}{4}(D^2 - d^2)$$

$$\Rightarrow \frac{\pi}{4}(D^2 - d^2) = \frac{F}{\sigma_{till}}$$

$$D = \sqrt{\frac{4 \cdot F}{\pi \cdot \sigma_{till}} + d^2} = \sqrt{\frac{4 \cdot 73\,000}{\pi \cdot \sigma_{till}} + 30^2} \approx 37,73 \text{ mm}$$

(12)



$A = 566\,mm^2$

$R_e = 355\,MPa$

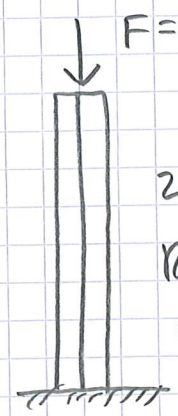
$R_m = 460\,MPa$

$$\sigma_{max} = \frac{F}{A} = \frac{20\,000}{566} \approx 35,34\,MPa$$

$$n_s = \frac{R_e}{\sigma_{max}} = \frac{355}{35,34} \approx \underline{\underline{10}}$$

$$n_b = \frac{R_m}{\sigma_{max}} = \frac{460}{35,34} \approx \underline{\underline{13}}$$

(13)



2x U260 balkar (area $2 \cdot 4830\,mm^2$)

$R_e = 355\,MPa$

$n_s = 7$

$$\sigma_{till} = \frac{R_e}{n_s} = \frac{355}{7} \approx 50,7\,MPa$$

$$\sigma = \frac{F}{A} \Rightarrow F = \sigma \cdot A = 50,7 \cdot 2 \cdot 4830 \approx 489\,762\,N$$

(14)

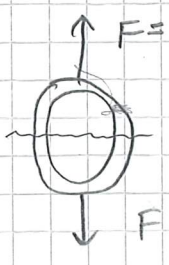
$R_e = 300 MPa$

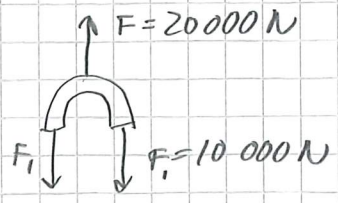
$n_s = 4$

$$\sigma_{till} = \frac{R_e}{n_s} = \frac{300}{4} = 75 MPa$$

$$\sigma = \frac{F}{A} \Rightarrow A = \frac{F}{\sigma} = \frac{140\,000}{75} \approx 1867\ mm^2 = 18{,}67\ cm^2$$

(15)





$n_b = 8, \quad R_m = 650\ MPa$

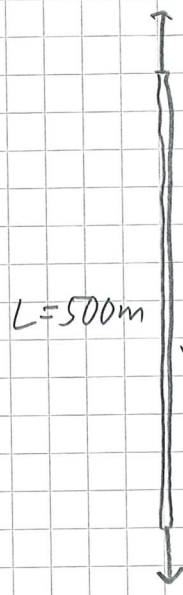
$$\sigma_{till} = \frac{R_m}{n_b} = \frac{650}{8} = 81{,}25\ MPa$$

Spänning

$$\sigma = \frac{F}{A} \Rightarrow A = \frac{F}{\sigma} \Rightarrow \frac{\pi d^2}{4} = \frac{F}{\sigma}$$

$$d = \sqrt{\frac{4 \cdot F}{\pi \sigma_{till}}} = \sqrt{\frac{4 \cdot 10000}{\pi \cdot 81{,}25}} \approx 12{,}52\ mm$$

(16)



$$\left[\frac{kg}{mm^3}\cdot mm^2\cdot mm\cdot\frac{N}{kg}=N\right]$$

$$G=\rho Vg=\rho\cdot A\cdot L\cdot g=7{,}8\cdot10^{-6}\cdot144\left(\frac{\pi\cdot1{,}2^2}{4}\right)\cdot500000\cdot10\approx6352\,N$$

$$E=120\,GPa$$

Spänning

$$\sigma=\frac{F+G}{A}=\frac{6352+12000}{\frac{\pi\cdot1{,}2^2}{4}\cdot144}\approx112{,}7\,MPa\approx113\,MPa$$

Förlängning

$$\delta_{tot}=\delta_F+\delta_G$$

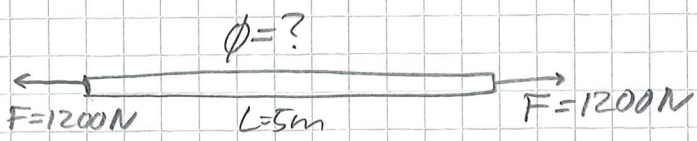
(verkar vid halva längden)

$$\delta_{tot}=\frac{FL}{EA}+\frac{GL}{2EA}=\frac{L}{EA}\left(F+\frac{G}{2}\right)=$$

$$=\frac{500\,000}{120000\cdot\frac{\pi\cdot1{,}2^2}{4}\cdot144}\left(12000+\frac{6352}{2}\right)\approx388{,}3\,mm$$

Förlängs ca: 390 mm

(17)



$\delta_{max} = 2\,mm$

$n_s = 4$ $\qquad E = 200\ GPa$

$R_e = 355\ MPa$

$$\sigma_{till} = \frac{R_e}{n_s} = \frac{355}{4} = 88{,}75\ MPa$$

Spänning

$$\sigma = \frac{F}{A} \Rightarrow A = \frac{F}{\sigma} \Rightarrow \frac{\pi d^2}{4} = \frac{F}{\sigma}$$

$$d = \sqrt{\frac{4 \cdot F}{\pi \cdot \sigma_{till}}} = \sqrt{\frac{4 \cdot 1200}{\pi \cdot 88{,}75}} \approx 4{,}15\ mm$$

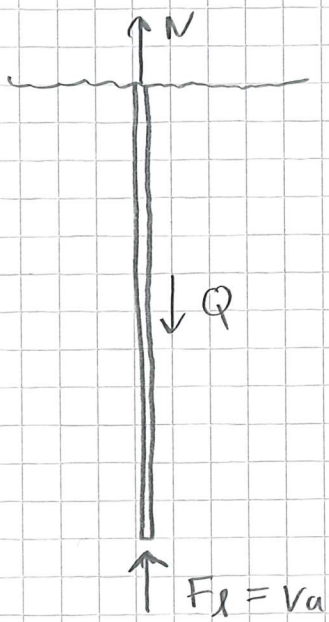
Förlängning

$$2 = \delta_{max} = \frac{FL}{EA} \Rightarrow A = \frac{FL}{2E} \Rightarrow \frac{\pi d^2}{4} = \frac{FL}{2E}$$

$$d = \sqrt{\frac{4\,FL}{2\pi E}} = \sqrt{\frac{4 \cdot 1200 \cdot 5000}{2 \cdot \pi \cdot 200000}} \approx 4{,}37\ mm$$

Välj en diameter på minst 4,4 mm.

(18)



Beräkna linans längd

då $\sigma_{max} = 300$ MPa

F_l = vattnets lyftkraft är tyngden av den undanträngda vätskans volym = $\rho_v \cdot A \cdot L \cdot g$

(ρ_v: vatten)

Spänningen

(densitet: ρ_s stål)

Linans tyngd $Q = A \cdot L \cdot g \, \rho_s$

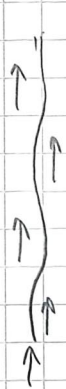
$$\sigma = \frac{Q - F_l}{A} = \frac{A \cdot L \cdot g \cdot \rho_s}{A} - \frac{\rho_v \cdot A \cdot L \cdot g}{A} = Lg(\rho_s - \rho_v)$$

$$\Rightarrow L = \frac{\sigma}{g(\rho_s - \rho_v)} = \frac{300}{10\,(7{,}8-1)\cdot 10^{-6}} \approx 4\,411\,765 \text{ mm} \approx$$

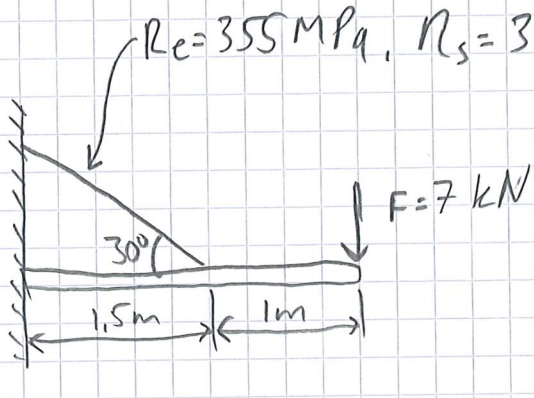
$$\approx 4\,412 \text{ m}$$

Svar: Ca: 4,4 km lång blir linan.

Om linan är rak verkar lyftkraften längst ned som i figuren ovan. Detta gör dock att linan kommer att slingra sig och lyftkraften kommer verka längs hela linan.

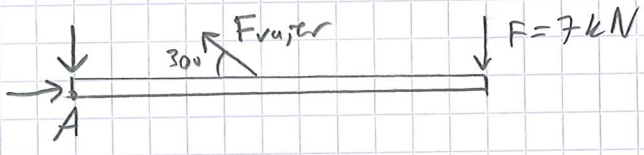


(19)



$$\sigma_{tillåtn} = \frac{R_e}{n_s} = \frac{355}{3}$$

Frilägg för att beräkna kraften i vajern.



$$\overrightarrow{A}: F \cdot (1,5+1) - F_{vajer} \cdot \sin(30°) \cdot 1,5 = 0$$

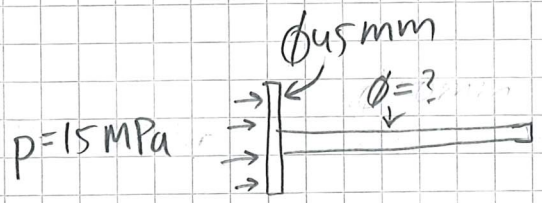
$$F_{vajer} = \frac{2,5 \cdot F}{\sin(30°) \cdot 1,5}$$

Spänning

$$\sigma = \frac{F_{vajer}}{A} \Rightarrow A = \frac{F_{vajer}}{\sigma} \text{ där } A = \frac{\pi d^2}{4}$$

$$\Rightarrow \frac{\pi d^2}{4} = \frac{F_{vajer}}{\sigma} \Rightarrow d = \sqrt{\frac{4 \cdot F_{vaj}}{\pi \cdot \sigma}} = \sqrt{\frac{4 \cdot \frac{2,5 \cdot 7000}{\sin(30°) \cdot 1,5}}{\pi \cdot \frac{355}{3}}} \approx 15,84 \text{ mm}$$

(20)



$n_s = 4$

$R_e = 355\ MPa$

$$F = \sigma \cdot A = 15 \cdot \frac{\pi 45^2}{4} \approx 23856\ N$$

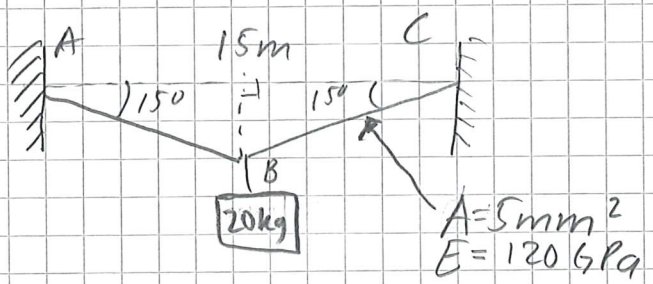
↑ 150 Bar = 15 MPa

$$\sigma_{t;II} = \frac{R_e}{n_s} = \frac{355}{4} = 88{,}75\ MPa$$

$$\sigma = \frac{F}{A} \Rightarrow A = \frac{F}{\sigma} \Rightarrow \frac{\pi d^2}{4} = \frac{F}{\sigma}$$

$$d = \sqrt{\frac{4 \cdot F}{\pi \cdot \sigma_{t;II}}} = \sqrt{\frac{4 \cdot 23856}{\pi \cdot 88{,}75}} \approx 18{,}5\ mm$$

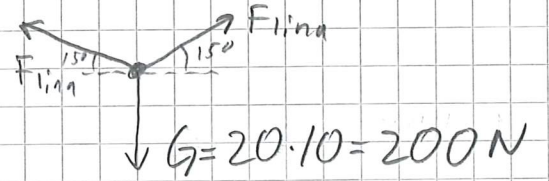
(21)



Spänningen

$$\sigma = \frac{F}{A} = \frac{386,4}{5} \approx 77,3 \text{ MPa}$$

Frilägg punkten B.

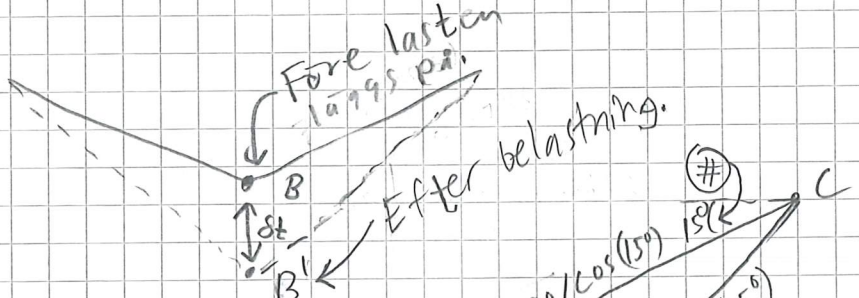


$\uparrow: F_{lina} \cdot \sin(15°) \cdot 2 - G = 0$

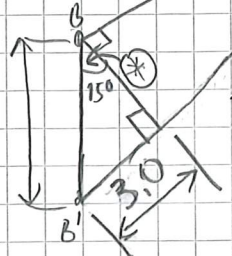
$$F_{lina} = \frac{G}{\sin(15°) \cdot 2} = \frac{200}{2 \cdot \sin(15°)} \approx 386,4 \text{ N}$$

Förskjutning

$$\delta = \frac{FL}{EA} = \frac{386,4 \cdot \frac{7500}{\cos(15°)}}{200000 \cdot 5} \approx 3,0 \text{ mm}$$

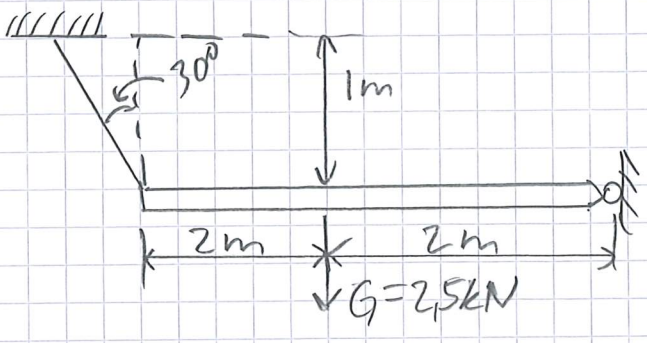


$$\delta_t = \frac{3,0}{\sin(15°)} \approx 11,6 \text{ mm}$$

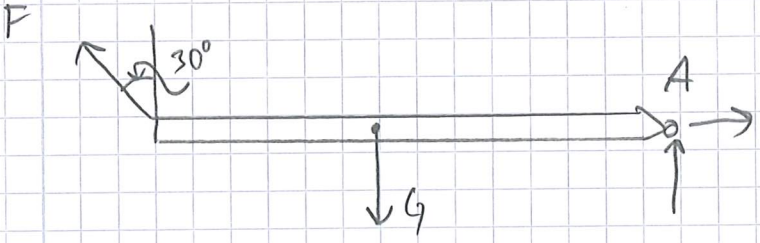


Om # går mot 0 går även * mot 0.
=> # = * (därför är vinklarna lika)

22

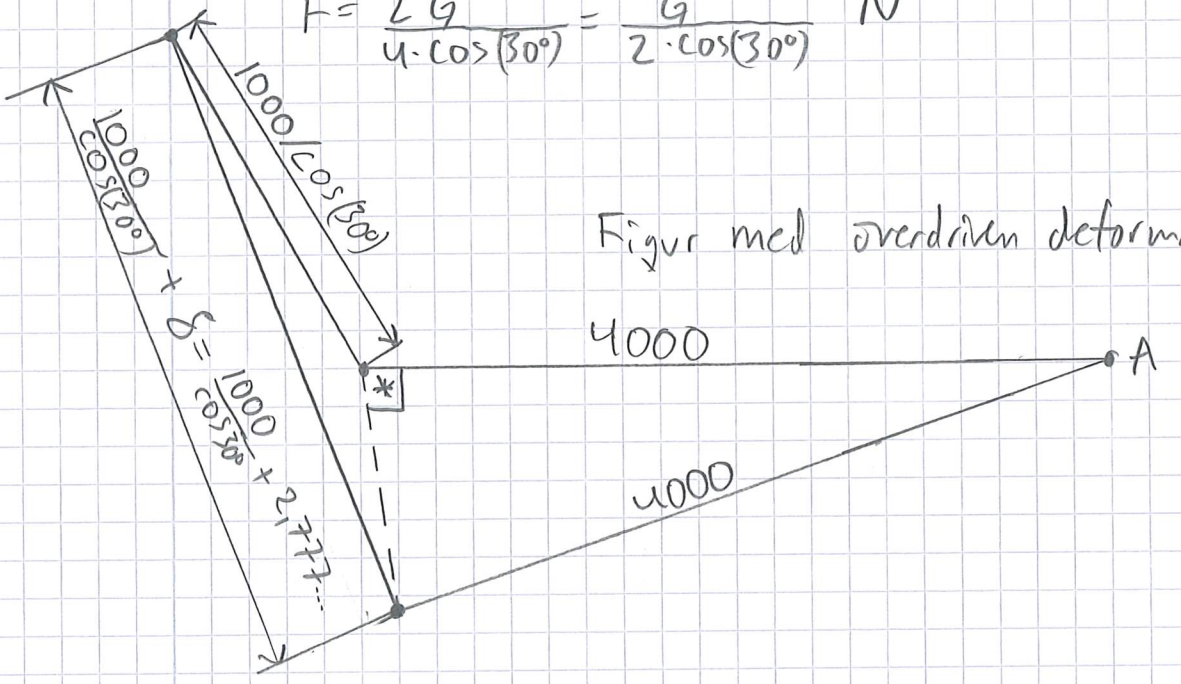


Balken frilägges



$\curvearrowright A: F \cdot \cos(30°) \cdot 4 - G \cdot 2 = 0$

$$F = \frac{2G}{4 \cdot \cos(30°)} = \frac{G}{2 \cdot \cos(30°)} \; N$$

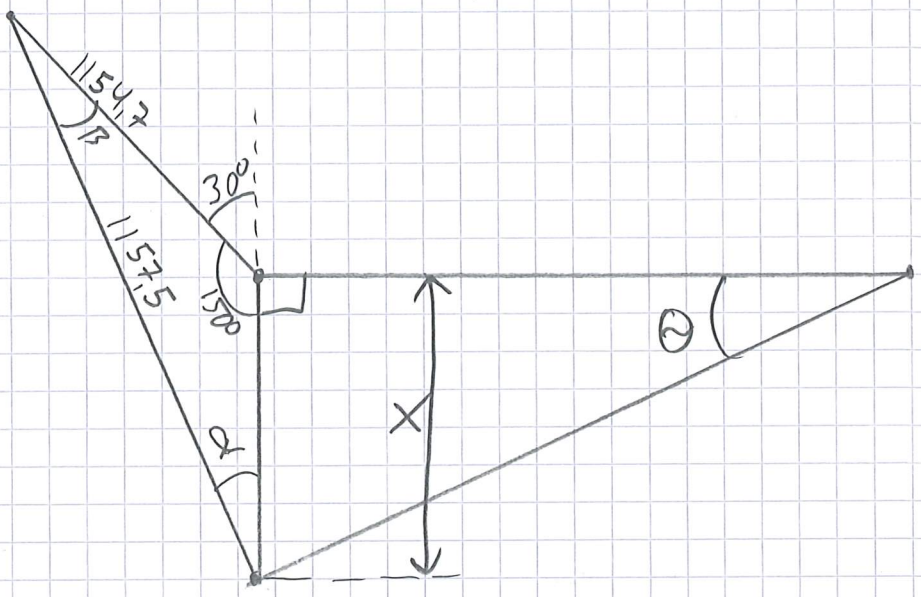


Figur med överdriven deformation...

$$\delta = \frac{FL}{EA} = \frac{\frac{G}{2 \cdot \cos(30°)} \cdot L}{E \cdot A} = \frac{\frac{2500}{2 \cdot \cos(30°)} \cdot \frac{1000}{\cos(30°)}}{15000 \cdot 40} \approx 2,778 mm$$

*anta att vinkeln är 90° här, egentligen är den 89,98° enligt CAD-program.

(22)



vinkeln α

$$\frac{\sin(150°)}{1157,5} = \frac{\sin(\alpha)}{1154,7} \Rightarrow \alpha \approx 29,92°$$

Vinkeln β

$$180 - 150 - \alpha = 0,08°$$

sträckan X

$$\frac{\sin(\beta)}{X} = \frac{\sin(150°)}{1157,5} \Rightarrow X \approx 3,23 \text{ mm}$$

Vinkeln Θ

$$\Theta = \arctan\left(\frac{X}{4000}\right) = \arctan\left(\frac{3,23}{4000}\right) \approx 0,046°$$

Vinkelförändringen blir cirka 0,05°. Svaret blir det samma även om vinkeln (*) inte antas vara 90°!

2/2