



Betongegenskaper og tøyning:

$$\begin{aligned}
 f_{yk} &:= 500 \frac{N}{mm^2} & f_{cd} &:= 25.5 \frac{N}{mm^2} & f_{yd} &:= 434 \frac{N}{mm^2} & (EC2 - Del\ 1-1, tabell\ 3.1) \\
 f_{ck} &:= 45 \frac{N}{mm^2} & f_{cm} &:= 53 \frac{N}{mm^2} & \varepsilon_{cu} &:= 0.0035 \\
 E_s &:= 200000 \frac{N}{mm^2} & \varepsilon_{yd} &:= \frac{f_{yd}}{E_s} = 0.00217 & E_{cm} &:= 36000 \frac{N}{mm^2}
 \end{aligned}$$

Spennstål egenskaper:

$$\begin{aligned}
 E_p &:= 195000 \frac{N}{mm^2} & f_{pk} &:= 1860 \frac{N}{mm^2} & (EC2 - Del\ 1-1, 3.3.6) \\
 f_{p0.1k} &:= 1640 \frac{N}{mm^2}
 \end{aligned}$$

Laster:

(Se vedlegg C for laster)

$$\text{Egenlast hulldekke: } g_{dekke} := 4.0 \frac{kN}{m^2} \cdot 1.2\ m = 4.8 \frac{kN}{m}$$

$$\text{Egenlast: } g_k := 1.0 \frac{kN}{m^2} \cdot 1.2\ m = 1.2 \frac{kN}{m}$$

$$\text{Nyttelast: } q_k := 2.0 \frac{kN}{m^2} \cdot 1.2\ m = 2.4 \frac{kN}{m}$$

Bruddgrensetilstand

$$A_p := 800 \text{ mm}^2$$

$$\gamma_s := 1.15$$

$$f_{pd} := \frac{f_{p0.1k}}{\gamma_s} = (1.426 \cdot 10^3) \frac{\text{N}}{\text{mm}^2}$$

Laster:

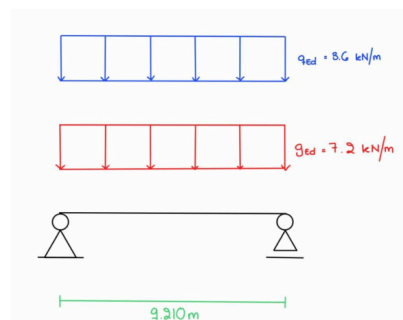
$$\text{Egenlast: } g_{Ed} := (g_k + g_{dekke}) \cdot 1.2 = 7.2 \frac{\text{kN}}{\text{m}}$$

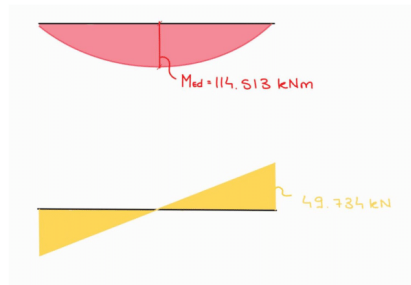
$$\text{Nyttelast: } q_{Ed} := q_k \cdot 1.5 = 3.6 \frac{\text{kN}}{\text{m}}$$

$$P_{Ed} := g_{Ed} + q_{Ed} = 10.8 \frac{\text{kN}}{\text{m}}$$

$$\text{Dimensjonerende moment: } M_{Ed} := \frac{(P_{Ed}) \cdot L^2}{8} = 114.513 \text{ kN} \cdot \text{m}$$

$$\text{Dimensjonerende skjærkraft: } V_{Ed} := \frac{(P_{Ed}) \cdot L}{2} = 49.734 \text{ kN}$$





oppspenning:  $\sigma_{p,max} = \min \{0.8 \cdot f_{pk}; 0.9 \cdot f_{p0.1k}\}$  (EC2, 5.10.2.1)

$$\sigma_{p,max} := 0.9 \cdot f_{p0.1k} = (1.476 \cdot 10^3) \frac{N}{mm^2}$$

Oppspenningskraft:  $P_{max} := A_p \cdot \sigma_{p,max} = (1.181 \cdot 10^3) \text{ kN}$  (EC2, 5.10.2.1)

Kontroll av momentkapasitet

Underarmert hulldekke:

$$\alpha := \frac{f_{pd} \cdot A_p}{0.8 \cdot f_{cd} \cdot b \cdot d} = 0.169$$

Momentkapasitet:

$$M_{Rd} := 0.8 \cdot (1 - 0.4 \cdot \alpha) \cdot \alpha \cdot b \cdot d^2 \cdot f_{cd} = 292.471 \text{ kN} \cdot \text{m}$$

$$M_{Rd} > M_{Ed} \quad \text{OK}$$

Kontroll av skjærkraftkapasitet

(EC2, 6.2.2)

Trykkspenning pga spennkraft:  $\sigma_{cp} := \frac{P_{max} \cdot 0.8}{A_c} = 5.17 \frac{\text{N}}{\text{mm}^2}$

$$C_{Rd,c} := \frac{0.18}{1.5} = 0.12$$

$$k := 1 + \sqrt{\frac{200 \text{ mm}}{d}} = 1.853 \quad k < 2.0 \quad \text{OK}$$

$$\rho_L := \frac{A_p}{A_c} = 0.004 \quad \rho_L < 0.02 \quad \text{OK}$$

$$k_1 := 0.15$$

$$V_{Rd,c} = \left( C_{Rd,c} \cdot k \cdot (100 \cdot \rho_L \cdot f_{ck})^{\frac{1}{3}} + k_1 \cdot \sigma_{cp} \right) \cdot b_w \cdot d$$

$$V_{Rd,c} := \left( 0.12 \cdot 1.853 \cdot (100 \cdot 0.004 \cdot 45)^{\left(\frac{1}{3}\right)} + 0.15 \cdot 5.17 \right) \cdot 296 \cdot 275 = 1.106 \cdot 10^5$$

$$V_{Ed,red} := \frac{P_{Ed} \cdot L}{2} - P_{Ed} \cdot d = 46.764 \text{ kN}$$

$$V_{Ed,red} < V_{Rd,c} \quad \text{OK}$$

Oppspenning kontroll:

$$\sigma_{uk} := \frac{P_{max}}{A_c} - \frac{P_{max} \cdot e}{I_y} \cdot z_c = -15.384 \frac{N}{mm^2} \quad \text{Sørensen del 2 lign. (6.12)}$$

$$s_{sement} := 0.38 \quad \text{Standard sement, klasse S}$$

$$\beta_{cc} := e^{s_{sement} \cdot \left(1 - \sqrt{\frac{28}{3}}\right)} = 0.458 \quad (\text{EC2, 3.1.2(6)})$$

$$f_{cm.t} := \beta_{cc} \cdot f_{cm} = 24.273 \frac{N}{mm^2}$$

$$-0.7 \cdot f_{cm.t} = -16.991 \frac{N}{mm^2}$$

$$\sigma_{uk} < -0.7 \cdot f_{cm.t} \quad \text{OK} \quad \text{Godkjent av intern rådgiver i Betongfaget}$$

## G.2 Dimensjonering av nytt hulldekke

Dimensjoner:

(Hentet fra Helgeland  
betong)

$$h := 265 \text{ mm}$$

$$b := 1200 \text{ mm}$$

$$L := 9210 \text{ mm}$$

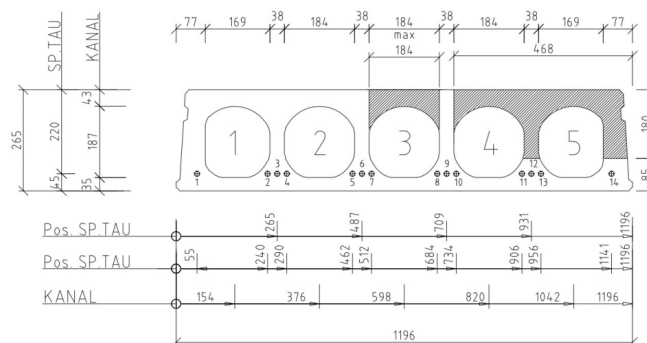
$$b_w := 38 \text{ mm} \cdot 4 + 2 \cdot 77 \text{ mm} = 306 \text{ mm}$$

$$d := 220 \text{ mm} \quad e := 87.5 \text{ mm}$$

$$A_c := 0.1653 \cdot 10^6 \text{ mm}^2$$

Tyngdepunkt fra underkant:  $z_c := 136.46 \text{ mm}$

Andre arealmoment:  $I_y := 1458.12 \cdot 10^6 \text{ mm}^4$



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 f_{ck} &:= 45 \frac{N}{mm^2} & f_{cm} &:= 53 \frac{N}{mm^2} & \varepsilon_{cu} &:= 0.0035 \\
 E_s &:= 200000 \frac{N}{mm^2} & \varepsilon_{yd} &:= \frac{f_{yd}}{E_s} = 0.00217 & E_{cm} &:= 36000 \frac{N}{mm^2}
 \end{aligned}$$

Spennstål egenskaper:

$$\begin{aligned}
 E_p &:= 195000 \frac{N}{mm^2} & f_{pk} &:= 1860 \frac{N}{mm^2} & (\text{EC2 - Del 1-1, 3.3.6}) \\
 f_{p0.1k} &:= 1640 \frac{N}{mm^2}
 \end{aligned}$$

Laster:

(Se vedlegg C for laster)

$$\text{Egenlast hulldekke: } g_{dekke} := 4.0 \frac{kN}{m^2} \cdot 1.2 \text{ m} = 4.8 \frac{kN}{m}$$

$$\text{Egenlast: } g_k := 1.0 \frac{kN}{m^2} \cdot 1.2 \text{ m} = 1.2 \frac{kN}{m}$$

$$\text{Nyttelast: } q_k := 2.0 \frac{kN}{m^2} \cdot 1.2 \text{ m} = 2.4 \frac{kN}{m}$$



Bruddgrensetilstand

$$A_p := 400 \text{ mm}^2$$

$$\gamma_s := 1.15$$

$$f_{pd} := \frac{f_{p0.1k}}{\gamma_s} = (1.426 \cdot 10^3) \frac{\text{N}}{\text{mm}^2}$$

Laster:

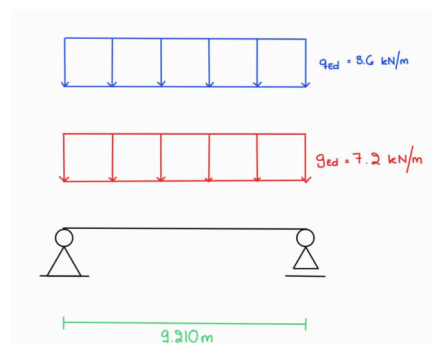
$$\text{Egenlast: } g_{Ed} := (g_k + g_{dekket}) \cdot 1.2 = 7.2 \frac{\text{kN}}{\text{m}}$$

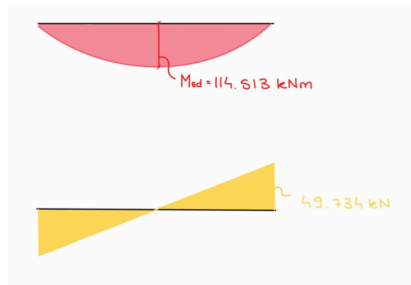
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$$\text{Dimensjonerende moment: } M_{Ed} := \frac{(P_{Ed}) \cdot L^2}{8} = 114.513 \text{ kN} \cdot \text{m}$$

$$\text{Dimensjonerende skjærkraft: } V_{Ed} := \frac{(P_{Ed}) \cdot L}{2} = 49.734 \text{ kN}$$





Oppspenning:  $\sigma_{p,max} = \min \{0.8 \cdot f_{pk}; 0.9 \cdot f_{p0.1k}\}$  (EC2, 5.10.2.1)

$$\sigma_{p,max} := 0.9 \cdot f_{p0.1k} = (1.476 \cdot 10^3) \frac{N}{mm^2}$$

Oppspenningskraft:  $P_{max} := A_p \cdot \sigma_{p,max} = 590.4 \text{ kN}$  (EC2, 5.10.2.1)

Kontroll av momentkapasitet

Underarmert hulldekke:

$$\alpha := \frac{f_{pd} \cdot A_p}{0.8 \cdot f_{cd} \cdot b \cdot d} = 0.106$$

Momentkapasitet:

$$M_{Rd} := 0.8 \cdot (1 - 0.4 \cdot \alpha) \cdot \alpha \cdot b \cdot d^2 \cdot f_{cd} = 120.179 \text{ kN} \cdot \text{m}$$

$$M_{Rd} > M_{Ed} \quad \text{OK}$$

Kontroll av skjærkraftkapasitet

(EC2, 6.2.2)

Trykkspenning pga spennkraft:  $\sigma_{cp} := \frac{P_{max} \cdot 0.8}{A_c} = 2.857 \frac{\text{N}}{\text{mm}^2}$

$$C_{Rd,c} := \frac{0.18}{1.5} = 0.12$$

$$k := 1 + \sqrt[2]{\frac{200 \text{ mm}}{d}} = 1.953 \quad k < 2.0 \quad \text{OK}$$

$$\rho_L := \frac{A_p}{A_c} = 0.002 \quad \rho_L < 0.02 \quad \text{OK}$$

$$k_1 := 0.15$$

$$V_{Rd,c} := \left( C_{Rd,c} \cdot k \cdot (100 \cdot \rho_L \cdot f_{ck})^{\frac{1}{3}} + k_1 \cdot \sigma_{cp} \right) \cdot b_w \cdot d$$

$$V_{Rd,c} := \left( 0.12 \cdot 1.953 \cdot (100 \cdot 0.002 \cdot 45)^{\left(\frac{1}{3}\right)} + 0.15 \cdot 2.857 \right) \cdot 306 \cdot 220 = 6.167 \cdot 10^4$$

$$V_{Ed,red} := \frac{P_{Ed} \cdot L}{2} - P_{Ed} \cdot d = 47.358 \text{ kN}$$

$$V_{Ed,red} < V_{Rd,c} \quad \text{OK}$$

Oppspenning kontroll:

Sørensen del 2 lign. (6.12)

$$\sigma_{uk} := -\frac{P_{max}}{A_c} - \frac{P_{max} \cdot e}{I_y} \cdot z_c = -8.406 \frac{N}{mm^2}$$

$$s_{sement} := 0.38 \quad \text{Standard sement, klasse S}$$

$$\beta_{cc} := e^{s_{sement} \cdot \left(1 - \sqrt{\frac{28}{3}}\right)} = 0.458 \quad (\text{EC2, 3.1.2(6)})$$

$$f_{cm,t} := \beta_{cc} \cdot f_{cm} = 24.273 \frac{N}{mm^2}$$

$$-0.7 \cdot f_{cm,t} = -16.991 \frac{N}{mm^2}$$

$$\sigma_{uk} < -0.7 \cdot f_{cm,t} \quad \text{OK} \quad \text{Godkjent av intern rådgiver i Betongfaget}$$

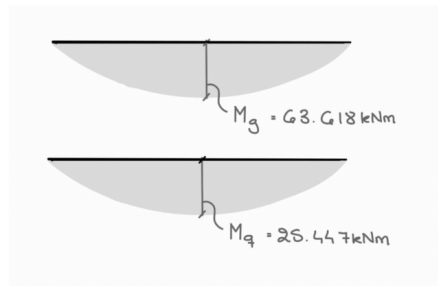
## Bruksgrensetilstand

Kontroll av strekkspenninger etter lang tid

Laster og momenter:

$$M_g := \frac{(g_k + g_{dekke}) \cdot L^2}{8} = 63.618 \text{ kN} \cdot \text{m}$$

$$M_p := \frac{q_k \cdot L^2}{8} = 25.447 \text{ kN} \cdot \text{m}$$



Antar tap pga. låsetap, kryp  
og svinn på 20%

Spennkraft etter lang tid:  $P_{langtid} := 0.8 \cdot P_{max} = 472.32 \text{ kN}$

Spenning etter lang tid:

$$\sigma := \frac{-P_{langtid}}{A_c} - \frac{P_{langtid} \cdot e}{I_y} \cdot z_c + \frac{M_g + M_p}{I_y} \cdot z_c = 1.61 \frac{\text{N}}{\text{mm}^2}$$

$$f_{ctk0.05} := 2.7 \frac{\text{N}}{\text{mm}^2}$$

$$\sigma < f_{ctk0.05} \quad \text{OK}$$