Slankhet og andre ordens effekter

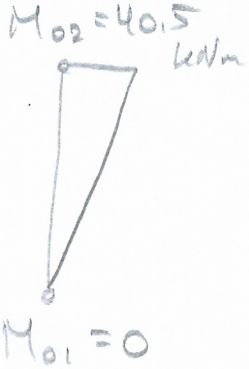
- Knekklengdeberegning:

Arealtreghetsmoment søyle: $I_s = \frac{1}{12} b h^3 = \frac{1}{12} \cdot 0{,}35^4\ m^4 = 1{,}25 \cdot 10^{-3}\ m^4$

$L_s = 3{,}5\ m.$

——— " ——— plate: $L_{b1} = 3{,}9\ m$, $L_{b2} = 7{,}2\ m$

$I_b = \frac{1}{12} \cdot 7{,}2 \cdot 0{,}28 \cdot 10^3\ m^4 = 0{,}0132\ m^4$



Uforskyvelig ramme: $c = 4{,}8$

$\Rightarrow R_B = 0 = R_{min}$

$$R_A = \frac{3I_b/L_{b1} + 3I_b/L_{b2}}{3I_b/L_{b1} + 3I_b/L_{b2} + 4{,}8 \cdot I_s/L_s}$$

$$= \frac{3 \cdot 0{,}0132/3{,}9 + 3 \cdot 0{,}0132/7{,}2}{3 \cdot 0{,}0132/3{,}9 + 3 \cdot 0{,}0132/7{,}2 + 4{,}8 \cdot 1{,}25 \cdot 10^{-3}/3{,}5}$$

$= 0{,}901 = R_{maks}$

$$\beta = \frac{2}{2 + 1{,}1 \cdot R_{min} + 0{,}9 \cdot R_{maks}} = \frac{2}{2 + 1{,}1 \cdot 0 + 0{,}9 \cdot 0{,}901} = 0{,}71$$

$\Rightarrow \underline{L_0 = \beta \cdot L_s = 3{,}5 \cdot 0{,}71 = 2{,}5\ m}$

- Slankhet:

$$\lambda = L_0/i = \sqrt{12} \cdot \frac{L_0}{h} = \sqrt{12} \cdot \frac{2{,}5 \cdot 10^3}{350} = 25 < \lambda_{grense} = 45 \quad \text{OK!}$$

$$\lambda_n = \lambda \cdot \sqrt{\frac{n}{1 + 2k_a \cdot \omega}}$$

$$= 25 \cdot \sqrt{\frac{1{,}52}{1 + 2 \cdot 1 \cdot 1{,}15}}$$

$= 17{,}0$

$N_{Ed} = 3687\ kN$

$$\Rightarrow n = \frac{N_{Ed}}{f_{cd} \cdot A_c} = \frac{3687 \cdot 10^3}{19{,}8 \cdot 350^2} = 1{,}52$$

$$\omega = \frac{f_{yd} \cdot A_s}{f_{cd} \cdot A_c} = \frac{434 \cdot 8.804}{19{,}8 \cdot 350^2} = 1{,}15$$

"k_a kan vanligvis settes lik 1,0".

Fra Robot: $M_{0Eqp} = 23,9$ kNm

$\Rightarrow \varphi_{ef} = 1,60 \cdot \frac{23,9}{40,6} = 0,94$

$\beta = 0,35 + f_{ck}/200 - \lambda/150 = 0,35 + 35/200 - 17/150 = 0,412$

$\Rightarrow \underline{K_\varphi = 1 + 0,412 \cdot 0,94 = 1,39}$

$\Rightarrow 1/r = 1,60 \cdot 10^{-5} \cdot 0,36 \cdot 1,39 = 8,01 \cdot 10^{-6}$

- Andre ordens utbøyning.

$e_2 = \frac{1}{r} \cdot \frac{L_0^2}{c} = 8,01 \cdot 10^{-6} \cdot \frac{2500^2}{10} = 5,0$ mm

- Andre ordens moment.

$M_2 = e_2 \cdot N_{Ed} = 3687$ kN $\cdot 0,005$ m $= 18,4$ kNm

- Ekvivalent 1. ordens moment.

$M_{0e} = 0,6 M_{02} + 0,4 M_{01} \geq 0,4 M_{02} = 0,4 \cdot 40,5$

$= 0,6 \cdot 40,5$ ok!

$= 24,3$ kNm

- Dimensjonerende moment:

$M_{Ed} = M_{0e} + M_2 = (24,3 + 18,4)$ kNm $= 42,7$ kNm

samlet eksentrisitet: $e_d = M_{Ed}/N_{Ed} = 42,7 \cdot 10^6 / 3687 \cdot 10^3 = 12$ mm

$\Rightarrow \underline{e_d < e_0 = 20 \text{ mm}}$.

Trenger ikke å ta hensyn til 2. ordens effekter!

• Slankhetskriteriet:

$\lambda_{n,lim} = 13(2 - r_m) \cdot A_\varphi$

$= 13(2 - 1{,}0) \cdot 1{,}0$

$= 13$

Siden $\lambda > \lambda_{n,lim}$ må andre ordens effekter inkluderes!

$r_m = \frac{M_{01}}{M_{02}} = \frac{0}{40{,}5} = 0$, men

$r_m = 1{,}0$ dersom $N_{Ed} \cdot \frac{h}{20} > M_{02}$

$\Rightarrow 3{,}687 \cdot \frac{350}{20} = 64{,}5 > 40{,}5$

$\Rightarrow r_m = 1{,}0$!

$A_\varphi = 1{,}0$ "under vanlige forhold"

• Andre ordens effekter:

Krumning: $\frac{1}{r} = \frac{1}{r_0} \cdot K_r \cdot K_\varphi$

$\frac{1}{r_0} = \frac{\varepsilon_{yd}}{0{,}45 \cdot d} = \frac{2{,}17 \cdot 10^{-3}}{0{,}45 \cdot 301}$

$= 1{,}60 \cdot 10^{-5}\ mm^{-1}$

$\varepsilon_{yd} = f_{yd}/E_s = 434/2{,}0 \cdot 10^5$

$= 2{,}17 \cdot 10^{-3}$

$d = 350 - 25 - 8 - 32/2 = 301$ mm

$K_r = \frac{n_u - n}{n_u - n_{bal}} \leq 1{,}0$

$\omega = \frac{A_s \cdot f_{yd}}{A_c \cdot f_{cd}} = 1{,}15 \Rightarrow n_u = 1 + \omega = 2{,}15$

$n_{bal} = 0{,}4$, $n = 1{,}52$

$K_r = \frac{2{,}15 - 1{,}52}{2{,}15 - 0{,}4} = 0{,}36$

$K_\varphi = 1 + \beta \cdot \varphi_{ef} \geq 1{,}0$

EC2 5.8.4 (4): "Kan se bort fra kryp dersom

- $\varphi(\infty, t_0) \leq 2{,}0$
- $\lambda \leq 75$
- $M_{0Ed}/N_{Ed} \geq h = 350$

$40 \cdot 10^6 / 3687 \cdot 10^3 = 11\ mm < 350\ mm$

$\varphi(\infty, 90) = 1{,}60$

$\varphi(\infty, 7) = 2{,}56$

): kan ikke se bort fra virkningen av kryp!

$\varphi_{ef} = \varphi(\infty, t_0) \cdot \frac{M_{0Eqp}}{M_{0Ed}}$

moment ved egenlast og 30 % nyttelast som antatt. "quasi-permanent"