

F Veggelement

F.1 Veggelement ELE.17 - Utregning av kapasitet

Dimensjoner:

$$h_{vegg} := 1000 \text{ mm} \quad L_{vegg} := 7512 \text{ mm}$$

$$b_{vegg} := 160 \text{ mm} \quad H_{vegg} := 3180 \text{ mm}$$

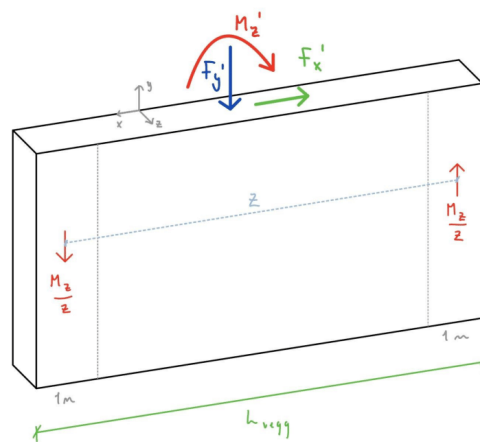
$$A_c := h_{vegg} \cdot b_{vegg} = (1.6 \cdot 10^5) \text{ mm}^2$$

Laster: Se Vedlegg C for laster

$$F_y := 1305.99 \text{ kN}$$

$$M_z := 418.87 \text{ kN} \cdot \text{m}$$

$$F_x := 146.79 \text{ kN}$$



$$z := L_{vegg} - 1 \text{ m} = 6.512 \text{ m} \quad \text{Arm mellom krefter pga. moment}$$

$$N_{Ed,y} := \frac{F_y}{\frac{L_{vegg}}{\text{mm}}} + \frac{M_z}{z} = 64.497 \text{ kN} \quad \text{Per meter} \quad V_{Ed,x} := F_x = 146.79 \text{ kN}$$

Betong-egenskaper, dimensjoner og tøyning:

$$\begin{array}{lll} f_{yk} := 500 \frac{N}{mm^2} & f_{cd} := 19.8 \frac{N}{mm^2} & f_{yd} := 434 \frac{N}{mm^2} \\ f_{ck} := 35 \frac{N}{mm^2} & f_{cm} := 43 \frac{N}{mm^2} & \varepsilon_{cu} := 0.0035 \end{array} \quad \begin{array}{l} \text{EC2 tabell} \\ 3.1 \end{array}$$

$$\sigma_{N.1} := \frac{N_{Ed,y}}{A_c} = 0.403 \frac{N}{mm^2} \quad \text{sigma er mindre enn } f_{cd}, \text{ OK}$$

$$E := 34000 \frac{N}{mm^2} \quad I := \frac{1}{12} \cdot b_{vegg} \cdot h_{vegg}^3 = (1.333 \cdot 10^{10}) mm^4$$

Mengde lengdearmring per meter:

$$\varnothing_1 := 8 mm$$

$$n_1 := 12$$

$$A_{s,faktisk} := \pi \cdot \left(\frac{\varnothing_1}{2} \right)^2 \cdot n_1 = 603.186 mm^2$$

Beregning av aksialkapasitet:

$$N_{Rd} := f_{cd} \cdot (A_c - A_{s,faktisk}) + f_{yd} \cdot A_{s,faktisk} = 3417.84 kN$$

$$N_{Rd} > N_{Ed,y} \quad \text{OK}$$

F.2 Dimensjonering av nytt veggelement

Dimensjoner:

$$h_{vegg} := 1000 \text{ mm} \quad L_{vegg} := 7512 \text{ mm}$$

$$b_{vegg} := 140 \text{ mm} \quad H_{vegg} := 3180 \text{ mm}$$

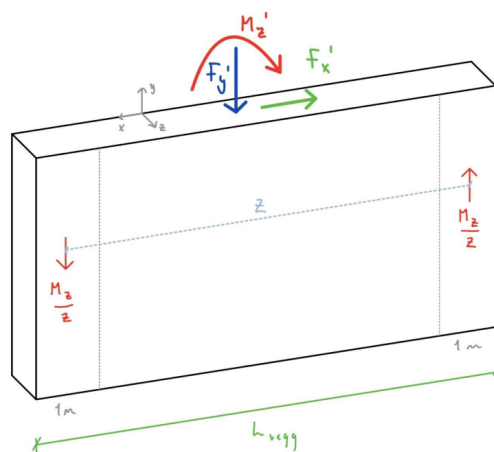
$$A_c := h_{vegg} \cdot b_{vegg} = (1.4 \cdot 10^5) \text{ mm}^2$$

Laster: Se Vedlegg C for laster

$$F_y := 1305.99 \text{ kN}$$

$$M_z := 418.87 \text{ kN} \cdot \text{m}$$

$$F_x := 146.79 \text{ kN}$$



$$z := L_{vegg} - 1 \text{ m} = 6.512 \text{ m} \quad \text{Arm mellom krefter pga. moment}$$

$$N_{Ed,y} := \frac{F_y}{\frac{L_{vegg}}{\text{mm}}} + \frac{M_z}{z} = 64.497 \text{ kN} \quad \text{Per meter} \quad V_{Ed,x} := F_x = 146.79 \text{ kN}$$

Betong-egenskaper, dimensjoner og tøyning:

$$\begin{array}{lll} f_{yk} := 500 \frac{N}{mm^2} & f_{cd} := 19.8 \frac{N}{mm^2} & f_{yd} := 434 \frac{N}{mm^2} \\ f_{ck} := 35 \frac{N}{mm^2} & f_{cm} := 43 \frac{N}{mm^2} & \varepsilon_{cu} := 0.0035 \end{array} \quad \begin{array}{l} \text{EC2 tabell} \\ 3.1 \end{array}$$

$$\sigma_{N,1} := \frac{N_{Ed,y}}{A_c} = 0.461 \frac{N}{mm^2} \quad \text{sigma er mindre enn } f_{cd}, \text{ OK}$$

$$E := 34000 \frac{N}{mm^2} \quad I := \frac{1}{12} \cdot b_{vegg} \cdot h_{vegg}^3 = (1.167 \cdot 10^{10}) mm^4$$

Bruddgrensetilstand:

Beregning av minimumarmering i vertikalretning per meter:

$$A_{s,vmin} := 0.002 \cdot A_c = 280 mm^2 \quad (\text{EC2 - Del 1-1, 9.6.2(1)})$$

Beregning av maksimalarmering i vertikalretning per meter:

$$A_{s,vmax} := 0.04 \cdot A_c = (5.6 \cdot 10^3) mm^2 \quad (\text{EC2 - Del 1-1, 9.6.2(1)})$$

Velger diameter på armering:

$$\varnothing_v := 6 mm$$

Krav til senteravstand mellom vertikalarmering:

$$s_v = \min(3 \cdot b_{vegg}, 400 mm) \quad (\text{EC2 - Del 1-1, 9.6.2(3)})$$

$$s_v = \min(420 mm, 400 mm)$$

$$s_v := 400 mm$$

Antall stenger per meter:

$$n_v := 10 \quad \text{delt på 2 sider}$$

$$A_{s,faktisk} := n_v \cdot \left(\frac{\varnothing_v}{2} \right)^2 \cdot \pi = 282.743 \text{ mm}^2$$

Senteravstand mellom vertikalarmering:

$$s_{v,faktisk} := \frac{h_{vegg}}{\left(\frac{n_v}{2} \right)} = 200 \text{ mm}$$

Overdekning:

Eksponeringsklasse = XC1

$$C_{min} = \max \{ C_{min,b}; C_{min,dur} + \Delta C_{dur,\gamma} - \Delta C_{dur,st} - \Delta C_{dur,add}; 10 \text{ mm} \} \quad (\text{EC2 - Del 1-1, 4.4.1.2(2)})$$

$$C_{min,b} := 12 \text{ mm} \quad (\text{EC2 - Del 1-1, 4.4.1.2(2)})$$

$$C_{min,dur} := 15 \text{ mm} \quad (\text{EC2 - Del 1-1, 4.4.1.2(5)})$$

$$\Delta C_{dur,\gamma} := 0 \text{ mm} \quad (\text{EC2 - Del 1-1, 4.4.1.2(6)})$$

$$\Delta C_{dur,st} := 0 \text{ mm} \quad (\text{EC2 - Del 1-1, 4.4.1.2(7)})$$

$$\Delta C_{dur,add} := 0 \text{ mm} \quad (\text{EC2 - Del 1-1, 4.4.1.2(8)})$$

$$C_{min} := C_{min,dur} = 15 \text{ mm}$$

Avvik:

$$\Delta C_{dev} := 10 \text{ mm} \quad (\text{EC2 - Del 1-1, 4.4.1.3(1)})$$

Nominell overdekning:

$$C_{nom} := C_{min} + \Delta C_{dev} = 25 \text{ mm}$$

Beregning av horisontalarmering:

$$A_{s,hmin} := 0.001 \cdot A_c = 140 \text{ mm}^2 \quad (\text{EC2 - Del 1-1, 9.6.3(1)})$$

Velger diameter:

$$\varnothing_h := 6 \text{ mm}$$

Krav til senteravstand til horisontalarmering:

$$s_h = \max (400 \text{ mm}) \quad (\text{EC2 - Del 1-1, 9.6.3(2)})$$

Senteravstand til horisontalarmering:

Velger samme mengde som vertikalarmoring

$$s_{h,faktisk} := s_{v,faktisk} = 200 \text{ mm}$$

Antall stenger stenger:

Velger samme mengde som vertikalarmoring

$$n_h := \frac{H_{vegg}}{s_{v,faktisk}} = 15.9$$

$$A_{s,h,faktisk} := \pi \cdot \left(\frac{\varnothing_h}{2} \right)^2 \cdot n_h = 449.562 \text{ mm}^2$$

Sjekker kapasiteten:

m - n diagram:

Minimumseksentrisitet:

$$e_0 = \max(20 \text{ mm}, h/30) \quad (\text{EC2 - Del 1-1, 6.1(4)})$$

$$\frac{h_{vegg}}{30} = 33.333 \text{ mm}$$

$$e_0 := \frac{h_{vegg}}{30} = 33.333 \text{ mm}$$

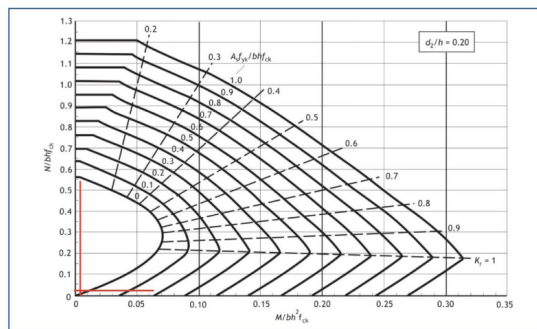
$$M_{0.Ed.x} := N_{Ed.y} \cdot e_0 = 2.15 \text{ kN} \cdot \text{m}$$

$$n_{Ed.1} := \frac{N_{Ed.y}}{f_{ck} \cdot b_{vegg} \cdot h_{vegg}} = 0.013$$

$$m_{Ed.1} := \frac{M_{0.Ed.x}}{f_{ck} \cdot b_{vegg} \cdot h_{vegg}^2} = 4.388 \cdot 10^{-4}$$

$$d_2 := C_{nom} + \frac{\varnothing_v}{2} = 28 \text{ mm}$$

$$\frac{d_2}{b_{vegg}} = 0.2$$



$$w_1 := 0$$

Trenger kun minimumsarmering i dette tverrsnittet

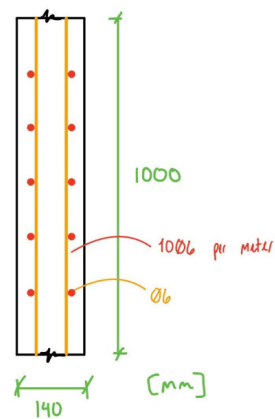
$$A_{s,faktisk} \quad \text{OK}$$

Aksialtrykkapasitet:

$$N_{Rd} := f_{cd} \cdot (A_c - A_{s,faktisk}) + f_{yd} \cdot A_{s,faktisk} = 2889.112 \text{ kN}$$

Sjekker om det er nok plass i tverrsnittet:

$$b_{n\ddot{o}dvendig} := 2 \cdot C_{nom} + 2 \cdot \varnothing_v + 2 \cdot \varnothing_h = 74 \text{ mm}$$



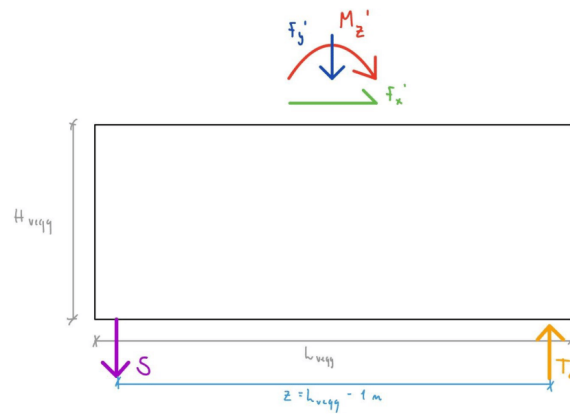
Sjekker knekking:

$$N_E := \frac{\pi^2 \cdot E \cdot I}{L_{vegg}^2} = (6.938 \cdot 10^4) \text{ kN} \quad N_E > N_{Ed} \quad \text{OK}$$

Sjekker for momentet om x-aksen:

Kraftlikevekt:

Antar arm mellom kreftene: $z = 6.512 \text{ m}$



$$T_c := \frac{M_z}{z} + \frac{F_y}{2} = 717.318 \text{ kN}$$

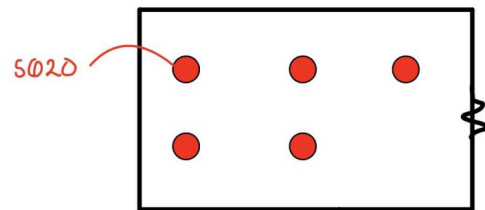
$$S := \frac{M_z}{z} - \frac{F_y}{2} = -588.672 \text{ kN}$$

Hvor mye mer armering trenger i hjørne med S:

$$A_{s,hjørne,behov} := -\frac{S}{f_{yd}} = (1.356 \cdot 10^3) \text{ mm}^2$$

$$n_{hjørne} := 5 \quad \quad \quad \varnothing_{hjørne} := 20 \text{ mm}$$

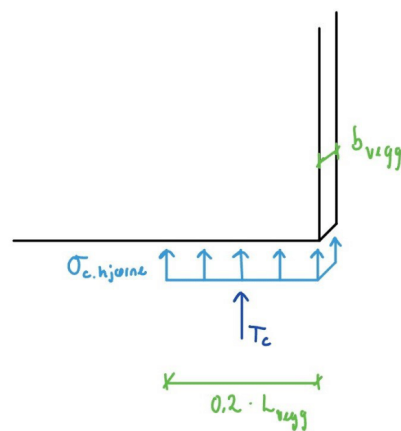
$$A_{s,hjørne} := n_{hjørne} \cdot \left(\frac{\varnothing_{hjørne}}{2} \right)^2 \cdot \pi = (1.571 \cdot 10^3) \text{ mm}^2$$



Tåler det andre hjørnet alt trykket:

$$\sigma_{c,hjørne} := \frac{T_c}{b_{vegg} \cdot 0.2 \cdot L_{vegg}} = 3.41 \text{ MPa}$$

$$\sigma_{c,hjørne} < f_{cd} \quad OK$$



Lengden $0.2 \cdot L_{vegg}$ er antatt

Sjekker skjærfriksjon mellom veggelementene i fugen:

$$f_{ctd} := 1.25 \text{ MPa} \quad (\text{Betongelementboka, Bind B, Tabell B 16.2})$$

$$\varnothing_{fuge} := 8 \text{ mm} \quad s_{fuge} := 300 \text{ mm} \quad \text{Antar } \varnothing \text{ og } s$$

$$A_{s,fuge} := \left(\frac{\varnothing_{fuge}}{2} \right)^2 \cdot \pi \cdot \frac{L_{vegg}}{s_{fuge}} = (1.259 \cdot 10^3) \text{ mm}^2$$

$$A_{c,tot} := L_{vegg} \cdot b_{vegg} = 1.052 \text{ m}^2$$

$$V_{Rd} := 0.03 \cdot f_{ctd} \cdot A_{c,tot} + 0.5 \cdot f_{yd} \cdot A_{s,fuge} + 0.5 \cdot F_y = 965.56 \text{ kN}$$

(Betongelementboka, Bind B, Tabell B 16.5)

$$V_{Rd} > V_{Ed,x} \quad OK$$