Assignment 9

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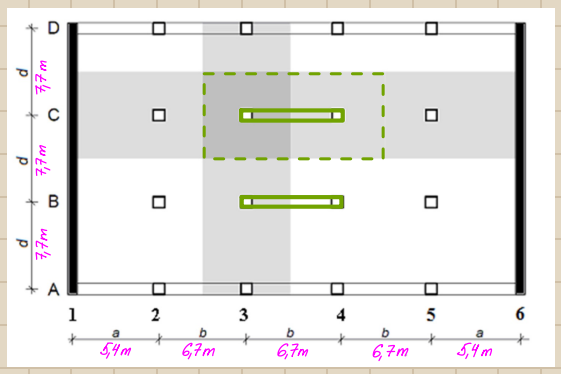
$T = III$

$W = II$

$h = 3,5\ m$

$n = 5$



1. Structure loads

Dimensions of the walls:

$L_w = 6,7 + 0,25 \cdot 2 = 7,2\ m$ (column)

$b_w = 0,25\ m$

I will use clear height of the column bc part of it is included in the slab

Tributary area: $(6,7 + 6,7) \cdot 7,7 = 103,18\ m^2$

$G_{s,k} = 103,18 \cdot 0,3 \cdot 25 \cdot 5 = 3869,25\ kN$ – slab self-weight (5 floors) (height from hw 7–8)

$G_{w,k} = 7,2 \cdot 0,25\ (3,5 - 0,3) \cdot 25 \cdot 5 = 720\ kN$ – walls weight (5 floors)

$(g - g_{0,floor,k} = 1,4\ kN/m^2$

$q_{floor,k} = 4,9\ kN/m^2$

$G_{f,k} = 1,4 \cdot 103,18 \cdot 5 = 722,3\ kN$ – other dead load from 5 floors

$Q_k = 4,9 \cdot 103,18\ 5 = 2527,9\ kN$ – live load from 5 floors

Min. load $= G_{s,k} + G_{w,k}$

$R_{min} = 3869,25 + 720 = 4589,25\ kN$

Max. load $= G_{s,d} + G_{w,d} + g_d + q_d$

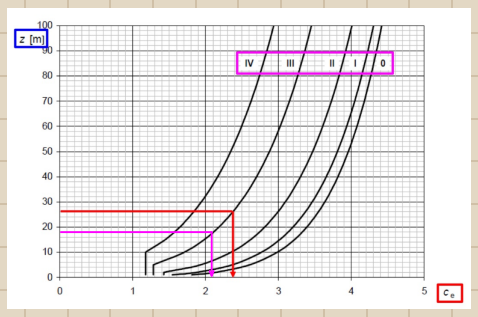
$R_{max} = 1,35(3869,25 + 720 + 722,3) + 1,5 \cdot 2527,9 = 10\,962,4\ kN$

2. Load effects

$\sigma_{N,min} = \frac{R_{min}}{b_w \cdot L_w} = \frac{4589,25}{0,25 \cdot 7,2} = 2549,6\ kPa$

$$\sigma_{N,max} = \frac{R_{max}}{b_w \cdot L_w} = \frac{10\,962,4}{0,25 \cdot 7,2} = 6090,2 \text{ kPa}$$

3. Wind loads



II wind load area $\Rightarrow$ $v_b = 25$ m/s

III terrain category, $z = 5 \cdot 3,5 = 17,5$ m $\Rightarrow$ $c_e = 2,08$

$c_{pe} = 1,3$

Characteristic value of wind load:

$$w_k = \left(\frac{\rho_v \cdot v_b^2}{2}\right) c_e(z) \cdot c_{pe} = (0,5 \cdot 1,25 \cdot 10^{-3} \cdot 25^2) \cdot 2,08 \cdot 1,3 = 1,06 \text{ kN/m}^2$$

$$w_d = \gamma_a \cdot w_k = 1,5 \cdot 1,06 = 1,59 \text{ kN/m}^2$$

Linear wind load

$$B = 7,7 \cdot 3 + 0,25 \cdot 2 = 23,6 \text{ m}$$

$$w_{k,lin} = w_k \cdot B = 1,06 \cdot 23,6 = 25,02 \text{ kN/m}$$

$$w_{d,lin} = w_d \cdot B = 1,59 \cdot 23,6 = 37,52 \text{ kN/m}$$

4. Load on individual walls

$$w_{ein,1} = \frac{E I_1}{\Sigma E I_i} \cdot w_{ein} = \frac{w_{lin}}{m}$$

$$w_{lin,1,k} = 25,02 \cdot 0,5 = 12,51 \text{ kN/m}$$

$$w_{lin,1,d} = 37,52 \cdot 0,5 = 18,76 \text{ kN/m}$$

5. Load effects

$$M_w = 0,5 \cdot w_{lin,1} \cdot H^2$$

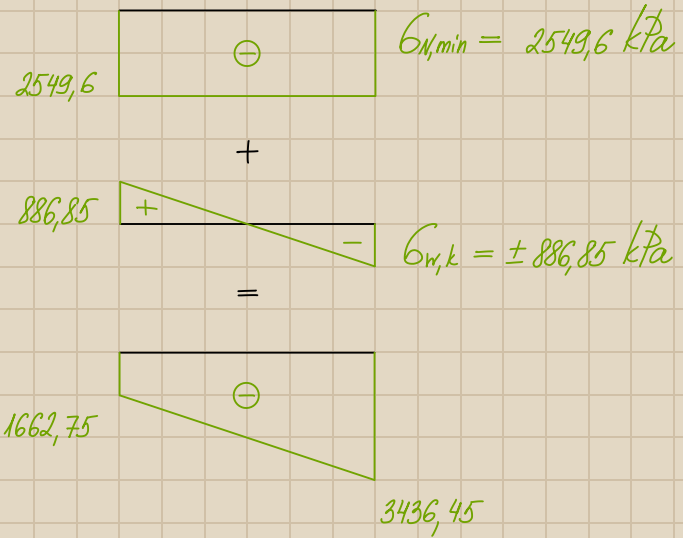
$$\sigma_w = \pm \frac{M_w}{W} = \frac{0,5 \cdot w_{lin,1} \cdot H^2}{\frac{1}{6} \cdot b_w \cdot L_w^2}$$

$$\sigma_{w,k} = \pm \frac{0{,}5 \cdot 12{,}51 \cdot 17{,}5^2}{\frac{0{,}25 \cdot 7{,}2^2}{6}} = \pm 886{,}85 \text{ kPa}$$

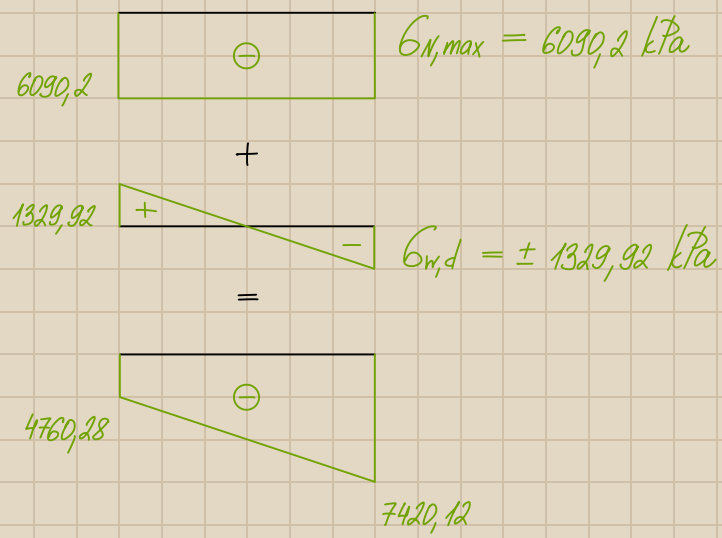
$$\sigma_{w,d} = \pm \frac{0{,}5 \cdot 18{,}76 \cdot 17{,}5^2}{\frac{0{,}25 \cdot 7{,}2^2}{6}} = \pm 1329{,}92 \text{ kPa}$$

6. Load combinations

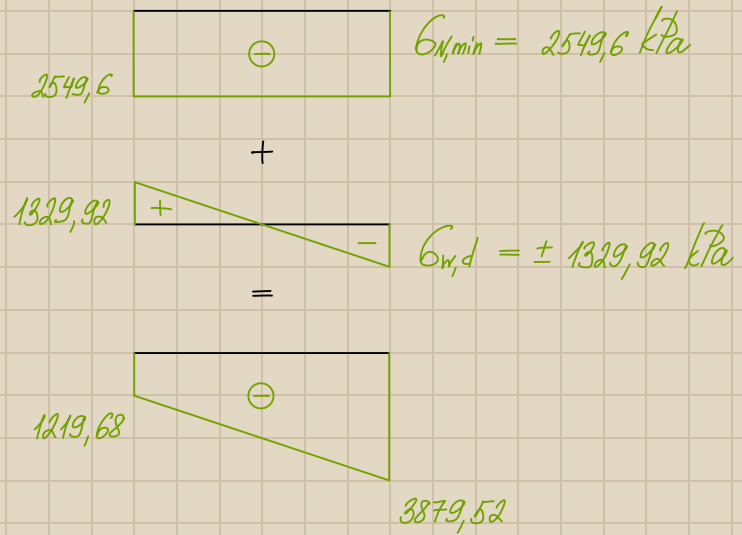
1) CO1 – Expected loads



2) CO2 – Compressive design loads



3) CO3 – Tensile design loads



No tensile stress => no need to use this combination in the most tensioned part

7. Basic reinforcement design

1) Vertical reinforcement

$0{,}002\,a_c \leq a_{s,v} \leq 0{,}04\,a_c$

$a_c = 0{,}25 \cdot 10^6\ mm^2$

$500\ mm^2 \leq a_{s,v} \leq 10\,000\ mm^2$

$s_v \leq \min(3t;\ 400\ mm) = \min(3 \cdot 250\ mm;\ 400\ mm) = 400\ mm$

Design: $\phi 8$ per 150 mm

$$a_{s,v} = 2\pi r^2 \cdot \frac{1000}{s} = \frac{2\pi \cdot 4^2 \cdot 1000}{150} = 670\ mm^2 \checkmark$$

2) Horizontal reinforcement

$a_{s,h} \geq \max(0{,}25\,a_{s,v};\ 0{,}001\,a_c) = \max(167{,}5\ mm^2;\ 250\ mm^2) = 250\ mm^2$

$s_h \leq 400\ mm$

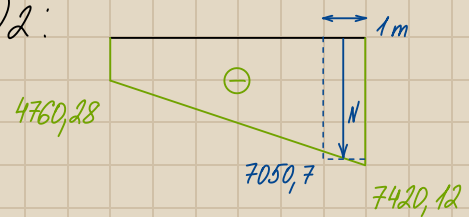
Design: $\phi 6$ per 150 mm

$$a_{s,h} = \frac{2\pi \cdot 3^2 \cdot 1000}{150} = 377\ mm^2 \checkmark$$

8. Assessment of the wall

1) Compressed reinforcement

CO2:



$$\frac{7420,12 - 4760,28}{7,2} = \frac{\sigma_1'}{6,2}$$

$$\sigma_1' = 2290,42 \text{ kPa}$$

$$\sigma_1 = 2290,42 + 4760,28 = 7050,7 \text{ kPa}$$

$$\sigma_\phi = \frac{7420,12 + 7050,7}{2} = 7235,41 \text{ kPa}$$

$$N = \sigma_\phi \cdot b_w \cdot 1 = 7235,41 \cdot 0,25 = 1808,85 \text{ kN}$$

$$a_{s,req,v} = \frac{N - 0,8 a_c \cdot f_{cd}}{\sigma_s} = \frac{1808,85 - 0,8 \cdot 0,25 \cdot 16,67 \cdot 10^3}{400 \cdot 10^3} = -0,0038 \text{ m}^2 \; *$$

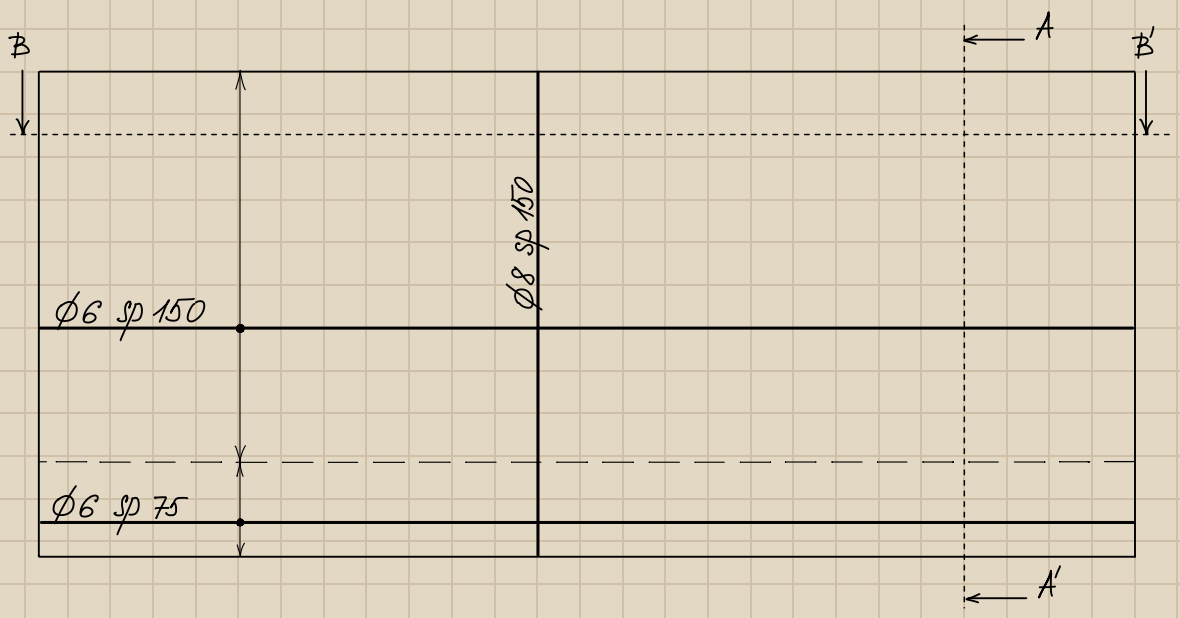
* concrete can sustain the load itself

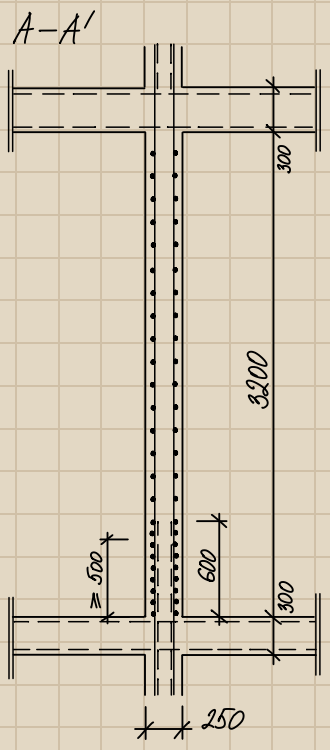
$a_{s,v} > a_{s,req,v} \Rightarrow$ no change in design

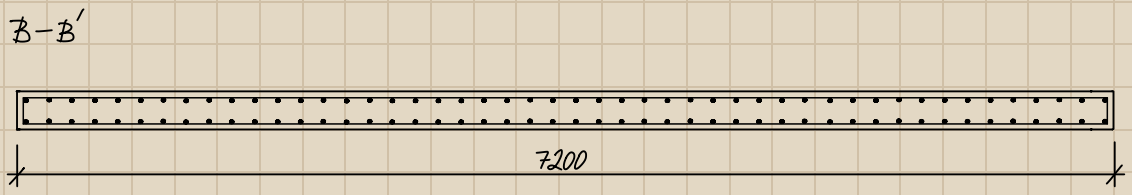
2) Tensile reinforcement

no tension has occured in CO3 => no tensile reinforcement

Sketch 1:50


B
B'
A
A'
Ø8 sp 150
Ø6 sp 150
Ø6 sp 75


A-A'
300
3200
≥ 500
600
300
250


B-B'
7200