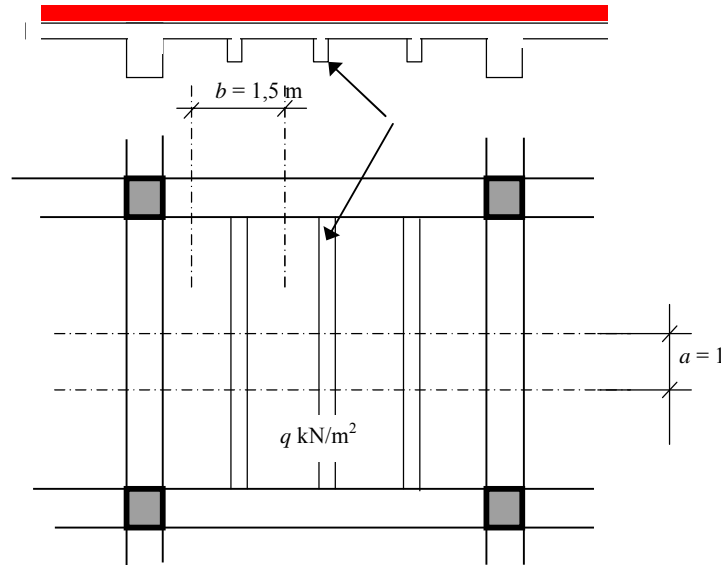


Assignment 1 - actions



Determine action on the beam for verification of the ultimate limit state. Axial distance of the beams is 1 to 2 m, cross section dimensions $0,45 \times 0,20$ m (including the slab thickness), slab thickness is 0,1 m. Consider the permanent load due to slab (volume weight is 25 kN/m^3) and imposed load $q_k = 1,50 \text{ kN/m}^2$. Partial factor for the permanent and imposed loads are $\gamma_G = 1,35$ and $\gamma_Q = 1,5$.

Solution of the assignment 1

The axial distance of the beams is assumed: 1,5 m

The characteristic loads:

Permanent from the slab $g = 1,5 \times 0,1 \times 25 = 3,75 \text{ kN/m}$

from the beam $g_k = (0,45 - 0,1) \times 0,2 \times 25 = 1,75 \text{ kN/m}$

Permanent total $g_k = 5,5 \text{ kN/m}$

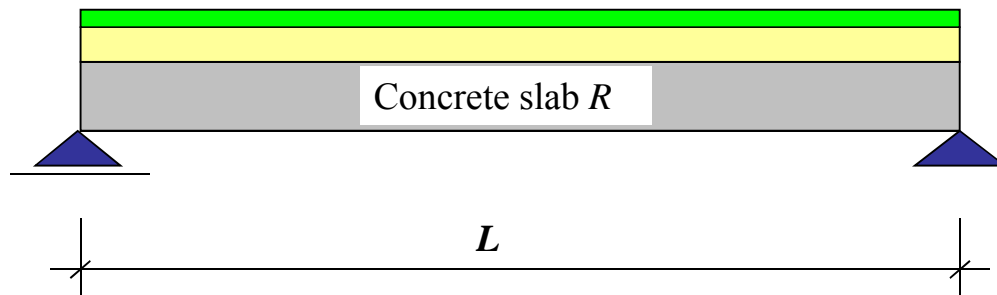
Imposed load $q_k = 1,5 \times 1,5 = 2,25 \text{ kN/m}$

Design load total:

$$\begin{aligned} p_d &= g_k \times 1,35 + q_k \times 1,5 = 5,5 \times 1,35 + 2,25 \times 1,5 = \\ &= 7,425 + 3,375 = 10,8 \text{ kN/m} \end{aligned}$$

Assignment 2 – concrete slab

$G + Q$



(1) Determine the maximum bending moment M_{Ed} of the simply supported reinforced concrete slab of the span $L = 3$ to 5 m exposed to permanent load due to own weight of the slab having the thickness $h \sim L/20$ m and imposed load 5 kN/m^2 . Consider 1 m width of the slab (volume weight is 25 kN/m^3), partial factor for the dead load $\gamma_G = 1,35$, for imposed load $\gamma_Q = 1,5$.

(2) Estimate reinforcement area A_s required for 1 m width of the slab using approximate formula $A_s \sim M_{Ed} / (z f_{yd})$, where $z \sim 0,9 d$ and $d = h - 0,03 \text{ m}$. Consider steel S 500 (the characteristic strength 500 MPa) and the partial factor for steel $\gamma_s = 1,15$.

Solution of the assignment 2

Assuming span $L = 3 \text{ m}$:

$$(1) M_{ed} = (25 \times 0,15 \times 1,35 + 5 \times 1,5) \times 3^2 / 8 = 14,13 \text{ kNm}$$

$$(2) f_{yd} = f_{yk} / \gamma_s = 500 / 1,15 = 435 \text{ MPa},$$

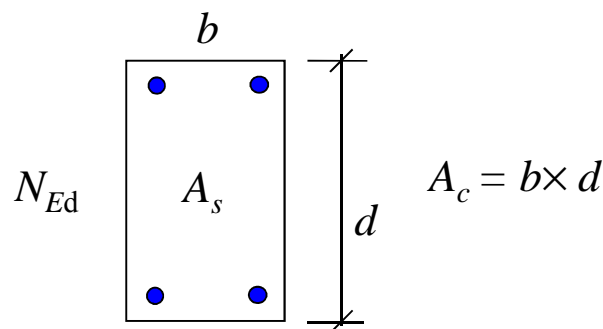
$$d = h - 0,03 = 0,12$$

$$z \cong 0,9 d = 0,9 \times 0,12 = 0,108 \text{ m}$$

$$A_s \cong M_{E'} / (z \times f_{yd}) = 0,01413 / (0,108 \times 435) = 0,0003 \text{ m}^2$$

Assignment 3 – concrete column

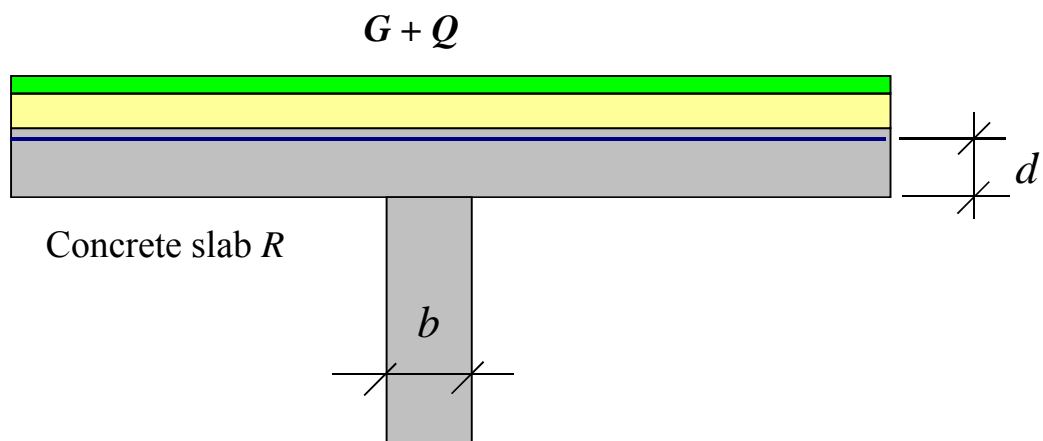
Assess required reinforcement area A_s of a short reinforced concrete column $0,3 \times 0,3$ m exposed to the centric force $N_{Ed} = 1500$ kN, consider the characteristic strength of reinforcement $f_{yk} = 500$ MPa, the partial factor $\gamma_s = 1,15$, the characteristic strength of concrete $f_{ck} = 20$ MPa the partial factor $\gamma_c = 1,5$. The column resistance is $N_{Rd} = 0,8 A_c f_{cd} + A_s f_{yd}$.



Solution of the assignment 3

- $f_{yd} = f_{yk} / \gamma_s = 500 / 1,15 = 435$ MPa,
- $f_{cd} = f_{ck} / \gamma_c = 20 / 1,5 = 13,3$ MPa
- $N_{Ed} = N_{Rd} = 0,8 A_c f_{cd} + A_s f_{yd} \rightarrow$
- $A_s = (1,5 - 0,8 \times 13,3 \times 0,3 \times 0,3) / 435 = 0,001247$ m²
- $0,003 \times 0,3 \times 0,3 = 0,00027 < 0,001247 <$
 $< 0,08 \times 0,3 \times 0,3 = 0,0072$ m²

Assignment 4 – Punching shear



Verify resistance of the flat slab exposed to permanent load due to permanent load $g_k = 7 \text{ kN/m}^2$ and imposed load $q_k = 5 \text{ kN/m}^2$ ($\gamma_G = 1,35$, $\gamma_Q = 1,5$). Consider loading area 36 m^2 . The effective depth of the slab is $d = 0,15 \text{ m}$, design shear strength $\tau_c = 2 \text{ MPa}$. The slab is supported by a circular column of the diameter $b = 0,30 \text{ m}$.

Solution of the assignment 4

The design shear force

$$N_{Ed} = 36 \times (7 \times 1,35 + 5 \times 1,5) = 610,2 \text{ kN}$$

The critical perimeter

$$u = \pi(b + 3d) = 3,14 (0,3 + 3 \times 0,15) = 2,355 \text{ m}$$

The shear resistance

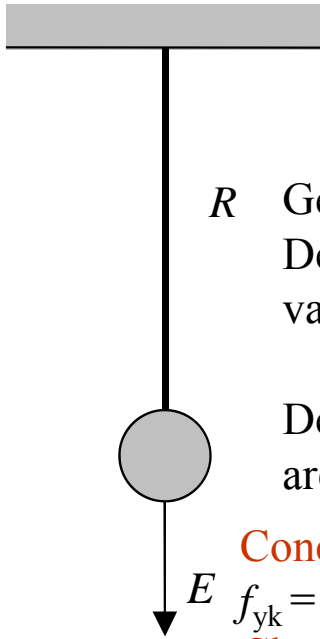
$$V_{Rd1} = 2 \times 0,15 \times 2,355 = 706,5 \text{ kN}$$

$$N_{Ed} < V_{Rd1}$$

The slab is resistant against punching shear without special shear reinforcement

Assignment 5 – A steel rod

Specify section area A of a steel rod



		Load effect	Resistance
R	General	$E = G + Q$	$R = A f_y$
	Design values	A: $E_d = \gamma_G G_k + \gamma_Q Q_k$ B: $E_d > \xi \gamma_G G_k + \gamma_Q Q_k$ $> \gamma_G G_k + \psi_0 \gamma_Q Q_k$	$R_d = A f_{yk} / \gamma_M = A f_{yd}$
	Design of the area A	$E_d < R_d$	$\Rightarrow A > E_d / f_{yd}$

Consider: $\gamma_G = 1,35$, $\gamma_Q = 1,5$, $\xi = 0,85$, $\psi_0 = 0,7$, $\gamma_M = 1,10$
 $f_{yk} = 235$ MPa, thus $f_{yd} = f_{yk} / \gamma_M = 214$ MPa

Choose your own values: $G_k \sim 0,6$ MN, $Q_k \sim 0,4$ MN,

A: $E_d = 1,35 \times 0,6 + 1,5 \times 0,4 = 1,41$ MN

B: $E_d = 1,35 \cdot 0,6 + 0,7 \times 1,5 \times 0,4 = 1,23$ MN

A: $A > 1,41 / 214 = 0,00659$ m²

B: $A > 1,23 / 214 = 0,00574$ m² ($= 0,87 \times 0,00659$)

Assignment 6 - Masonry

Specify resistance of a masonry wall (modify dimensions):

Fired bricks $f_u = 25$ MPa, units I, production B, $\gamma_M = 2,2$

$K = 0,4$; $f_b = \delta f_u = 0,77 \times 25 = 19,25$ Mpa; M10: $f_m = 10$ Mpa

$f_k = 0,4 \times 19,25^{0,65} \times 10^{0,25} = 4,86$ MPa, $f_d = f_k / \gamma_M = 4,86 / 2,2 = 2,07$ MPa

$M = 0$, $e_{fi} = e_{fm} = 0$; $h_{ef} = 0,75 \times 3,3 = 2,5$ m, $b = 1$ m, $t = 0,44$ m

$$N_{Rd} = \Phi_{i,m} \times b \times t \times f_d = \Phi_{i,m} \times 0,911 \text{ MN}$$

Foot and head of the wall:

$$e_a = h_{ef} / 450 = 2,5 / 450 = 0,0055 \text{ m}$$

$$e_i = e_{fi} + e_a = 0 + 0,0055 (\geq 0,05 t); 0,05 t = 0,05 \times 0,44 = 0,022 \text{ m}$$

$$e_i = 0,022 \text{ m}, \Phi_i = 1 - 2 e_i / t = 1 - 2 \times 0,022 / 0,44 = 0,9$$

$$N_{Rd} = \Phi_i \times b \times t \times f_d = 0,9 \times 1 \times 0,44 \times 2,07 = 0,820 \text{ MN}$$

Middle of the wall:

$e_k = 0$, for $\alpha_{sec} = 1000$, $h_{ef} / t_{ef} = 5,64$ and $e_{mk} / t = 0,05$ graph: $\Phi_m = 0,88$

$$N_{Rd} = \Phi_m \times b \times t \times f_d = 0,88 \times 1 \times 0,44 \times 2,07 = 0,802 \text{ MN}$$