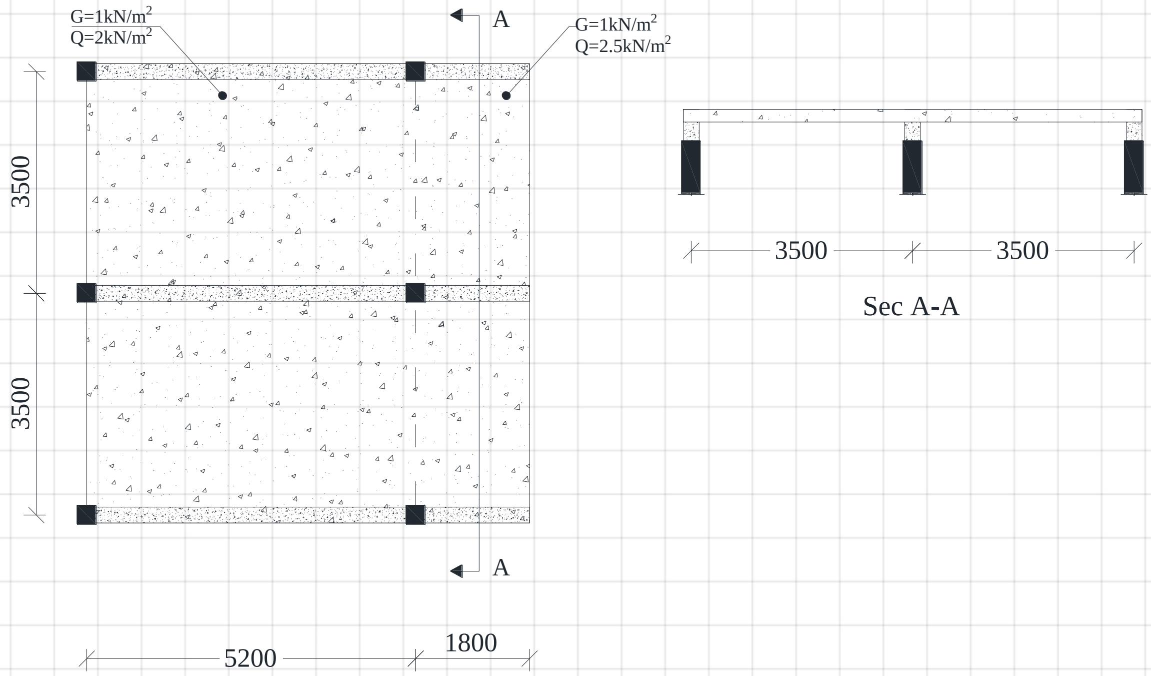
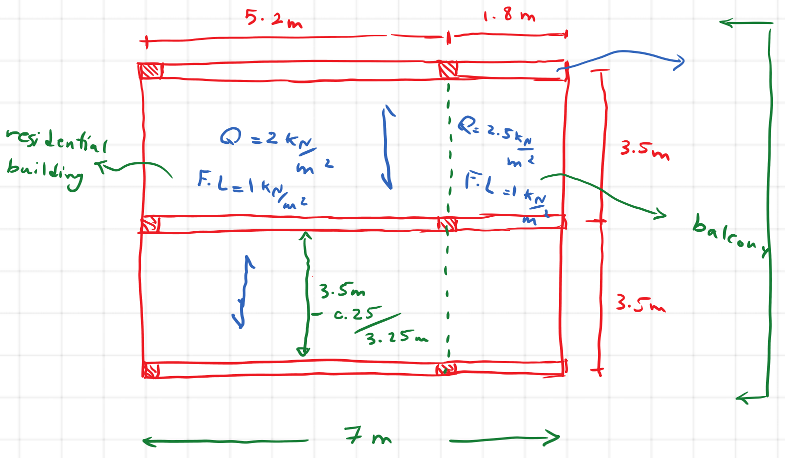
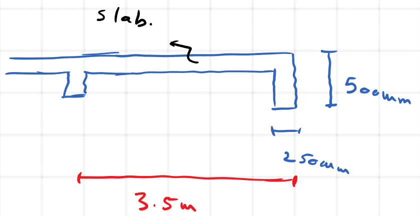
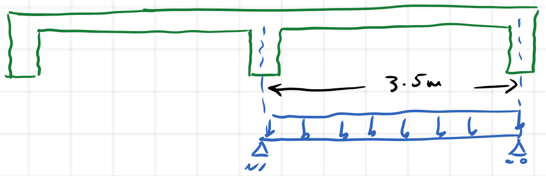
In a residential building, a slab is designed on the top of three beams as shown in the figure below. The cantilever of 1.8 meters is supposed to be used as a balcony. A dead load of $1kN/m^2$ is considered for the finishing layer. The nominal cover is assumed to be 25mm for the slab, concrete class C30/37, and steel of B500. The primary and secondary reinforcement can be from 12mm in diameter. According to the given information:

a) Determine the required depth of the slab.
b) Design the primary and secondary reinforcement on the top and bottom layers.
c) Check the design to comply with the Eurocode detailing requirement based on Finnish National Annex.

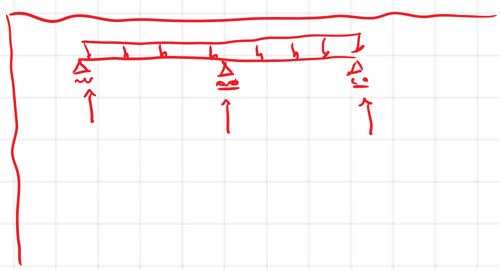








slab { b = 7m, a = 3.5m } → $\frac{b}{a} \geq 2$ → one way slab



7.4.N → { $\rho = 1.5\%$ → $L/d \leq 14$; $\rho = 0.5\%$ → $L/d \leq 20$ }

(Assume)

ρ is 0.5% → $\frac{L}{d} \leq 20$ ⇒ $\frac{3500\,mm}{d} \leq 20$ ⇒ $d \geq 175\,mm$

C 30/37

CC : 2

(B500) $f_{yk} = 500$ Mpa

$c_{nom}(slab) = 25mm$

(T12)

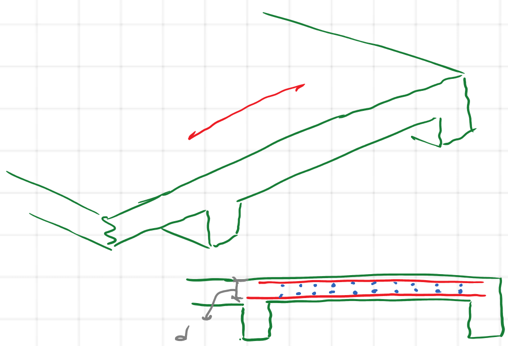
→ $h_{min} = d + c_{nom} + 1.1 \times \frac{12mm}{2} = 206\,mm$

→ $h = 200\,mm$

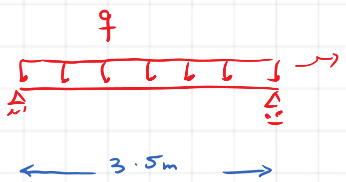
C 30/37 → $f_{cd} = \alpha_{cc} \cdot \frac{f_{ck}}{\gamma_c} = 17\,Mpa$ (α_{cc} = 0.85, f_{ck} = 30 Mpa, γ_c = 1.5)

$f_{yk} = 500\,Mpa$ → $f_{yd} = \frac{f_{yk}}{\gamma_s} = 435\,Mpa$ (γ_s = 1.15)

$c_{nom} = 25mm$



$d = 200mm - 25mm - 1.1 \times \frac{12mm}{2} = 168\,mm$



$Q = 2.5\,kN/m^2$

$D = 1\,kN/m^2 + 0.2\,m \times 25\,kN/m^2 = 6\,kN/m^2$

$$M = \frac{q \cdot L^2}{8} \rightarrow \begin{cases} M_D = \dfrac{6\,kN/m^2 \cdot (3.5\,m)^2}{8} = 9.2\,\dfrac{kN \cdot m}{m} \\ M_Q = \dfrac{2.5\,kN/m^2 \cdot (3.5\,m)^2}{8} = 3.83\,\dfrac{kN \cdot m}{m} \end{cases}$$

$$ULS: \begin{cases} 1.35\,D \\ 1.15\,D + 1.5\,L \end{cases}$$

$$M_{ULS}: \begin{cases} 1.35 \times 9.2\,\dfrac{kN \cdot m}{m} = 12.4\,\dfrac{kN \cdot m}{m} \\ 1.15 \times 9.2\,\dfrac{kN \cdot m}{m} + 1.5 \times 3.83\,\dfrac{kN \cdot m}{m} = 16.3\,\dfrac{kN \cdot m}{m} \end{cases}$$

$$M_{Ed} = 16.3\,\frac{kN \cdot m}{m}$$

$$M_{Rd,c} = \mu_{bd} \cdot f_{cd} \cdot b \cdot d^2$$

f_{cd}: 17 Mpa

μ_{bd}: 0.372 ($f_{yk} = 500$ Mpa) $\rightarrow M_{Rd,c} = 178\,\frac{kN \cdot m}{m} > M_{Ed} \rightarrow$ Tensile reinforcement is enough.

$b = 1000$ mm , $d = 168$ mm

$$\mu = \frac{M_{Ed}}{f_{cd} \cdot b \cdot d^2} = \frac{16.3\,\frac{kN \cdot m}{m}}{17\,Mpa \cdot (1\,m) \cdot (168\,mm)^2} = 0.034$$

$$\mu \Rightarrow \beta = 1 - \sqrt{1 - 2\mu} = 0.0346 \longrightarrow \beta = \frac{A_s}{b \cdot d} \cdot \frac{f_{yd}}{f_{cd}} \Rightarrow A_{s,rqd} = 227\,\frac{mm^2}{m}$$

T3.1 → 2.9 Mpa

$$A_{s,min} = \max\left\{0.26 \cdot \frac{f_{ctm}}{f_{yk}}, 0.0013\right\} \cdot b \cdot d = 253\,mm^2/m$$

$$A_s = \max\{A_{s,rqd}, A_{s,min}\} = 253\,mm^2/m$$

$A_s = 253\ mm^2/m$, T12 → $n_s = \dfrac{253\ mm^2/m}{\pi(12mm)^2/4} = 2.24$

$S = \dfrac{1000}{2.24\ 1/m} = 446\ mm$

General

9.3.1.1(3)

The maximum value for bar spacing $s_{max,slabs}$ is: → $S \leq 400\ mm$

- for the principal reinforcement, $3h \leq 400$ mm, where h is the total depth of the slab;
- for the secondary reinforcement, $4h \leq 600$ mm. → $S \leq 600\ mm$

In areas with concentrated loads or areas of maximum moment the provisions are respectively:

- for the principal reinforcement, $2h \leq 250$ mm → $S \leq \min\{2 \cdot h = 400\ mm,\ 250\ mm\} = 250\ mm$
- for the secondary reinforcement, $3h \leq 400$ mm. → $S \leq \min\{3 \cdot h = 600\ mm,\ 400\ mm\} = 400\ mm$

T12 @ 250mm
T12 k 250mm

P. R.

Secondary R. at least 20% P.R

T12 @ 250mm → $A_{s.p} = \dfrac{\pi \times (12mm)^2}{4} \times \dfrac{1000\ mm}{250\ mm} = 452.3\ mm^2/m$

$A_{s.s} = \max\{0.2 \times 452.3\ mm^2/m,\ 253\ mm^2/m\} = 253\ mm^2/m$

$n_{s.s} = 2.24/m$ → $S = 446\ mm$ → $S \leq \min\{3h, 400\ mm\} = 400\ mm$

$S = 400\ mm$ →

T12 @ 400
T12 k 400