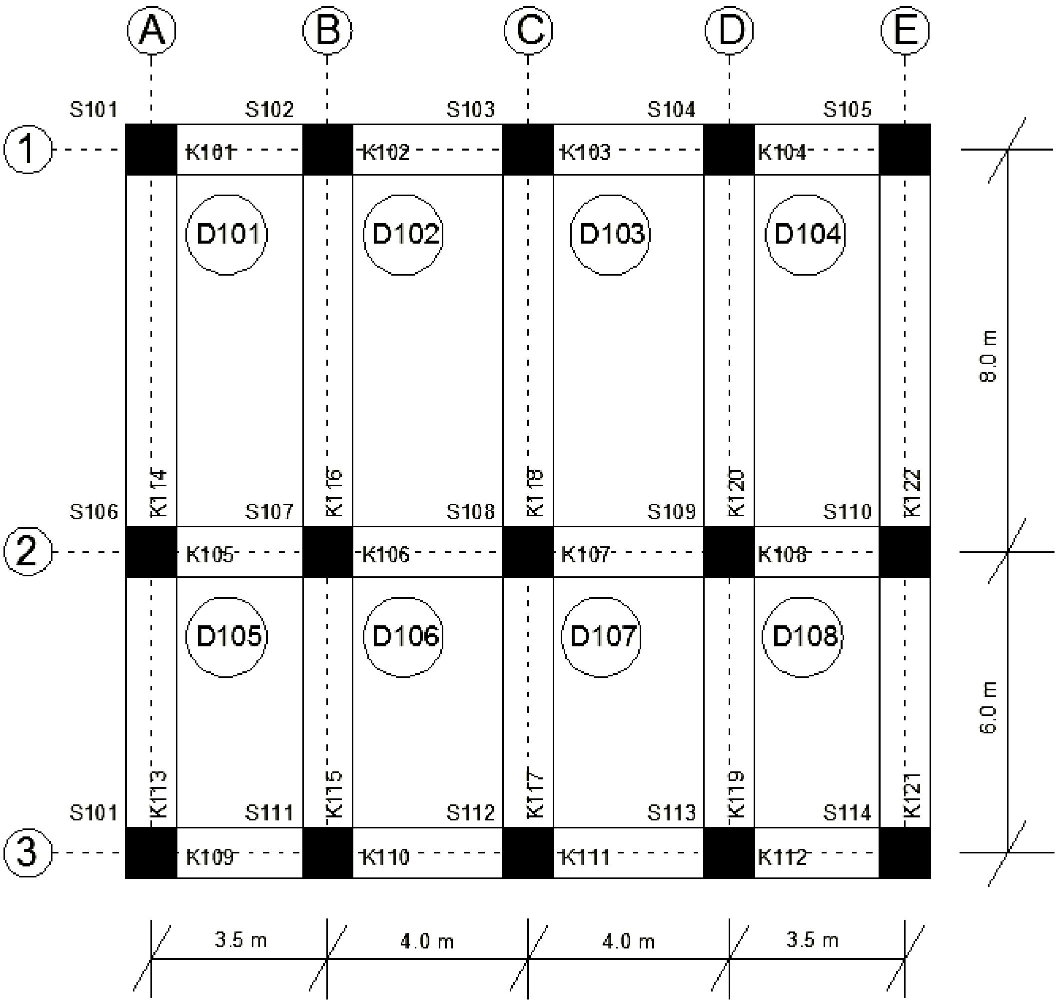
Middle East Technical University
Civil Engineering Department
CE 486 Structural Design - Concrete Structures

From: 16.10.2014
Deadline: 23.10.2014

Homework #1 Solution

Slab thickness is to be determined using TS500 provisions.



Material properties were selected as:

fck=	**25**	**Mpa**
fyk=	**420**	**Mpa**

- ***For the entire slab system select a single thickness of slab:***

The m ratios ($m= l_l/l_s$) for each slab is calculated and the slabs are categorized considering the below criteria:

If $m>2$ $\longrightarrow$ One-way slab

If $m\leq2$ $\longrightarrow$ Two-way slab

The results are shown in the below table. All the slabs in the typical floor will be considered as two-way slab systems.

	L_{long}	L_{short}	m ratio	Slab Type
D101	8	3.5	2.29	one-way slab
D102	8	4	2.00	two-way slab
D103	8	4	2.00	two-way slab
D104	8	3.5	2.29	one-way slab
D105	6	3.5	1.71	two-way slab
D106	6	4	1.50	two-way slab
D107	6	4	1.50	two-way slab
D108	6	3.5	1.71	two-way slab

Slab Thickness

A common slab thickness is desired because of the ease of construction and architectural appearance.

h ≥ 80 mm for slabs according to the

To avoid deflection calculations;

	Support Type			
Members	**Simply**	**Exterior**	**Interior**	**Cantilever**
one-way slab	1/20	1/25	1/30	1/10
two-way slab	1/25	1/30	1/35	

	L_{long}	L_{short}	Slab Type	Support*		Thickness (cm)
D101	8	3.5	one-way slab	Exterior	3.5*100/25	14.00
D102	8	4	two-way slab	Interior	4*100/35	11.43
D103	8	4	two-way slab	Interior	4*100/35	11.43
D104	8	3.5	one-way slab	Exterior	3.5*100/25	14.00
D105	6	3.5	two-way slab	Exterior	3.5*100/25	11.67
D106	6	4	two-way slab	Interior	4*100/35	11.43
D107	6	4	two-way slab	Interior	4*100/35	11.43
D108	6	3.5	two-way slab	Exterior	3.5*100/30	11.67

Max.thickness (cm)= 14 cm

If we select deflection calculation option Selected thickness will be = 12 cm

For the two-way slabs, the requirements in TS500 are checked. Results are shown in the below table.

$$h \geq \frac{l_{sn}}{15+\frac{20}{m}}\left(1-\frac{\propto_s}{4}\right)$$

	L_{long}	L_{short}	Cont.Edges	Total Edges	α_s	h ≥ (mm)
D101	8	3.5	11.5	23	0.50	129
D102	8	4	20	24	0.83	127
D103	8	4	20	24	0.83	127
D104	8	3.5	11.5	23	0.50	129
D105	6	3.5	9.5	19	0.50	115
D106	6	4	16	20	0.80	113
D107	6	4	16	20	0.80	113
D108	6	3.5	9.5	19	0.50	115

To be able to avoid deflection check the thickness of the slabs must have to be ***14 cm*** for all of them.

- Determine the positive and negative design moments for slab D104 per TS500 requirements for the gravity load combination of (1.4G + 1.6Q):

Dead Load:

Slab=(0.14m)(2.5t/m^3)(1m)=0.35t/m^3 = 3.5 kN/m

Finish work=(2.2 kN/m^2)(1m)= 2.2 kN/m

Total DL= 5.7 kN/m

Live Load:

According to the TS498; live load for office building is 2 kN/m^2.

Total LL= (2 kN/m^2)(1m)= 2 kN/m

P_d= (1.4)(5.7)+(1.6)(2)= 11.18 kN/m

According to the TS500 11.2.2
3.5/4 > 0.8 for cont. slabs and LL/DL=2/3.5 < 2. Thus we can use the approximate method which is given in 11.2.2.

Positive moment:

Exterior Span → $\boxed{M_d = \frac{P_d l^2}{11}}$

Interior Span → $M_d = \frac{P_d l^2}{15}$

Negative moment: @two span slabs:

Exterior Support → $M_d = -\frac{P_d l^2}{24}$

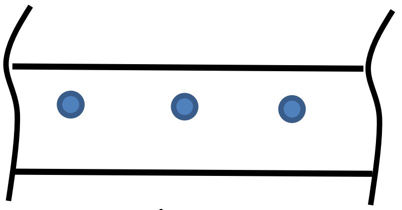
Interior Support → $M_d = -\frac{P_d l^2}{8}$

@ more than two span slabs:

Exterior Support → $M_d = -\frac{P_d l^2}{24}$

Exterior span - interior Support → $\boxed{M_d = -\frac{P_d l^2}{9}}$

Other interior supports → $M_d = -\frac{P_d l^2}{10}$



Positive span moment: $M_d = \frac{P_d l^2}{11} = \frac{11.18 \cdot 3.5^2}{11} = 12.45\ kNm/m$

Negative support moment: $M_d = \frac{P_d l^2}{9} = \frac{11.18 \cdot 3.5^2}{9} = 15.22\ kNm/m$

First let's calculate the span reinforcement;

- Check K>K$_l$

K$_l$= 291 mm^2/kN

b$_w$= 1000 mm d= 140-20(cover)=120 mm

$$K = \frac{b_w d^2}{M_d} = \frac{1000 \cdot 120^2}{12.45 \cdot 10^3} = 1156 > 291 \text{ mm}^2/\text{kN}$$

Assume minimum use of reinforcement according to TS500, section 11.2.3;

ρ=0.002

As$_{min}$=(0.002)(1000)(140)= 280 mm^2/mm

Φ 8/ 150 mm → $As_{provided} = \frac{3.14 \cdot 8^2}{4} \cdot \frac{1000}{150} = 335$ mm^2/mm > 280 mm^2/mm

Check: $M_r = A_s f_{yd} jd = 335 \cdot \frac{420}{1.15} \cdot 0.85 \cdot \frac{140}{1000^2} = 14.56\ kNm/m$ > 12.45 kNm/m

Half of the reinforcement will be bent to transfer the support region.

So; Φ8 / 300 mm plain reinforcement bar
Φ8 / 300 mm bent reinforcement bar

For the other direction (long side) use Φ8 / 300 as distribution reinforcement (TS500, Section 11.2.3).

Φ8 / 300 mm plain reinforcement bar
Φ8 / 300 mm bent reinforcement bar

Let's calculate the support reinforcement;

- Check $K>K_l$

K_l= 291 mm^2/kN
b_w= 1000 mm d= 140-20(cover)=120 mm

$$K=\frac{b_w d^2}{M_d}=\frac{1000\cdot120^2}{15.22\cdot10^3}=946.12>291 \text{ mm}^2/\text{kN}$$

Assume minimum use of reinforcement according to TS500, section 11.2.3;

$A_{s,provided}$, Φ8 / 300 bent from the span.

$$\text{As}_{\text{provided}}=\frac{3.14\cdot8^2}{4}\cdot\frac{1000}{300}=167.5 \text{ mm}^2/\text{mm}$$

ρ=0.002

$$\text{As}_{\text{required}}=\frac{15.22\cdot10^6\cdot1.15}{420\cdot0.85\cdot120}=408.6 \text{ mm}^2/\text{mm}$$

$A_{s,add}$ = $A_{s,required}$ - $A_{s,provided}$= 408.6-167.5 =241,1

Φ 10/ 200 mm → $\text{As}_{\text{add}}=\frac{3.14\cdot10^2}{4}\cdot\frac{1000}{200}=392.5$ mm^2/mm > 241.1 mm^2/mm

Check: $M_r=A_s f_{yd} jd=392.5\cdot\frac{420}{1.15}\cdot0.85\cdot\frac{140}{1000^2}=17.05\ kNm/m$ > 15.22 kNm/m

Shear Check

$$V_d=\frac{P_d l}{2}=\frac{11.18\cdot3.5}{2}=19.565\ kN$$
$$V_{cr}=0.65 f_{ctd} b_w d\left(1+\gamma\frac{N_d}{A_c}\right)=0.65\cdot1.8/1.5\cdot1000\cdot120\cdot(1+0)=93.6\text{ kN}$$

$$V_c=0.8\cdot V_{cr}=0.8\cdot93.6=74.88\ kN$$

Vd<Vc so thickness of the slab is adequate.

- Draw reinforcement detailing for slab D104.