Budapest University of Technology and Economics

Department of Mechanics, Materials and Structures

English courses

Reinforced Concrete Structures

Code: BMEEPSTK601

Lecture no. 8:

ONE-WAY SLABS, STAIR SLABS

Content:

I. One-way slabs

1. Definition of one-way and two-way slabs
2. Special characteristics of rc slabs
3. Static models
4. Fulfilment of the rigidity requirement of slabs
5. Section design for moment
6. Reinforcement system of simple supported and continuous one-way slabs, the distribution steel
7. Special reinforcement details: anti-crack reinforcement, free-edge reinforcement, additional reinforcement at holes and under linear loading
8. Example of a floor

II. Stair slabs

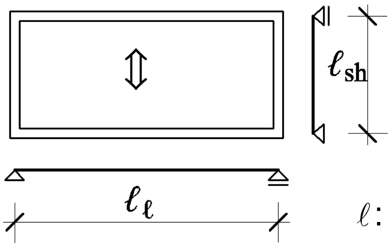
1. Static models
2. Substitutive static model of a two-flight staicase in flight direction
3. System of reinforcement

Formázott: Automatikus sorszámozás + Szint: 1 + Számozás stílusa: 1, 2, 3, … + Kezdő sorszám: 1 + Igazítás: Bal oldalt + Igazítás: 1,25 cm + Tabulátorhely: 1,89 cm + Behúzás: 1,89 cm

4. Stairs spanning transversally
5. Geometry of landing with and without transverse beam

I. One-way slabs
1. Definition of one-way and two-way slabs

Rectangular slab panel simply supported along the perimeter:



Indication of diff. support conditions

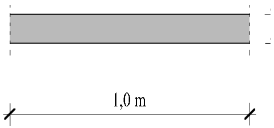
free edge   restrained edge

ℓ: longer   sh: shorter

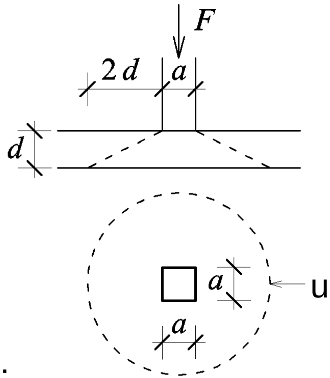
If $\frac{\ell_{\ell}}{\ell_{sh}} \geq 2$, the slab is regarded one-way slab, otherwise two-way slab

2. Special characteristics of rc slabs

-for convenience, 1 m wide strip of the slab is investigated:



t≥70 mm (cantilever slab:100 mm)



-with the ecception of introduction of important concentrated loads at column heads of flat slabs or column support points on foundation slabs, *no shear reinforcement* is needed:

$$u = 4a + 2 \cdot 2d\pi$$

$$v_{Rd,c} = cf_{dt,d}$$ c tabulated in DA

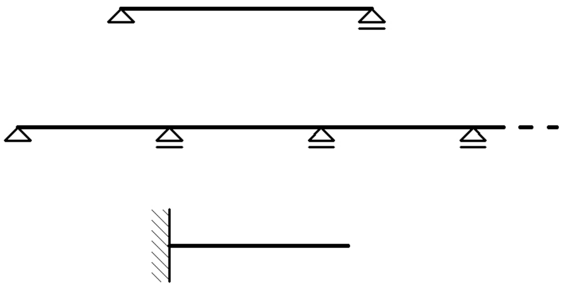
Shear rerinforcement must be designed only, if:

$$F \geq v_{Rd,c} ud$$

3. Static models

The way of determination of the *position of the support points* is the same as for beams with *h=t* (slab thickness)

Static models:



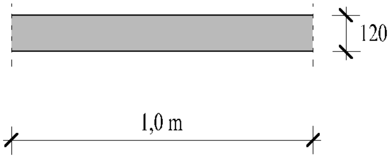
4. Fulfilment of the rigidity requirement of slabs

Slabs are flexible, ductile structures. At large (not allowable) deflections the suspension effect may impede rupture and fall down of slabs.

$\left(\frac{\ell / K}{d}\right)_{allowable}$ rates range from 20 to 40 (see DA table) and can be effected by:

- over reinforcing ($A_{s,prov} \succ A_{s,req}$)
- pre-camber (overlifting) by $\frac{\ell}{250}$ or $\frac{\ell}{500}$
- applying restraint at the support (that is increasing K)
- prescribing higher concrete grade
- increasing slab thickness

5. Section design for moment (numerical example)



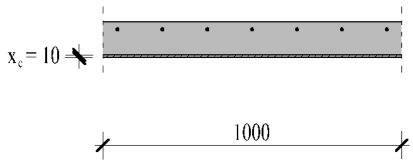
Concrete: C20/25-X0-24-F3
Steel: C15.H welded mesh
Concrete cover: c_{nom} = 20 mm

m_{Ed} = -12 kNm/m (- means tension on top!)
Design the necessary steel section!
Solution:

d = 120 – 20 – 10/2 = 95 mm (no link diameter subtracted!)

$\underline{\Sigma M_s = 0}$: $x_c = d(1-\sqrt{1-\frac{2m_{Ed}}{bd^2 f_{cd}}})$, b = 1000 mm, f_{cd} = 13,3 N/mm^2

$$x_c = 95\cdot(1-\sqrt{1-\frac{2\cdot 12\cdot 10^6}{1000\cdot 95^2\cdot 13{,}3}}) = 10{,}0\text{mm} <$$



$< x_{co} = \xi_{co}\, d = 0{,}49 \cdot 95 = 46{,}6$ mm OK!

$$z = d - \frac{x_c}{2} = 95 - 10/2 = 90 \text{ mm}$$

$\underline{\Sigma M_c = 0}$: $a_s\, f_{yd}\, .z - m_{Ed} = 0$, $f_{yd} = 435$ N/mm^2

$$a_s = \frac{m_{Ed}}{f_{yd} \cdot z} = \frac{12 \cdot 10^6}{435 \cdot 90} = 306{,}5 \text{ mm}^2/\text{m} > a_{s,min} \text{ OK!}$$

$$a_{s,min} = \rho_{min}.bd = \frac{1{,}3}{1000} \cdot 1000 \cdot 95 = 123{,}5 \text{ mm}^2/\text{m}$$

Let use Ø8,2/150 (a_s = 352,1 mm^2) intensity welded mesh!

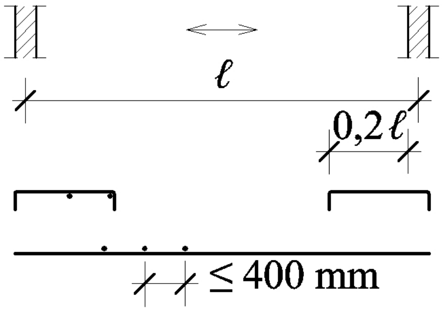
Ckeck of further constructional rules:

$t \leq 150$ mm esetén $s_{max} = 150$ mm, rendben!

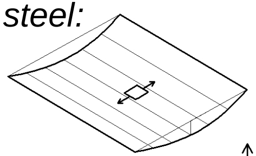
$$Ø_{max} \leq \frac{t}{10} = \frac{120}{10} = 12 \text{ mm, OK!}$$

6. Reinforcement system of simple supported and continuous one-way slabs, the distribution steel

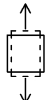
Simple supported slab
Plan detail



Reasons and quantity of *distribution steel:*

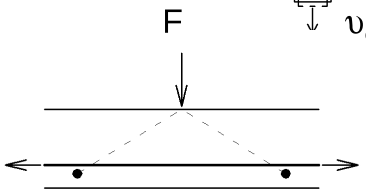


lateral supports impede transverse contraction, provocing tension



$$\upsilon_c \cong \frac{1}{6} \cong 0,2 \rightarrow 20\%$$

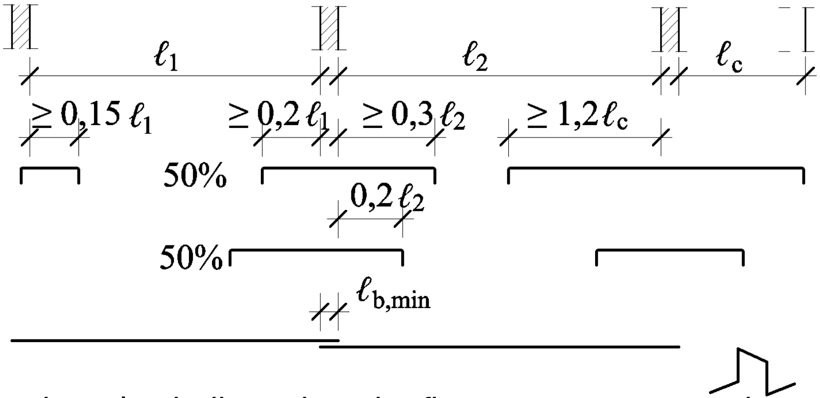
$$a_{s,distr} = 0,2 a_s$$



Distribution steel is also needed to distribute effect of uneven (concentrated) loads

Continuous slab:

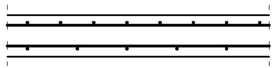
Plan detail:



When respecting the rules indicated on the figure, no enveloping of the extreme applied moment diagram is needed.

standees to support top steel

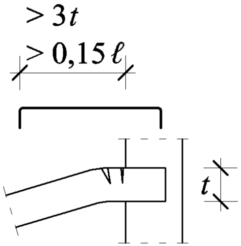
Correct order of the layers of main and distribution steel on cross-section at intermediate support:



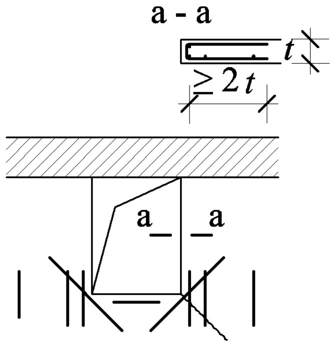
Formázott: Középre zárt

7. Special reinforcement details: anti-crack reinforcement, free-edge reinforcement, additional reinforcement at holes and under linear loading

anti-crack reinforcement along lateral supports of one-way slabs:

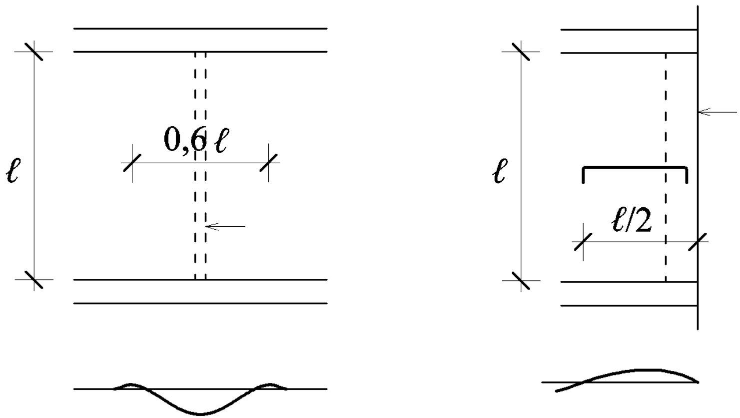


Free edge reinforcement and elements of additional reinforcement at holes:



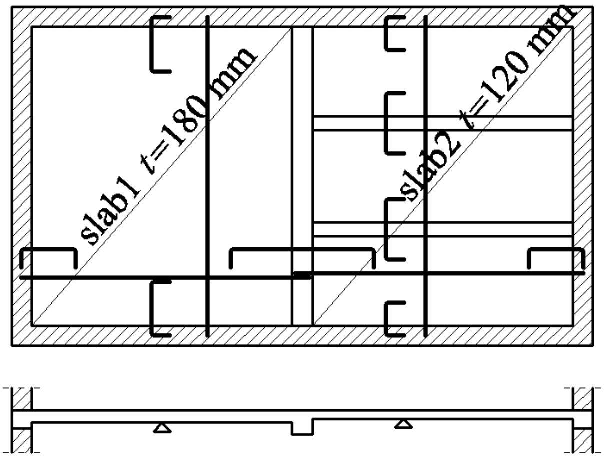
danger of diagonal cracking!

Local strengthening of the slab reinforcement needed for moments due to linear (or concentrated) loading of heavyer partition wall, facade wall etc.



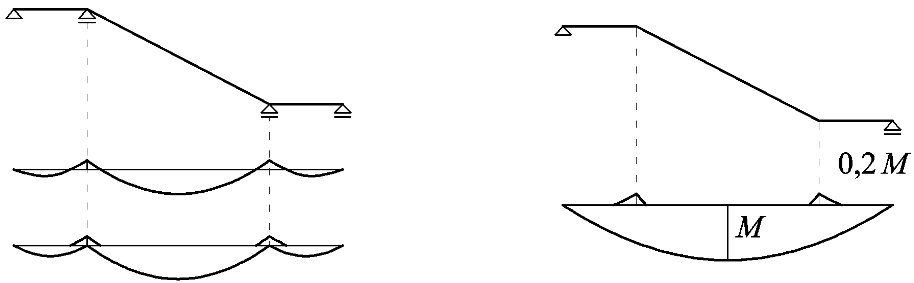
8. Example of a floor

Elements of the reinforcement to be designed for the slab indicated on the structural plan below:



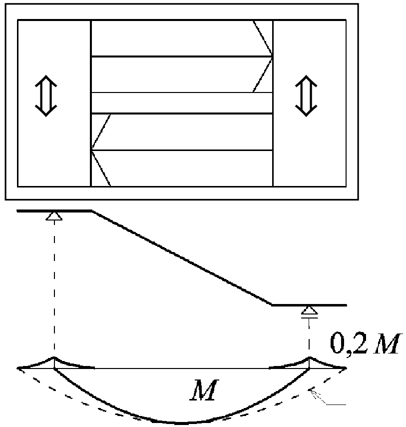
II. Stair slabs
1. Static models

Acceptable static models and design moment diagrams



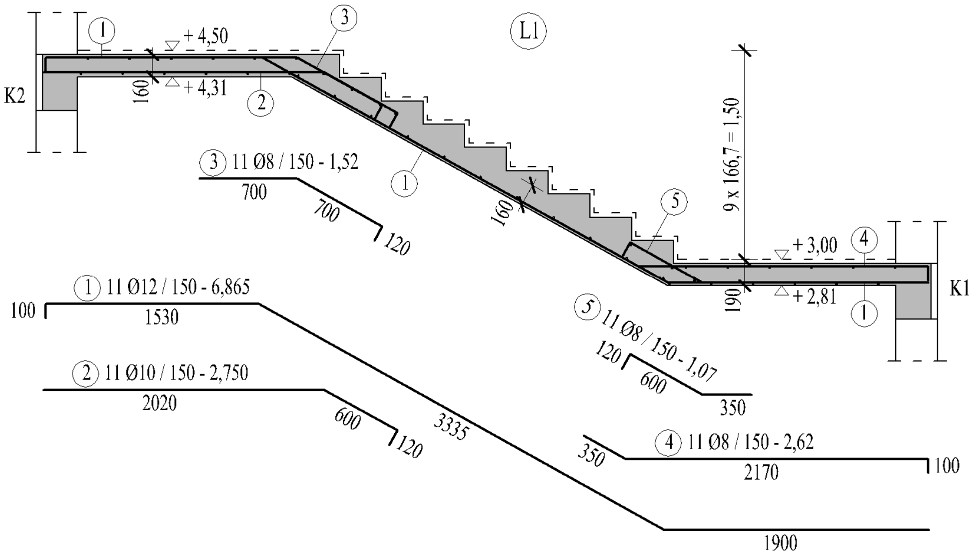
2. Substitutive static model of a two-flight staicase in flight direction

Landing slabs can be regarded as wide supports, considering the support line along the axis of them: this approximation reduces significantly moments in flight direction.
(The practice has proved this approximation)



3. System of reinforcement

Elements of the reinforcement system from numerical example of a two flight staircase



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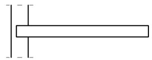
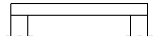
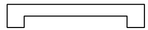
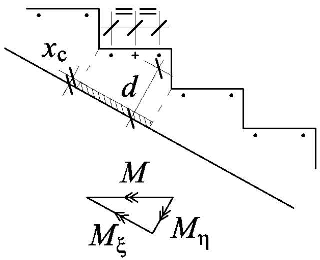
4. Stairs spanning transversally

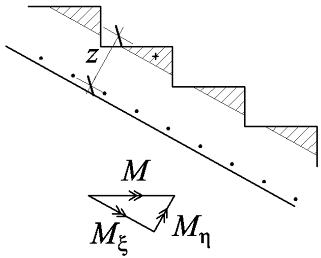
Stair restrained in (rc) wall 

supported by parallel walls 

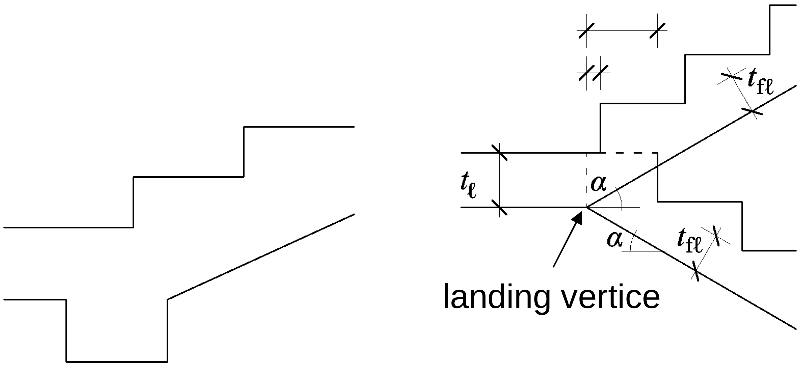
supported by parallel stringer beams 

The way of flxural design for negative and positive moments:





5. Geometry of landing with and without transverse beam



Elaboration of details like this requires intensive cooperation of the architect and the structural designer.