FAKULTA
STAVEBNÍ
ČVUT V PRAZE

CM01 – Concrete and Masonry Structures 1

HW10 & HW11 – Staircase

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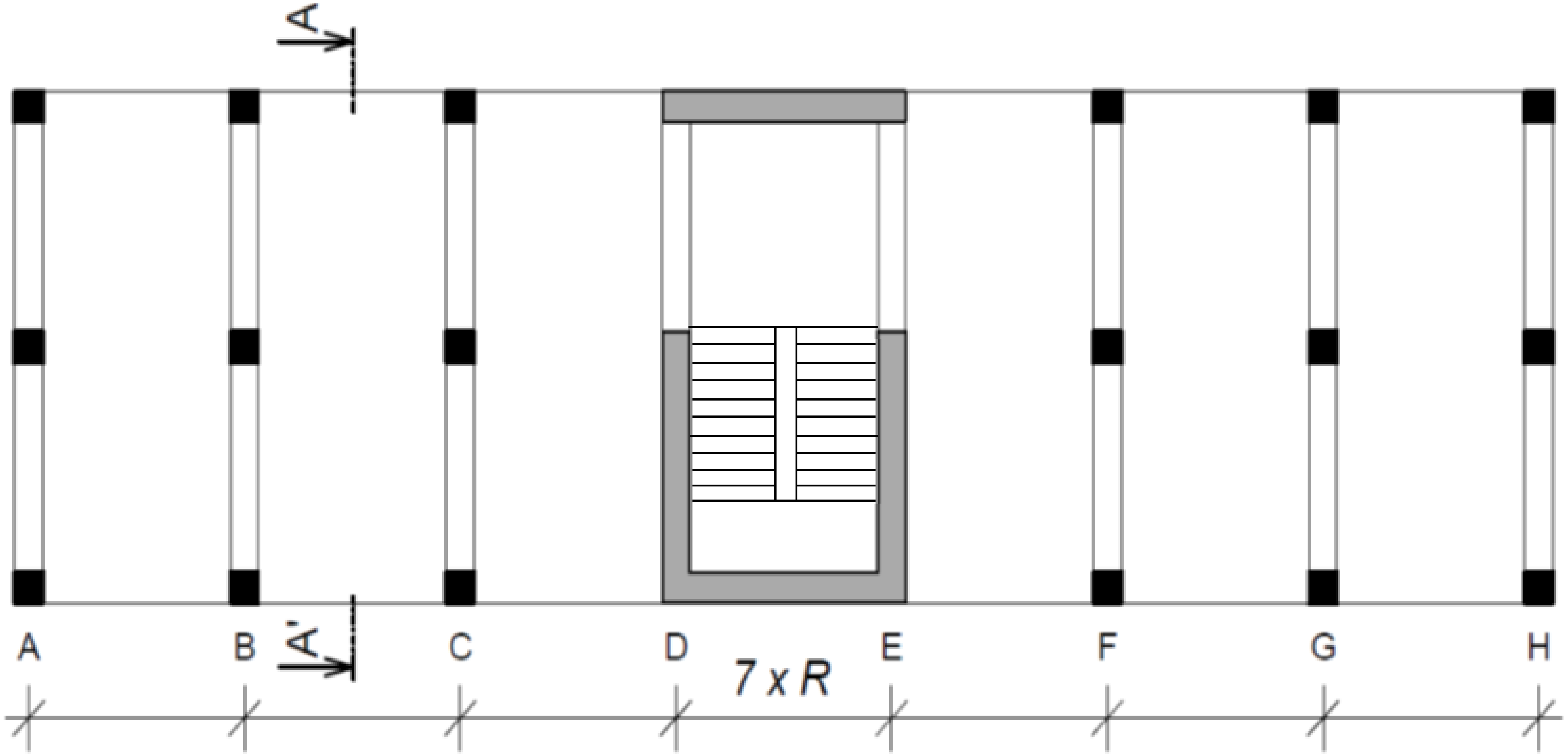
Task 5

Task 5 – Staircase

In Task 5, **reinforced concrete staircase** will be designed into the structure from Task 1.



Task 5 – Assignment

Task 5: Reinforced concrete staircase

Design a staircase for the structure from Task 1. Staircase will be supported by the reinforced concrete core. Adjust the span of the core if necessary (the distance between axes D and E need not to be equal to *R*).

Please work out:

1. **Design of dimensions of a reinforced concrete staircase** (including details of flight-landing connections)
2. **Design of staircase reinforcement**.
3. **Sketch of staircase reinforcement**.
4. **Structural drawing** of a part of the structure from Task 1 with the designed staircase in 1:25 scale.

Task 5 – Assignment goals

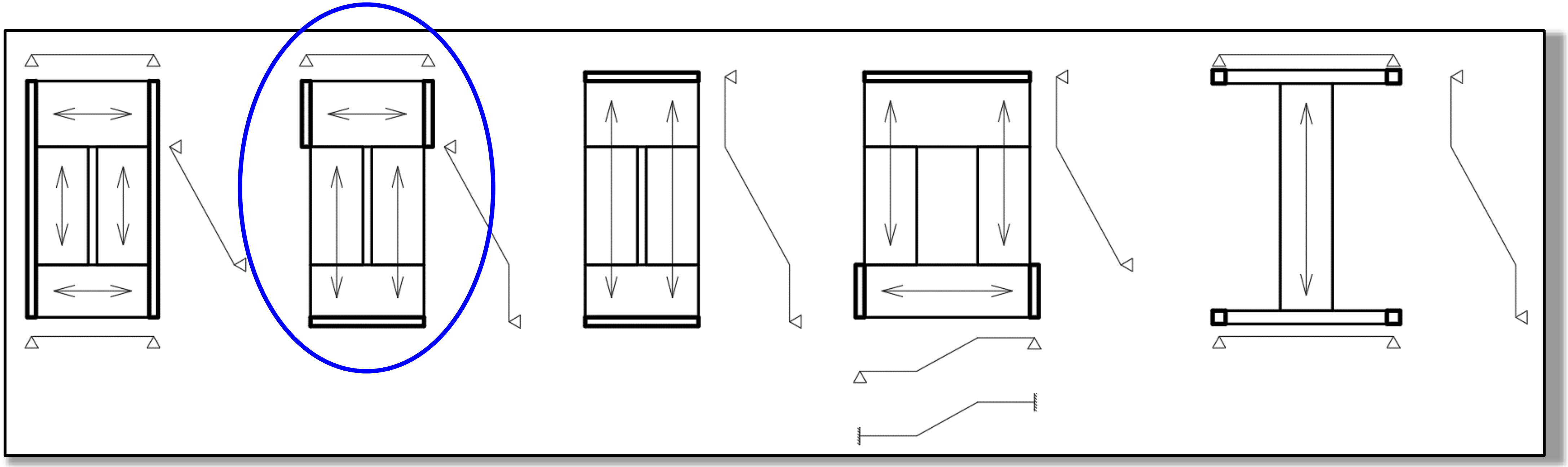
<u>Our goal</u> will be to:

1) Design the **geometry** of the staircase.
2) Calculate **loads** and bending **moments**.
3) Design the **reinforcement**.
4) Sketch a **drawing** of the reinforcement.

Conceptual design

Conceptual design

In general, there are usually **many possibilities** how to design the staircase. This **presentation describes just one possible approach** for our particular structure.



Geometry

Geometry

The specific geometry of the staircase is up to you. However, the design must be done according to **staircase design rules**:

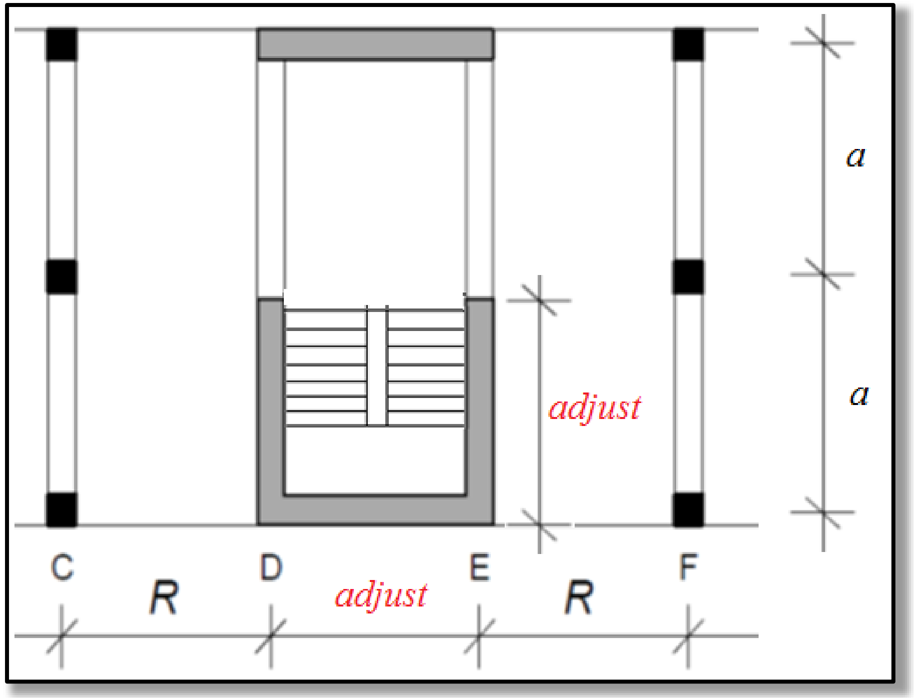
- dimensions of a step must satisfy: $b_{step} = 630 - 2h_{step}$,
- maximal number of steps in one flight: 16,
- minimal width of the flight: 1100 mm,
- minimal width of the landing: 1100 mm,
- minimal the gap between the flights: 200 mm,
- minimal perpendicular clearance: $750 + 1500 \cdot \cos\alpha$,
- minimal head clearance: $1500 + 750/\cos\alpha$.

Follow the example on my webpage.

Geometry

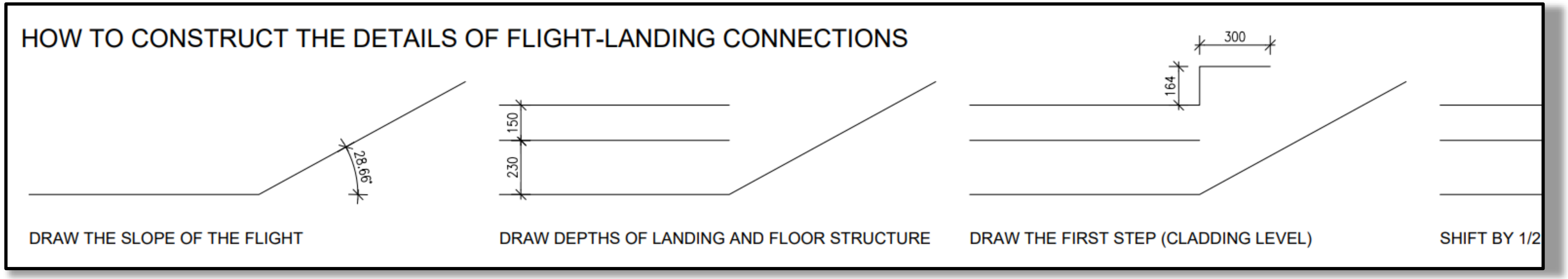
Design the staircase and **draw a scheme of the staircase**.

If needed, **you can adjust the dimensions of the supporting walls** according to your staircase geometry.



Geometry of flight-landing connection

Geometry of flight-landing is already given by the designed geometry! We have to **adhere to the designed geometry when drawing the connection**.

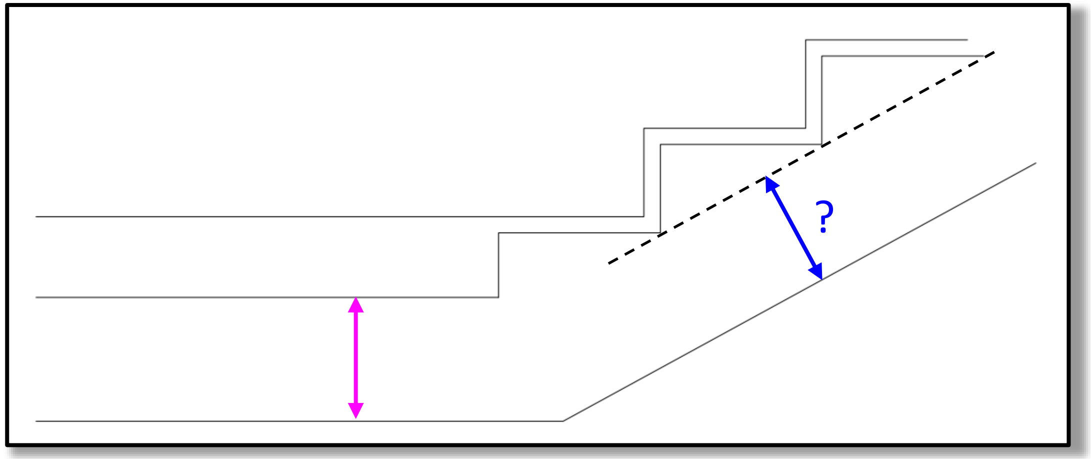


See the guide for connection drawing.

Geometry of flight-landing connection

Why do we draw the flight-landing connection?

To find the exact thickness of the flight for our given thickness of landing (see slab thickness in Task 1).

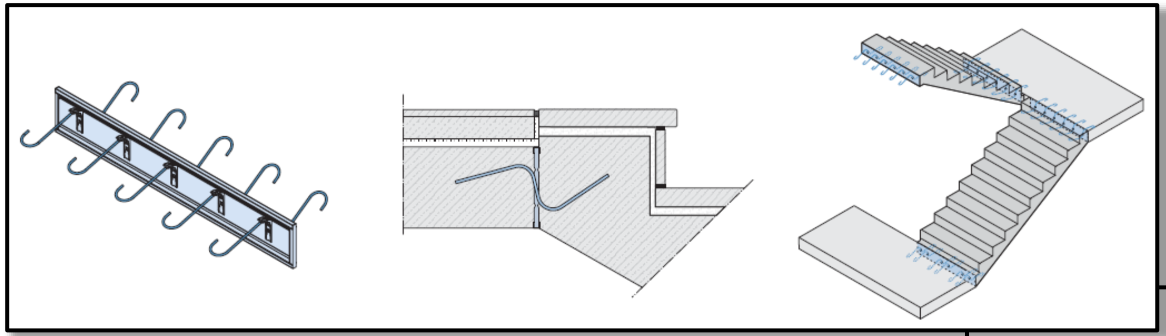


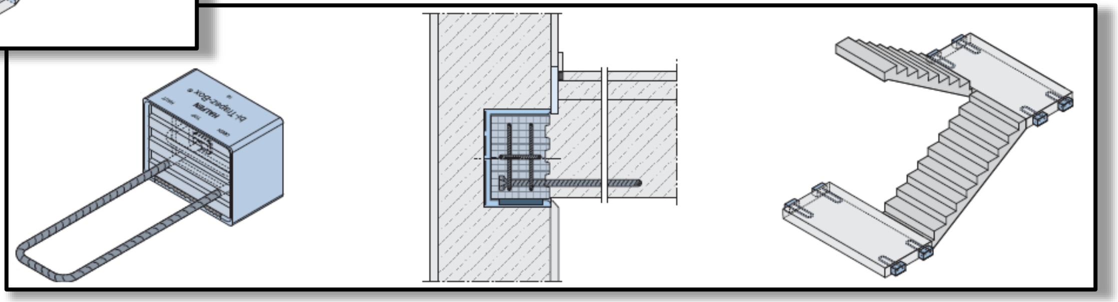
Supports

Supports

After the geometry of the staircase is designed, we must **determine how the staircase will be supported**.

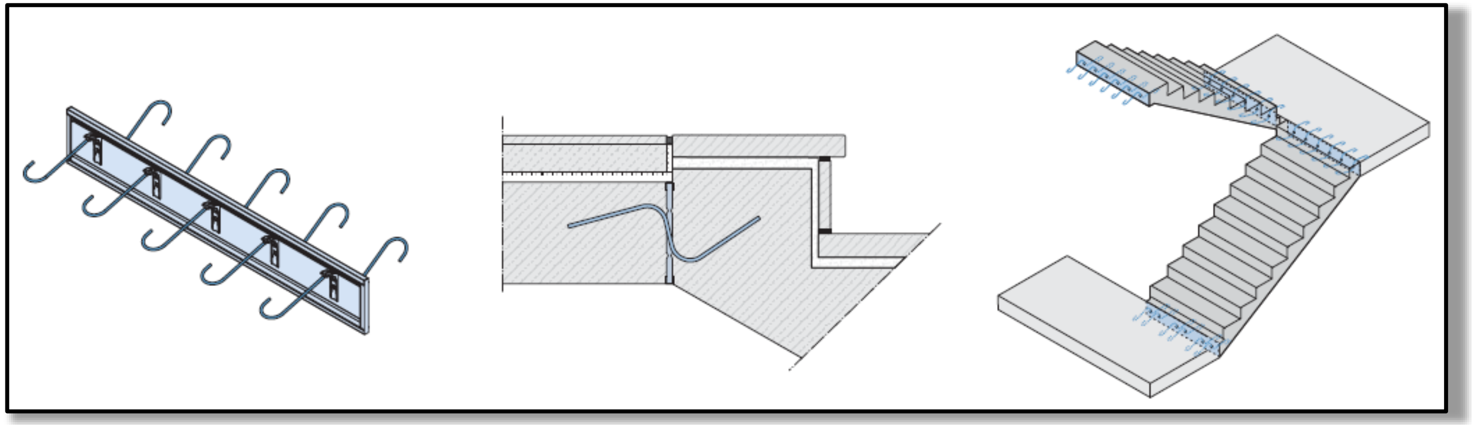
The staircase will be connected with the supporting members by **special elements to prevent transfer of impact sound** to the rest of the building.

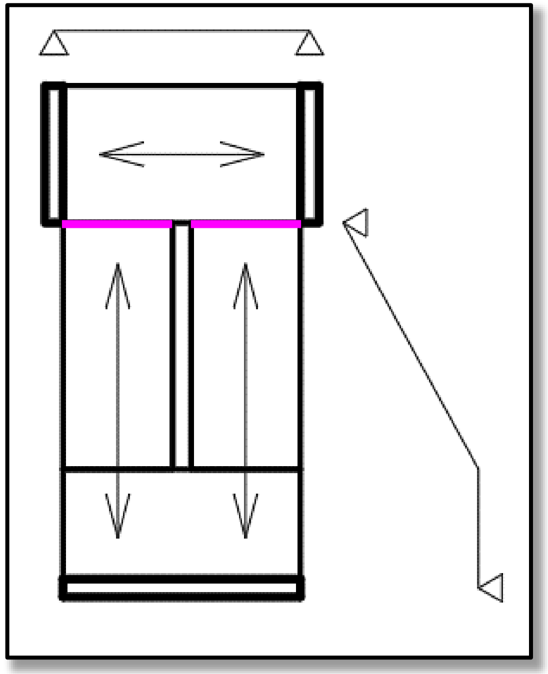




ISI unit

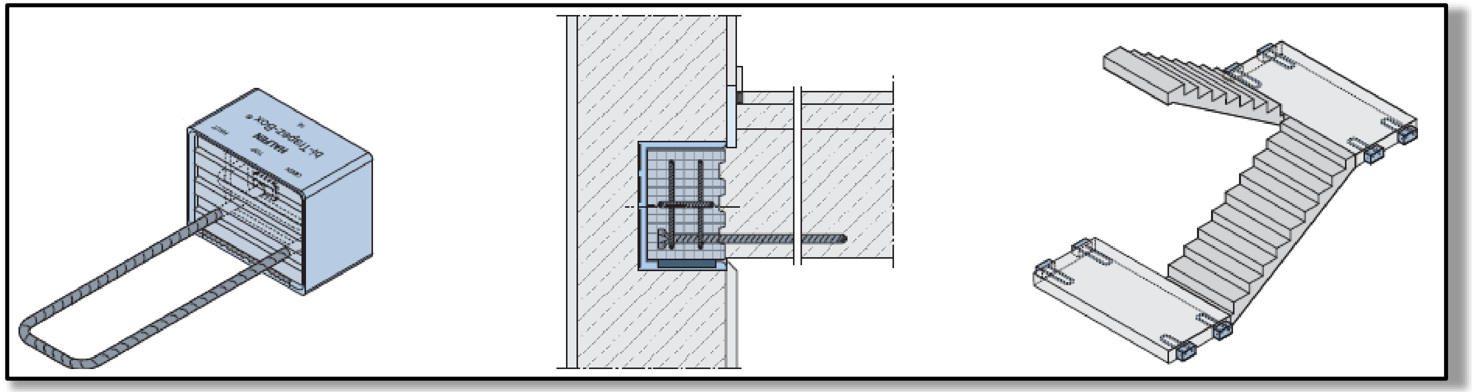
The **ISI units** are used for the connection between **flight and transversal landing**.

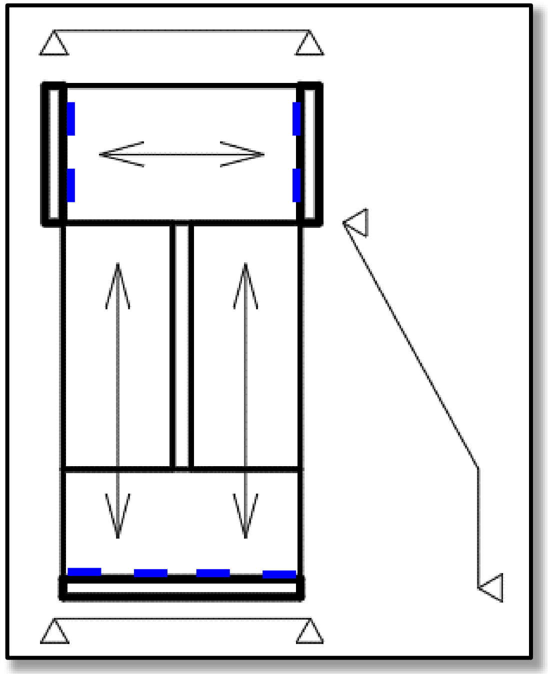




Trapez boxes

The **trapez boxes** are used for the connection between **landing and wall**.





Loads

Loads

Following loads are acting on the landing:

- self-weight of the slab: $g_{0,k} = h_{slab} \cdot 25$,
- self-weight of floor structure: use $g_{floor} = 1\ \mathrm{kN/m^2}$,
- live load: use $q_{floor} = 3.5\ \mathrm{kN/m^2}$.

Following loads are acting on the flight:

- self-weight of the slab: $g_{0,k} = h_{slab,vertical} \cdot 25$,
- self-weight of the steps: $g_s = \left(h_{step,vertical}/2\right) \cdot 25$,
- self-weight of the cladding of the steps: use $g_{floor} = 0.5\ \mathrm{kN/m^2}$,
- live load: use $q_{floor} = 3.5\ \mathrm{kN/m^2}$.

Follow the example on my webpage.

Loads

Landing

Load	Char. value [kN/m²]	γ	Design value [kN/m²]
Slab	0,23 · 25	1,35	7,8
Floor	1	1,35	1,35
Live load	3,5	1,5	5,25

f_{dl} = 14,4 kN/m²

$\mathrm{N/m^2}$,

Following loads are acting on the fli

- self-weight of the slab: $g_{0,k} = h_{sl}$
- self-weight of the steps: $g_s = (h_s$
- self-weight of the cladding of the
- live load: use $q_{floor} = 3.5\ \mathrm{kN/m^2}$

Follow the [example on my webpage](#)

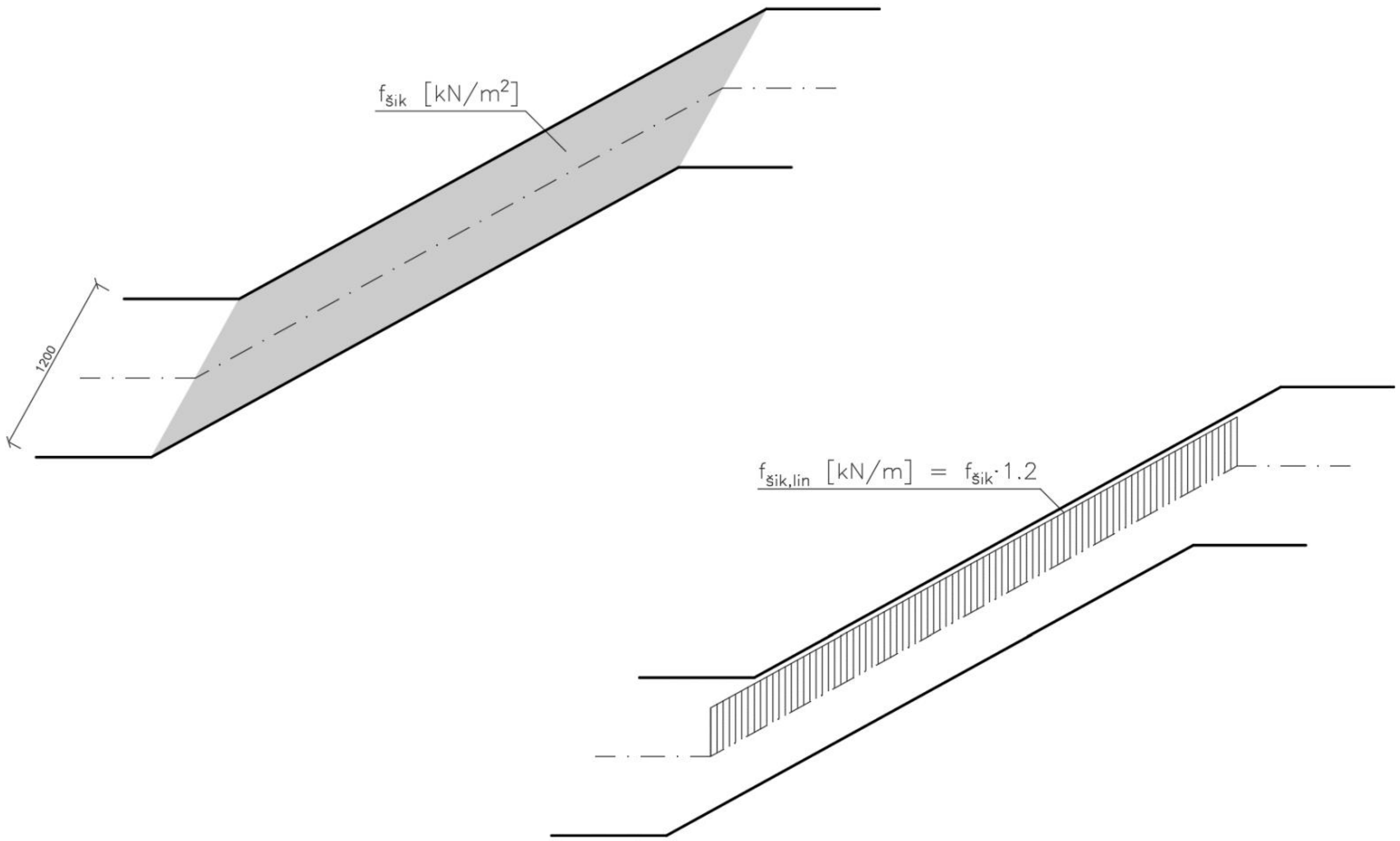
Flight

Load	Char. value [kN/m²]	γ	Design value [kN/m²]
Slab	$\frac{0,22}{\cos 28,66°} \cdot 25$ ①	1,35	8,5
Cladding	$0,5 \cdot \frac{164+300}{300}$ ②	1,35	1,04
Steps	$\frac{0,164}{2} \cdot 25$ ③	1,35	2,78
Live load	3,5	1,5	5,25

f_{df} = 17,6 kN/m²

Loads

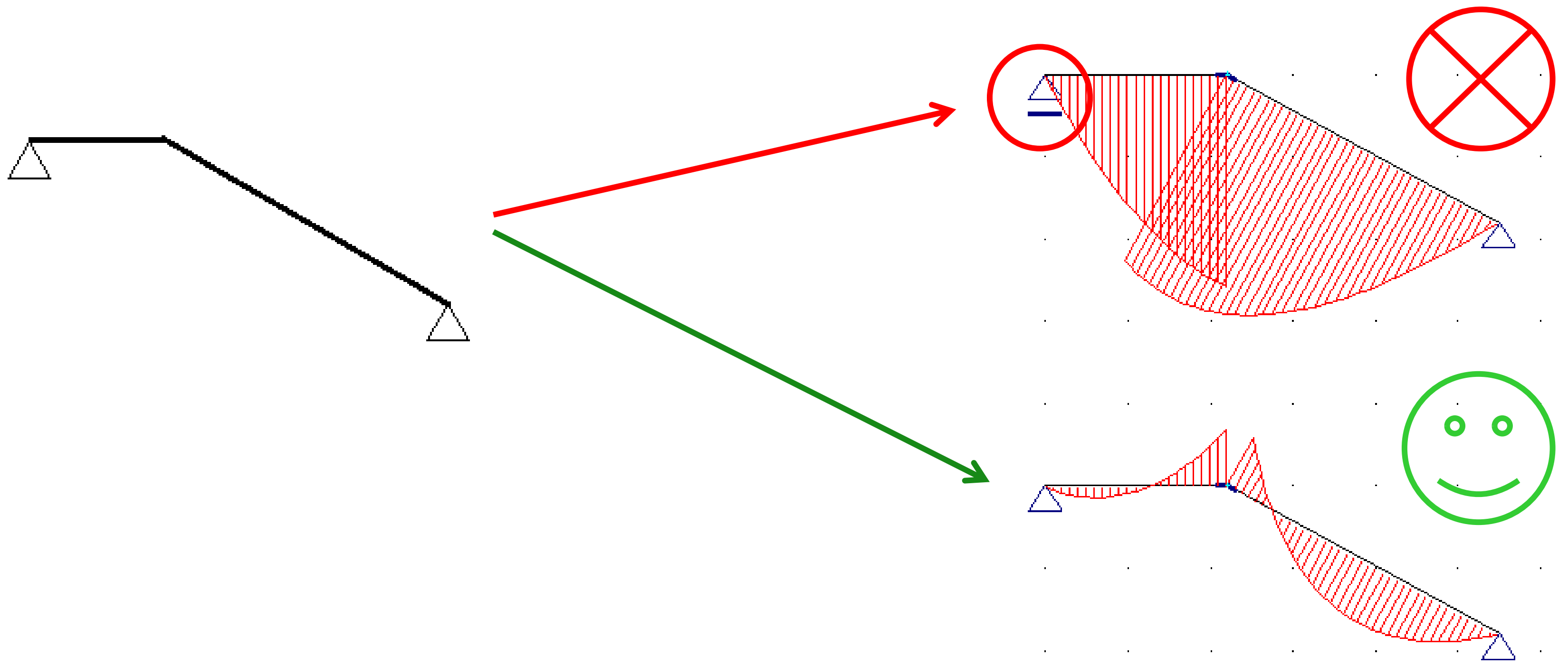
Finally, convert all area loads to **linear loads**!



Structural scheme

Structural scheme

The **supporting elements** that we selected **do not transfer bending moments**, and therefore, they act as **pinned supports**. Also, they **do transfer horizontal forces**!



Internal forces

Internal forces

The structure is **statically indeterminate** ⟶ we **should use a FEM program** or slope deflection method to calculate **real bending moments**.

However, we can make a **conservative (safe) estimation**:

$$m_{Ed} = \frac{1}{12} f_{\mathrm{df}} l^2$$

Horizontal length of the staircase (landing+flight)

Design load of stair flight or landing (use the higher value) [kN/m]

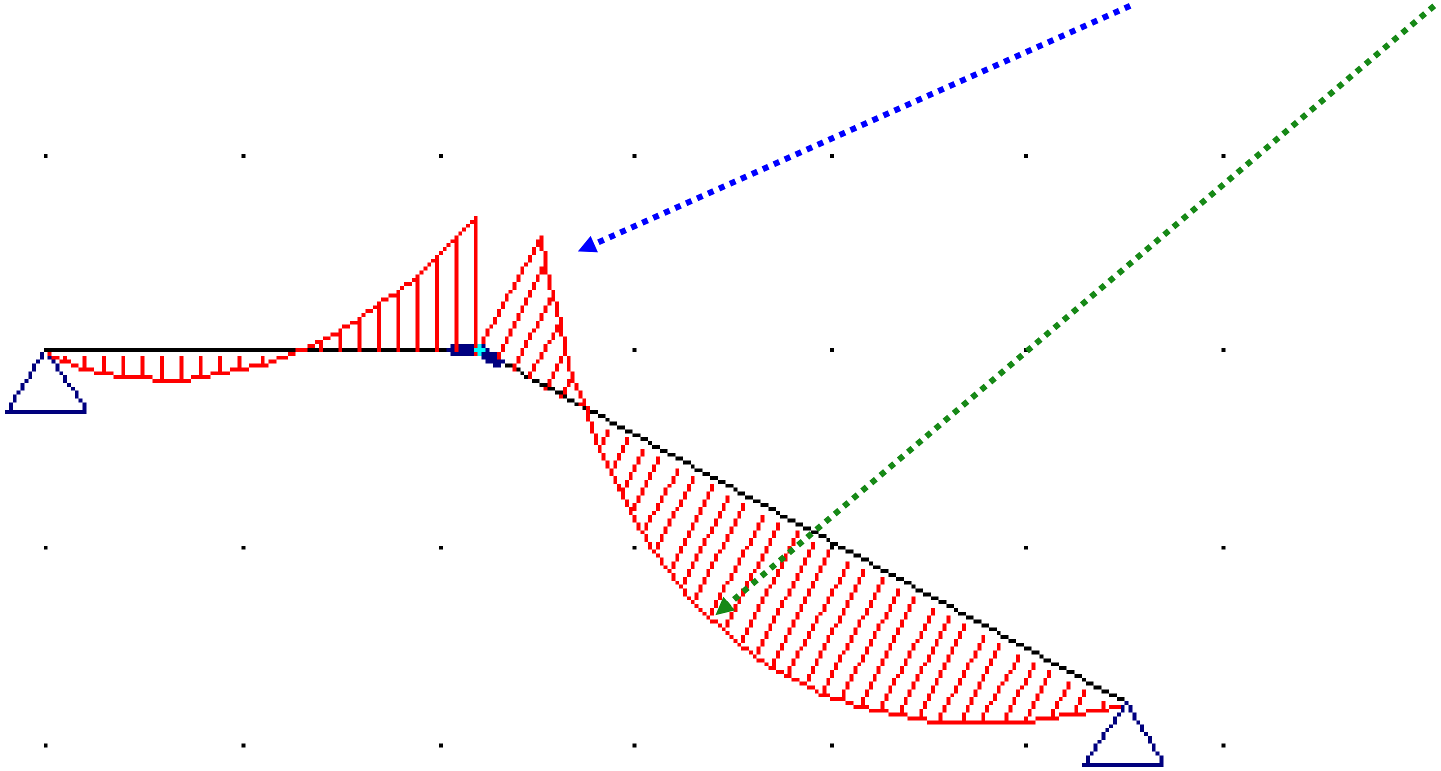
End of HW10

Start of HW11

Design of reinforcement

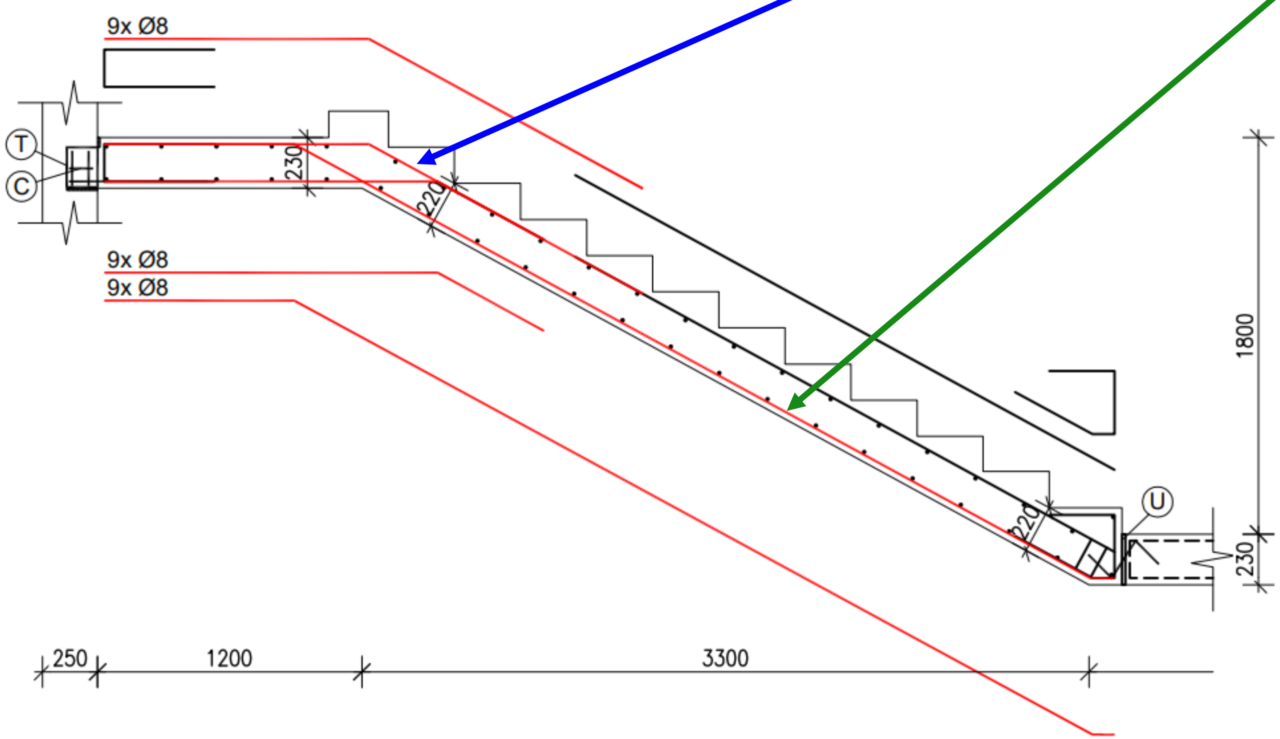
Design of reinforcement

Use the **estimated design bending moment** for both upper and lower main reinforcement.



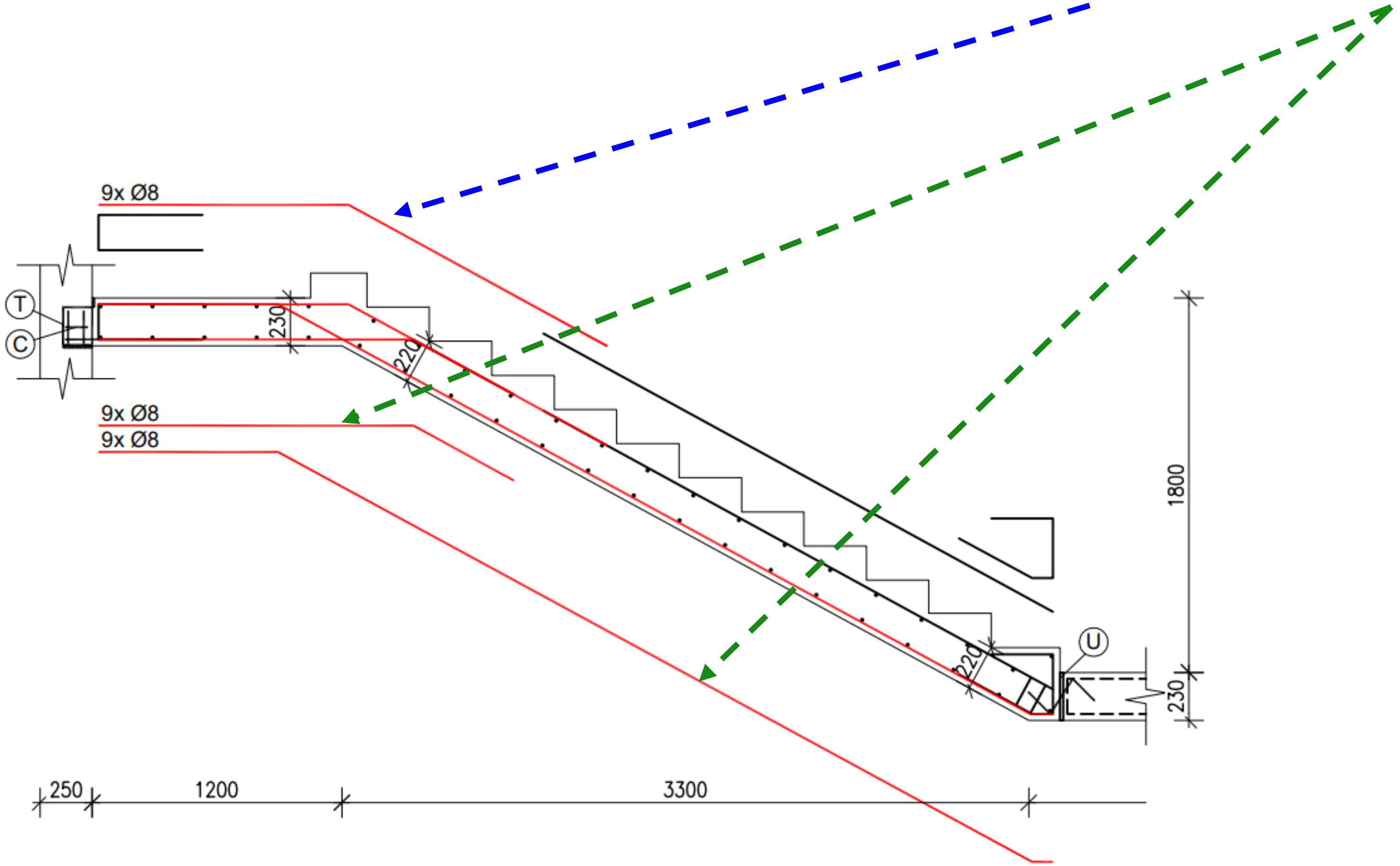
Design of reinforcement

Use the **estimated design bending moment** for both upper and lower main reinforcement.



Design of reinforcement

Use the **estimated design bending moment** for both upper and lower main reinforcement.



Design of reinforcement

Staircase is a one-way slab ⟶ **design of reinforcement is the same as for any other one-way RC structural member** (see HW3 and HW8):

$A_{s,req} = \ ...$

$A_{s,prov} = \ ...$

$x = \ ...$

$z = \ ...$

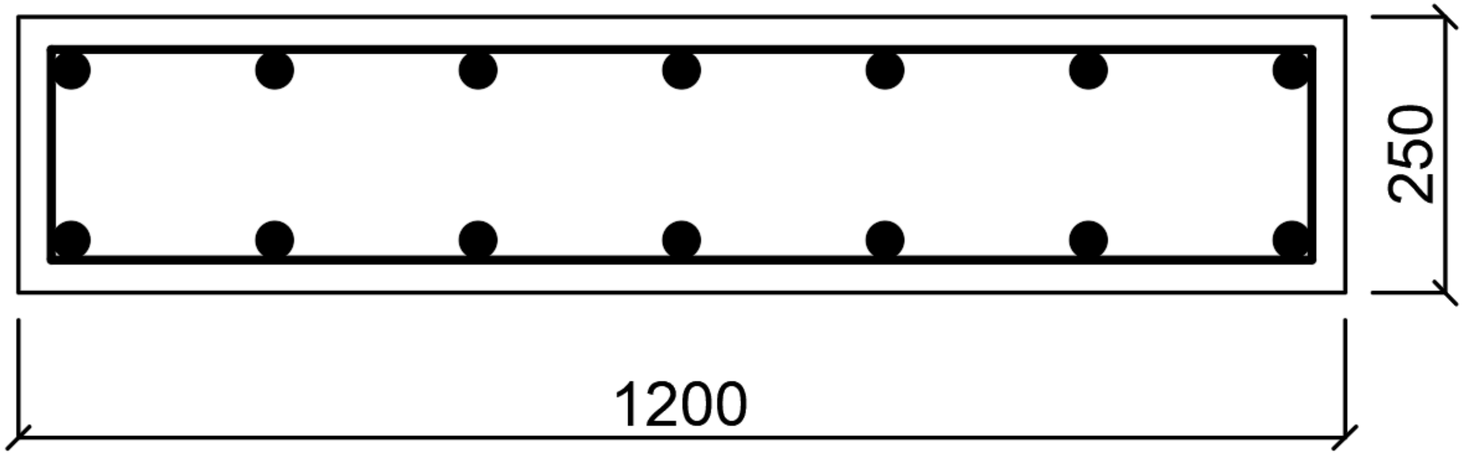
$M_{rd} = \ ...$

Don‘t forget to **also check the detailing rules**!

Design of reinforcement

For planar members (such as slabs), we usually calculate the moment and reinforcement per 1 m, but **in the case of staircase** (both landing and flight) we **use the real width** – i.e., we design it like a flat beam:

M_{Ed} [kNm] $\longrightarrow n \times \varnothing \longrightarrow As\ [mm2] \longrightarrow M_{Rd}$



Sketch of reinforcement

Sketch of reinforcement

Sketch the reinforcement of **both flights**.

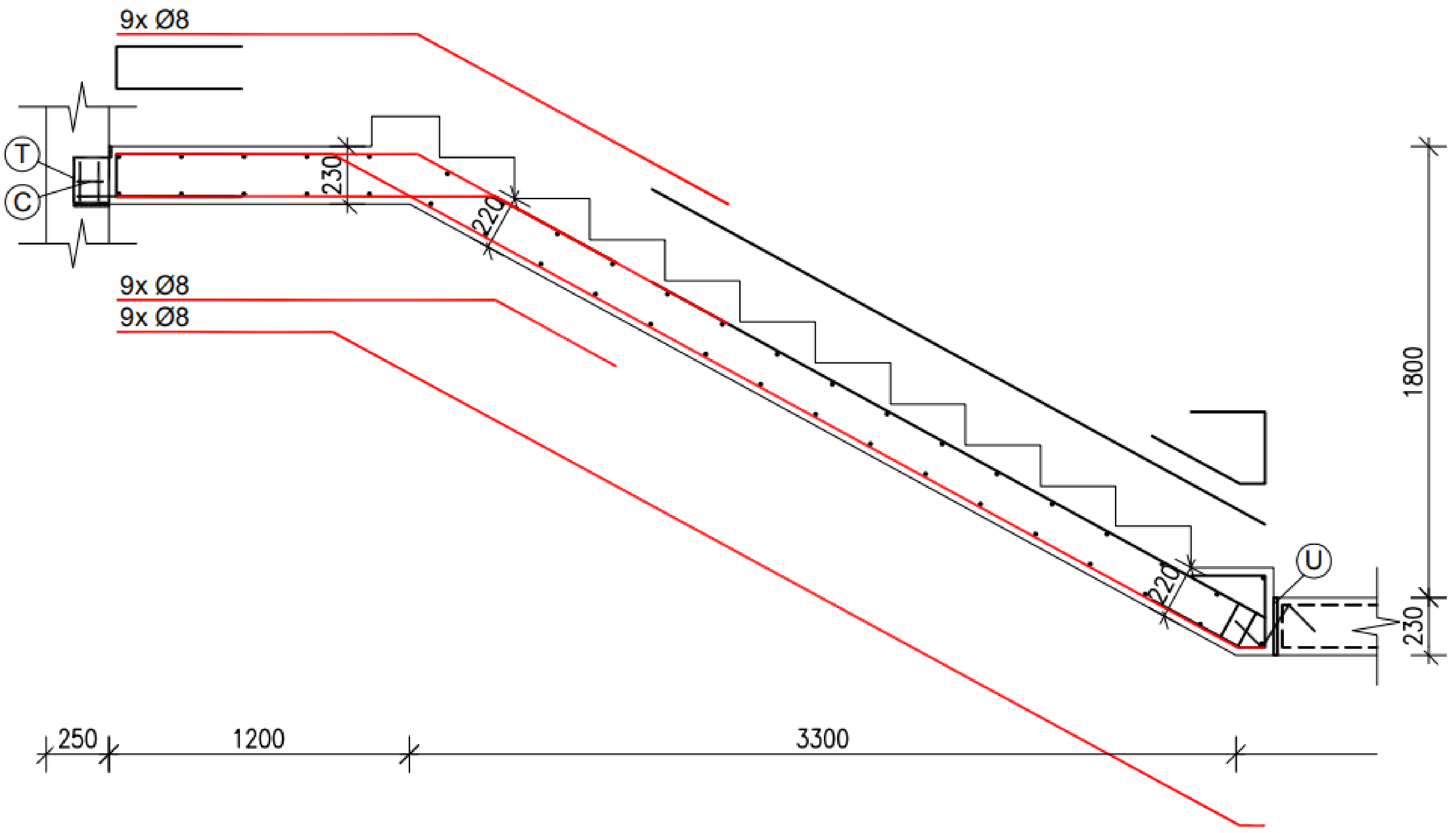
Main reinforcement:

- draw the shapes **in red colour**.
- write the **number and diameter of bars** according to design.

Secondary reinforcement:

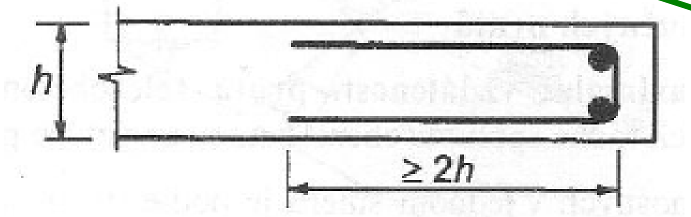
- draw the shapes in **black colour**,
- consists of:
  - edge reinforcement,
  - transverse reinforcement,
  - secondary reinforcement of the upper surface,
  - end stirrups.

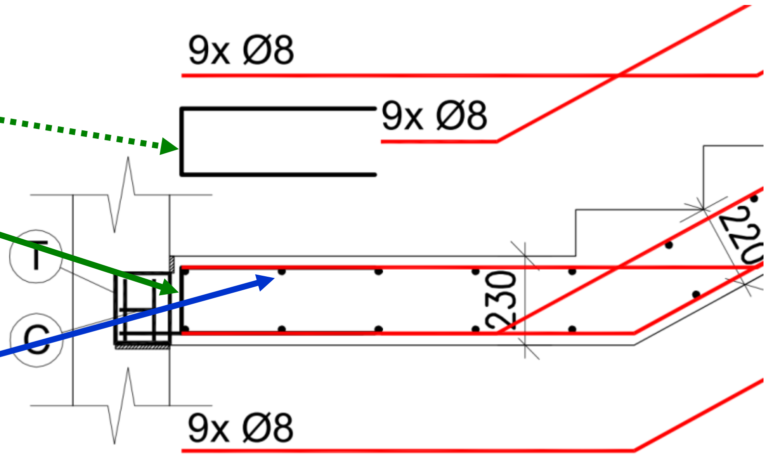
Primary reinforcement



Secondary reinforcement

Edge reinforcement:

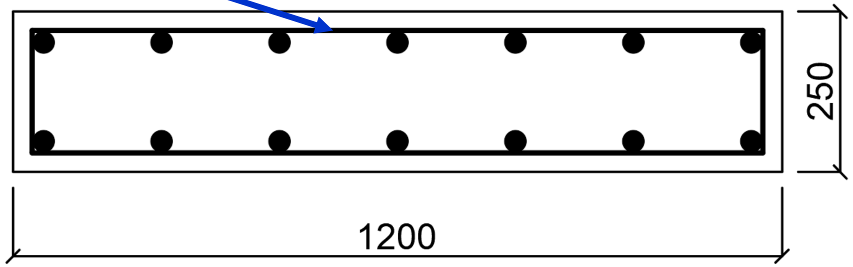




Transverse reinforcement:

$$a_{s,tr} \geq 0.25 a_{s,main}$$

$$s_{tr} \leq \min(3h; 400\ mm)$$

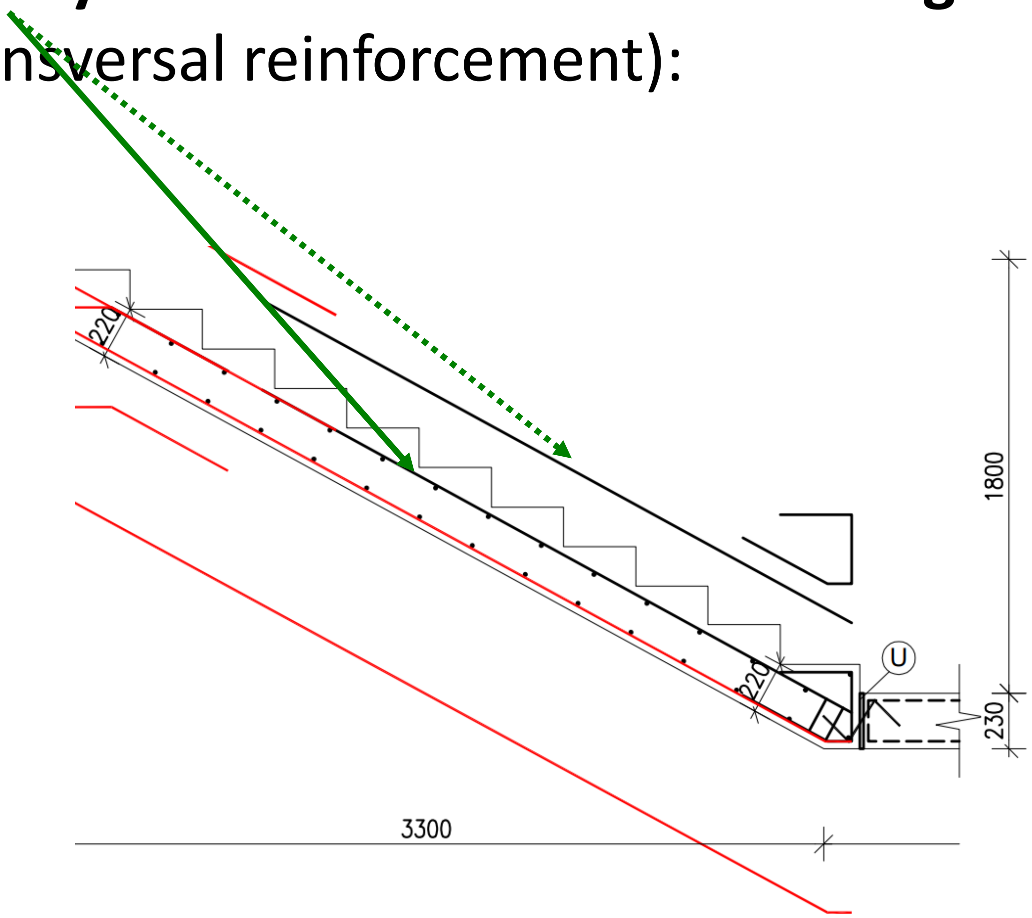


Secondary reinforcement

In the **places where no main reinforcement was designed** (e.g., upper reinforcement in the flight), **secondary reinforcement must be designed** using detailing rules (same rules as for transversal reinforcement):

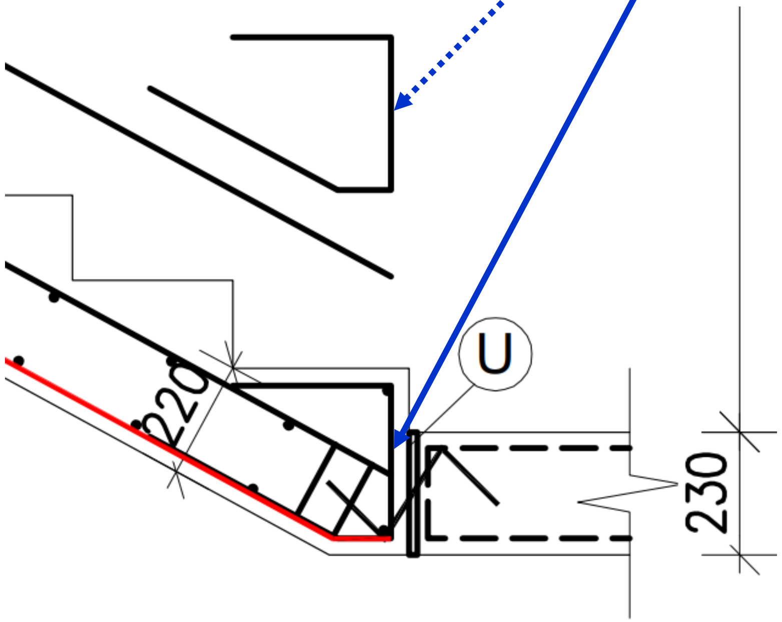
$$a_{s,tr} \geq 0.25 a_{s,main}$$

$$s_{tr} \leq \min(3h; 400\ mm)$$

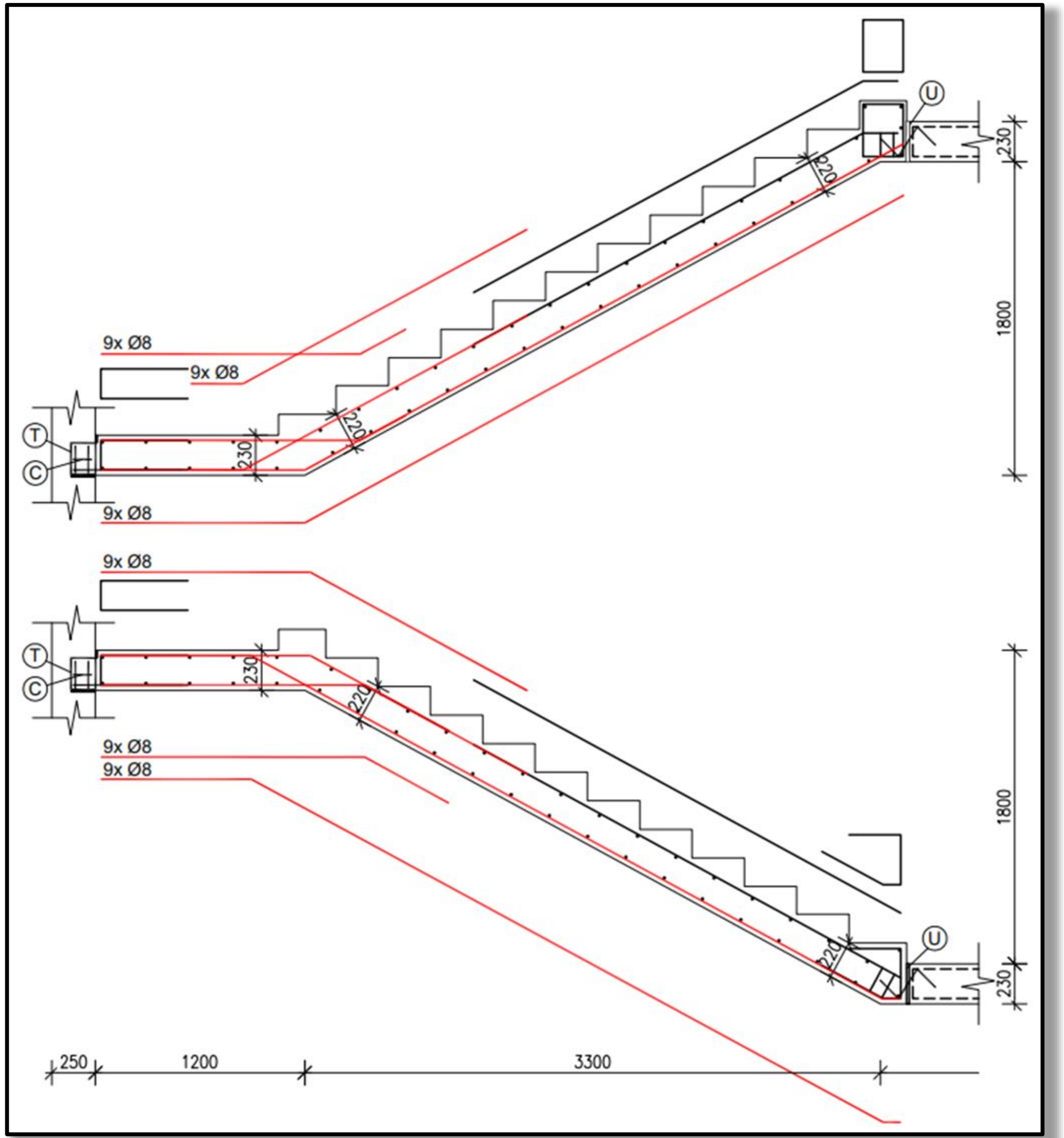


Secondary reinforcement

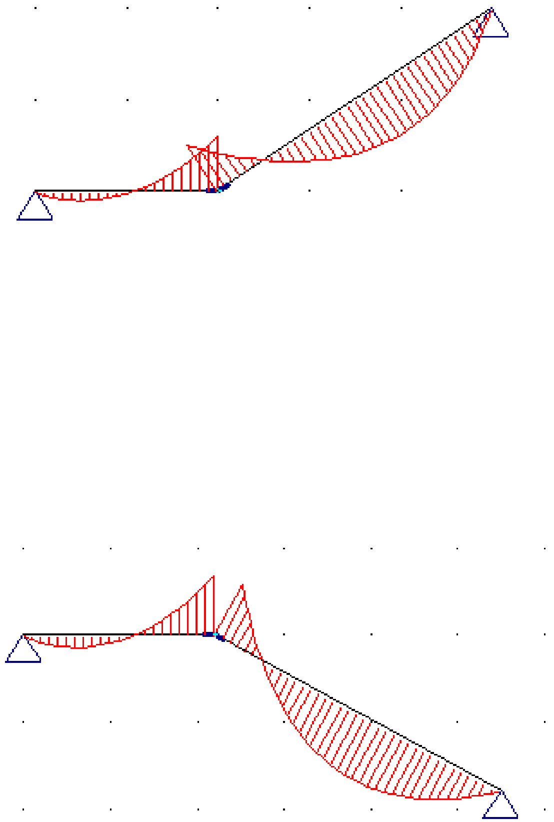
At the end of each reinforced concrete members, **end stirrups** must be used. End stirrups are designed according to the manufacturer of the sound insulation elements (usually $2 \times$ Ø8).



Sketch of reinforcement



Corresponding bending moments



thank you for your attention

Recognitions

I thank **Assoc. Prof. Petr Bílý** for his original seminar presentation and other supporting materials from which this presentation was created.