FAKULTA
STAVEBNÍ
ČVUT V PRAZE

CM01 – Concrete and Masonry Structures 1

HW5 – Drawings of reinforcement

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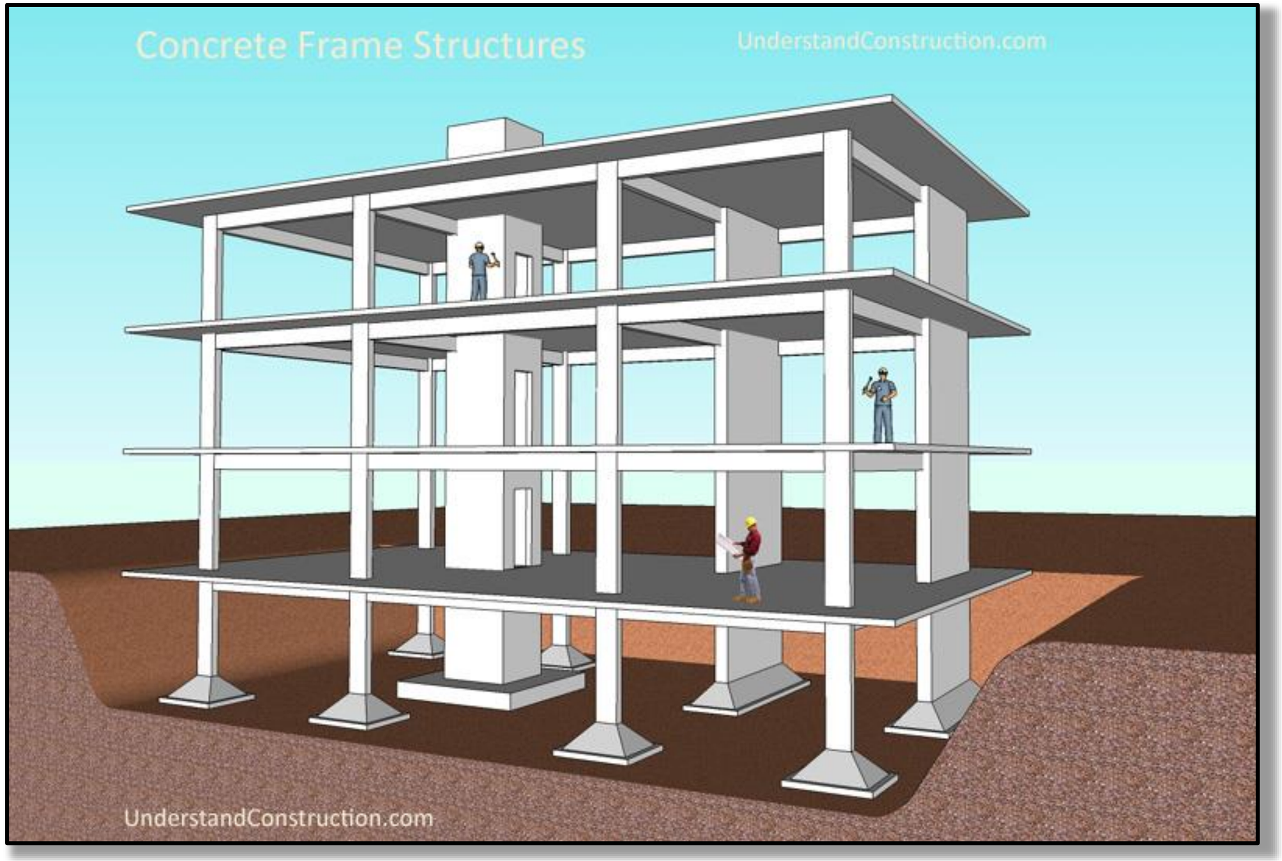
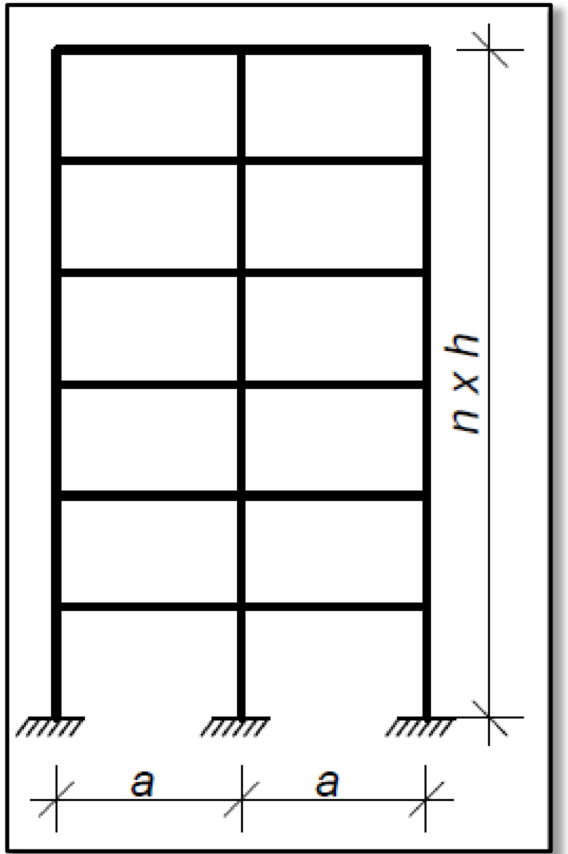
Task 1

Task 1 – Frame structure

In Task 1, frame structure will be designed.

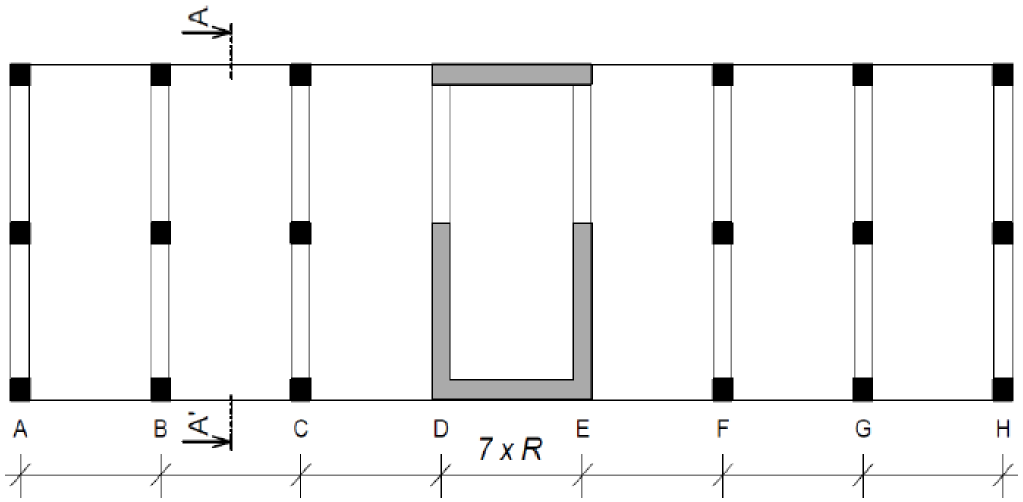




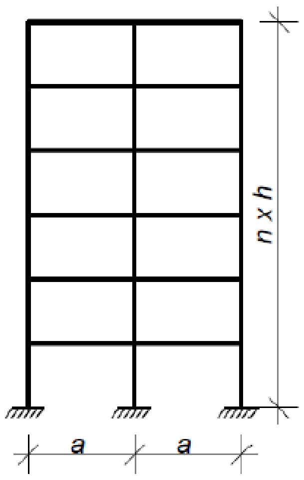
Task 1 – Assignment

Scheme of the stucture:

Plan:



Section A -A´:



Individual parameters (parameters in **bold** you can find on teacher's website):

Geometry: ***R***, ***a*** [m] – horizontal dimensions, ***h*** [m] – floor height, ***n*** – number of floors

Materials: Concrete – **concrete class**
Steel B 500 B (f_{yk} = 500 MPa)

Loads: Other permanent load of typical floor $\boldsymbol{(g\text{-}g_0)_{floor,k}}$ [kN/m^2]
Other permanent load of the roof $\boldsymbol{(g\text{-}g_0)_{roof,k}}$ [kN/m^2]
Live load of typical floor $\boldsymbol{q_{floor,k}}$ [kN/m^2]
Live load of the roof $q_{roof,k}$ = 0,75 kN/m^2
Self-weight of the slab according to calculated depth

Another parameters: ***S*** – Exposure class related to environmental conditions
Z – Working life of the structure

Task 1 – Assignment goals

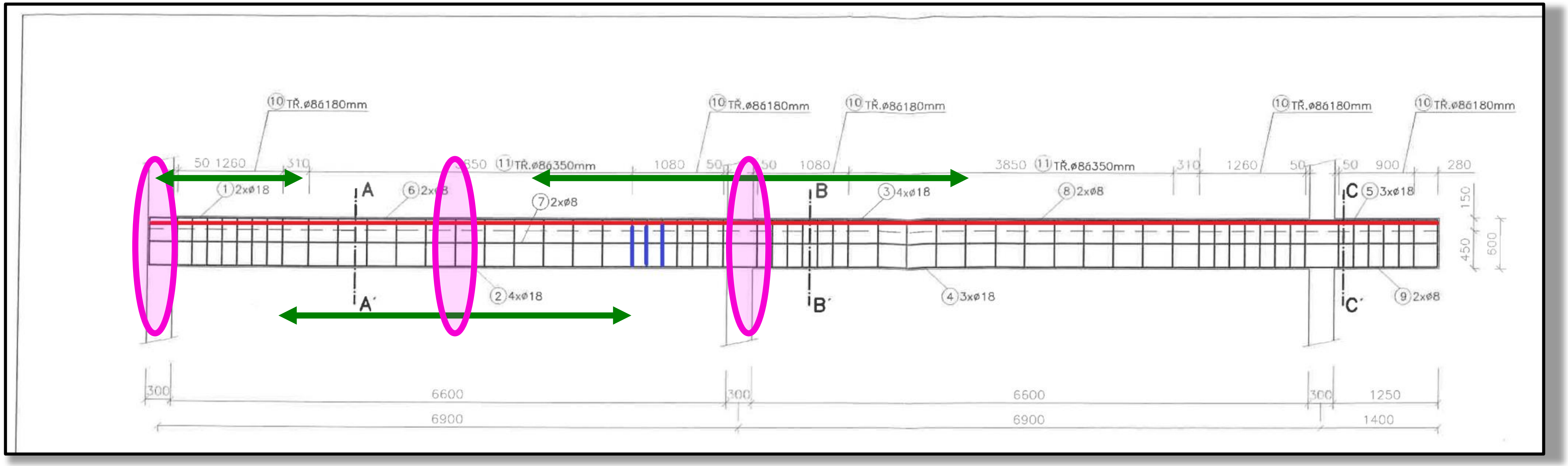
<u>Our goal</u> will be to:

- Design the dimensions of all elements.
- Do detailed calculation of 2D frame – calculation of bending moments, shear and normal forces using FEM software.
- Design steel reinforcement in the 1st floor members:
    - beam,
    - column.
- **Draw layout of the reinforcement.**

Bending beam reinforcement

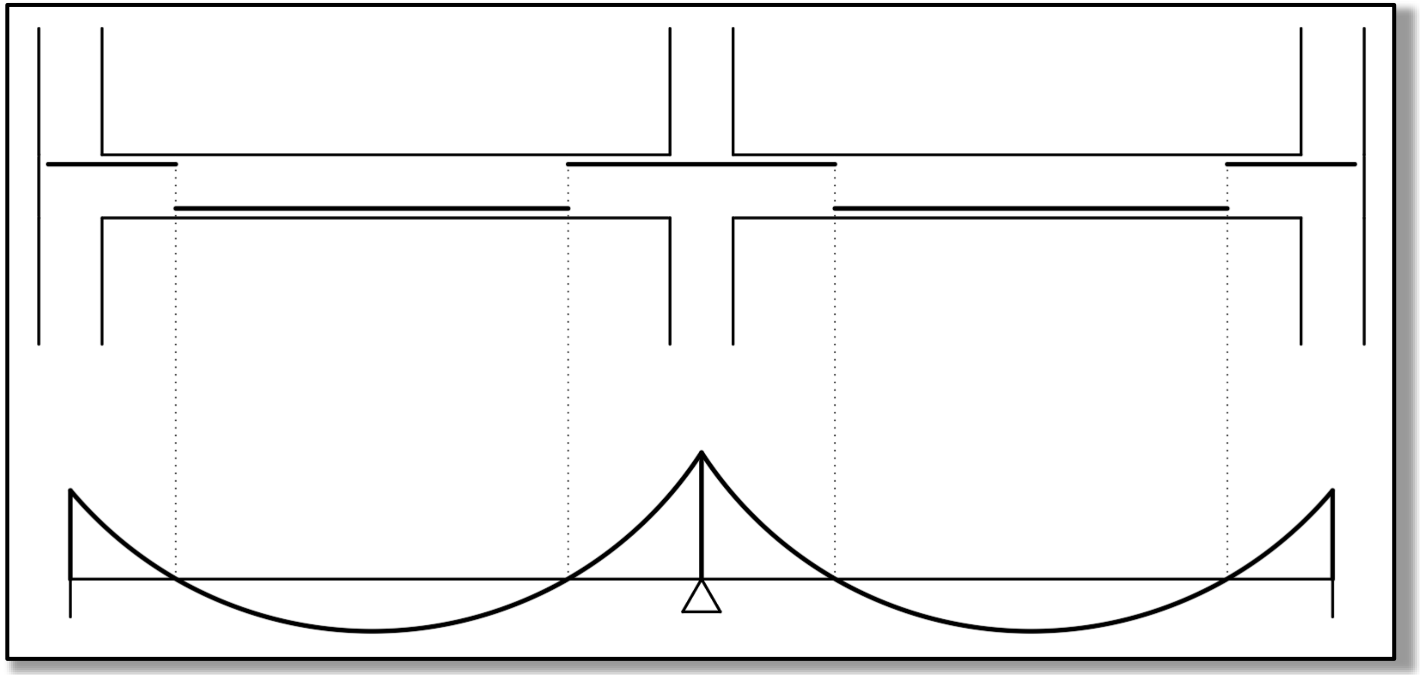
Cross-sections

We have designed reinforcement in 3 cross-sections. Now we must decide, where to “stretch” the reinforcement bars (rebars).



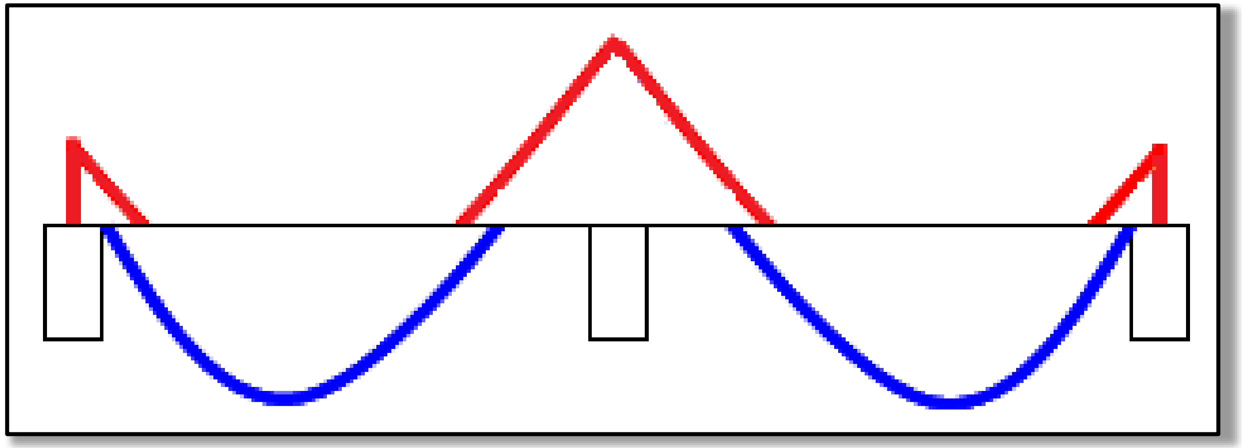
Locations of reinforcement

Rebars MUST be on the side of the beam where the bending moment is (because this is where tension is).



Bending moments envelope

First, we will take the moments envelope from IdeaStatica and copy it to AutoCAD.

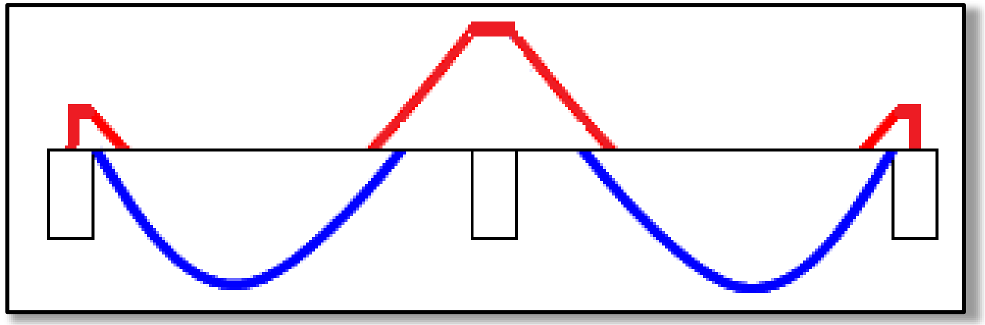


HOW?

- Printscreen the moment curves in IdeaStatica, insert them to model space in AutoCAD, and adjust to the desired scale.
- Draw “spline” lines using the IdeaStatica curves as a background.

Adjusted envelope

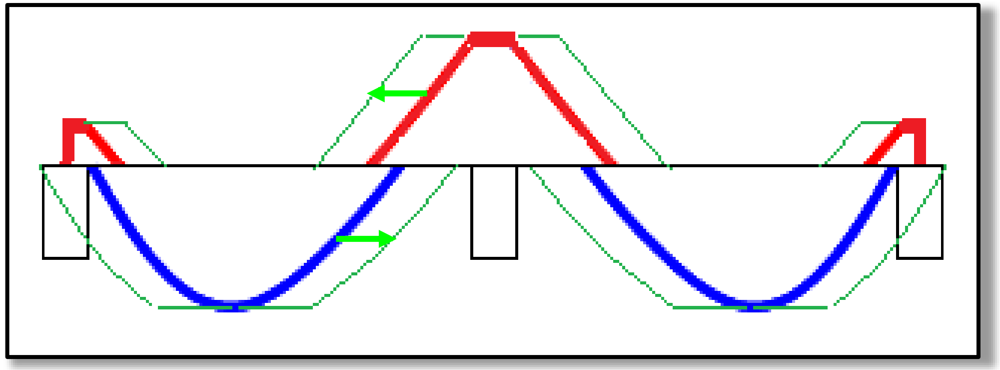
Reduce support moments to values in the face of the column (like in HW3).



Shift the envelope by $a_l = \frac{z}{2} \cot \theta$.

Lever arm of internal forces (see HW3).

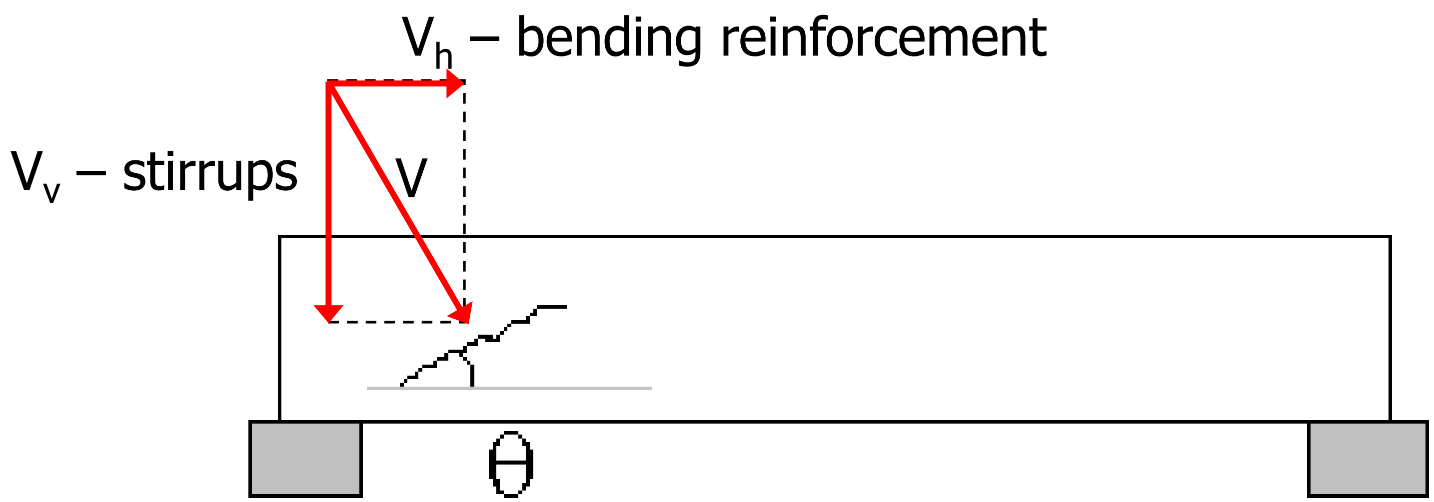
Shear crack angle (see HW3).



Adjusted envelope

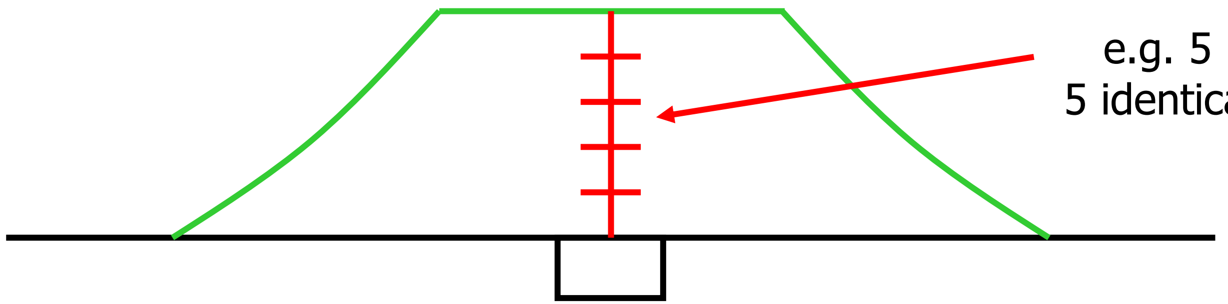
Why is the shift necessary?

- Shear stresses are perpendicular to shear cracks.
- Shear force has vertical and horizontal part.
- Stirrups are vertical ⟶ horizontal part of shear force is carried by bending reinforcement.



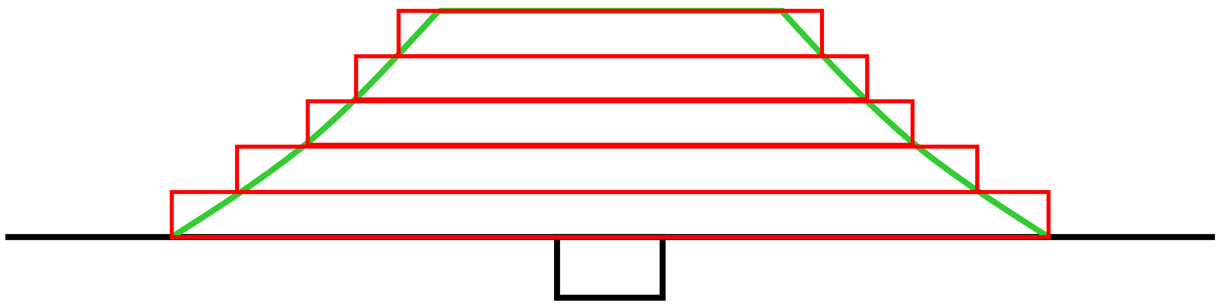
Rebar length

Divide the design bending moment by the number of rebars designed for the cross-section.



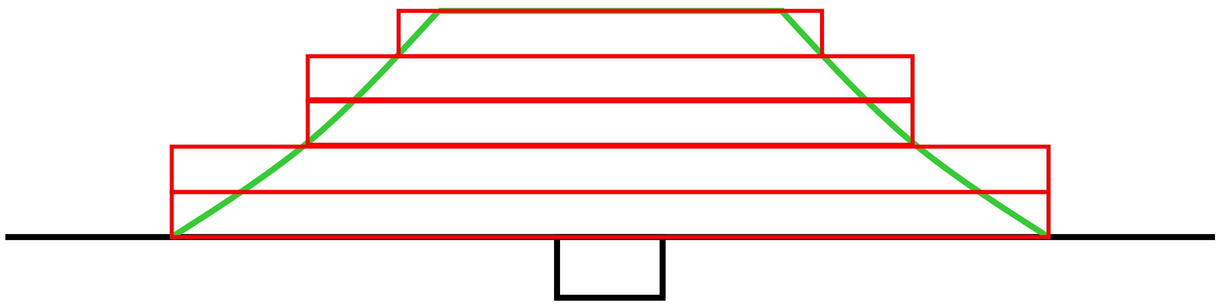
Summary

Using this division, we can obtain “needed” length of each rebar.



Summary

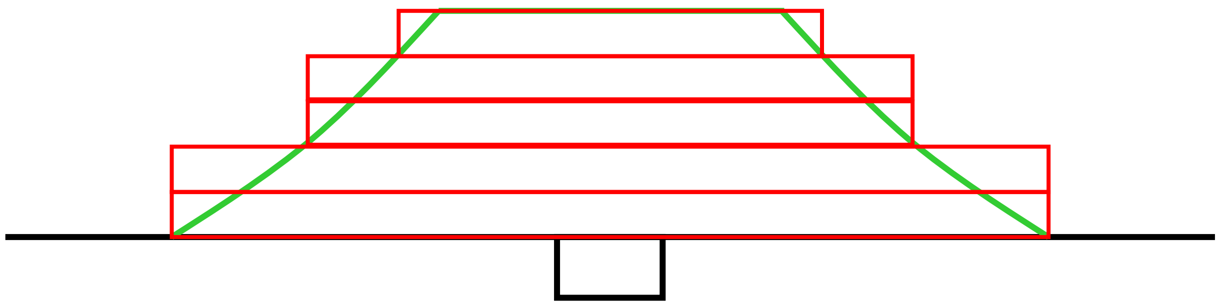
However, rebars must be in pairs (except for the last one, if you have odd number).



Why?

Summary

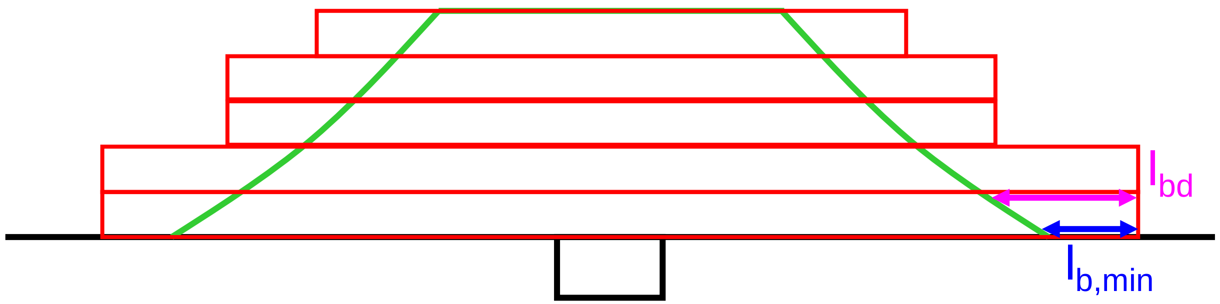
However, rebars must be in pairs (except for the last one, if you have odd number).

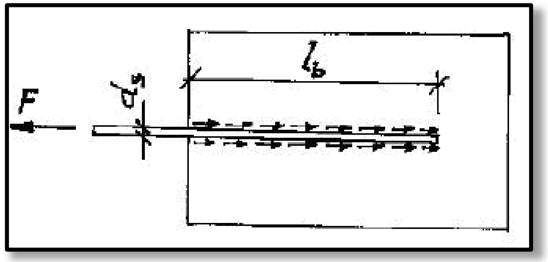


Why? Because every cross-section must be reinforced symmetrically.

Summary

Moreover, each rebar must be "anchored" beyond the moment envelope using the *minimal anchorage length* $l_{b,min}$ and *design anchorage length* l_{bd}.





The length required to transfer a force from a rebar to the surrounding concrete.

This is how we get the final required length of the rebars.

Anchorage length

We need to calculate the minimal and design anchorage length, but first, we need the **basic anchorage length**

$$l_{b,req} = \frac{\varnothing_s}{4} \times \frac{\sigma_{sd}}{f_{bd}},$$

where $\varnothing_s$ is the rebar diameter,

σ_{sd} is the stress in the reinforcement (assume f_{yd}),

$f_{bd} = 2.25 n_1 n_2 f_{ctd}$, (bond stress between the rebars and concrete)

where $n_1 = 1.0$ for good rebar position*,

$n_1 = 0.7$ for other rebar positions,

$n_2 = 1.0$ for $\varnothing_s \leq 32$ mm,

$n_2 = (132 - \varnothing_s)/100$ for $\varnothing_s > 32$ mm,

$f_{ctd} = f_{ctk,0.05}/1.5$, (for $f_{ctk,0.05}$ see table of concrete strengths).

* For bars more than 250 mm above formwork.

Anchorage length

Using the basic anchorage length, we can calculate the **minimal anchorage length**

$$l_{b,min} = \max(0.3 l_{b,req}, 10\varnothing_s, 100\ \mathrm{mm}),$$

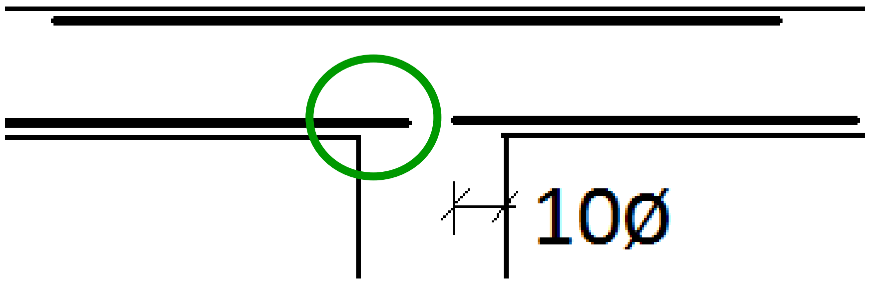
and the **design anchorage length**

$$l_{b,d} = \max\left(\alpha_1 \alpha_2 \alpha_3 \alpha_4 \alpha_5 l_{b,req}; l_{b,min}\right)$$

where α_i are coefficients expressing influence of shape of the end of rebars, cover depth, transverse unwelded rebars and transverse pressure (you can assume $\alpha_i = 1.0$).

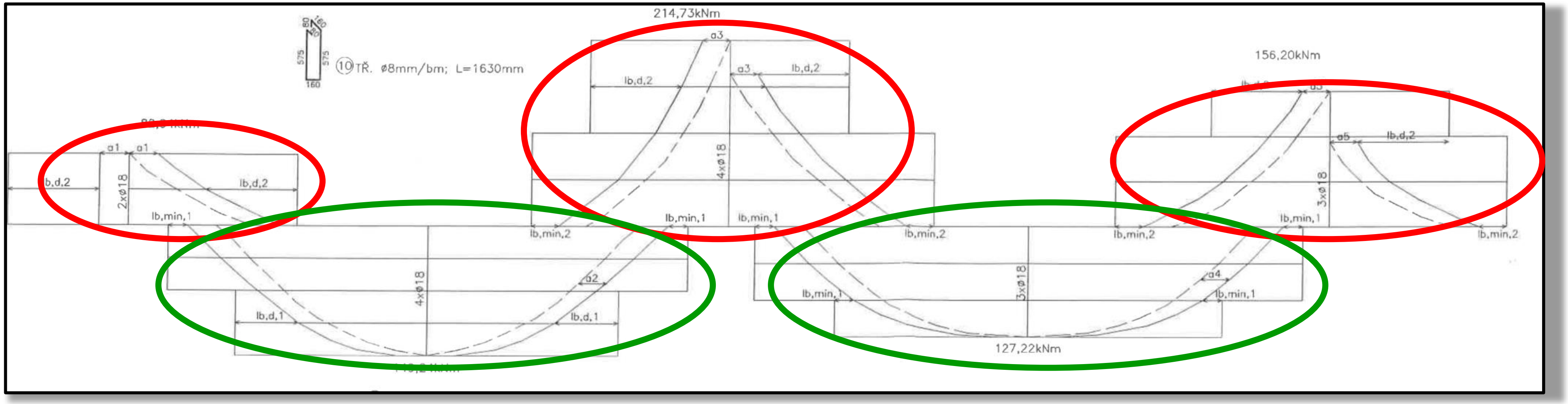
Anchorage length

For bottom reinforcement, at least two bars must be extended at least 10ø behind the face of the column.



Summary

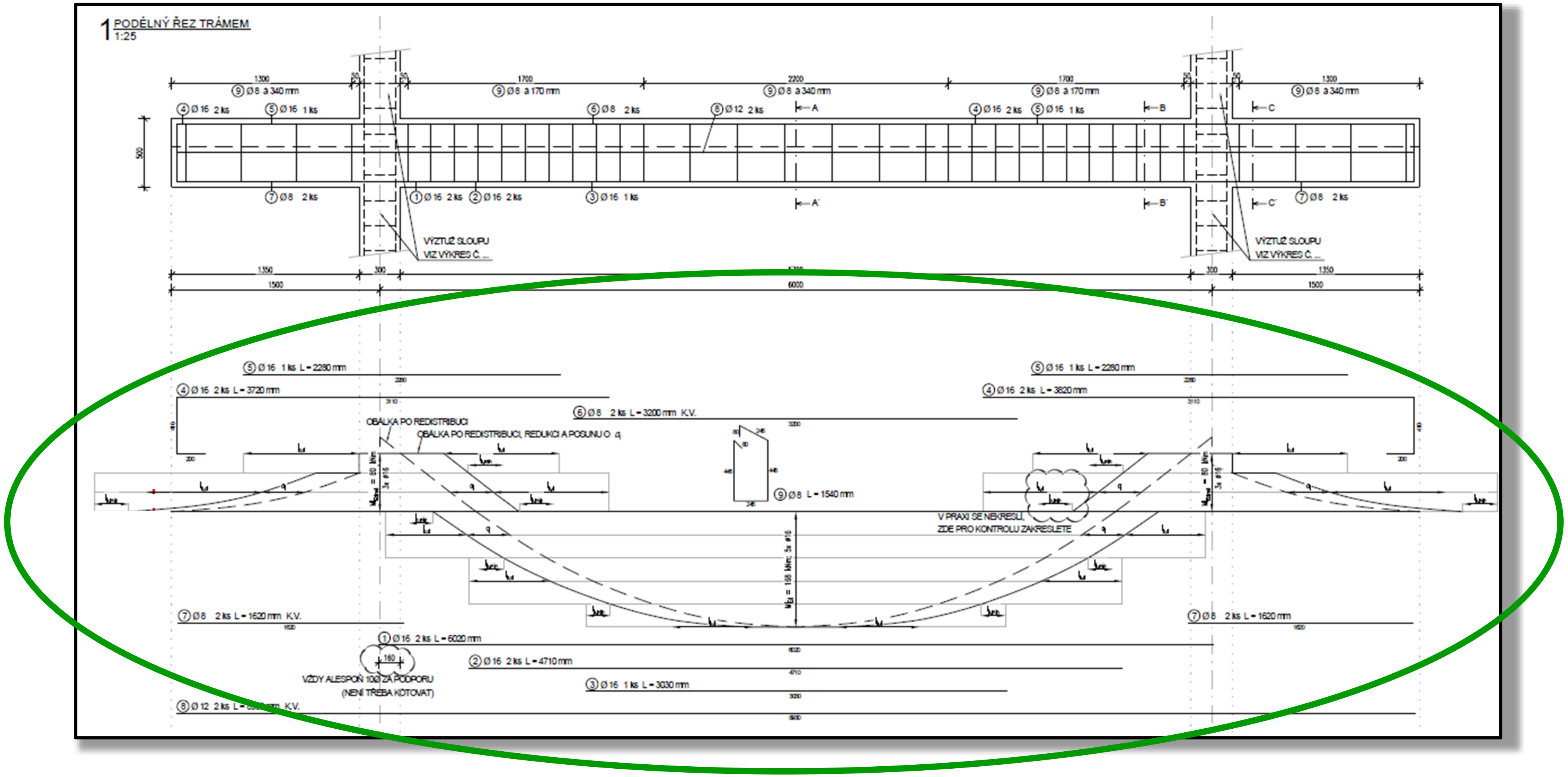
We must draw this scheme for all supports and mid-spans.



In the left mid-span (where you didn't design reinforcement) assume the same reinforcement as in the right span.
In the left support assume the same reinforcement as in the right support.

Summary

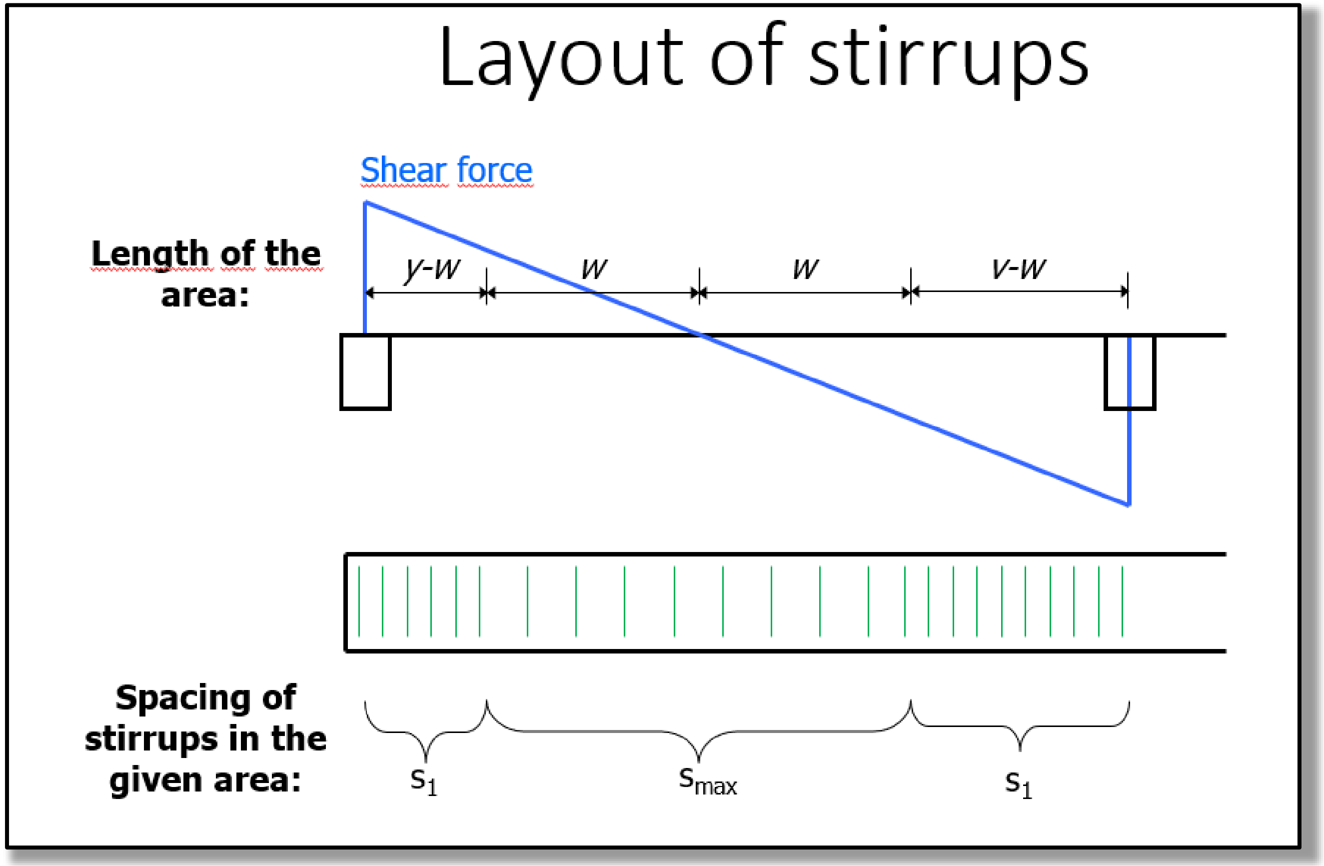
Using the schemes, we can design the rebar length.



Shear beam reinforcement

Shear beam reinforcement

Shear beam reinforcement (including its positions) was already designed in HW3. Use the values from this homework.



Column shear reinforcement (column ties)

Column ties

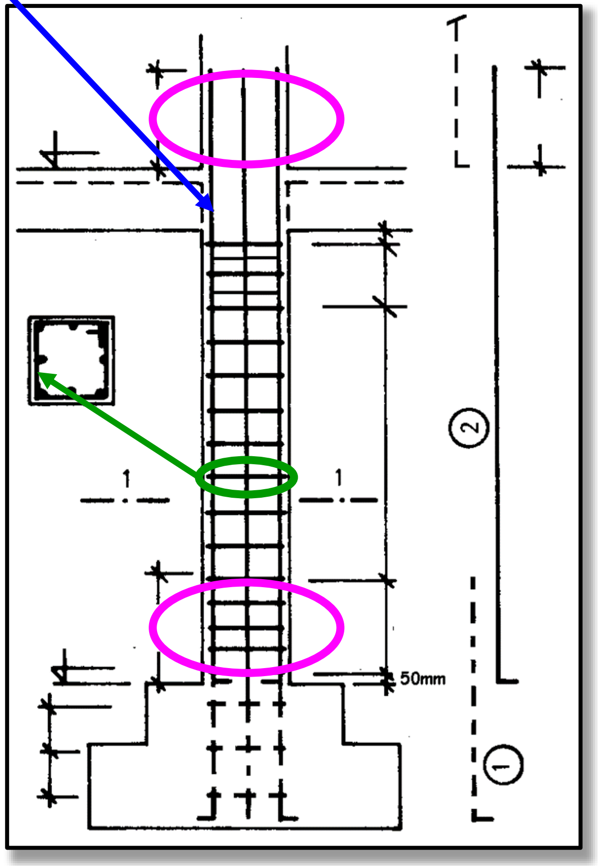
In column, we have designed only the vertical reinforcement in HW4. However, we must also design column ties, which prevent buckling of reinforcement.

Diameter: $\varnothing_{tie} \geq \max\left(\frac{\varnothing_s}{4}; 6\text{ mm}\right)$

Diameter of vertical column reinforcement

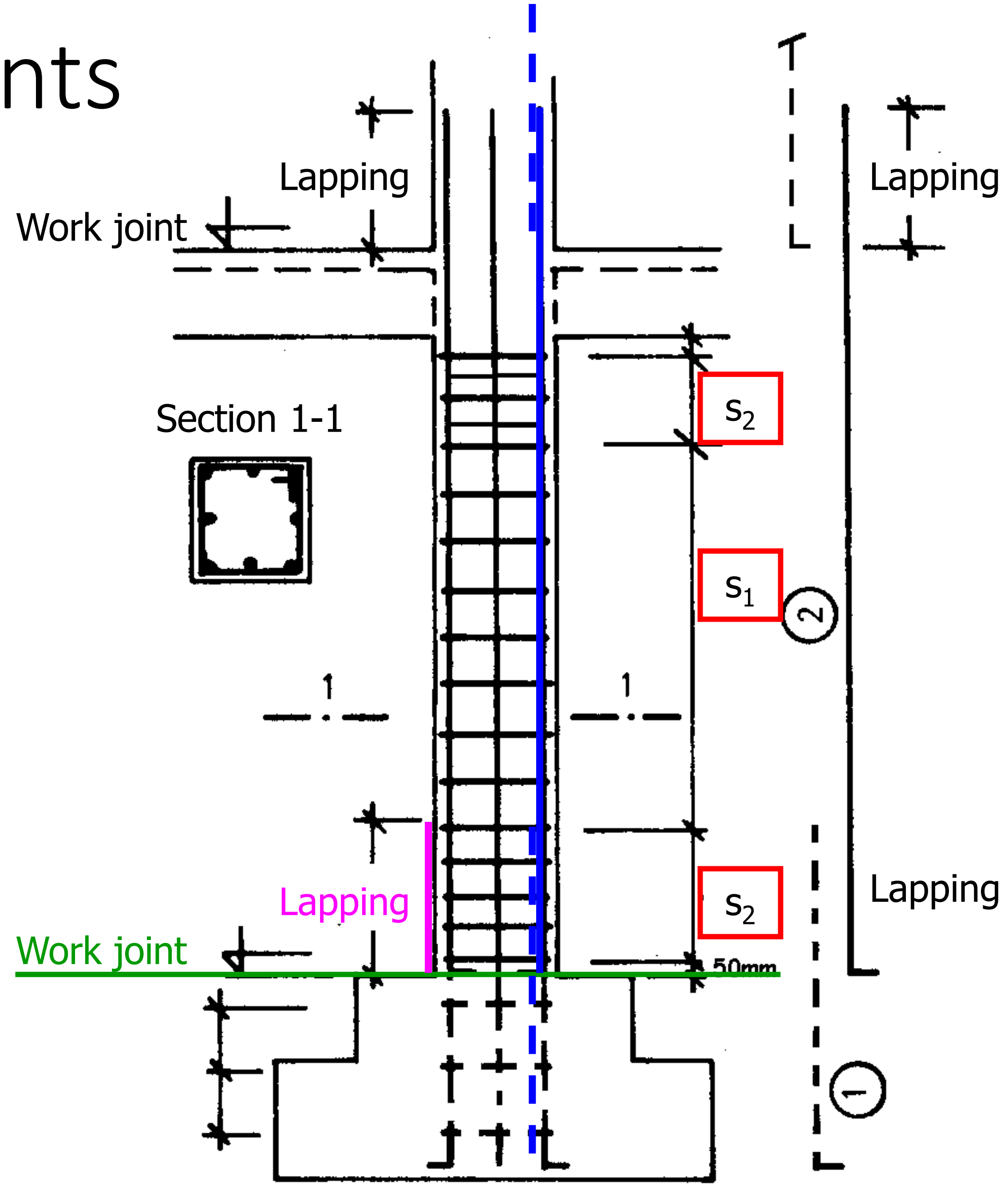
Basic spacing: $s_1 \leq \min\left(20\varnothing_s; \min\left(b_{col}; h_{col}\right); 400\text{ mm}\right)$

Spacing in lapping area and below and above beam (in the distance of $\max(b_{col};\ h_{col})$): $s_2 \leq 0.6 s_1$



Work joints

After concreting of 1st floor, you have to wait some time before you concrete the 2nd floor. Therefore, column vertical reinforcement is not continual over all floors but only on one floor, and individual rebars from each floor must be connected by lapping.



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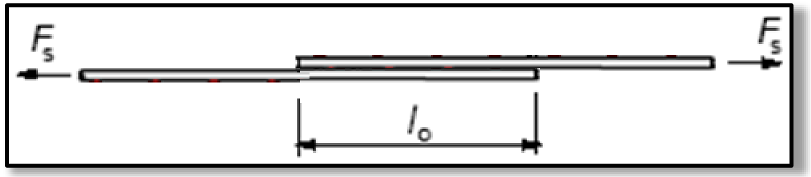
Lapping length

Equation for lapping length is very similar to equation for anchorage length. The equation is:

$$l_{0,d} = \max\left(\alpha_1 \alpha_2 \alpha_3 \alpha_5 \alpha_6 l_{b,req}; l_{0,min}\right)$$



The length required to transfer a force from one rebar to another rebar.

where

$l_{b,req}$ is the same as for anchorage,

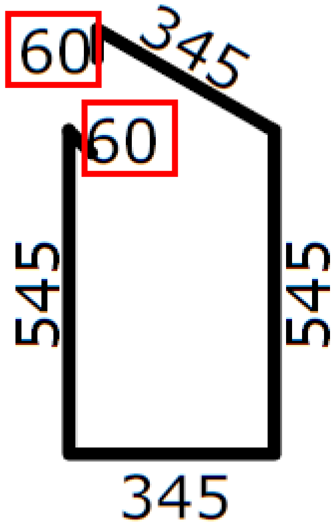
$l_{0,min} = \max(0.3\alpha_6 l_{b,req}, 15\varnothing_s, 200 \text{ mm})$,

$\alpha_6 = 1.5$

Tie (stirrup) ends

We need to close the tie.

The closing end length can be estimated as 10x the tie diameter.



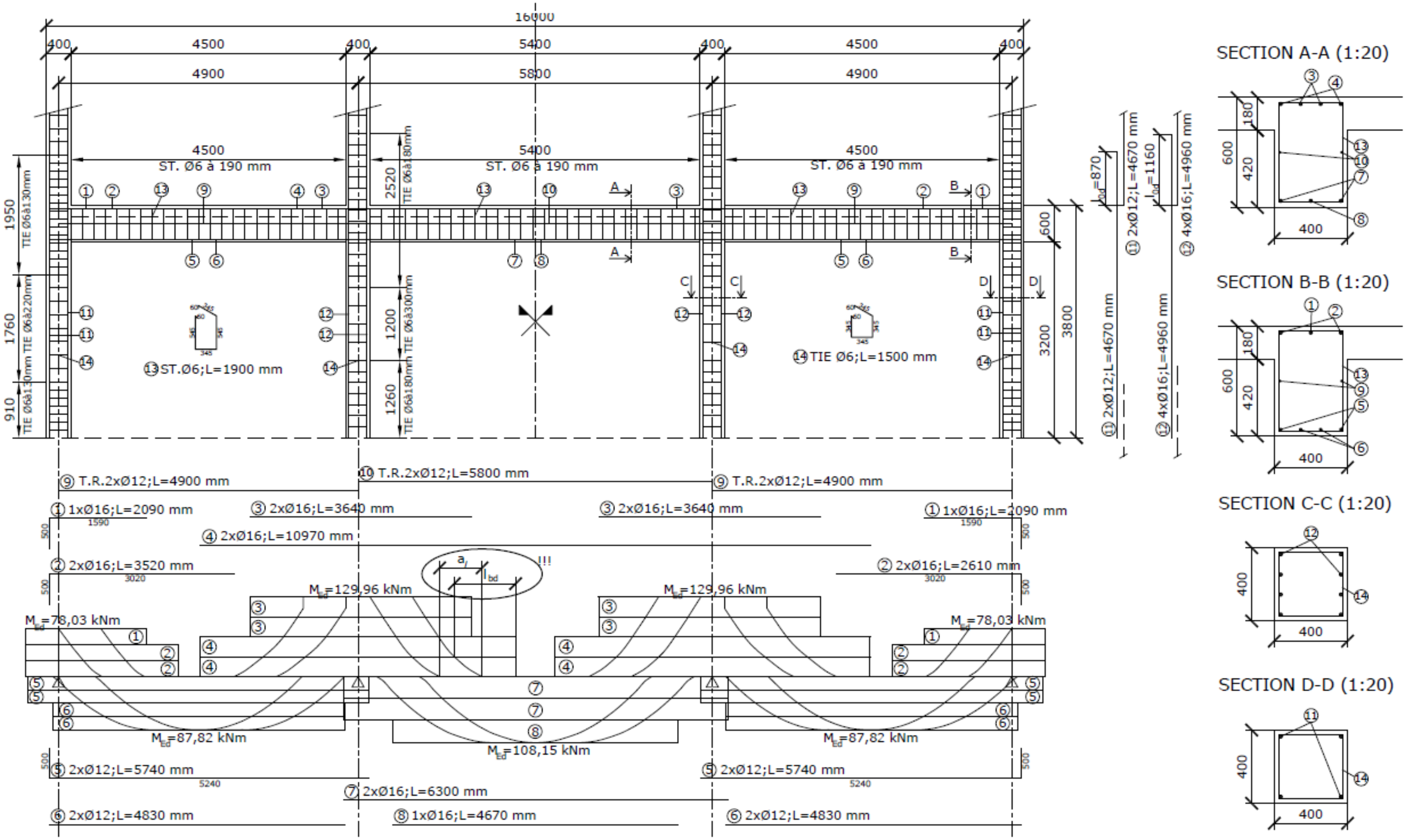
This is also true for beam stirrups!

Example drawings

Example 1 (with commentary)

Longitudinal section

Sections



Layout of moments (the curve must be SYMMETRIC in our structure)

+ shapes of rebars

Notes

MATERIALS:
CONCRETE C20/25
STEEL B500B

COVER DEPTH 25 mm

AXIAL DIMENSIONS OF REBARS

FRAME REINFORCEMENT DRAWING		CST2
Prepared by: JÁRA CIMRMAN	WT 1910/11	FSV ČVUT
Checked byl: prof. KLOKNER	1:50	

Drawing Title

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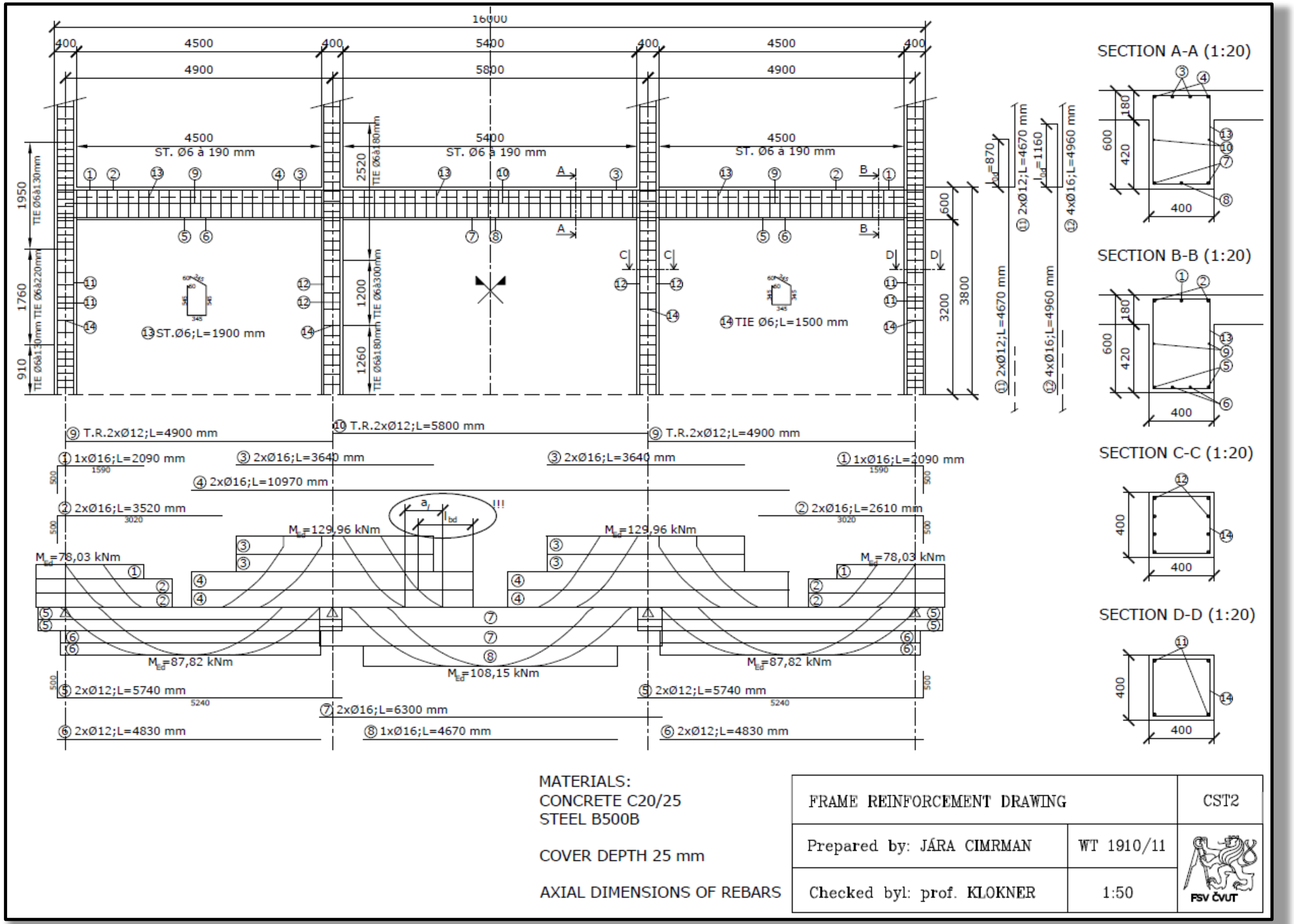
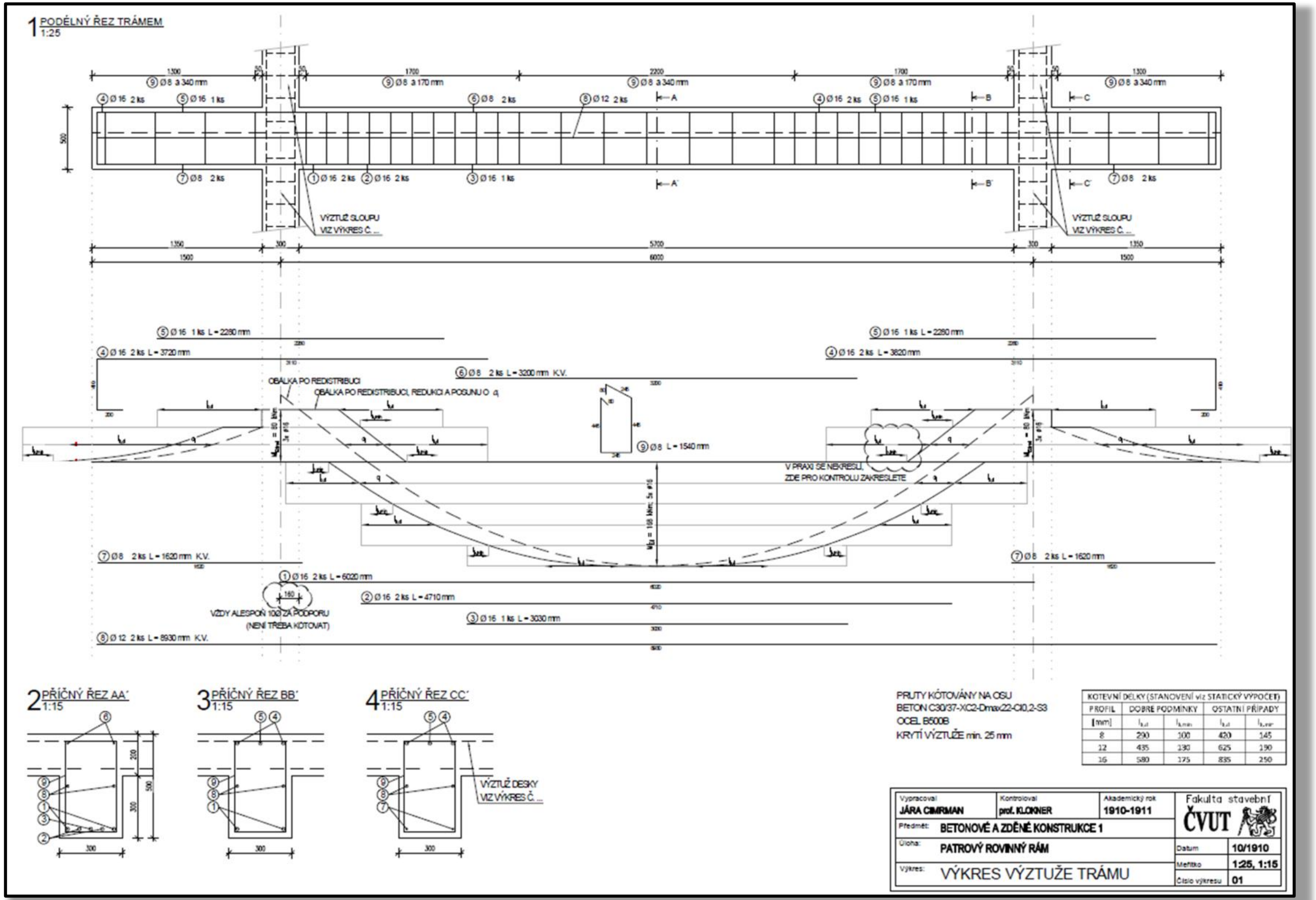
Example 1

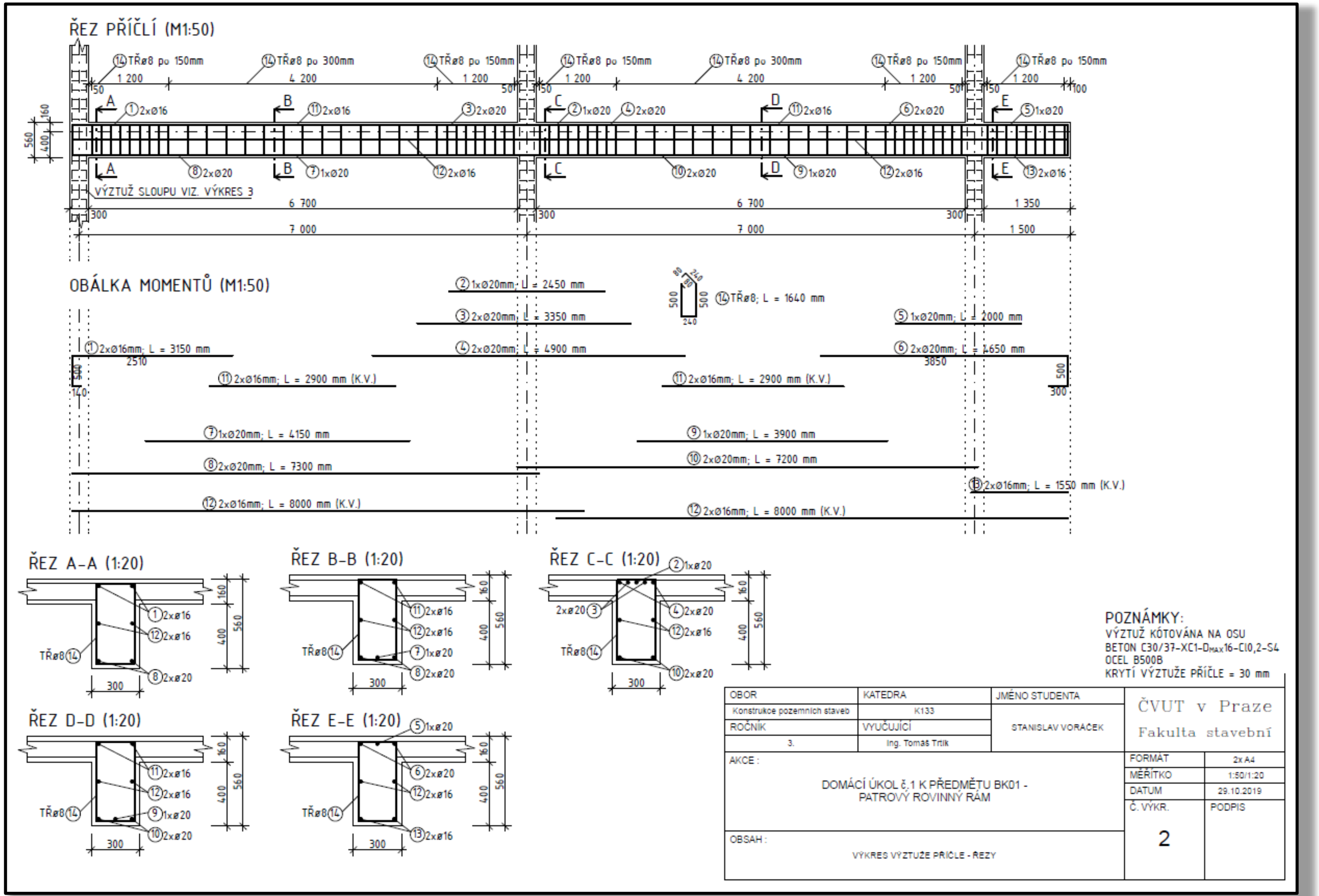

SECTION A-A (1:20)
SECTION B-B (1:20)
SECTION C-C (1:20)
SECTION D-D (1:20)
ST. Ø6 à 190 mm
13 ST.Ø6;L=1900 mm
14 TIE Ø6;L=1500 mm
9 T.R.2xØ12;L=4900 mm
10 T.R.2xØ12;L=5800 mm
1 1xØ16;L=2090 mm
3 2xØ16;L=3640 mm
4 2xØ16;L=10970 mm
2 2xØ16;L=3520 mm
2 2xØ16;L=2610 mm
M_Ed=129,96 kNm
M_Ed=78,03 kNm
M_Ed=87,82 kNm
M_Ed=108,15 kNm
5 2xØ12;L=5740 mm
7 2xØ16;L=6300 mm
6 2xØ12;L=4830 mm
8 1xØ16;L=4670 mm
11 2xØ12;L=4670 mm
12 4xØ16;L=4960 mm
MATERIALS:
CONCRETE C20/25
STEEL B500B
COVER DEPTH 25 mm
AXIAL DIMENSIONS OF REBARS
FRAME REINFORCEMENT DRAWING
CST2
Prepared by: JÁRA CIMRMAN
WT 1910/11
Checked byl: prof. KLOKNER
1:50
FSV ČVUT

Example 2



KOTEVNÍ DÉLKY (STANOVENÍ viz STATICKÝ VÝPOČET)				
PROFIL	DOBRÉ PODMÍNKY		OSTATNÍ PŘÍPADY	
[mm]	$l_{b,d}$	$l_{b,min}$	$l_{b,d}$	$l_{b,min}$
8	290	100	420	145
12	435	130	625	190
16	580	175	835	250

Example 3



ŘEZ PŘÍČLÍ (M1:50)
⑭TŘø8 po 150mm
⑭TŘø8 po 300mm
1 200
4 200
ⓐ2xø16
⑪2xø16
③2xø20
②1xø20
④2xø20
⑥2xø20
⑤1xø20
⑧2xø20
⑦1xø20
⑫2xø16
⑩2xø20
⑨1xø20
⑬2xø16
VÝZTUŽ SLOUPU VIZ. VÝKRES 3
6 700
7 000
1 350
1 500
OBÁLKA MOMENTŮ (M1:50)
②1xø20mm; L = 2450 mm
③2xø20mm; L = 3350 mm
④2xø20mm; L = 4900 mm
⑭TŘø8; L = 1640 mm
⑤1xø20mm; L = 2000 mm
⑥2xø20mm; L = 4650 mm
①2xø16mm; L = 3150 mm
⑪2xø16mm; L = 2900 mm (K.V.)
⑦1xø20mm; L = 4150 mm
⑨1xø20mm; L = 3900 mm
⑧2xø20mm; L = 7300 mm
⑩2xø20mm; L = 7200 mm
⑬2xø16mm; L = 1550 mm (K.V.)
⑫2xø16mm; L = 8000 mm (K.V.)
ŘEZ A-A (1:20)
ŘEZ B-B (1:20)
ŘEZ C-C (1:20)
ŘEZ D-D (1:20)
ŘEZ E-E (1:20)
TŘø8⑭
300
160
400
560
POZNÁMKY:
VÝZTUŽ KÓTOVÁNA NA OSU
BETON C30/37-XC1-Dmax16-Cl0,2-S4
OCEL B500B
KRYTÍ VÝZTUŽE PŘÍČLE = 30 mm
OBOR
Konstrukce pozemních staveb
KATEDRA
K133
JMÉNO STUDENTA
STANISLAV VORÁČEK
ROČNÍK
3.
VYUČUJÍCÍ
Ing. Tomáš Trtík
ČVUT v Praze
Fakulta stavební
AKCE :
DOMÁCÍ ÚKOL č.1 K PŘEDMĚTU BK01 - PATROVÝ ROVINNÝ RÁM
FORMÁT
2x A4
MĚŘÍTKO
1:50/1:20
DATUM
29.10.2019
Č. VÝKR.
2
PODPIS
OBSAH :
VÝKRES VÝZTUŽE PŘÍČLE - ŘEZY

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.