



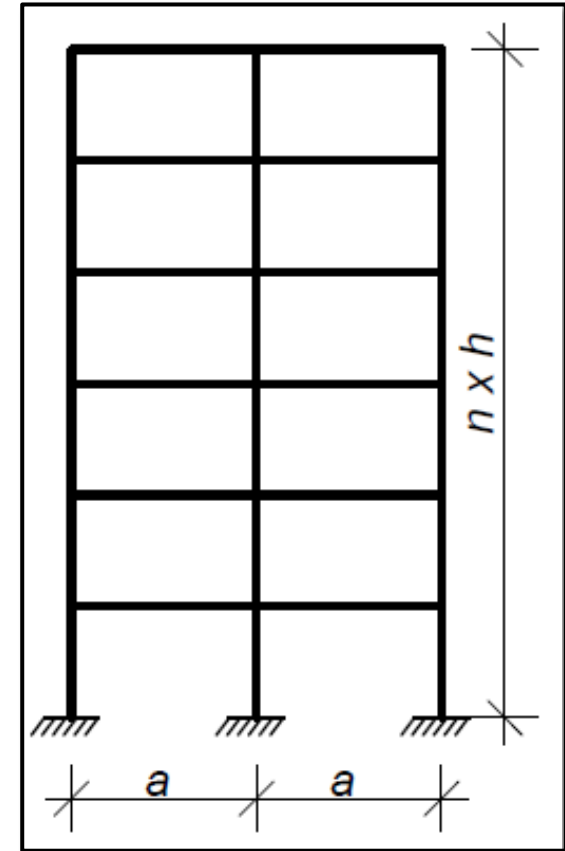
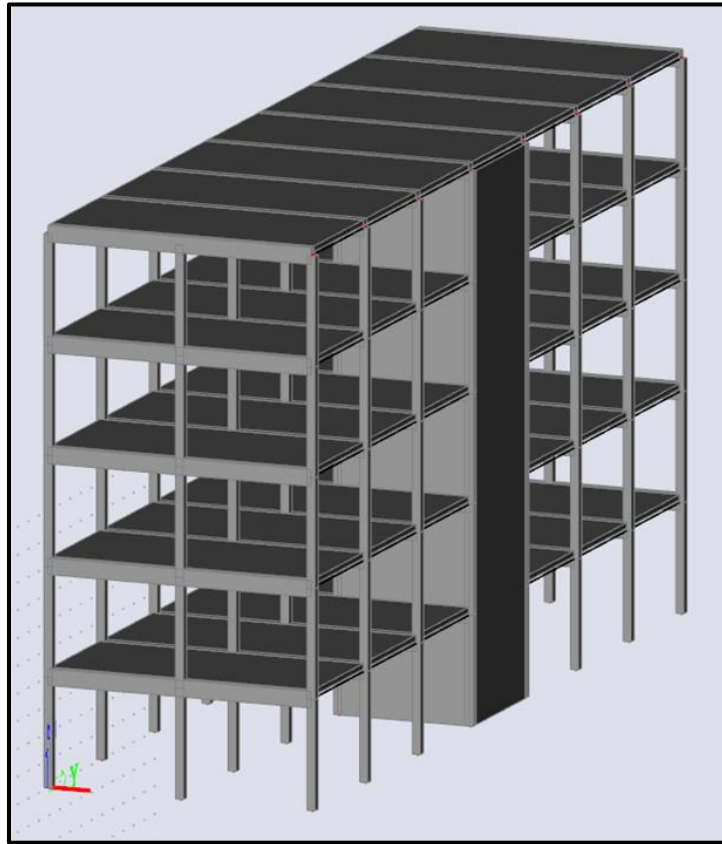
*CM01 – Concrete and Masonry Structures 1*

# HW2 – Calculation of internal forces

# Task 1

# Task 1 – Frame structure

In Task 1, frame structure will be designed.



# Task 1 – Assignment

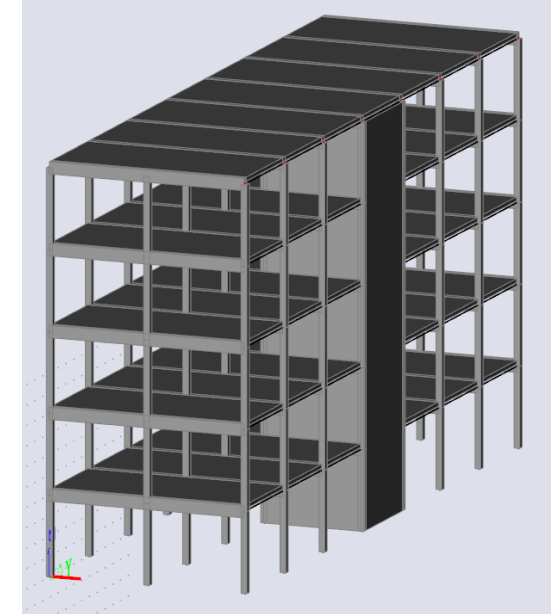
Geometry:  **$R$** ,  **$a$**  [m] – horizontal dimensions,  **$h$**  [m] – floor height,  **$n$**  – number of floors

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

Loads: Other permanent load of typical floor  **$(g-g_0)_{\text{floor},k}$**  [kN/m<sup>2</sup>]  
Other permanent load of the roof  **$(g-g_0)_{\text{roof},k}$**  [kN/m<sup>2</sup>]  
Live load of typical floor  **$q_{\text{floor},k}$**  [kN/m<sup>2</sup>]  
Live load of the roof  **$q_{\text{roof},k} = 0,75$**  kN/m<sup>2</sup>  
Self-weight of the slab  **$g_{0,k}$**  (calculate from the slab depth)

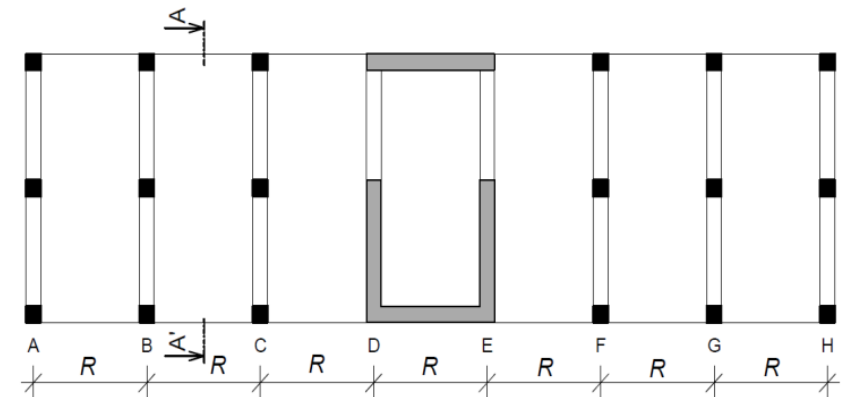
Another parameters:  **$S$**  – Exposure class related to environmental conditions  
 **$Z$**  – Working life of the structure

**Parameters in bold** are individual parameters, which you can find on the course website.



Your individual parameters:

[https://docs.google.com/spreadsheets/d/1uQluyyKEcG5jaZVLrsmm1ZRRNib\\_ow3MIwgZSEDgnW8/](https://docs.google.com/spreadsheets/d/1uQluyyKEcG5jaZVLrsmm1ZRRNib_ow3MIwgZSEDgnW8/)



# Task 1 – Assignment goals

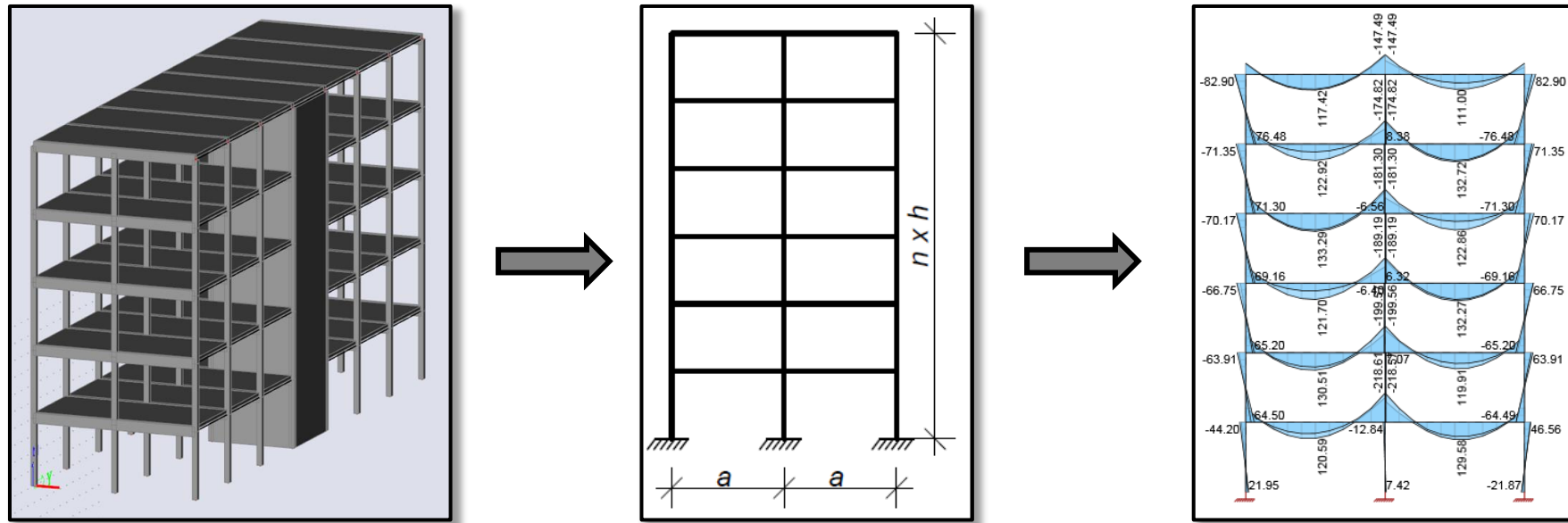
**Our goal** will be to:

- 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 members.
- Draw layout of the reinforcement.

# Calculation of internal forces in 2D frame

# Calculation of internal forces in 2D frame

In this part of the task, we will **calculate internal forces in the frame structure** (2D transverse section of the building).



We will use the **SCIA Engineer software** for the calculation of internal forces\*.

\*In your homework, you can use any other software, if you are familiar with it, or calculate the forces manually by hand.

# Calculation of internal forces in 2D frame

This part consists of the following steps:

- **calculate beam loading,**
- download and **install SCIA Engineer,**
- **model the frame, calculate internal forces, and create a report** in SCIA Engineer.



# Calculation of internal forces in 2D frame

## *Beam loading*

# Beam loading

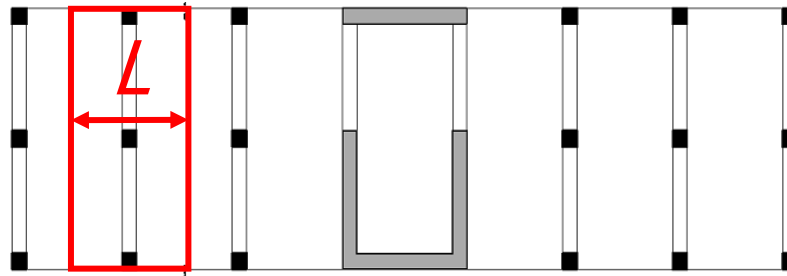
First, we must **determine the loads acting on the beams**, which we will later input into the software.

# Beam loading

Manually calculate 4 values of linear loads per 1 meter of the beam (in kN/m):

- Characteristic permanent\* load in typical floor  $g_{k,t}$ ,
- Characteristic permanent load on the roof  $g_{k,r}$ ,
- Characteristic variable load in typical floor  $q_{k,t}$ ,
- Characteristic variable load on the roof  $q_{k,r}$ .

Linear load [kN/m] = area load [kN/m<sup>2</sup>] \* L [m].



# Beam loading

Floor slab load							
Load type	Load name	h	ρ	ρ <sub>pl</sub>	f <sub>k</sub>	γ	f <sub>d</sub>
-	-	mm	kg/m <sup>3</sup>	kg/m <sup>2</sup>	kN/m <sup>2</sup>	-	kN/m <sup>2</sup>
DEAD (G)	slab self weight	190	2500	475	4.75	1.35	6.41
	other permanent load	<i>from assignment</i>			0.50		0.68
	Σ				5.25		7.09
LIVE (Q)	variable	<i>from assignment</i>			3	1.5	4.50
	Σ				3		4.50
<b>SUM</b>					<b>f<sub>k</sub> = 8.25</b>		<b>f<sub>d</sub> = 11.59</b>



Floor beam load						
Load type	Load name	f <sub>a,k</sub>	tributing width	f <sub>lin,k</sub>	γ	f <sub>lin,d</sub>
-	-	kN/m <sup>2</sup>	m	kN/m	-	kN/m
DEAD (G)	slab dead load	5.25	6.5	34.13	1.35	46.07
	beam self weight	<i>calculated automatically by SCIA</i>		0.00		0.00
	Σ			34.13		46.07
LIVE (Q)	slab live load	3	6.5	19.50	1.5	29.25
	Σ			19.50		29.25
<b>SUM</b>				<b>f<sub>k</sub> = 53.63</b>		<b>f<sub>d</sub> = 75.32</b>

Slab span: R = 6.5 m

$$g_{k,t} = 34.13 \text{ kN/m}$$

$$q_{k,t} = 19.50 \text{ kN/m}$$

Roof slab load							
Load type	Load name	h	ρ	ρ <sub>pl</sub>	f <sub>k</sub>	γ	f <sub>d</sub>
-	-	mm	kg/m <sup>3</sup>	kg/m <sup>2</sup>	kN/m <sup>2</sup>	-	kN/m <sup>2</sup>
STALE (G)	slab self weight	190	2500	475	4.75	1.35	6.41
	other permanent load	<i>from assignment</i>			2.00		2.70
	Σ				6.75		9.11
PROM. (Q)	variable	<i>from assignment</i>			0.75	1.5	1.13
	Σ				0.75		1.13
<b>SUM</b>					<b>f<sub>k</sub> = 7.50</b>		<b>f<sub>d</sub> = 10.24</b>



Roof beam load						
Load type	Load name	f <sub>a,k</sub>	tributing width	f <sub>lin,k</sub>	γ	f <sub>lin,d</sub>
-	-	kN/m <sup>2</sup>	m	kN/m	-	kN/m
DEAD (G)	slab dead load	6.75	6.5	43.88	1.35	59.23
	beam self weight	<i>calculated automatically by SCIA</i>		0.00		0.00
	Σ			43.88		59.23
LIVE (Q)	slab live load	0.75	6.5	4.88	1.5	7.31
	Σ			4.88		7.31
<b>SUM</b>				<b>f<sub>k</sub> = 48.75</b>		<b>f<sub>d</sub> = 66.54</b>

Slab span: R = 6.5 m

$$g_{k,r} = 43.88 \text{ kN/m}$$

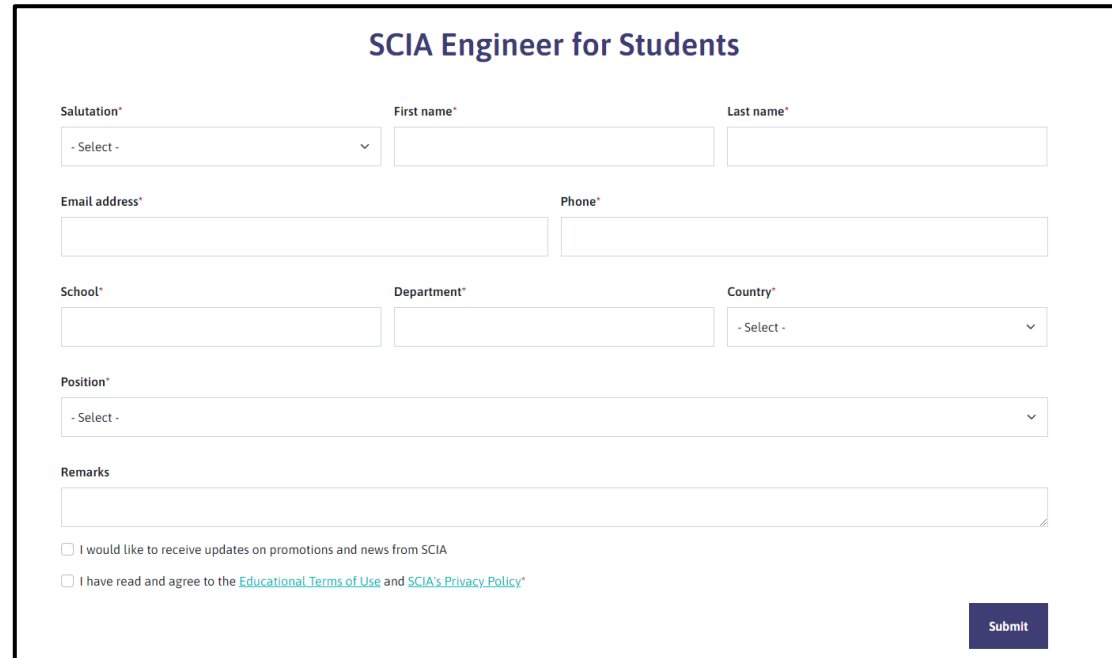
$$q_{k,r} = 4.88 \text{ kN/m}$$

# Calculation of internal forces in 2D frame

*Download and install of SCIA Engineer*

# Download and install SCIA Engineer

First, apply for the [student license](#) of SCIA. When applying, **use your school student email** (e.g., “name.surname@estudiantat.upc.edu”).



The image shows a registration form titled "SCIA Engineer for Students". The form contains the following fields and options:

- Salutation\*: A dropdown menu with "- Select -" as the current selection.
- First name\*: A text input field.
- Last name\*: A text input field.
- Email address\*: A text input field.
- Phone\*: A text input field.
- School\*: A text input field.
- Department\*: A text input field.
- Country\*: A dropdown menu with "- Select -" as the current selection.
- Position\*: A dropdown menu with "- Select -" as the current selection.
- Remarks: A large text area for additional comments.
- Two checkboxes at the bottom:
  - I would like to receive updates on promotions and news from SCIA
  - I have read and agree to the [Educational Terms of Use](#) and [SCIA's Privacy Policy](#)
- A blue "Submit" button in the bottom right corner.

Wait until you receive an activation email with your login credentials.

# Download and install SCIA Engineer

Download and install the latest version of SCIA.

**SCIA Engineer 22 downloads**

**Latest version release 22**

On this page you will find all released versions of SCIA Engineer 22 and the necessary guides to help you start a new installation, or update an existing one.

SCIA Engineer is only backward-compatible.  
Files from version 21 can be opened in version 22, but files from 22 cannot be opened in 21.

All installation guides can be found in the tab named 'Installation Guides'.

- Update to the SCIA Cloud License Protection: follow the [cloud license installation guide](#)

SCIA Engineer 64-Bit Release 22.1.2011 >

**After installing SCIA, run the software and log in using your credentials.**

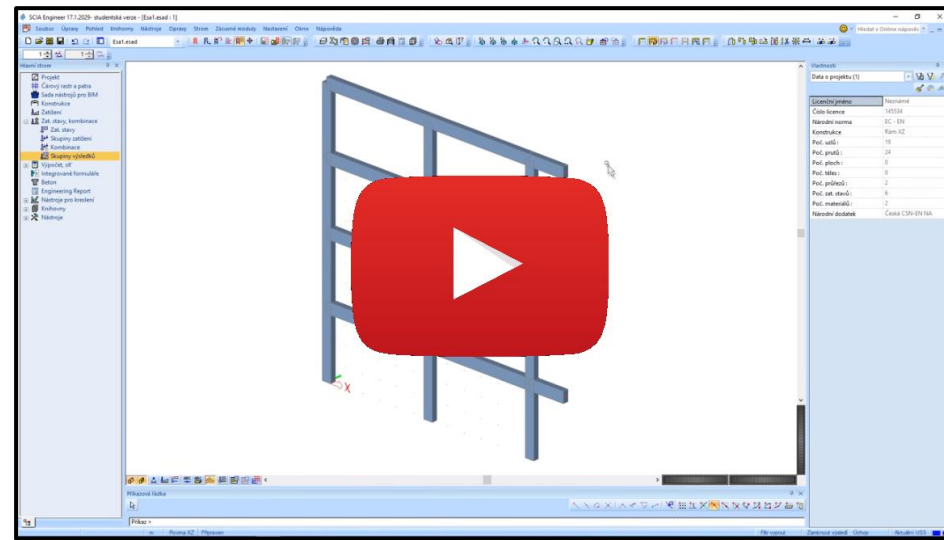
# Calculation of internal forces in 2D frame

## *Modelling of the frame in SCIA Engineer*



# Using the software

Use [this video tutorial](#) to model the structure, perform the calculations and obtain the results.



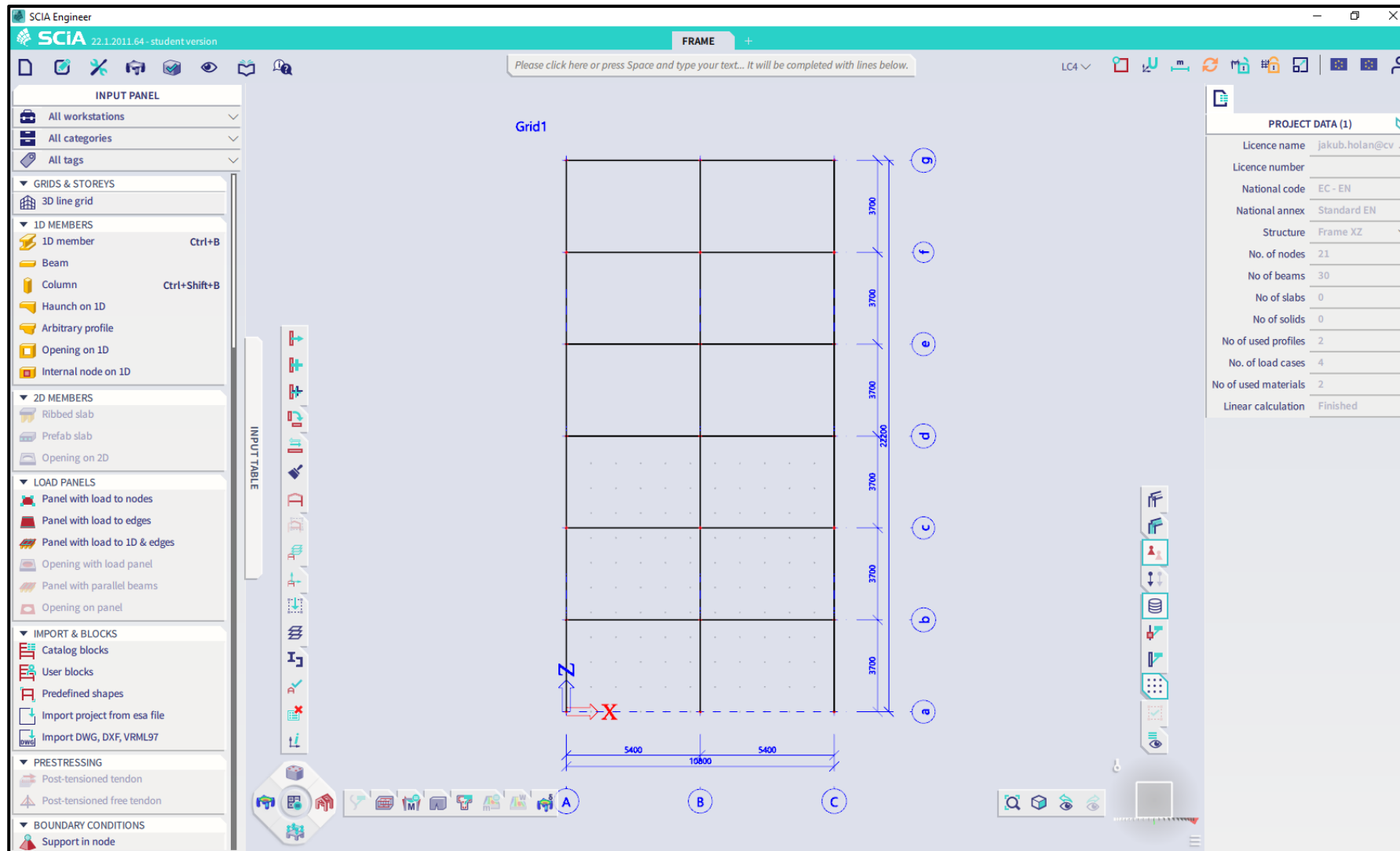
The following part of the presentation only highlights the main steps.

# Using the software

The process of obtaining the internal forces using SCIA Engineer consists of the following main steps.

- a) Modelling the **structure**.
- b) Inputting **loads** into load cases.
- c) Creating **load combinations**.
- d) Creating **result groups**.
- e) **Calculation**.
- f) Creating the **Engineering report**.

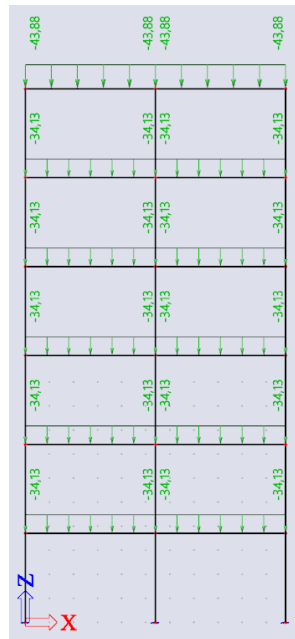
# a) Modelling the structure



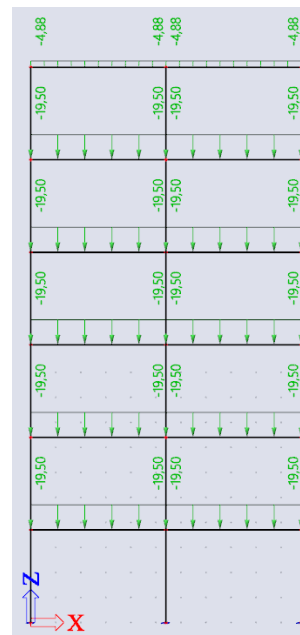
## b) Inputting loads into load cases

We will create and use the following load cases.

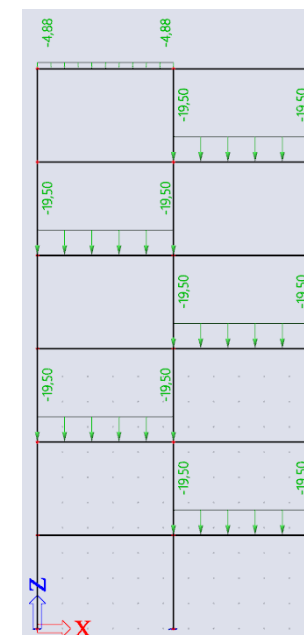
- LC1: Self-weight of the frame – created and calculated automatically by SCIA,
- LC2: Full permanent load,
- LC3: Full variable load,
- LC4: Checkerboard variable load.



LC2: Full permanent load



LC3: Full variable load



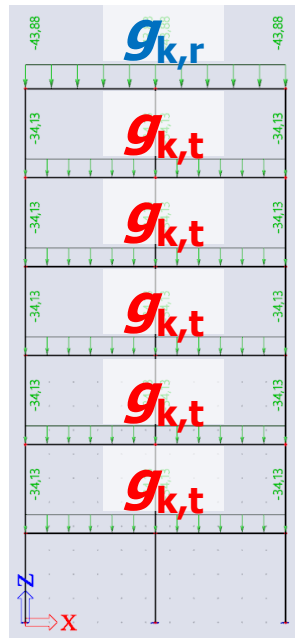
LC4: Checkerboard variable load

## b) Inputting loads into load cases

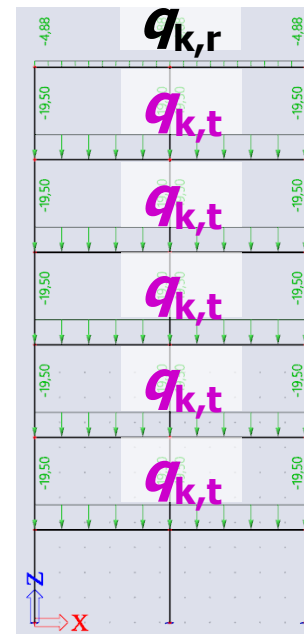
### Beam loading

Manually calculate 4 values of linear loads per 1 meter of the beam (in kN/m):

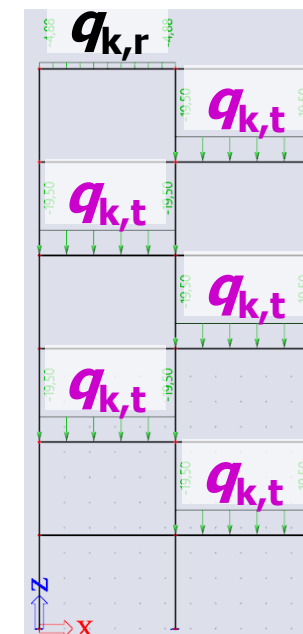
- Characteristic permanent\* load in typical floor  $g_{k,t}$
- Characteristic permanent load on the roof  $g_{k,r}$
- Characteristic variable load in typical floor  $q_{k,t}$
- Characteristic variable load on the roof  $q_{k,r}$



LC2: Full permanent load



LC3: Full variable load

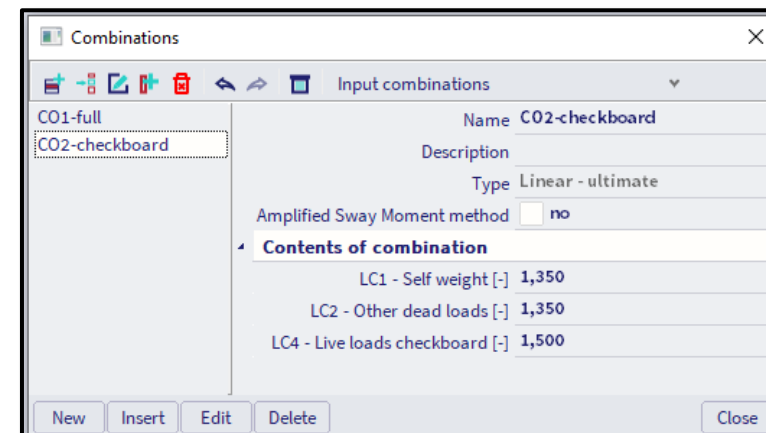
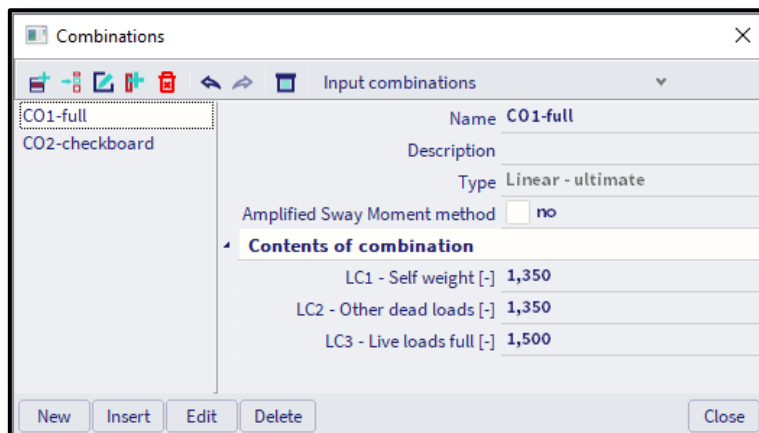


LC4: Checkerboard variable load

## c) Creating load combinations.

After creating the load cases, we must select **which load cases act together** – i.e., we must create **load combinations (CO)**.

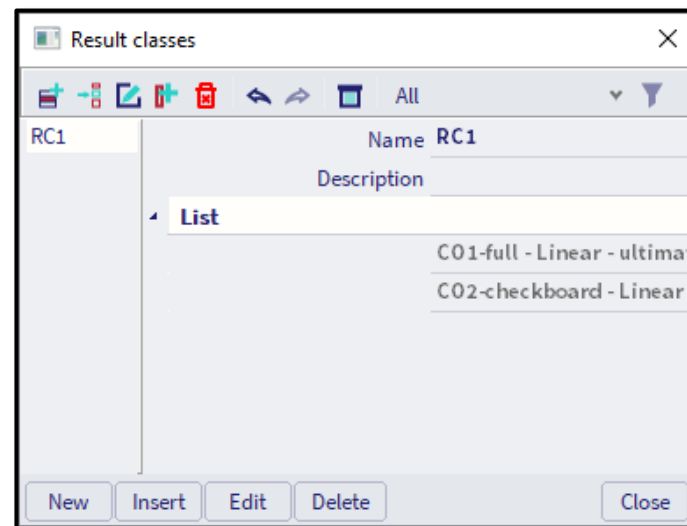
- Full (CO1) = Self-weight of the frame + Full permanent load + Full variable load  
*(LC1)*
*(LC2)*
*(LC3)*
- Checkerboard (CO2) = Self-weight of the frame + Full permanent load + Checkerboard variable load  
*(LC1)*
*(LC2)*
*(LC4)*



## d) Creating result groups.

Last, we must **create a “group of results”** in order to view the envelope of the internal forces from the individual load combinations:

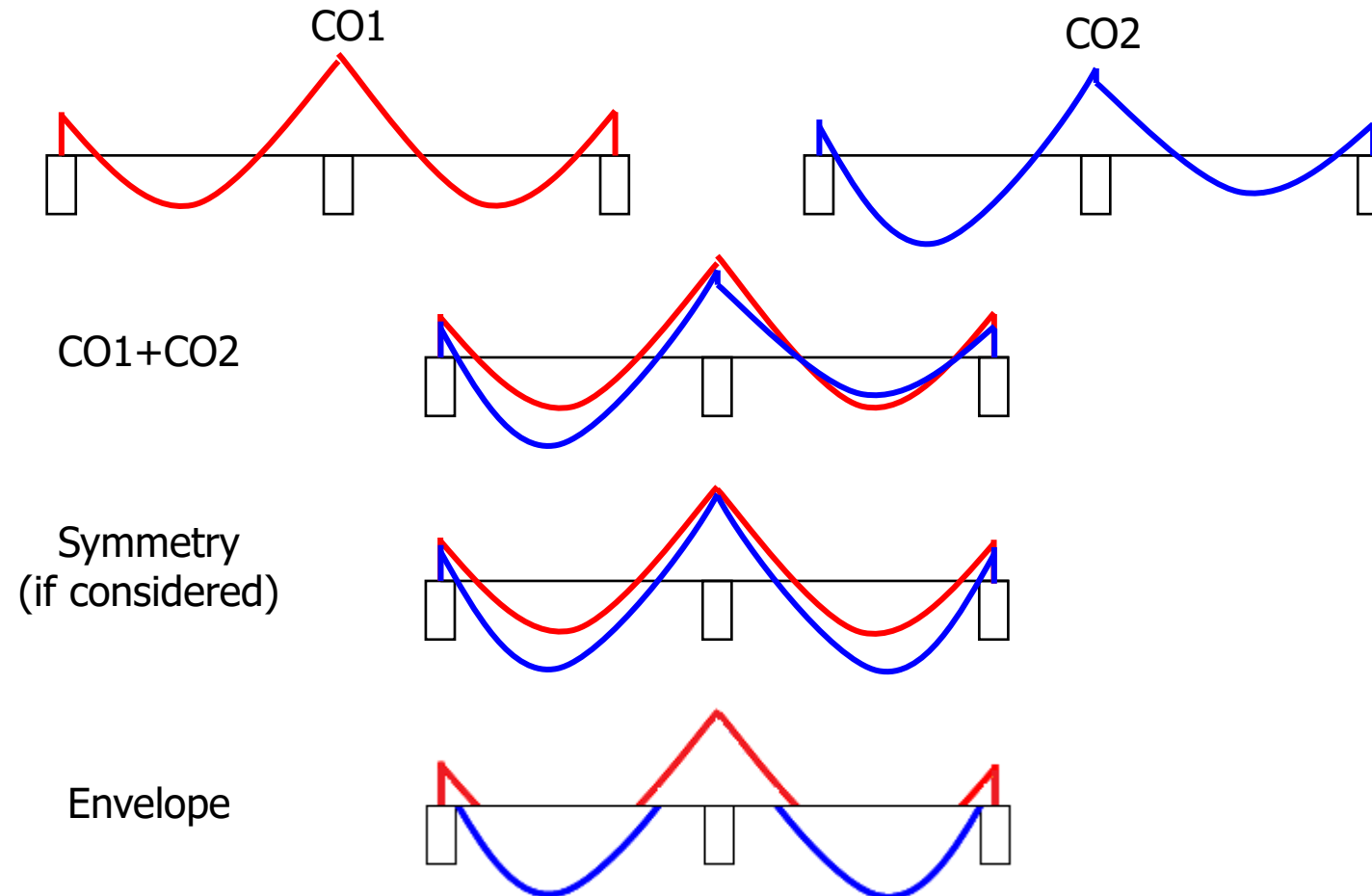
$$RG1 = \{CO1, CO2\}$$



What is an **“envelope”** of an internal force?

## d) Creating result groups.

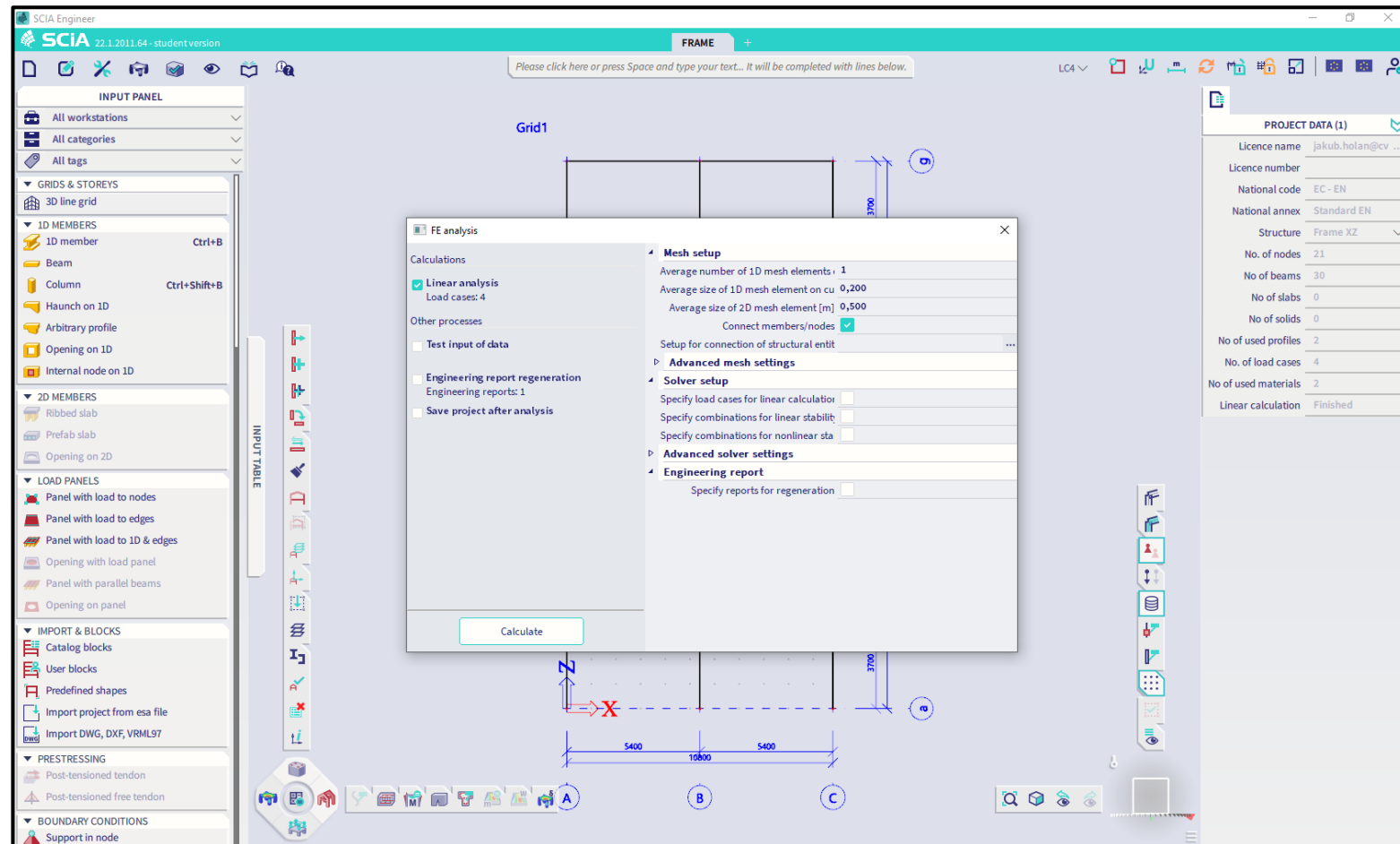
What is an “envelope” of an internal force?





# e) Calculation

Finally, we can **run the calculation**.



# f) Creating Engineering report

After running the calculation, we can **check the results and create the Engineering report.**

Engineering report is a document that you can create in the SCIA Engineer software. We will put the most important inputs and results into the report.

The screenshot displays the SCIA Engineer software interface for creating an engineering report. The main window shows a report titled "Report\_1 (FRAME.asad) - Engineering report". The interface includes a menu bar, a toolbar, a Navigator panel on the left, a main content area, and a Properties panel on the right.

**Navigator Panel (Left):**

- Header / Footer
- Analysis model (Picture in scale)
- Members
- LC2 / Tot. value / Value (Picture in scale)
- LC3 / Tot. value / Value (Picture in scale)
- LC4 / Tot. value / Value (Picture in scale)
- Combinations
- 3D displacement, U<sub>i</sub> total (Picture in scale)
- RC1 - N (Picture in scale)
- RC1 - V (Picture in scale)
- RC1 - M (beams) (Picture in scale)**
- RC1 - M (columns) (Picture in scale)
- CO1 - N (Picture in scale)
- CO1 - V (Picture in scale)
- CO1 - M (beams) (Picture in scale)
- CO1 - M (columns) (Picture in scale)
- CO2 - N (Picture in scale)
- CO2 - V (Picture in scale)
- CO2 - M (beams) (Picture in scale)
- CO2 - M (columns) (Picture in scale)

**Main Content Area:**

**10. RC1 - V**  
 Values: V<sub>y</sub>  
 Linear calculation  
 Class: RC1  
 Coordinate system: Member  
 Extreme 1D: Local  
 Selection: B4, B5, B9, B10, B14, B15, B19, B20, B24, B25, B29, B30

**11. RC1 - M (beams)**  
 Values: M<sub>y</sub>  
 Linear calculation  
 Class: RC1  
 Coordinate system: Member  
 Extreme 1D: Local  
 Selection: B4, B5, B9, B10, B14, B15, B19, B20, B24, B25, B29, B30

**Properties Panel (Right):**

**Representation**

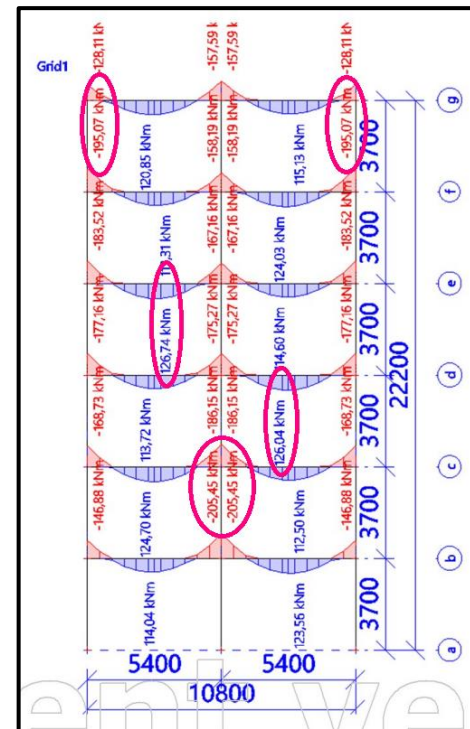
- Name: Picture in scale
- Caption: RC1 - M (beams)
- Caption visible:
- Picture size definition: Two per page
- Automatic scale to: [ ]
- Scale 1: 251,89195188406
- Stretch mode: Dark lines
- Rendering: Standard
- Antialiasing quality: None
- Rotation: None
- Result information: Inside picture
- Export to PDF as 3D:
- Position: One below another
- Image raster:
- Scale for model data: 0,5
- Scale for results: 1

**Tasks Panel (Bottom Right):**

Request	State
P.	

## f) Creating Engineering report

Print the report, and in the printed report, **manually highlight the values of the most extreme bending moment, shear force and normal force.**



The report **will not be accepted without this manual amendment!**

# Video

The whole process of modelling in SCIA Engineer is shown in [this video](#).

Next week

# Next week

Next week we will focus on **design and assessment of reinforcement of the beam** and **reinforcement of the column**.

**NEXT WEEK THE SEMINAR IS ON FRIDAY (13.10.2023) AT 09:00 A.M.!**

Den	8 <sup>00</sup>	1 8 <sup>50</sup>	9 <sup>00</sup>	2 9 <sup>50</sup>	10 <sup>00</sup>	3 10 <sup>50</sup>	11 <sup>00</sup>	4 11 <sup>50</sup>	12 <sup>00</sup>	5 12 <sup>50</sup>	13 <sup>00</sup>	6 13 <sup>50</sup>	14 <sup>00</sup>	7 14 <sup>50</sup>	15 <sup>00</sup>	8 15 <sup>50</sup>	16 <sup>00</sup>	9 16 <sup>50</sup>	17 <sup>00</sup>	10 17 <sup>50</sup>	18 <sup>00</sup>	11 18 <sup>50</sup>	19 <sup>00</sup>	12 19 <sup>50</sup>
Po																								
Út																								
St																								
Čt																								
Pá																								

133CM01 Concrete and Masonry Structures 1  
B-786 (C101, 13 studentů)  
Holan J.

133CM01 Concrete and Masonry Structures 1  
B-787 (P1, 13 studentů)  
Broukalová I., Bílý P.

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.