FAKULTA
STAVEBNÍ
ČVUT V PRAZE

CM01 – Concrete and Masonry Structures 1

HW2 – Calculation of internal forces

beton4life

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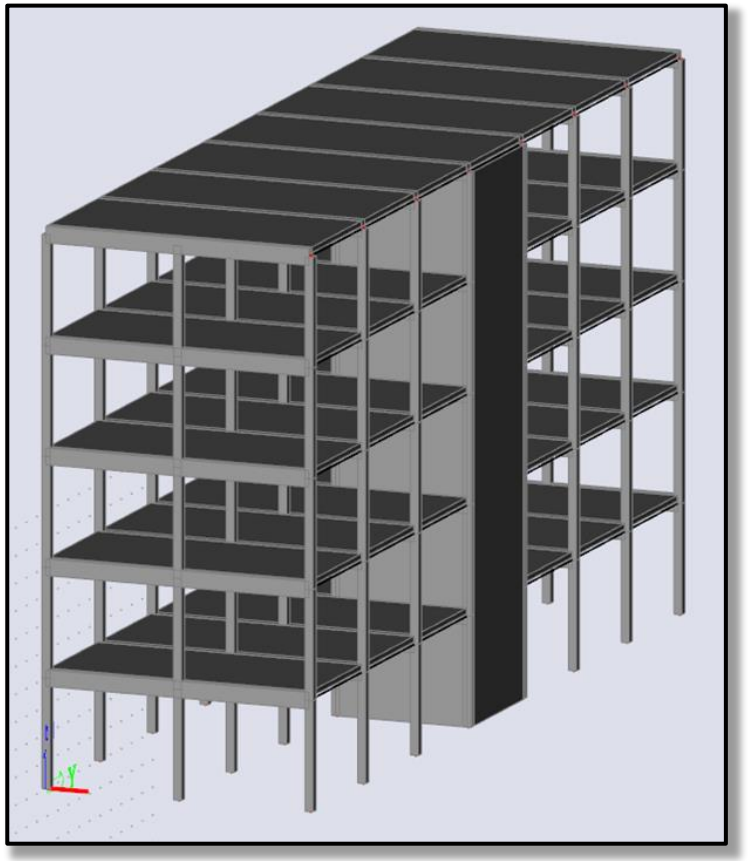
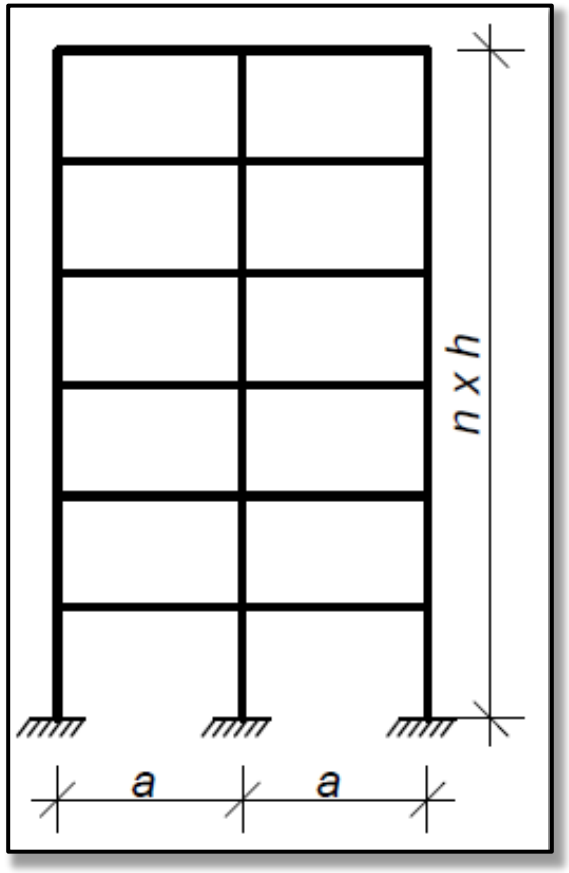
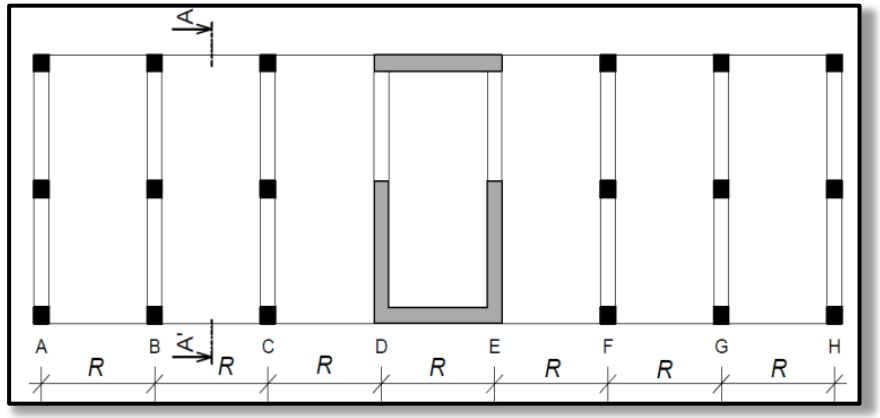
Task 1

Structure

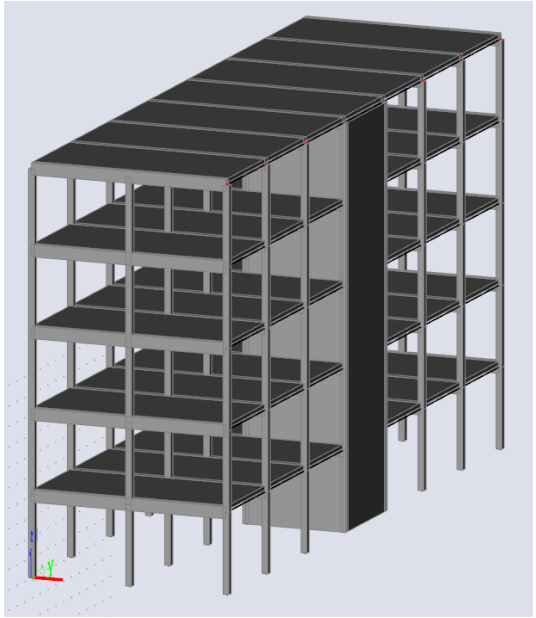
In this HW, we continue with the design of the frame structure (Task 1).







Assignment



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

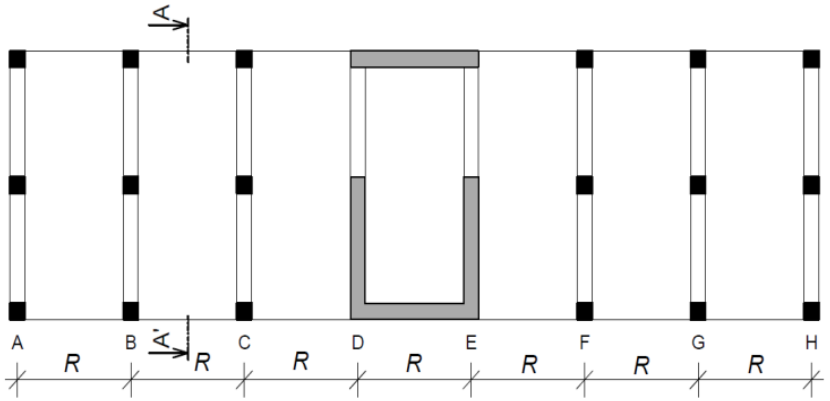
Materials: Concrete – **concrete class**
Steel B 500 B (f_{yk} = 500 MPa)

Loads:

Other permanent load of typical floor	$(g\text{-}g_0)_{floor,k}$ [kN/m^2]
Other permanent load of the roof	$(g\text{-}g_0)_{roof,k}$ [kN/m^2]
Live load of typical floor	$q_{floor,k}$ [kN/m^2]
Live load of the roof	$q_{roof,k}$ = 0,75 kN/m^2
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.



Individual parameters:
https://docs.google.com/spreadsheets/d/1uQIuyyKEcG5jaZVLrsmm1ZRRNib_ow3MIwgZSEDgnW8/

Assignment goals

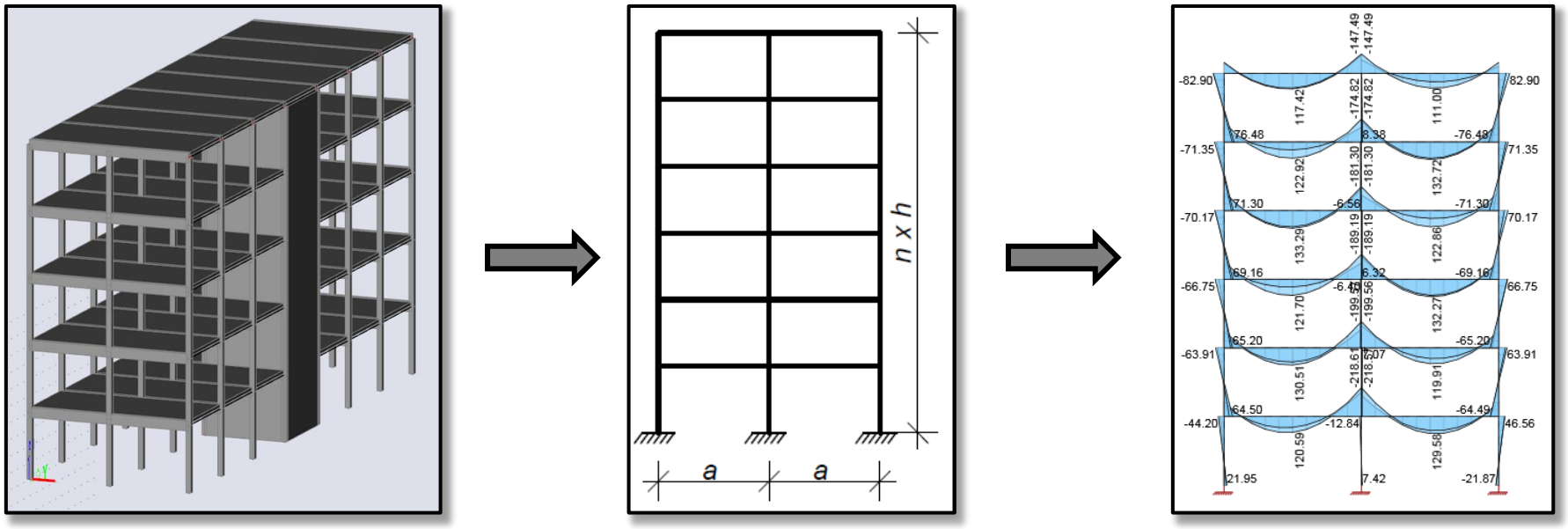
Our goal will be to:

- HW1: Design the dimensions of all elements.
- **HW2: Do detailed calculation of 2D frame – calculation of bending moments, shear and normal forces using FEM software.**
- HW3: Design steel reinforcement in the beam.
- HW4: Design steel reinforcement in the column.
- HW5: Draw layout of the reinforcement.

Calculation of internal forces in 2D frame

Calculation of internal forces in 2D frame

In this HW, 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

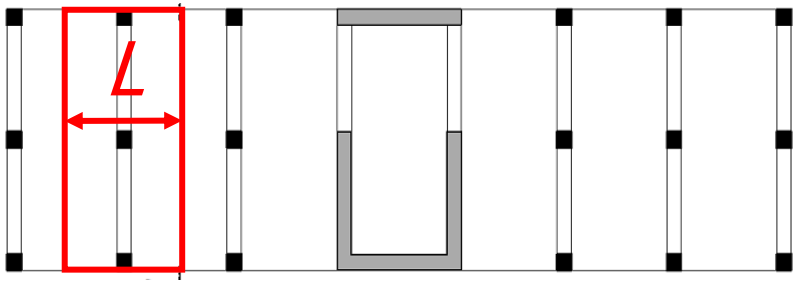
First, we must **determine the loads acting on the beams**, which we will later input into the software.

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^2] * L [m].



* Permanent load consists of the self-weight of the slab [kN/m^2] and other permanent load.

Beam loading

Floor slab load							
Load type	Load name	h	ρ	ρ_{pl}	f_k	γ	f_d
-	-	mm	kg/m³	kg/m²	kN/m²	-	kN/m²
DEAD (G)	slab self weight	190	2500	475	4.75	1.35	6.41
	other permanent load	*from assignment*			0.50		0.68
	Σ				5.25		7.09
LIVE (Q)	variable	*from assignment*			3	1.5	4.50
	Σ				3		4.50
SUM					**f_k =** **8.25**	**f_d =**	**11.59**

Floor beam load						
Load type	Load name	$f_{a,k}$	tributing width	$f_{lin,k}$	γ	$f_{lin,d}$
-	-	kN/m²	m	kN/m	-	kN/m
DEAD (G)	slab dead load	5.25	6.5	34.13	1.35	46.07
	beam self weight	*calculated automatically by SCIA*		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
SUM			**f_k =**	**53.63**	**f_d =**	**75.32**

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_{pl}	f_k	γ	f_d
-	-	mm	kg/m³	kg/m²	kN/m²	-	kN/m²
STÁLÉ (G)	slab self weight	190	2500	475	4.75	1.35	6.41
	other permanent load	*from assignment*			2.00		2.70
	Σ				6.75		9.11
PROM. (Q)	variable	*from assignment*			0.75	1.5	1.13
	Σ				0.75		1.13
SUM					**f_k =** **7.50**	**f_d =**	**10.24**

Roof beam load						
Load type	Load name	$f_{a,k}$	tributing width	$f_{lin,k}$	γ	$f_{lin,d}$
-	-	kN/m²	m	kN/m	-	kN/m
DEAD (G)	slab dead load	6.75	6.5	43.88	1.35	59.23
	beam self weight	*calculated automatically by SCIA*		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
SUM			**f_k =**	**48.75**	**f_d =**	**66.54**

Slab span: R = 6.5 m

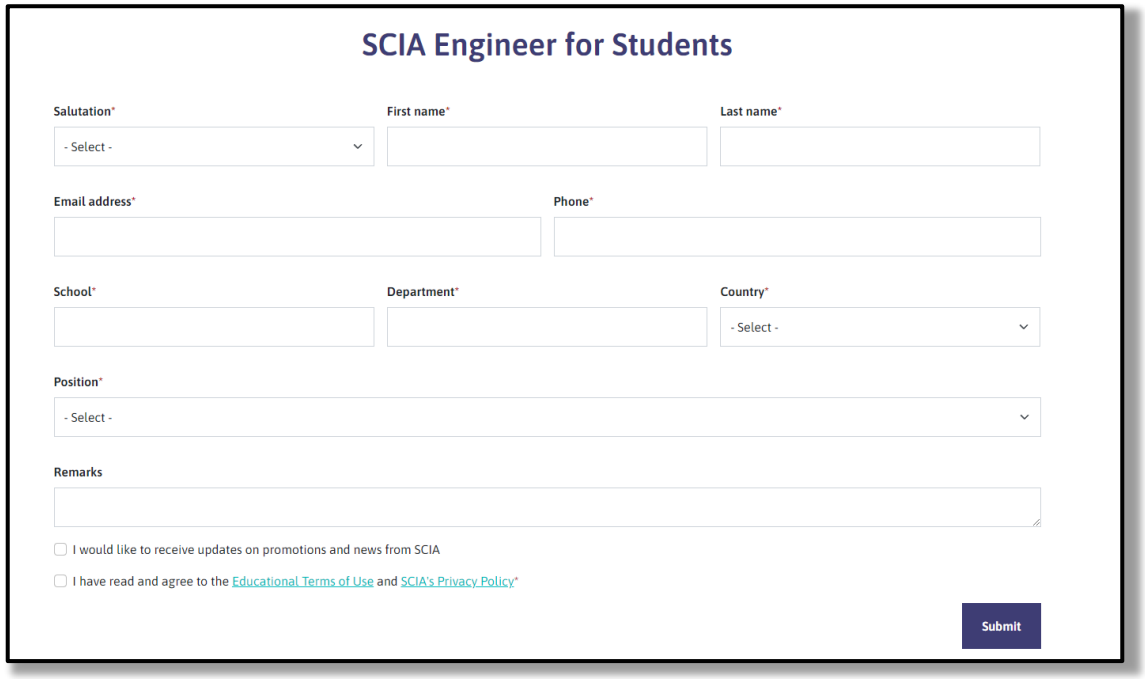
$$g_{k,r} = 43.88 \text{ kN/m}$$
$$q_{k,r} = 4.88 \text{ kN/m}$$

Calculation of internal forces in 2D frame

Download and install of SCIA Engineer

Download and install SCIA Engineer

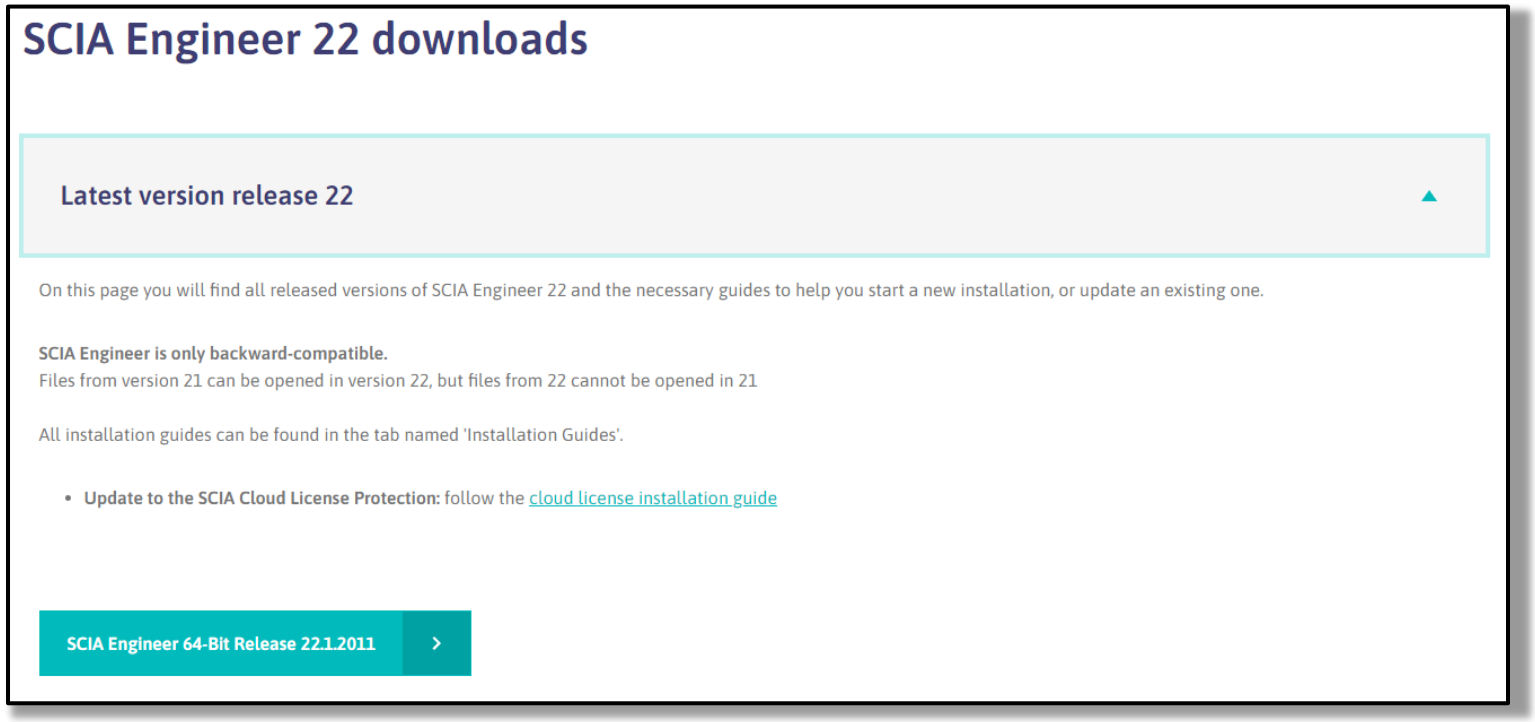
First, apply for the **student license** of SCIA. When applying, **use your school student email** (e.g., “name.surname@estudiantat.upc.edu”).



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

Download and install SCIA Engineer

Download and install the latest version of SCIA.



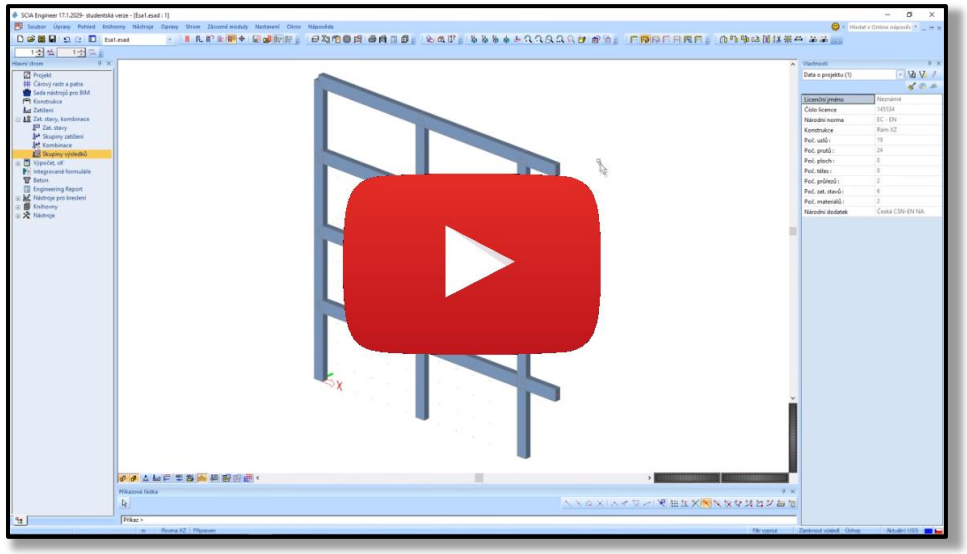
After installing SCIA, **run the software and log in using your credentials**.

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.



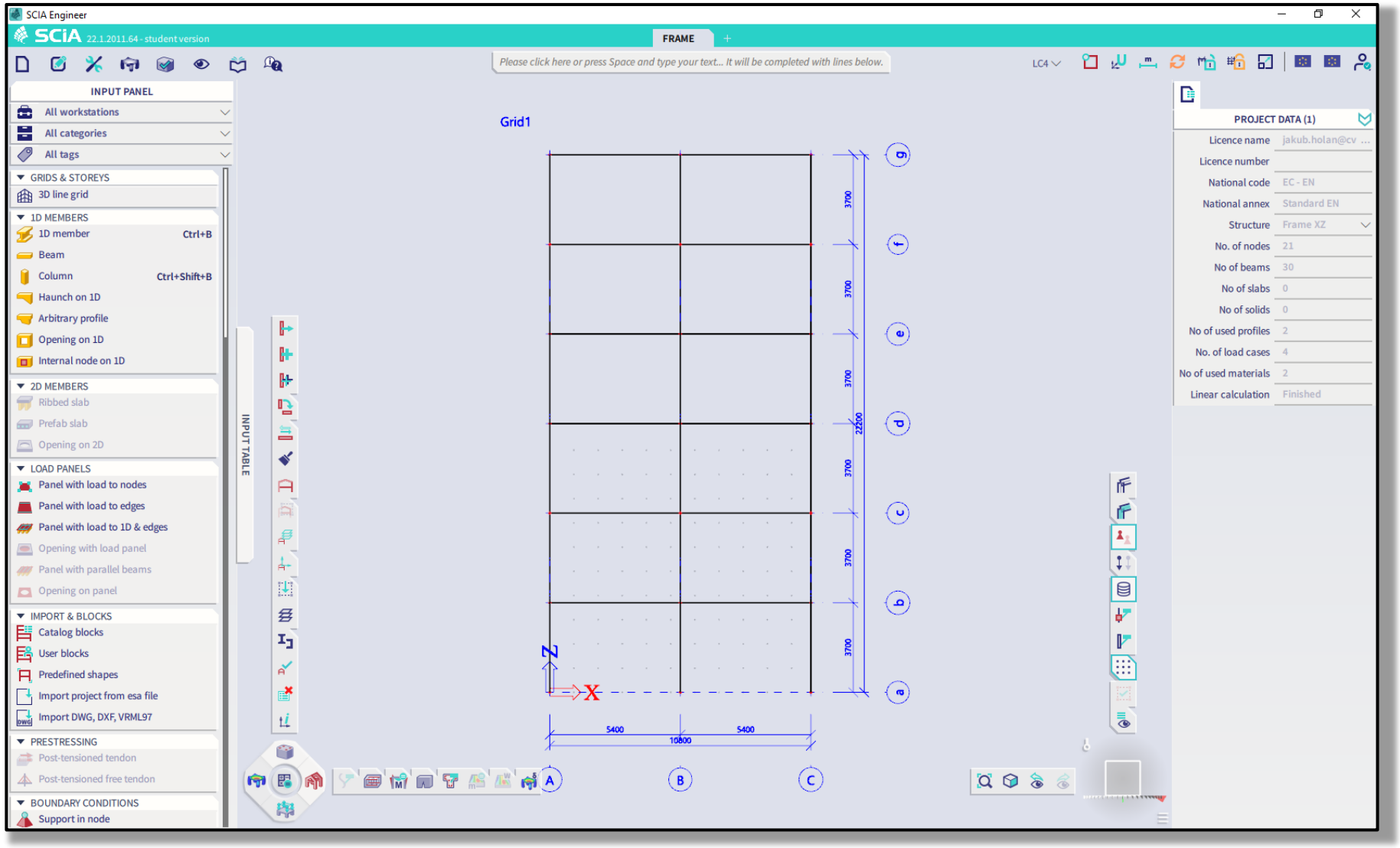
The following part of the presentation only highlights the main steps.

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**.

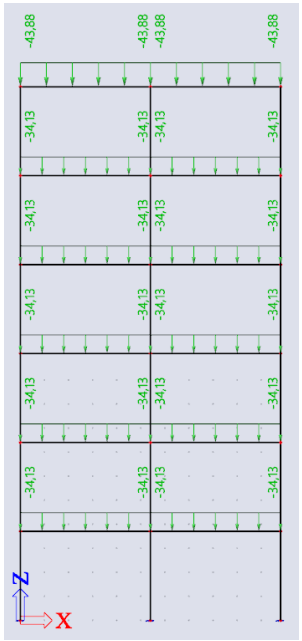
a) Modelling the structure



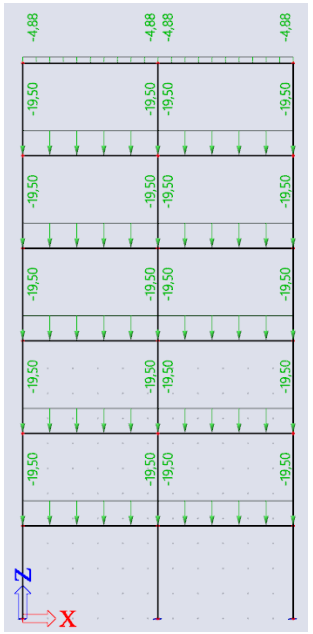
b) Inputting loads into load cases

We will **create and use the following load cases**.

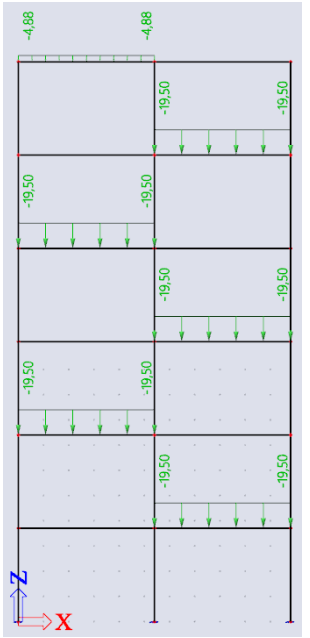
- LC1: Self-weight of the frame – created and calculated automatically by SCIA,
- LC2: Full permanent load,
- LC3: Full variable load,
- LC4: Checkerboard variable load.



LC2: Full permanent load



LC3: Full variable load



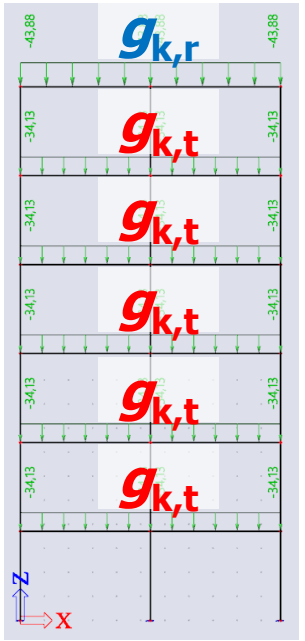
LC4: Checkerboard variable load

b) Inputting loads into load cases

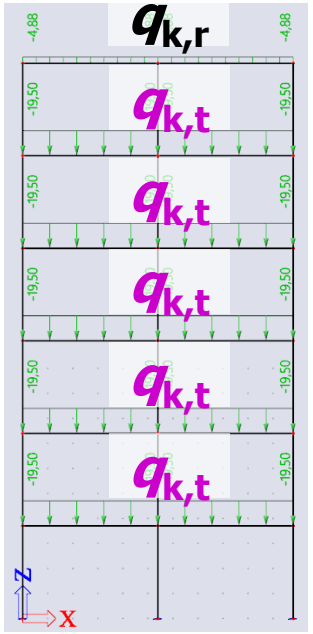
Beam loading

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

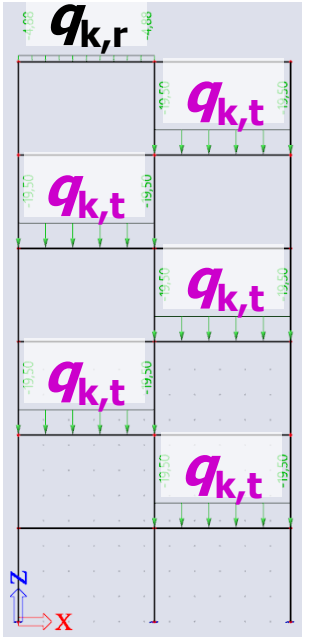
- Characteristic permanent* load in typical floor $g_{k,t}$,
- Characteristic permanent load on the roof $g_{k,r}$,
- Characteristic variable load in typical floor $q_{k,t}$,
- Characteristic variable load on the roof $q_{k,r}$,



LC2: Full permanent load



LC3: Full variable load



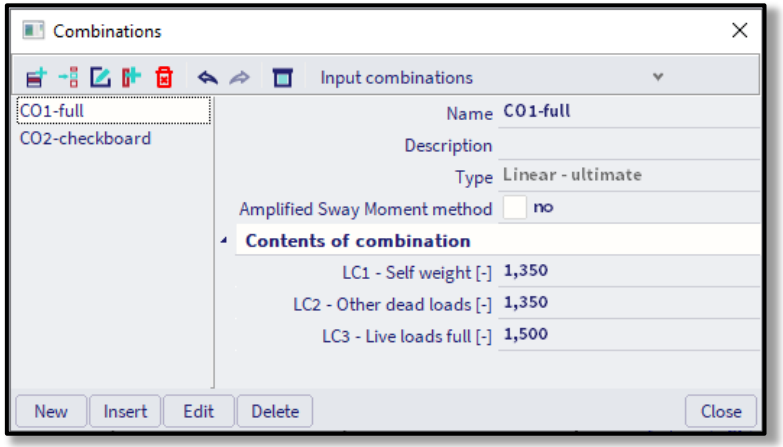
LC4: Checkerboard variable load

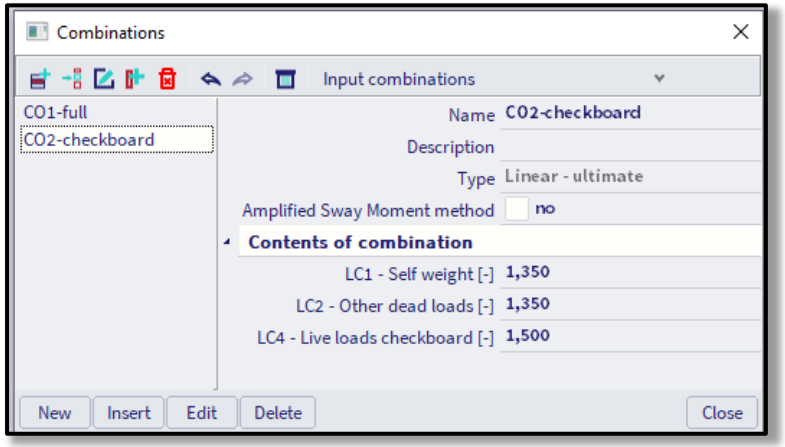
c) Creating load combinations.

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)*

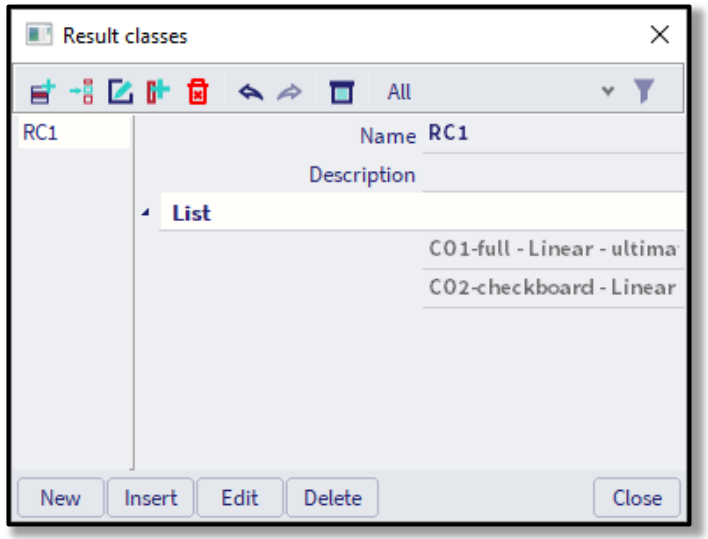




d) Creating result groups.

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

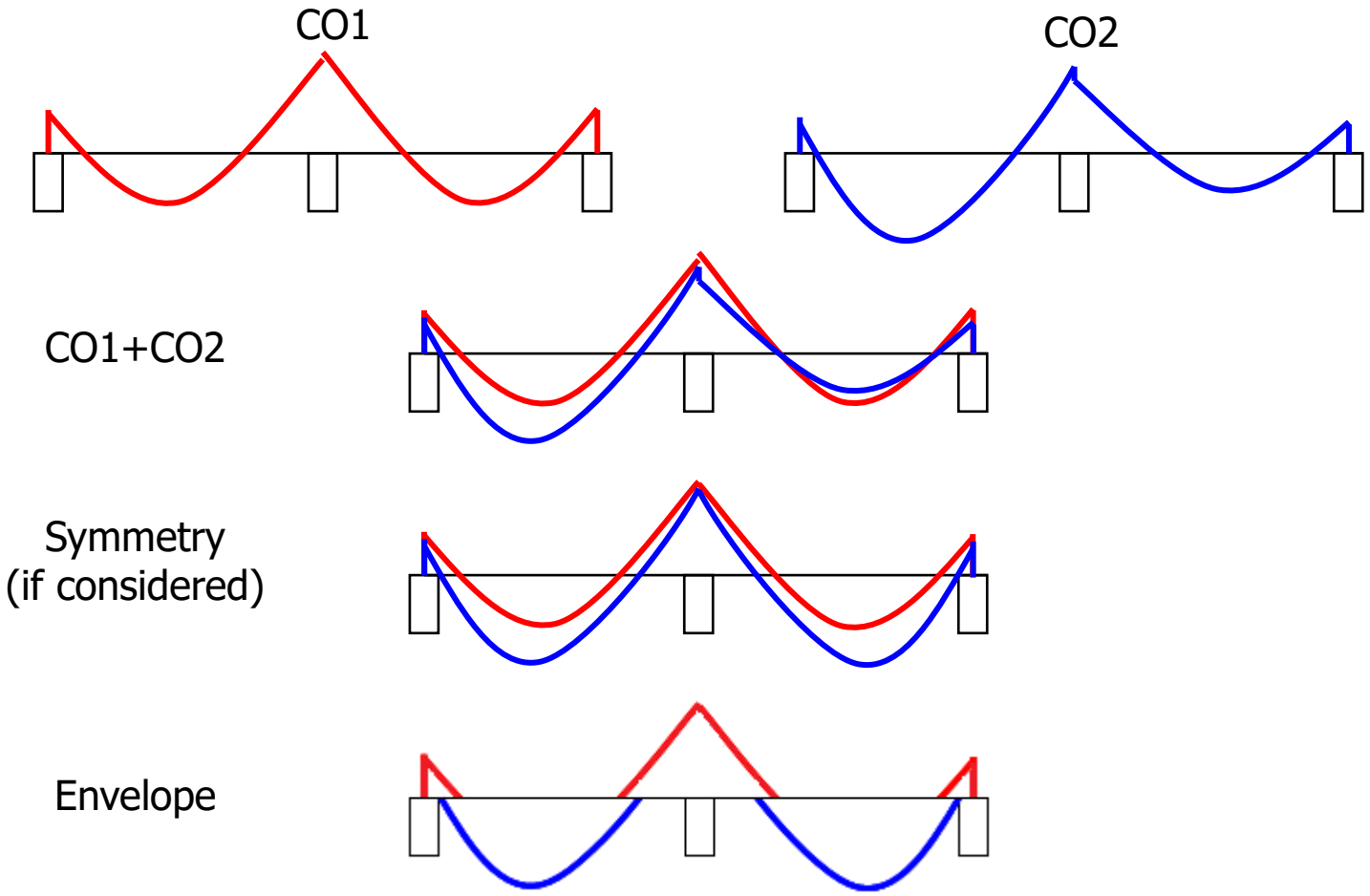
RG1 = {CO1, CO2}



What is an **"envelope" of an internal force**?

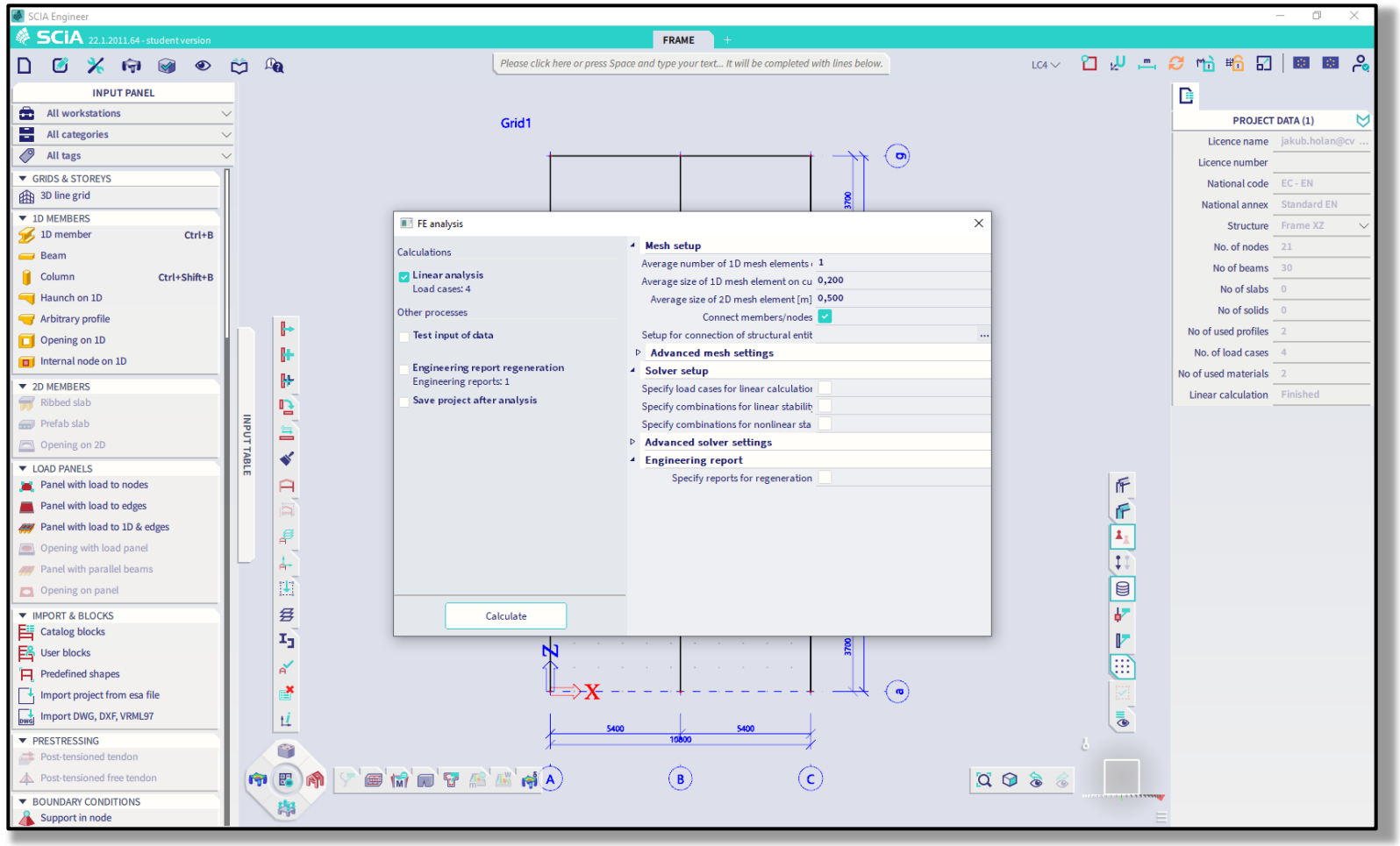
d) Creating result groups.

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



e) Calculation

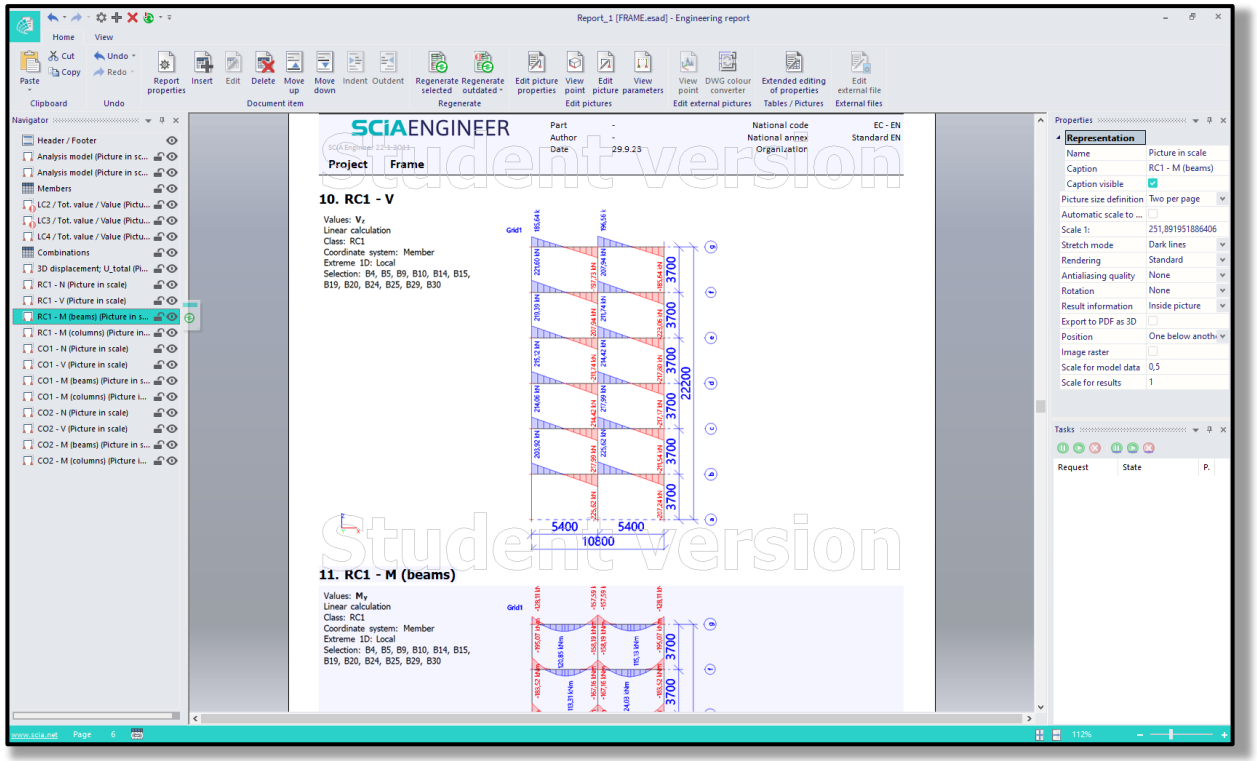
Finally, we can **run the calculation**.



f) Creating Engineering report

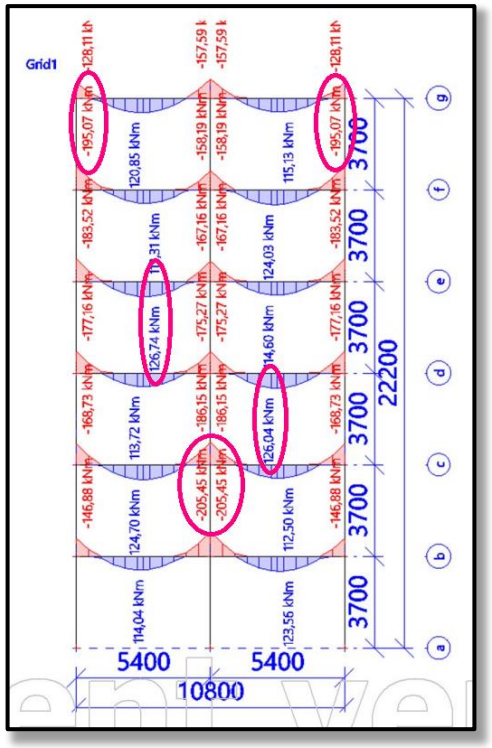
After running the calculation, we can **check the results and create the Engineering report**.

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.



f) Creating Engineering report

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



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**.

thank you for your attention