



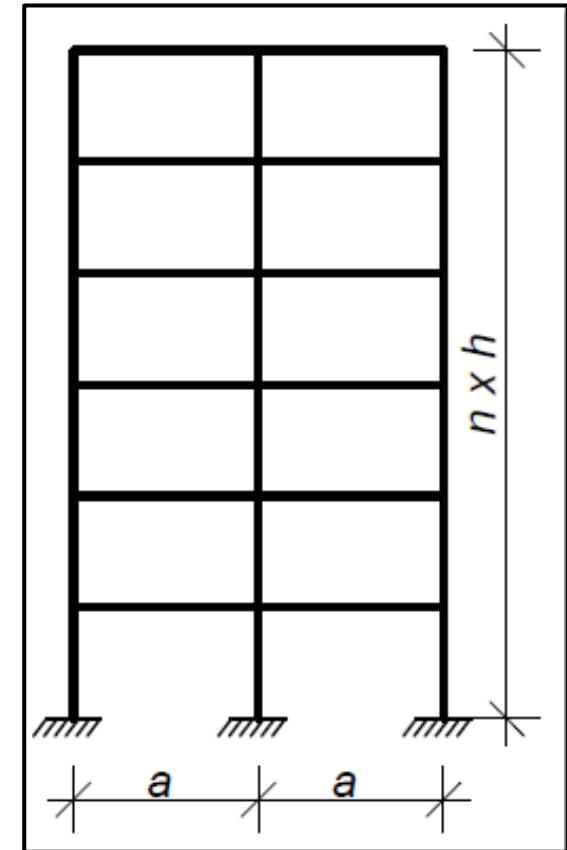
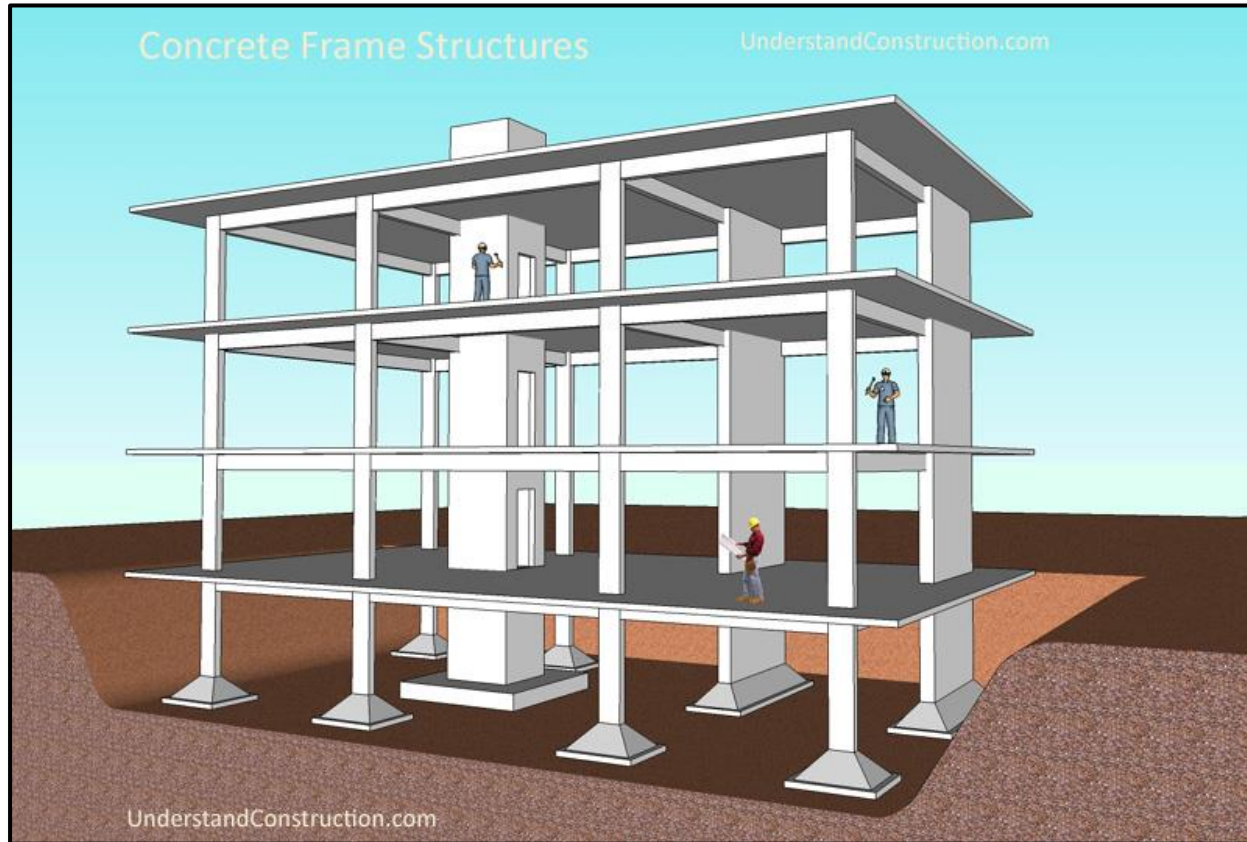
CM01 – Concrete and Masonry Structures 1

HW2 – Calculation of internal forces

Task 1

Task 1 – Frame structure

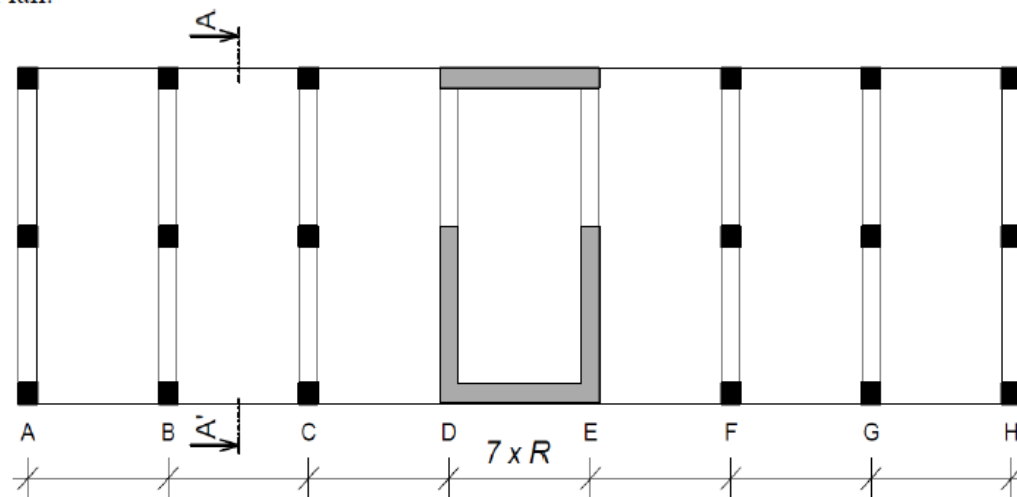
In Task 1, frame structure will be designed.



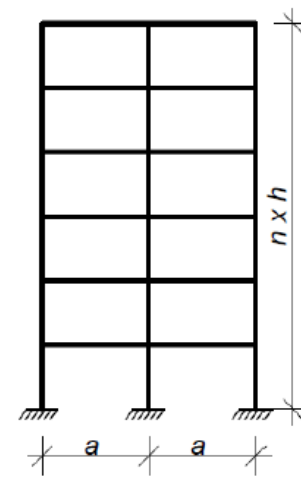
Task 1 – Assignment

Scheme of the structure:

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 (**$g-g_0$**)_{floor,k} [kN/m²]
Other permanent load of the roof (**$g-g_0$**)_{roof,k} [kN/m²]
Live load of typical floor **q** _{floor,k} [kN/m²]
Live load of the roof **q** _{roof,k} = 0,75 kN/m²
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

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 **IdeaStatica software** for the calculation of internal forces*.

Calculation of internal forces in 2D frame

This part consists of the following steps:

- **calculate beam loading,**
- download and **install IdeaStatica 21.0,**
- **model the frame, calculate internal forces,** and **create a report** in IdeaFrame module.

Calculation of internal forces in 2D frame

Beam loading

Beam loading

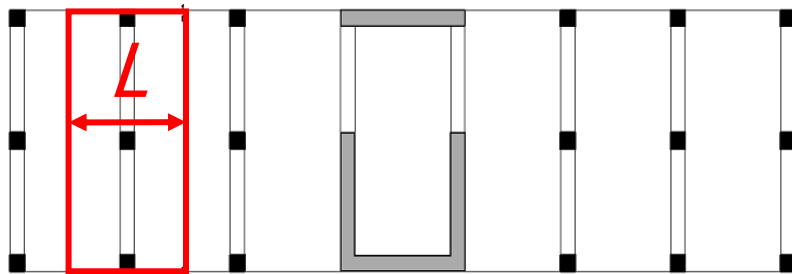
First, we must determine the loads acting on the beams, which we will later input into Idea software.

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 $q_{k,r}$,

self-weight of the slab + other permanent load

Linear load [kN/m] = area load [kN/m²] * L [m].



Beam loading

Floor slab load								
Load type	Load name	h	ρ	ρ_{pl}	f_k	γ	f_d	
-	-	mm	kg/m ³	kg/m ²	kN/m ²	-	kN/m ²	
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	
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/m ²	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 Idea</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	
SUM				$f_k =$	53.63	$f_d =$	75.32

Slab span: R = 6.5 m

Roof slab load								
Load type	Load name	h	ρ	ρ_{pl}	f_k	γ	f_d	
-	-	mm	kg/m ³	kg/m ²	kN/m ²	-	kN/m ²	
STÁLÉ (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	
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/m ²	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 Idea</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	
SUM				$f_k =$	48.75	$f_d =$	66.54

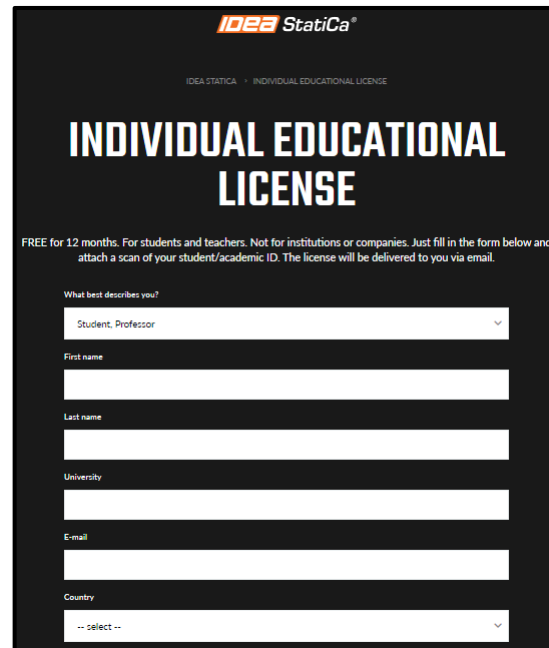
Slab span: R = 6.5 m

Calculation of internal forces in 2D frame

Download and install of IdeaStatica 21.0

Download and install of IdeaStatica 21.0

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

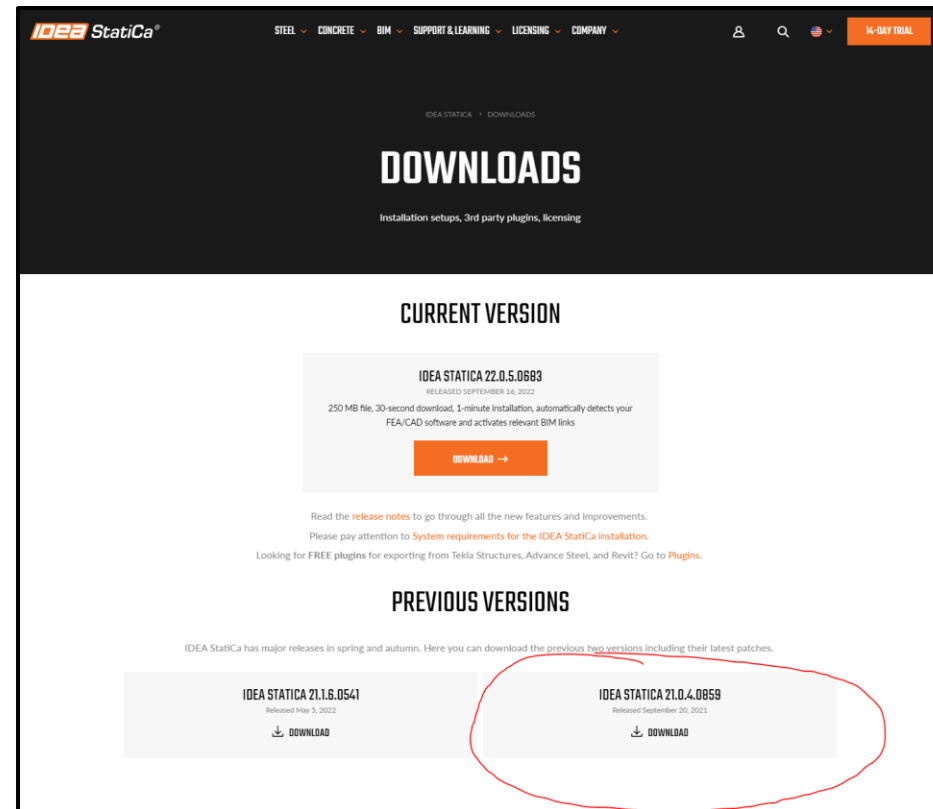


The image shows a dark-themed web form for applying for an Individual Educational License. At the top, the 'IDEA StatiCa' logo is visible. Below it, the text 'INDIVIDUAL EDUCATIONAL LICENSE' is prominently displayed. A small note states: 'FREE for 12 months. For students and teachers. Not for institutions or companies. Just fill in the form below and attach a scan of your student/academic ID. The license will be delivered to you via email.' The form contains several input fields: a dropdown menu for 'What best describes you?' with 'Student, Professor' selected; text boxes for 'First name', 'Last name', and 'University'; an 'E-mail' field; and a dropdown menu for 'Country' with '-- select --' chosen.

Wait (up to 3 days) until you receive an activation email with your login credentials.

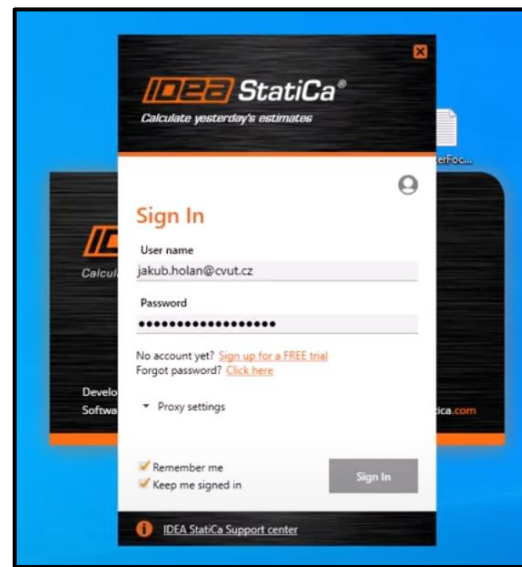
Download and install of IdeaStatica 21.0

For our task, we will use the IdeaFrame module. This module is available only in **IdeaStatica 21.0** so we will download and install this version. Do NOT download any other version as they do not have the IdeaFrame module!



Download and install of IdeaStatica 21.0

After installing IdeaStatica 21.0., run the software and log in using your credentials from the activation email.



And also check, whether the **IdeaFrame** module is installed.

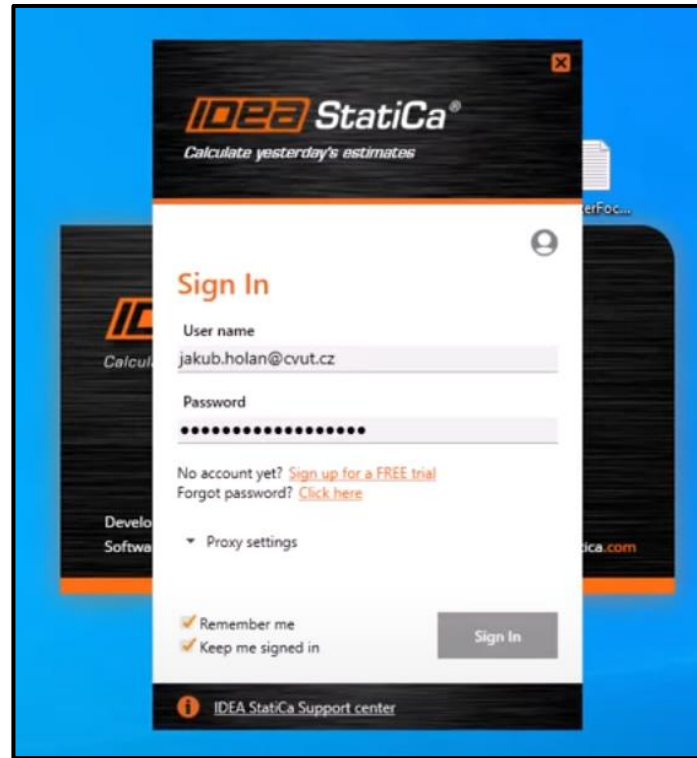
Název	Datum změny	Typ	Velikost
Idea4SAP2000\21x64	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4StaadPro	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla210	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla211	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla2016	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla2016i	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla2017	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla2017i	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla2018	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla2018i	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla2018Partner	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla2019	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla2019i	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla2020	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4Tekla2021	17.09.2021 10:27	Dávkový soubor s...	1 kB
Idea4TeklaLog	17.09.2021 10:27	Dávkový soubor s...	1 kB
IdeaBeam	17.09.2021 10:27	Aplikace	399 kB
IdeaBeam.exe.config	17.09.2021 10:27	Soubor CONFIG	7 kB
IDEABeamProjectManager	17.09.2021 10:27	Soubor skriptu v j...	1 kB
IDEABeamSystemsPlugin_x64.dll	17.09.2021 10:27	Rozšíření aplikace	63 kB
IdeaCodeCheck	17.09.2021 10:27	Aplikace	977 kB
IdeaCodeCheck.exe.config	17.09.2021 10:27	Soubor CONFIG	10 kB
IdeaColumn	17.09.2021 10:27	Aplikace	444 kB
IdeaColumn.exe.config	17.09.2021 10:27	Soubor CONFIG	7 kB
IdeaConnection	17.09.2021 10:27	Aplikace	640 kB
IdeaConnection.exe.config	17.09.2021 10:29	Soubor CONFIG	11 kB
IDEAConnectionCodecheckManager	17.09.2021 10:27	Soubor skriptu v j...	1 kB
IDEAConnectionSystemsPlugin_x64.dll	17.09.2021 10:27	Rozšíření aplikace	126 kB
IdeaCorbel	17.09.2021 10:27	Aplikace	399 kB
IdeaCorbel.exe.config	17.09.2021 10:27	Soubor CONFIG	6 kB
IdeaCSS	17.09.2021 10:27	Aplikace	400 kB
IdeaCSS.exe.config	17.09.2021 10:27	Soubor CONFIG	7 kB
IdeaCssAddOn_x64.dll	17.09.2021 10:27	Rozšíření aplikace	79 kB
IDEADetail	17.09.2021 10:27	Aplikace	409 kB
IDEADetail.exe.config	17.09.2021 10:27	Soubor CONFIG	6 kB
IdeaFrame	17.09.2021 10:27	Aplikace	400 kB
IdeaFrame.exe.config	17.09.2021 10:27	Soubor CONFIG	7 kB
IdeaMember	17.09.2021 10:27	Aplikace	332 kB
IdeaMember.exe.config	17.09.2021 10:27	Soubor CONFIG	13 kB
IdeaRCS	17.09.2021 10:27	Aplikace	702 kB
IdeaRCS.exe.config	17.09.2021 10:27	Soubor CONFIG	9 kB
IdeaRCSMPPlugin.dll	17.09.2021 10:27	Rozšíření aplikace	99 kB

Calculation of internal forces in 2D frame

Modelling of the frame in IdeaFrame module

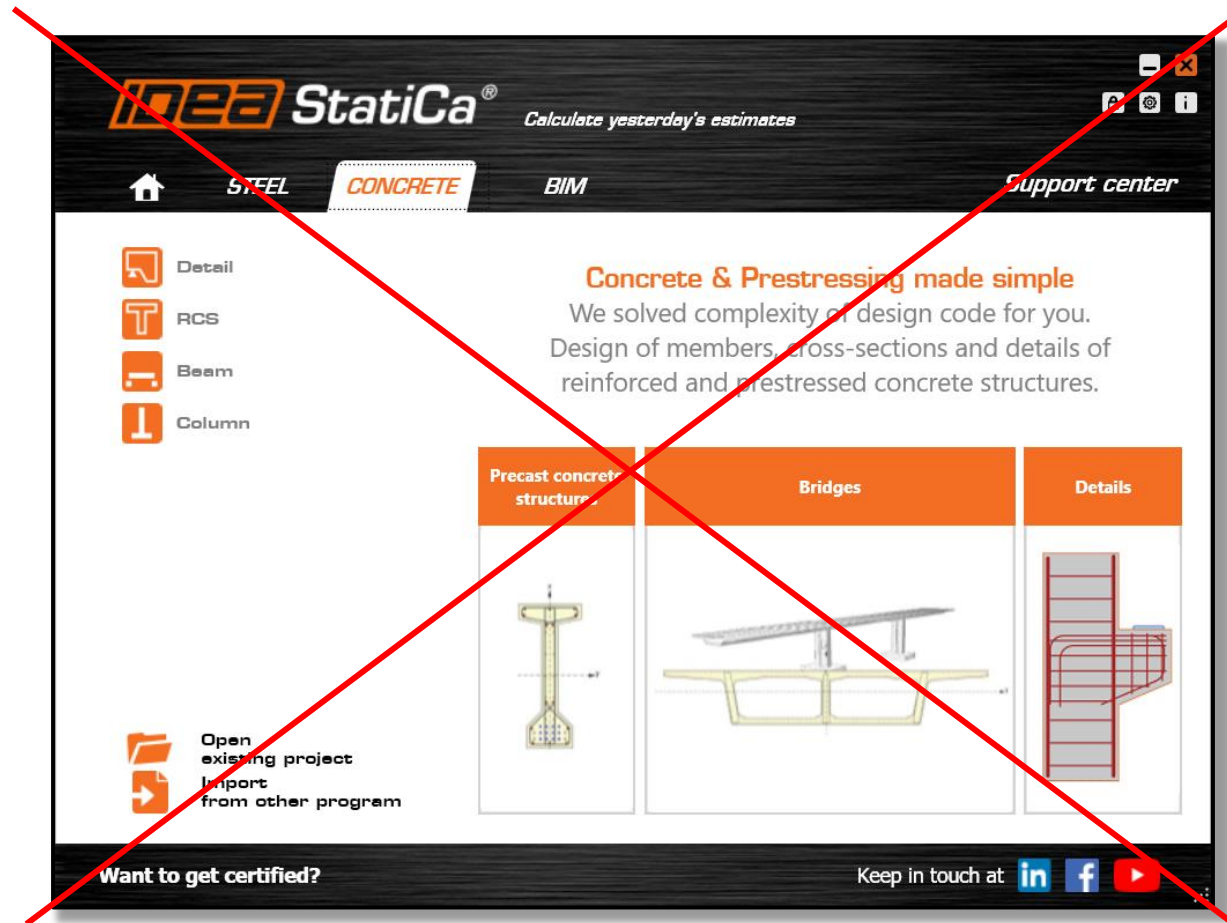
Initialization of the program

Run the program and fill in the login details from activation e-mail.



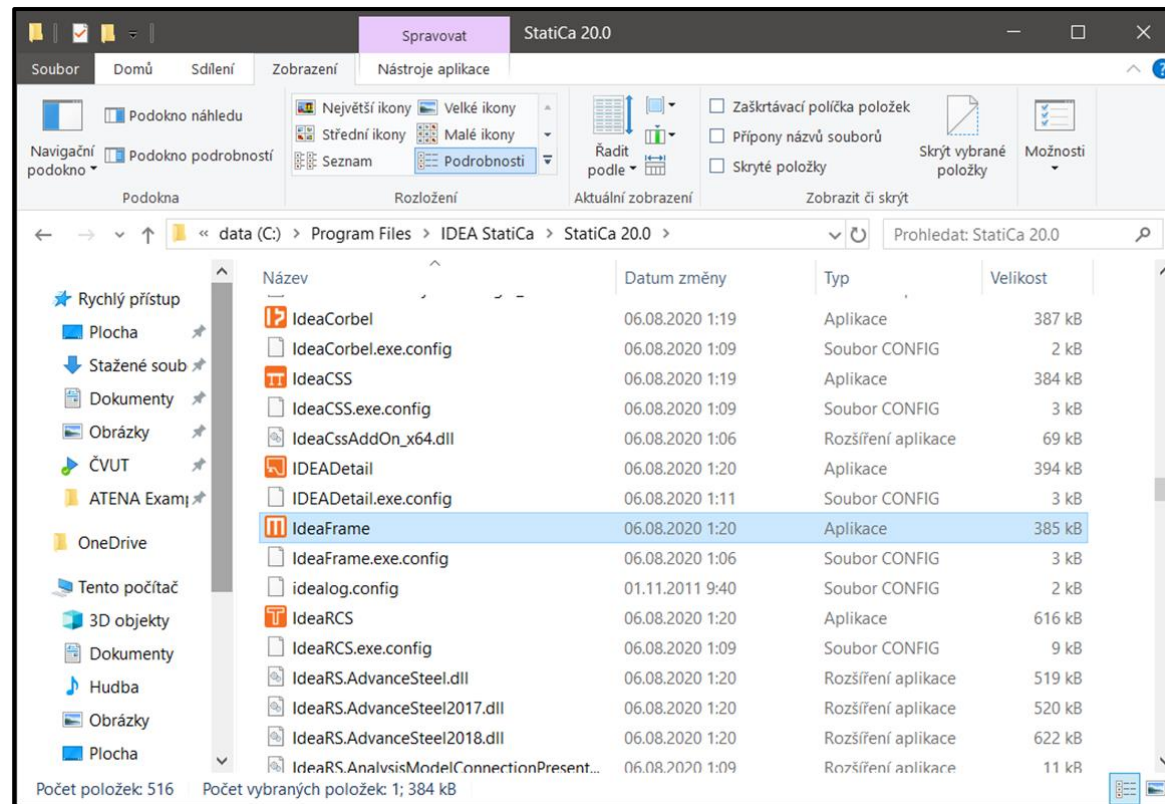
Initialization of IdeaFrame

IdeaFrame module is **NOT** accessible from main window.



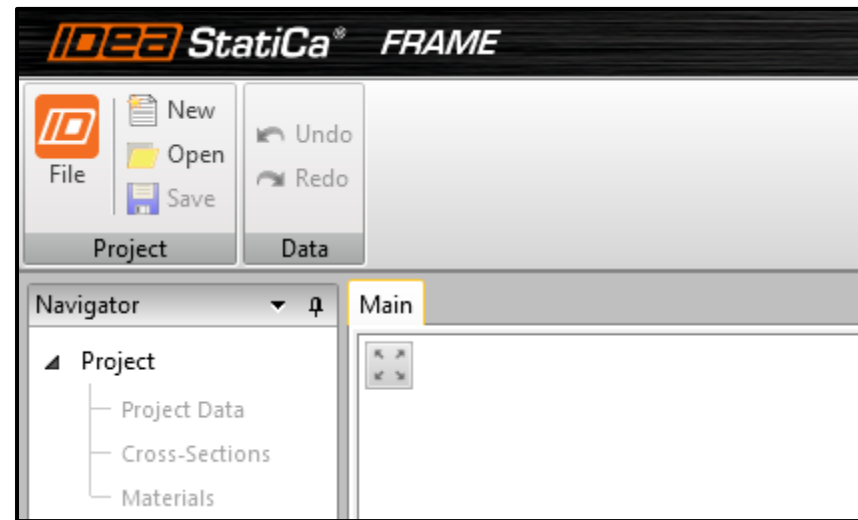
Initialization of IdeaFrame

You have to locate IdeaStatica folder in your computer and **run the IdeaFrame.exe file directly.**



New project

Create new project.

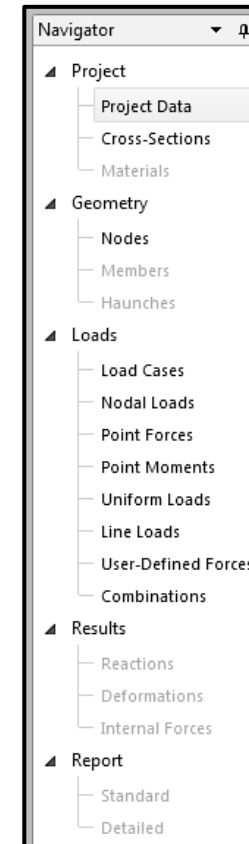


Project data

Use *Navigator* menu to enter *Project data* properties:

Change Project data as follows:

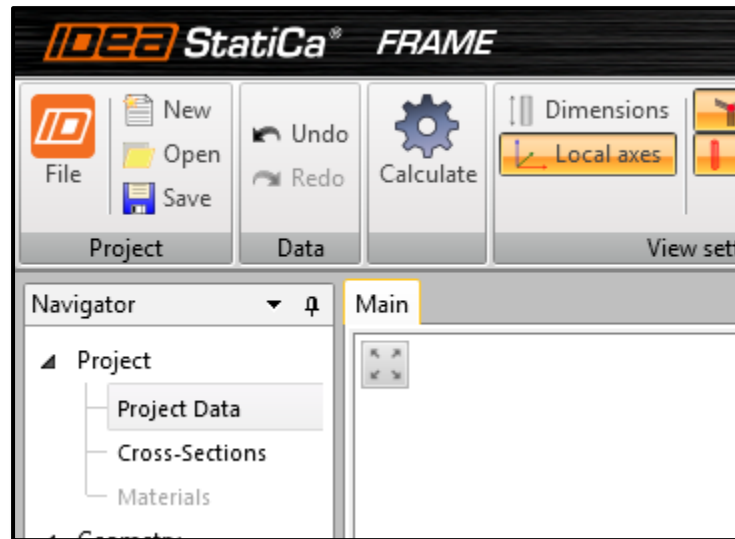
Data	
Project data	
▲ Frame parameters	
Design code	EN
National annex	Czech
EN 1992-2	<input type="checkbox"/>
Type of bridge	No bridge
Type of material	Concrete
Prestressing	<input type="checkbox"/>
Flexible supports	<input type="checkbox"/>
Bridge load rating	<input type="checkbox"/>
▲ Identification	
Name	CM01-Frame
Number	01
Author	Petr Bily
Description	Homework
Date	11.6.2019



Save

Save and name your project.

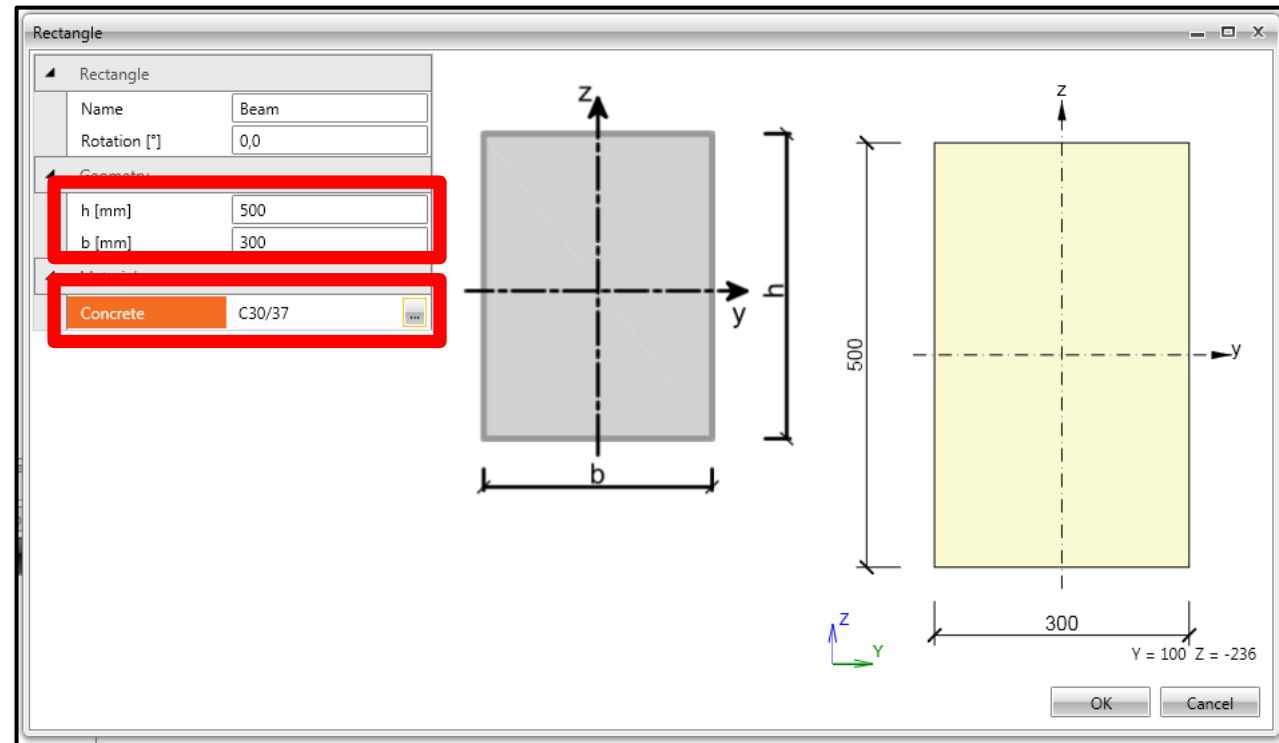
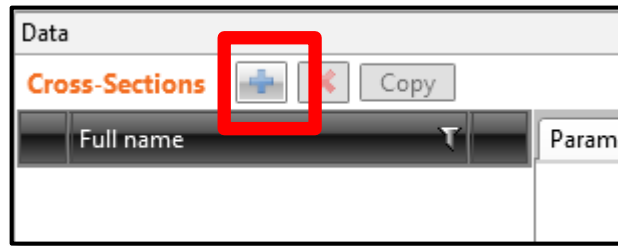
Save your project regularly to avoid losing unsaved data!



Cross-sections

Go to: Navigator → Project → Cross-Sections.

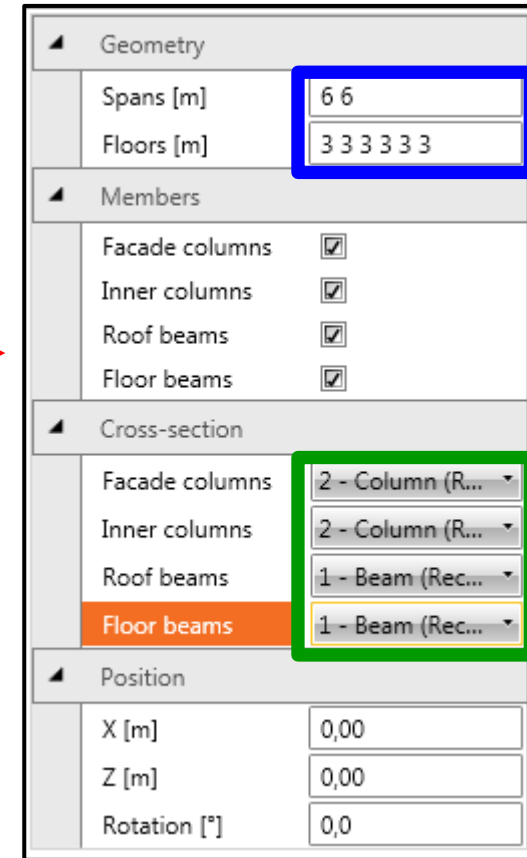
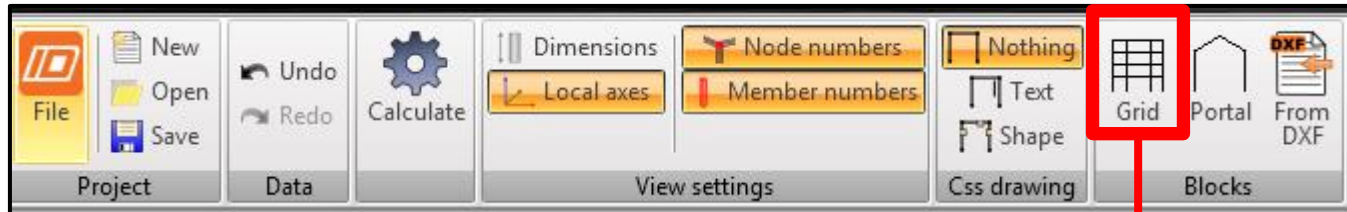
Enter cross-sections of **your** beam and column as designed in homework HW1 (name, dimensions, material).



Creating the frame

Go to: Navigator → Geometry → Nodes.

Use **Grid block** to create the frame.



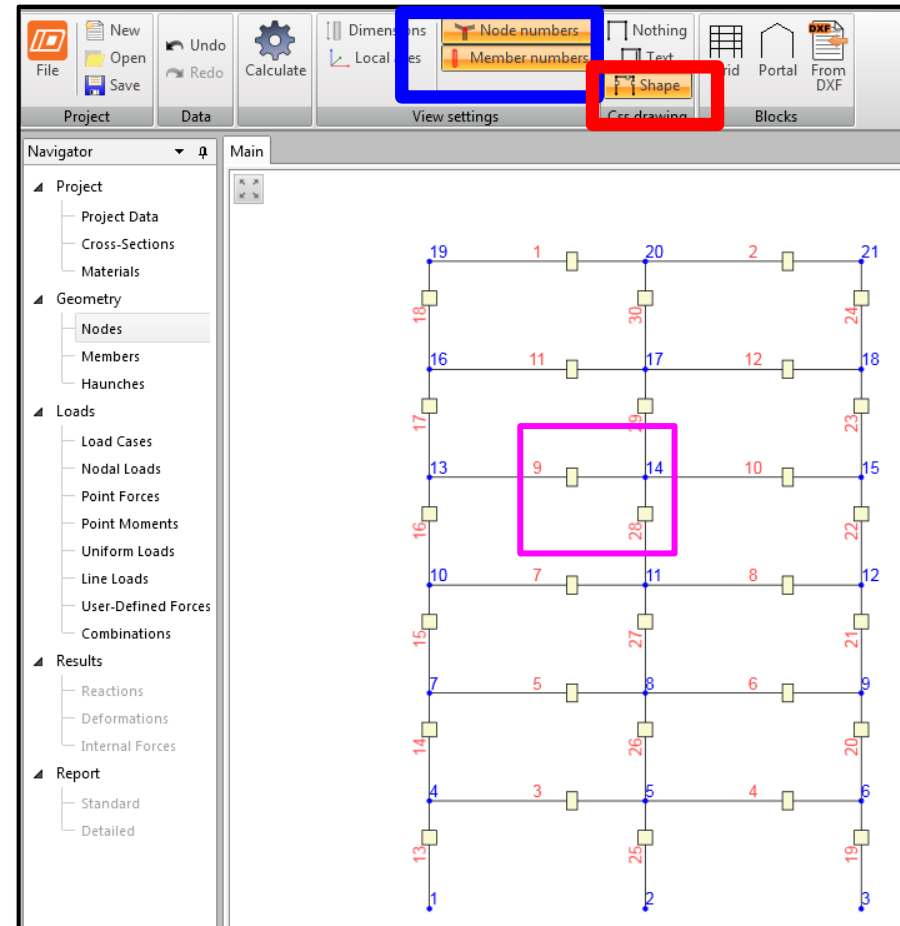
Set **dimensions and number of spans/floors** (divide the numbers simply by spacebar).

Select **cross-sections of columns and beams**.

Creating the frame

Display **Shapes** to check whether you entered the **cross-sections correctly**.

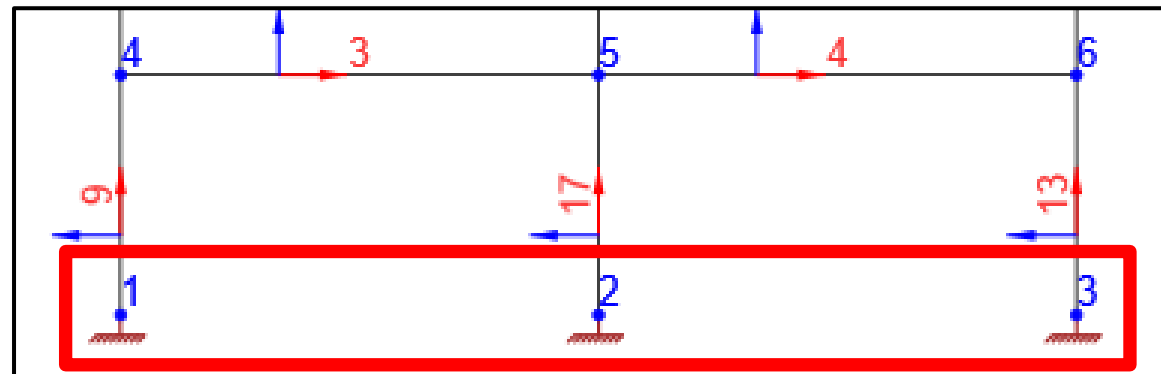
Display **Node numbers and Member numbers**.



Supports

We must also define the supports of the frame (rigid supports in column bases).

In Data window, check all nodal supports for the nodes in column bases.

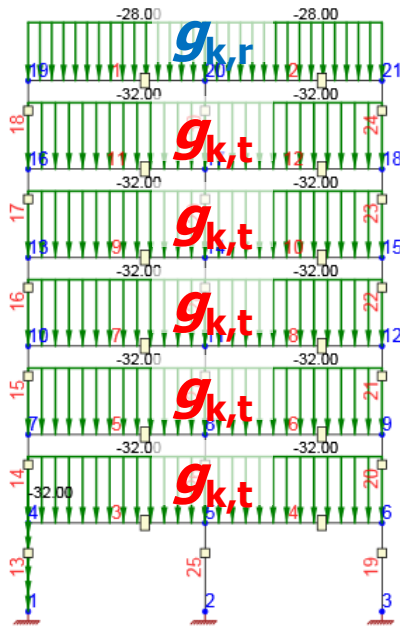


Data						
Nodes + Cleanup						
Node	X [m]	Z [m]	Nodal Support			
			X	Z	Ry	
1	0,00	0,00	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2	6,00	0,00	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
3	12,00	0,00	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
4	0,00	3,00	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

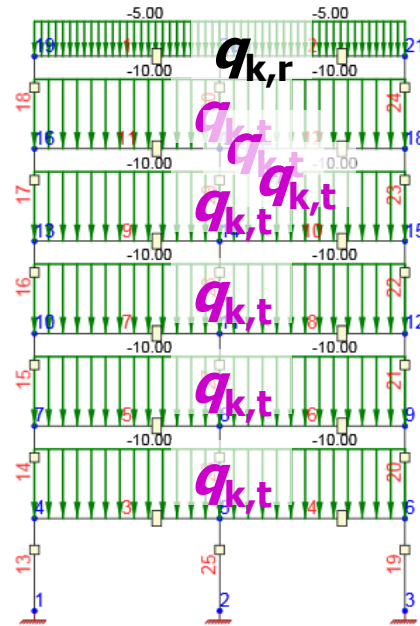
Load cases

We must consider **4 load cases**:

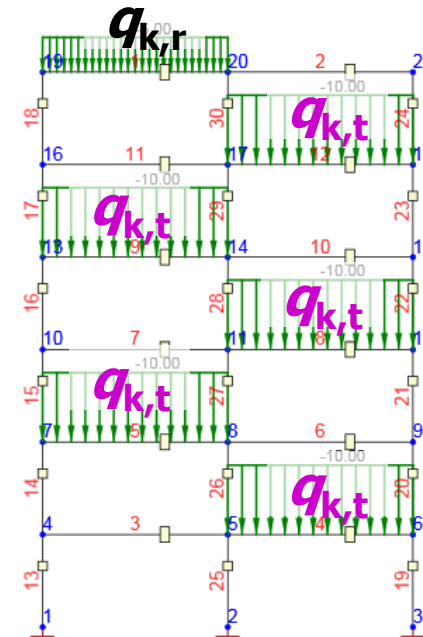
- SW: Self-weight of the frame – calculated automatically by IdeaStatica,
- LC1: Full permanent load,
- LC2: Full variable load,
- LC3: Checkerboard variable load.



LC1: Full permanent load



LC2: Full variable load

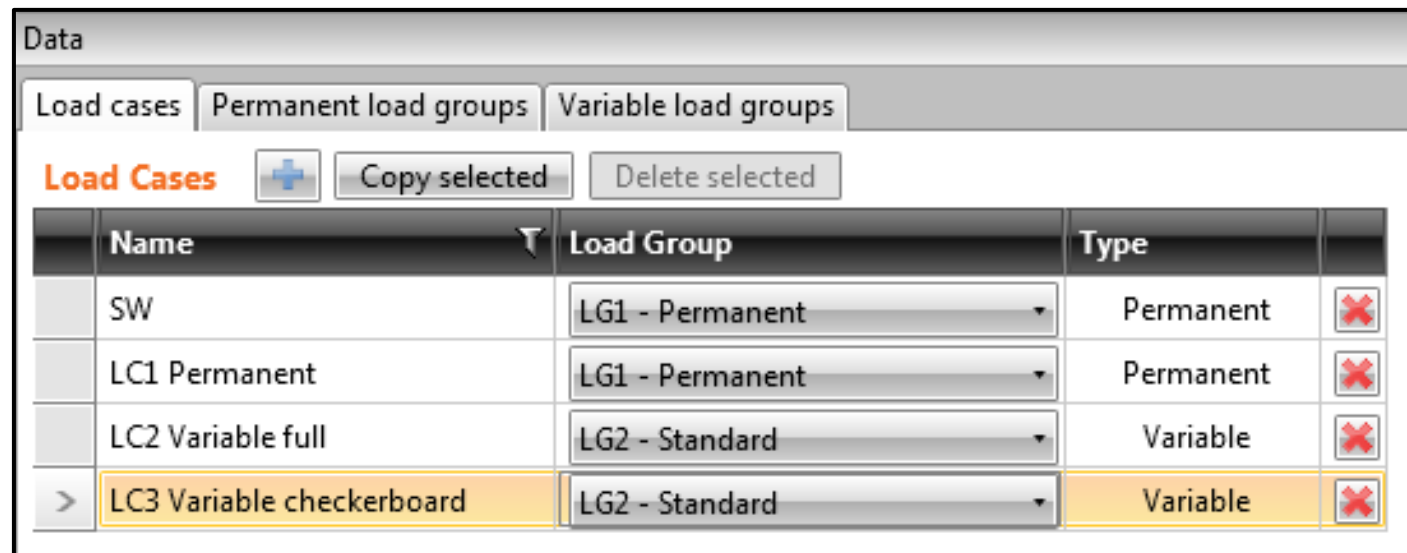


LC3: Checkerboard variable load

Load cases

Go to: Navigator → Loads → Load cases.

Create the 3 load cases (SW* is already created automatically) and adjust Load Group and Type as follows:



Data

Load cases Permanent load groups Variable load groups

Load Cases + Copy selected Delete selected

Name	Load Group	Type	
SW	LG1 - Permanent	Permanent	✘
LC1 Permanent	LG1 - Permanent	Permanent	✘
LC2 Variable full	LG2 - Standard	Variable	✘
> LC3 Variable checkerboard	LG2 - Standard	Variable	✘


Inputting loads

Go to: Navigator → Loads → Uniform loads.

- 1) Select LC1.
- 2) Enter new load.
- 3) Enter member number.
- 4) Enter load value (with „minus“).
- 5) Select vertical direction (Z).
- 6) Repeat for other members.

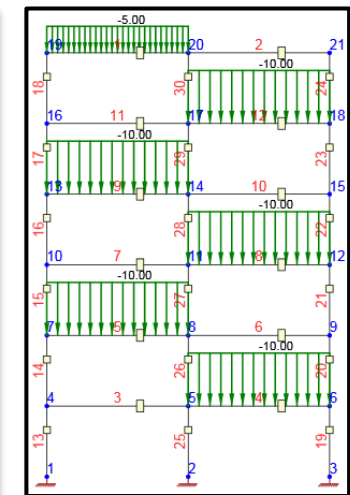
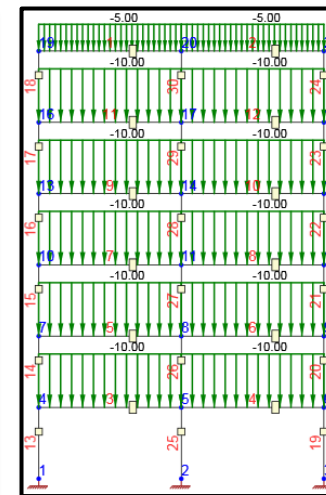
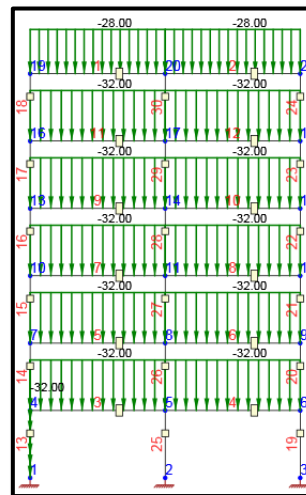
Repeat for LC2 and LC3.

Data

Uniform Loads 

Load Case **LC1 Permanent**

Membe	Value [kN/m]	Direction	Angle [°]	Location
3	-32,0	Global Z	0,0	Length
4	-32,0	Global Z	0,0	Length
5	-32,0	Global Z	0,0	Length

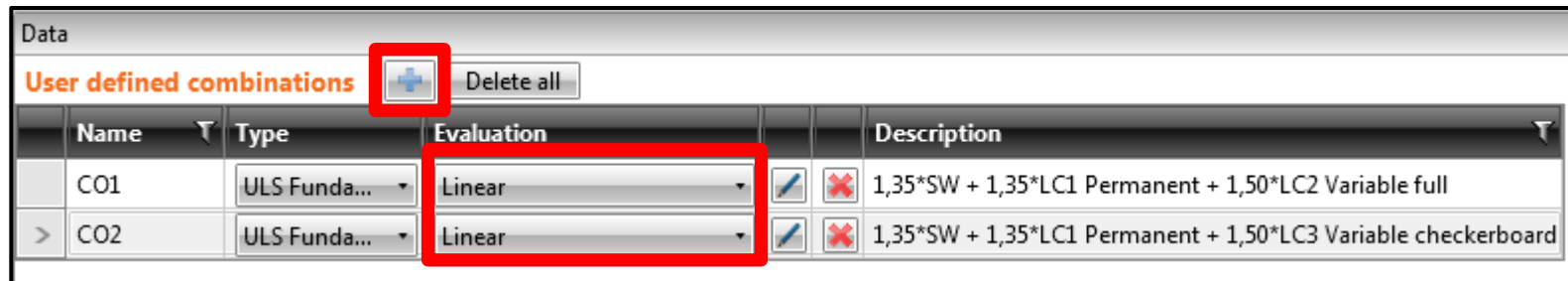


Load combinations

Go to: Navigator → Loads → Combinations.

Create 2 load combinations and set them to “Linear”:

- CO1 Full (SW + LC1 + LC2),
- CO2 Checkerboard (SW + LC1 + LC3).



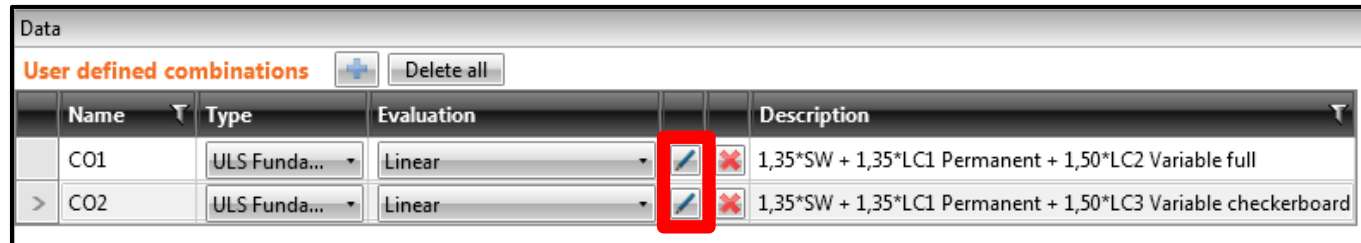
Name	Type	Evaluation	Description
CO1	ULS Funda...	Linear	1,35*SW + 1,35*LC1 Permanent + 1,50*LC2 Variable full
CO2	ULS Funda...	Linear	1,35*SW + 1,35*LC1 Permanent + 1,50*LC3 Variable checkerboard



Why do we do Full and Checkerboard loads/combinations?

- Full generates extreme N and support M,
- Checkerboard generates extreme V and midspan M.

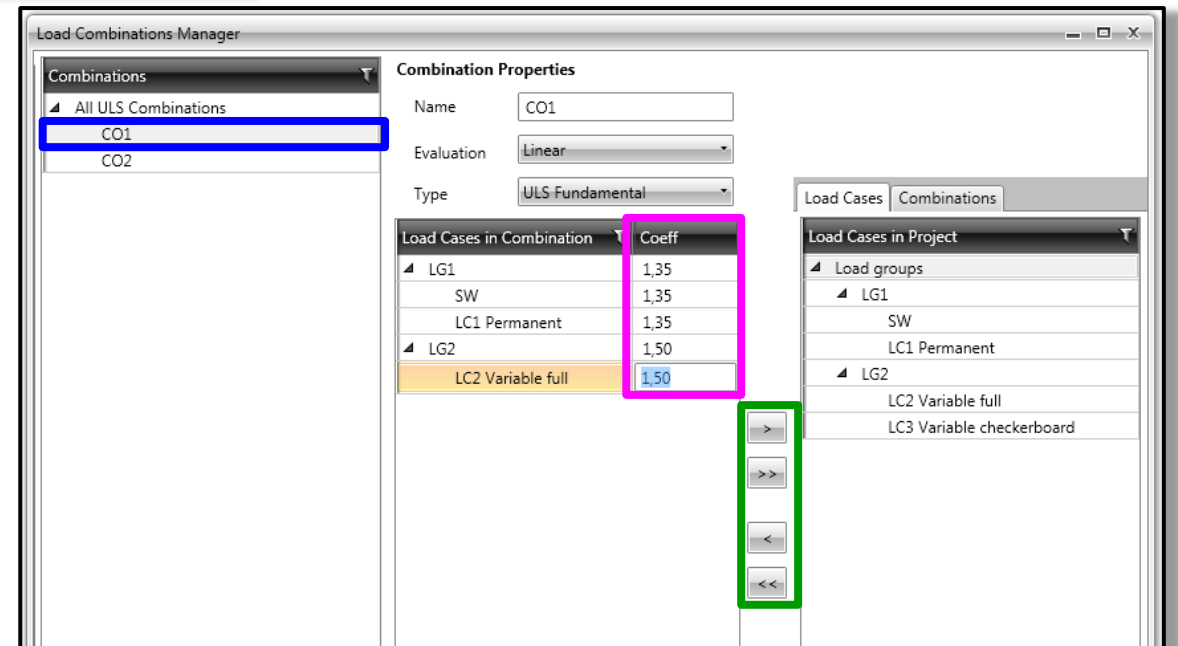
Load combinations

Edit the combinations.



Name	Type	Evaluation		Description
CO1	ULS Funda...	Linear		1,35*SW + 1,35*LC1 Permanent + 1,50*LC2 Variable full
CO2	ULS Funda...	Linear		1,35*SW + 1,35*LC1 Permanent + 1,50*LC3 Variable checkerboard

- 1) Select the combination.
- 2) Add/remove load cases to the combination.
- 3) Adjust the coefficients (1.35 for permanent loads, 1.5 for variable loads)



Load Combinations Manager

Combinations

- All ULS Combinations
 - CO1
 - CO2

Combination Properties

Name: CO1

Evaluation: Linear

Type: ULS Fundamental

Load Cases in Combination	Coeff
LG1	1,35
SW	1,35
LC1 Permanent	1,35
LG2	1,50
LC2 Variable full	1,50

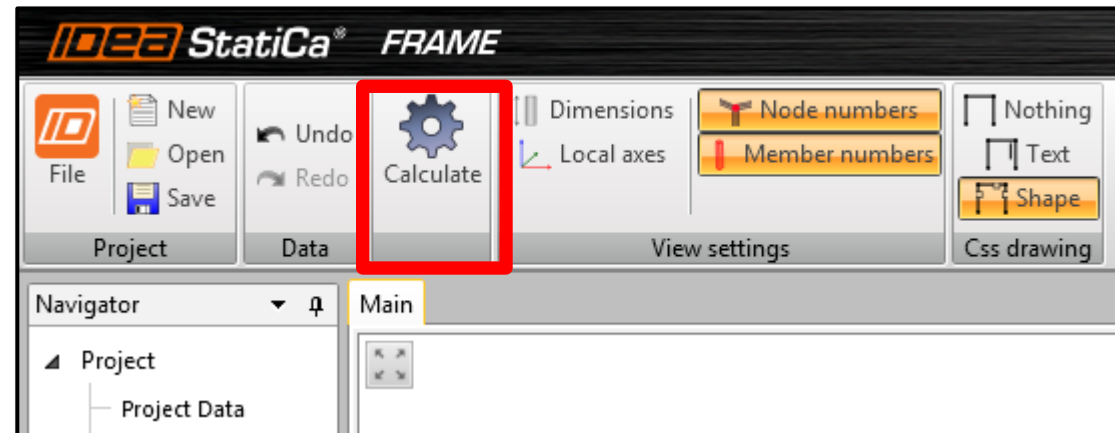
Load Cases in Project

- Load groups
 - LG1
 - SW
 - LC1 Permanent
 - LG2
 - LC2 Variable full
 - LC3 Variable checkerboard

Navigation buttons: >, >>, <-, <<

Calculation

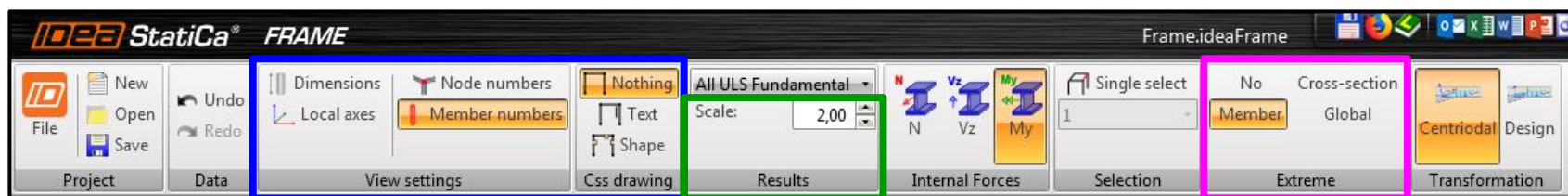
Calculate the internal forces.



Results – settings

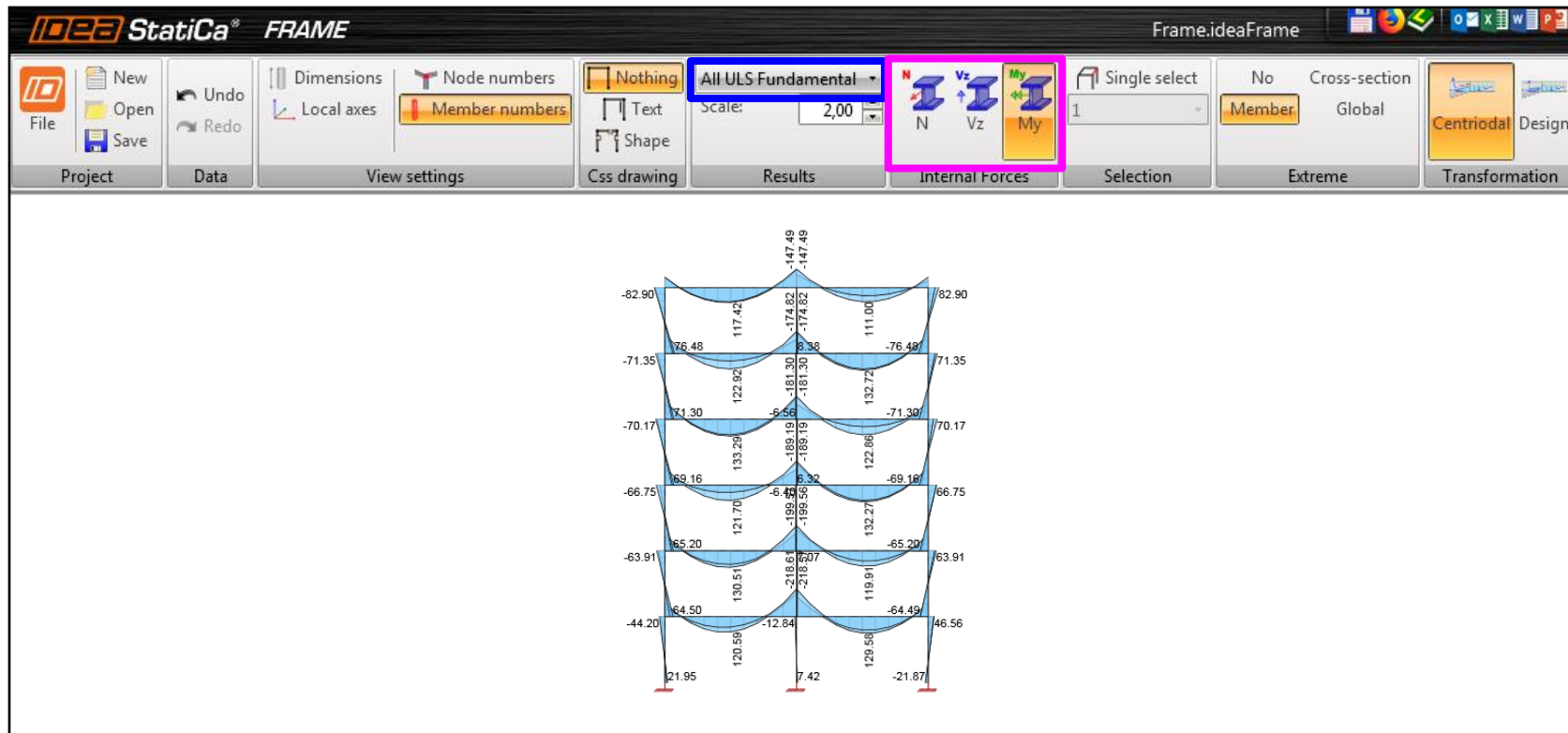
Go to: Navigator → Results → Internal forces.

- 1) Turn off all labels except Member numbers.
- 2) Adjust the result scale.
- 3) Display extreme values on members.



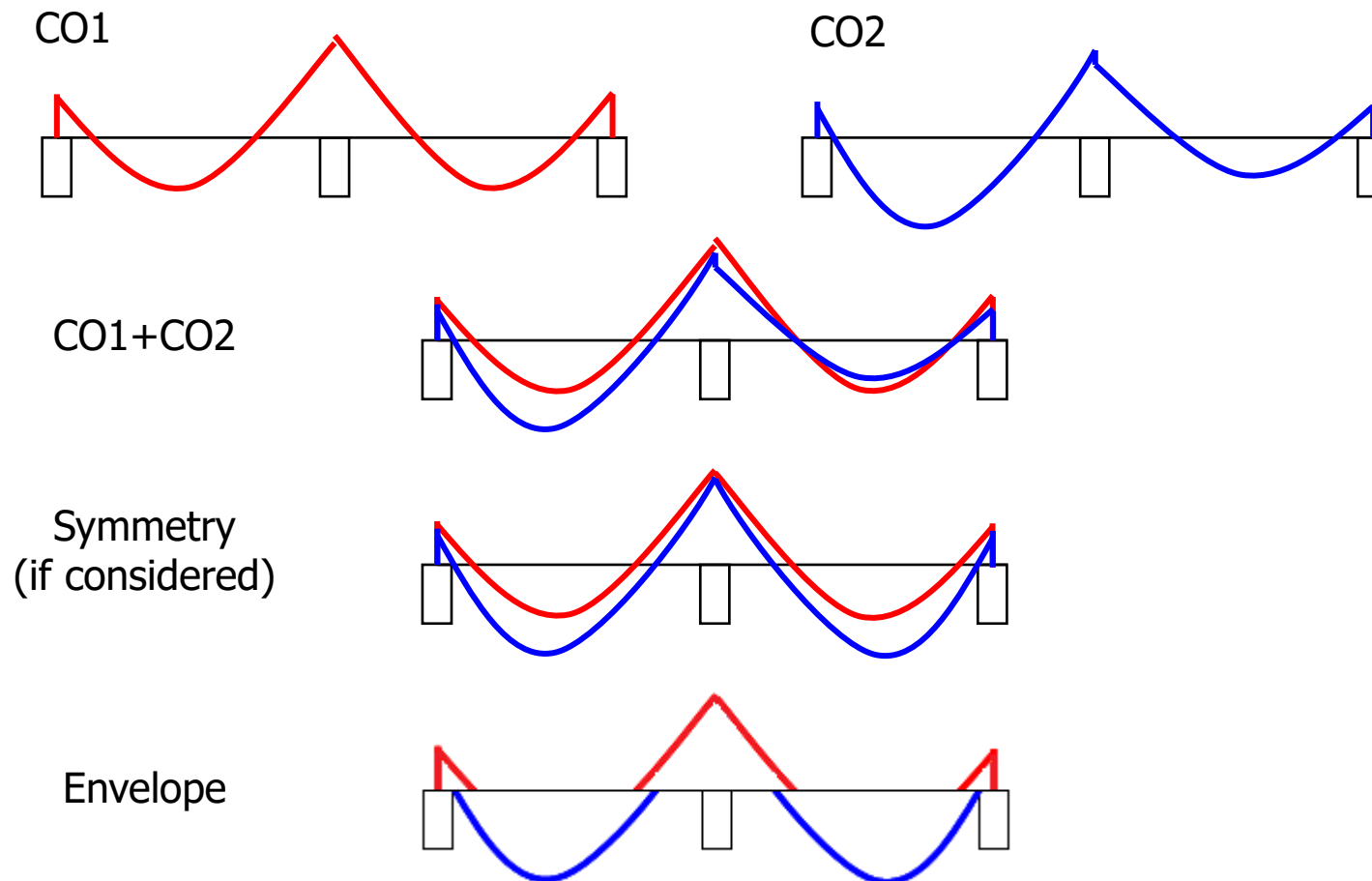
Results

- 1) Select load combination to display – CO1, CO2 or All ULS (“envelope” of CO1 and CO2)*.
- 2) Select internal force to display.



Envelope

What is an “envelope” of an internal force?

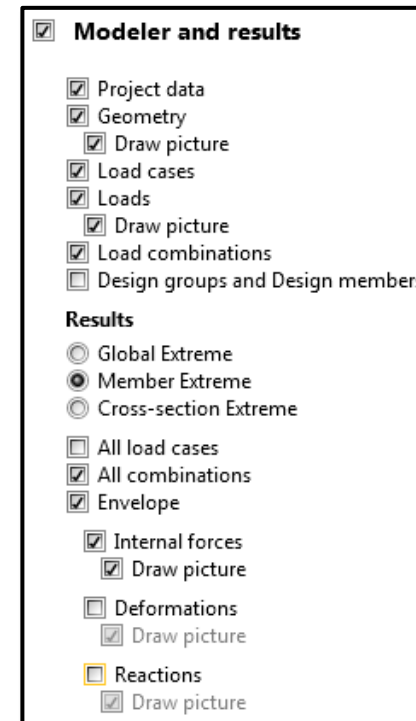
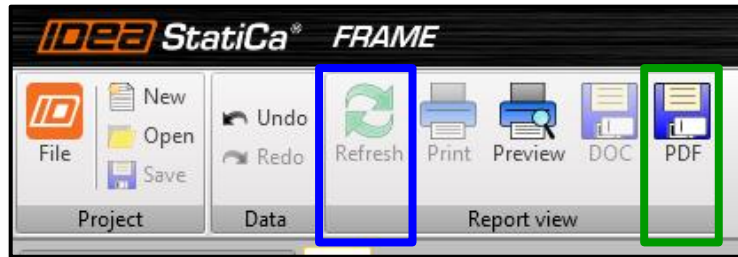


Report

Go to: Navigator → Report → Detailed.

In the menu on the right, select the following:

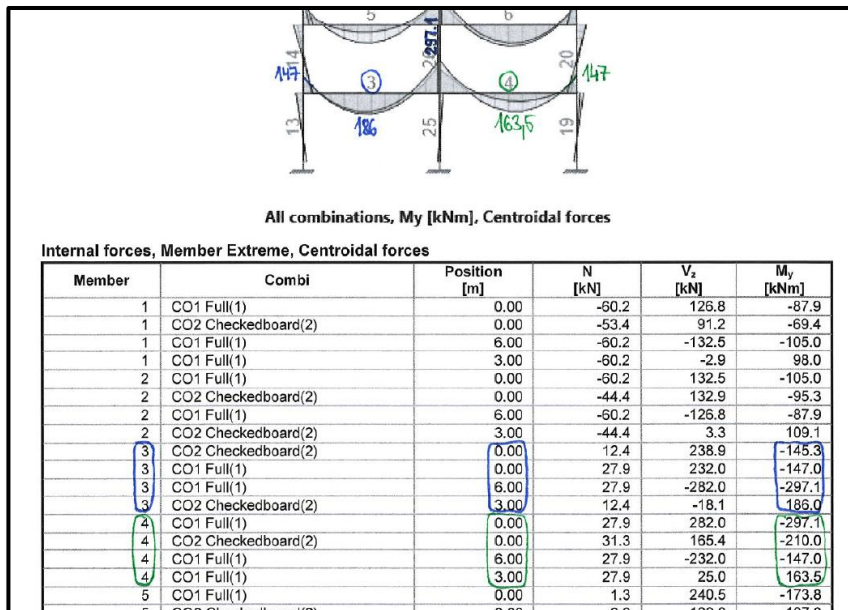
Then **refresh** the report and **export the report**.



Report

Print the report.

In the printed report, **manually add the values of the bending moments to the schemes of the bottom floor beam** for all combinations (you will find the values in the tables):



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

Video

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

Next week

Next week

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

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.