

#### CM01 – Concrete and Masonry Structures 1 HW2 – Calculation of internal forces



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#### Task 1



#### Structure

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



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#### Assignment

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

<u>Materials:</u> Concrete – **concrete class** Steel B 500 B ( $f_{xk}$  = 500 MPa)

Loads: Other permanent load of typical floor Other permanent load of the roof Live load of typical floor Live load of the roof Self-weight of the slab  $(g-g_0)_{\text{floor},k} [kN/m^2]$   $(g-g_0)_{\text{roof},k} [kN/m^2]$   $q_{\text{floor},k} [kN/m^2]$   $q_{\text{roof},k} = 0.75 \text{ kN/m^2}$  $g_{0,k}$  (calculate from the slab depth)

R

<u>Another parameters:</u> 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/1uQluyyKEcG5jaZVLrsmm1ZRRNib\_ow3MI wgZSEDgnW8/



# 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\*.

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

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# 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<sup>\*</sup> 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  $[kN/m^2] * L [m]$ .



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#### Beam loading

		Floo	r slab load	-			
Load type	Load name	h	ρ	ρ <sub>pl</sub>	f <sub>k</sub>	Ŷ	f <sub>d</sub>
-	0 <b>—</b> 0	mm	kg/m <sup>3</sup>	kg/m <sup>2</sup>	kN/m <sup>2</sup>	-	kN/m <sup>2</sup>
-	slab self weight	190	2500	475	4.75		6.41
(G)	other permanent load	fror	n assignme	ent	0.50	1.35	0.68
-	Σ			•	5.25		7.09
AE (E	variable	fro	om assignr	nent	3	4 5	4.50
	Σ				3	1.5	4.50
SUM				f <sub>k</sub> =	8.25	f <sub>d</sub> =	11.59

		Floor be	eam 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
	slab dead load	5.25	6.5	34.13		46.0
(G)	beam self weight	calculated autor	natically by SCIA	0.00	1.35	0.0
-	Σ			34.13		46.0
) X	slab live load	3	6.5	19.50	4.5	29.2
	Σ			19.50	1.5	29.2
SUM			f <sub>k</sub> =	53.63	f <sub>d</sub> =	75.3

0.00	$\sim -2/12$ l-N/ $\sim$
46.07	$g_{k,t} = 34.13 \text{ km/m}$
29.25	a = 10  G  J  N  /m
29.25	$q_{k,t} = 19.50 \text{ km/m}$
75.32	

46.07

Slab span: R = 6.5 m

		Roof	slab load				
Load type	Load name	h	ρ	ρ <sub>pl</sub>	f <sub>k</sub>	γ	f <sub>d</sub>
	Ľ.	mm	kg/m <sup>3</sup>	kg/m <sup>2</sup>	kN/m <sup>2</sup>	12	kN/m <sup>2</sup>
NUL.	slab self weight	190	2500	475	4.75		6.41
(G)	other permanent load	from	n assignme	nt	2.00	1.35	2.70
5	Σ				6.75		9.11
M.	variable	fre	om assignr	nent	0.75	4 5	1.13
PRO (O	Σ			10	0.75	1.5	1.13
SUM				f <sub>k</sub> =	7.50	f <sub>d</sub> =	10.24



 $\begin{array}{c} \begin{array}{c} \begin{array}{c} 0.00\\ \hline 59.23\\ \hline 7.31\\ \hline 7.31\\ \hline \end{array} & g_{k,r} = 43.88 \ \mathrm{kN/m} \end{array}$ 

Slab span: R = 6.5 m

### Calculation of internal forces in 2D frame Download and install of SCIA Engineer



#### Download and install SCIA Engineer

First, apply for the <u>student license</u> of SCIA. When applying, use your school student email (e.g., "name.surname@estudiantat.upc.edu").

autation	First name*	Last name*	
- Select -	~		
Email address*		Phone*	
School*	Department*	Country*	
		- Select -	~
Position*			
- Select -			~
Remarks			
Luculd like to receive undates or	a promotions and nows from SCIA		l.

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

Use <u>this video tutorial</u> to model the structure, perform the calculations and obtain the results.



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

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

SCIA Engineer		– 0 ×
SCIA 22.1.2011.64 - student version	FRAME +	
D 🖸 💥 👘 🎯 👁 🛱 🗛	Please click here or press Space and type your text It will be completed with lines below.	LC4 🗸 🎦 🚽 📇 🧭 🖬 🏪 🔝 💷 🙈
INPUT PANEL		
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All categories	Grid I	
All tags		
▼ GRIDS & STOREYS		National code EC - EN
3D line grid	8	National annex Standard EN
▼ 1D MEMBERS		Structure Frame XZ 🗸 🗸
D member Ctrl+B		No. of nodes 21
Column Column		No of beams 30
Hausch on 1D	82	No of slabs 0
Arbitrary profile		No of solids 0
Opening on 1D		No of used profiles 2
Internal node on 1D		No. of load cases 4
	8	No of used materials 2
Ribbed slab		Linear calculation Finished
Prefab slab		
Opening on 2D		
▼ LOAD PANELS	8	
Panel with load to nodes		ſF.
Panel with load to edges		F
# Panel with load to 1D & edges		A.
Opening with load panel	en e	
/// Panel with parallel beams	and the second	++
C Opening on panel		
▼ IMPORT & BLOCKS		<b>₽</b>
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PRESING     Post-tensioned tendon	X	6
A Post-tensioned free tendon	<u>⊯'</u> #A (B) (C)	
BOUNDARY CONDITIONS     Support in node		

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# 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



Deton4life 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)

📑 📲 🗹 📴 🔍	🗙 🗢 🔲 Input combinations 🔹 👻
CO1-full	Name CO1-full
CO2-checkboard	Description
	Type Linear - ultimate
	Amplified Sway Moment method no
	Contents of combination
	LC1 - Self weight [-] 1,350
	LC2 - Other dead loads [-] 1,350
	LC3 - Live loads full [-] 1,500

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# 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**.



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# 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 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

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

### thank you for your attention

