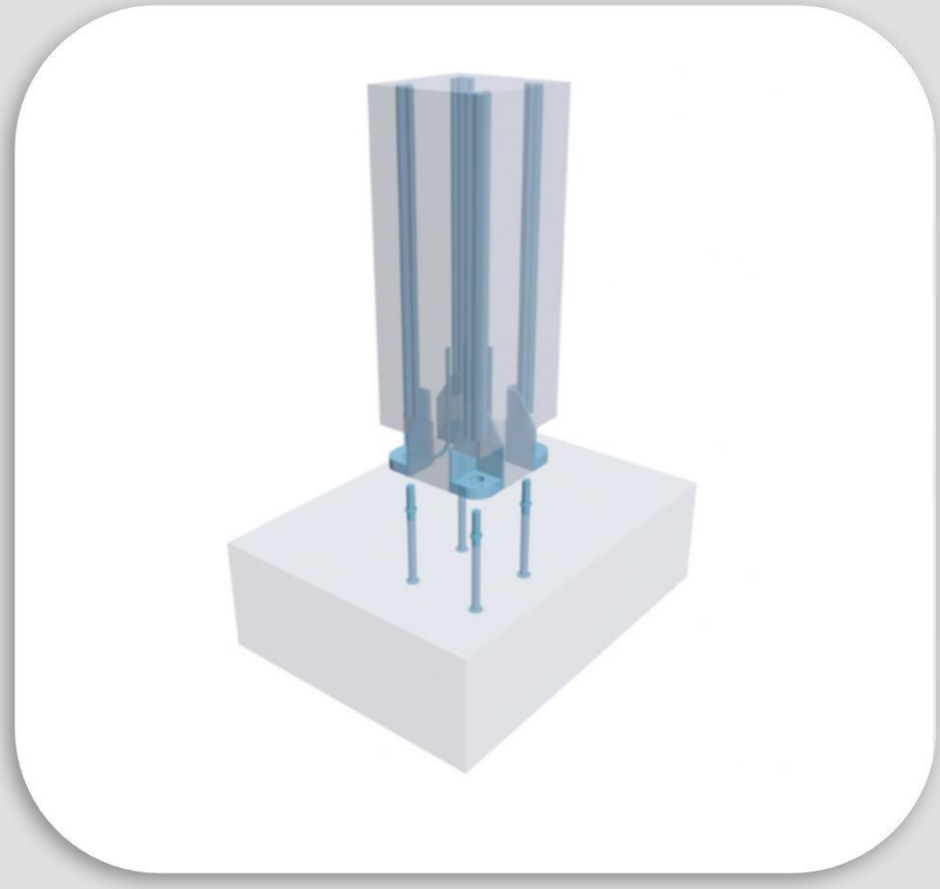
RSTEEL®



USER MANUAL

Technical changes and errors reserved

R-DESIGN SUITE

COLUMN SHOE DESIGN APPLICATION

Version: **01.10.2022***

RSTEEL®

Index

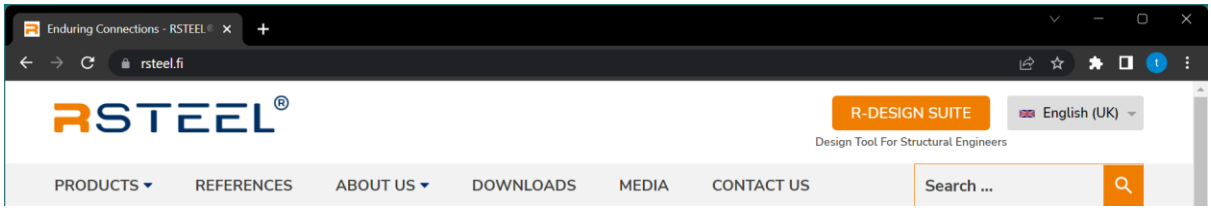
1. Introduction

R-Steel design suite is developed by R-Steel Structure & Software Engineers to help clients to better use R-Steel products. Calculations are based on the rules of design codes, such as EN 1992, EN 1993, and ETA TR 029. Applications have detailed reports which help to users to better understand calculation methods.

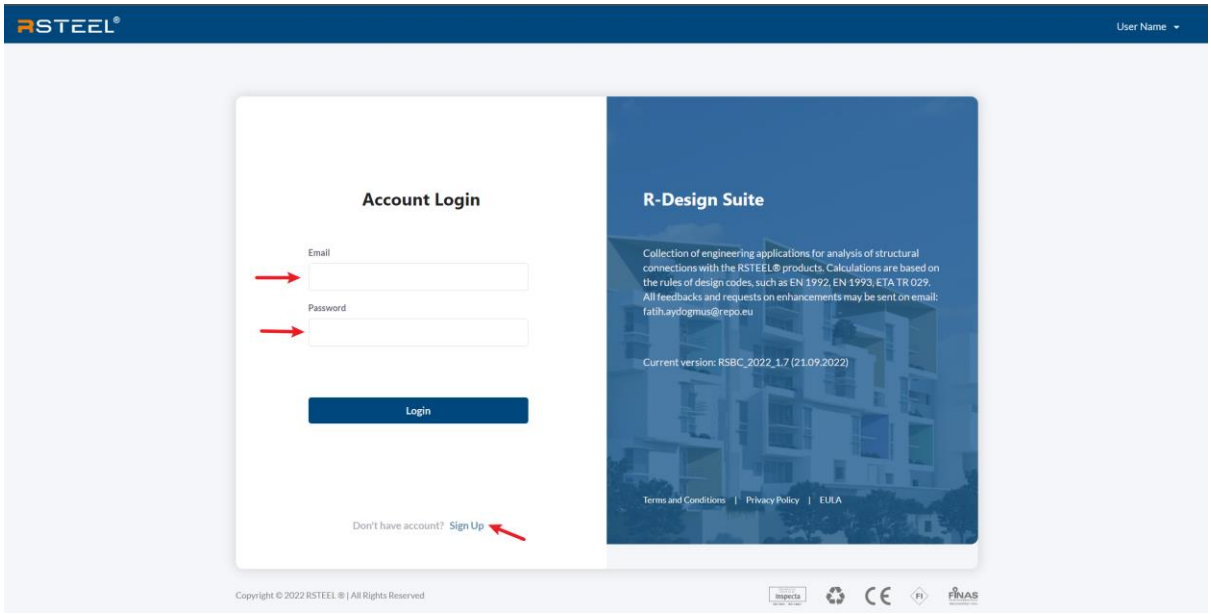
The use of the program and results require good expert knowledge in the field of the program (structure designer). R-Group Baltic OÜ and authors take no responsibilities for direct or indirect costs incurred by faults in the program or its applications.

1.1. Application registry

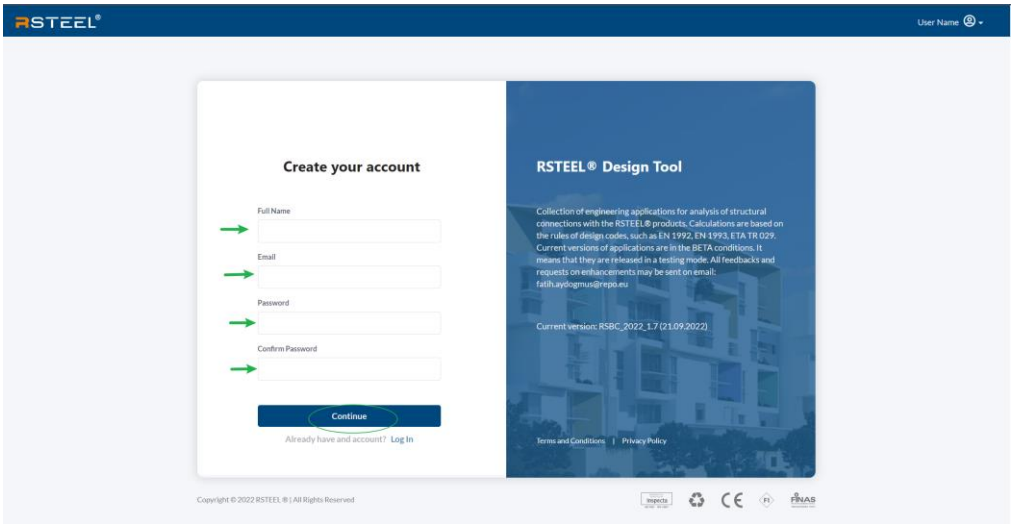
Application (R-Design Suite) link can be found from right top of the www.rsteel.fi web page.



After clicking R-DESIGN SUITE button, login page will appear



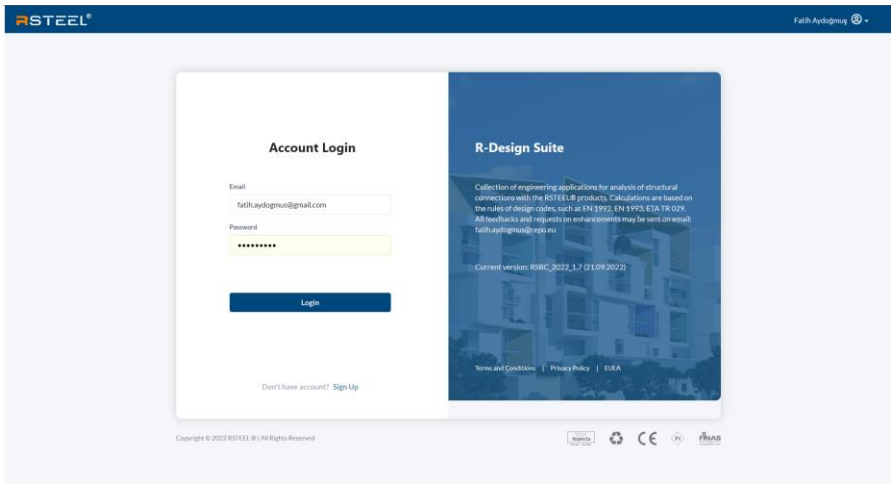
If you already have an account, you can login with your e-mail address and password. If you don't, click Sign Up link on the bottom right to enter your information.



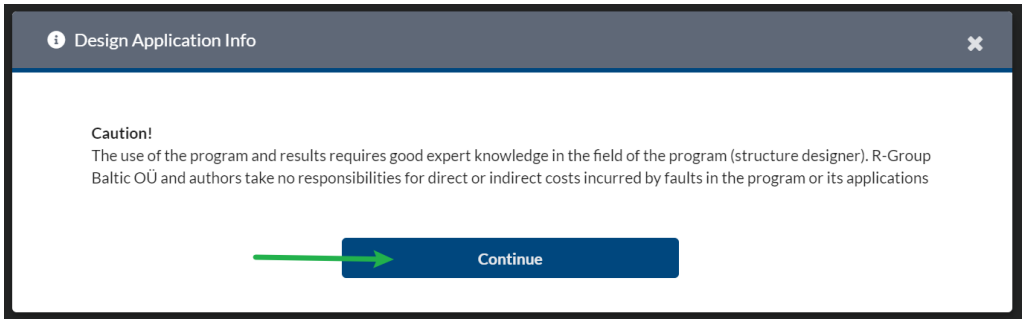
If you lose your password and can't enter your account, please note that there is no remind password option yet. So please write an e-mail to technical@repo.eu from your registered email address then we will be sure that it is you. We will send you a message to get back your password.

1.2. Login

Login can be done from Account Login page

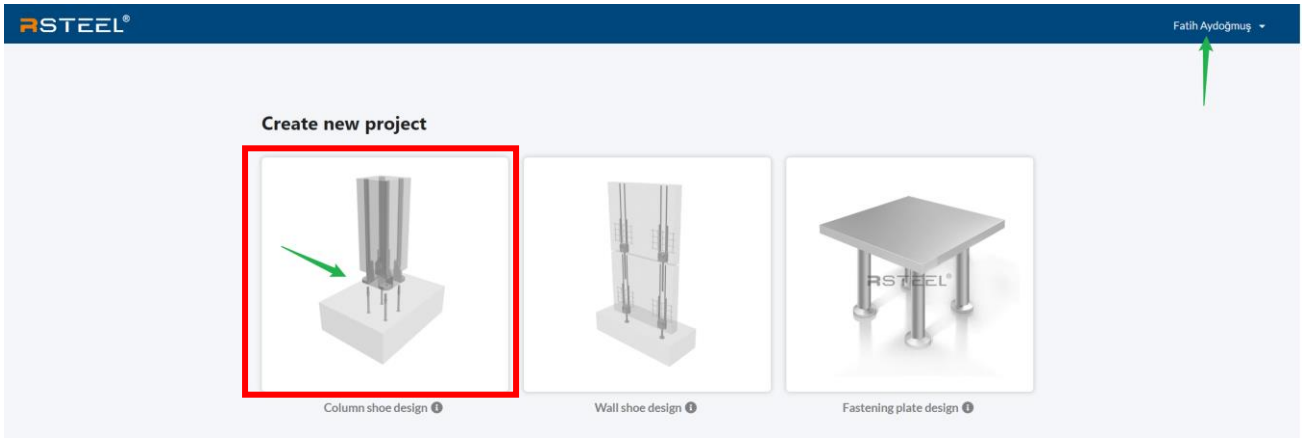


After login caution message appears, press continue button to enter "Create New Project" page.



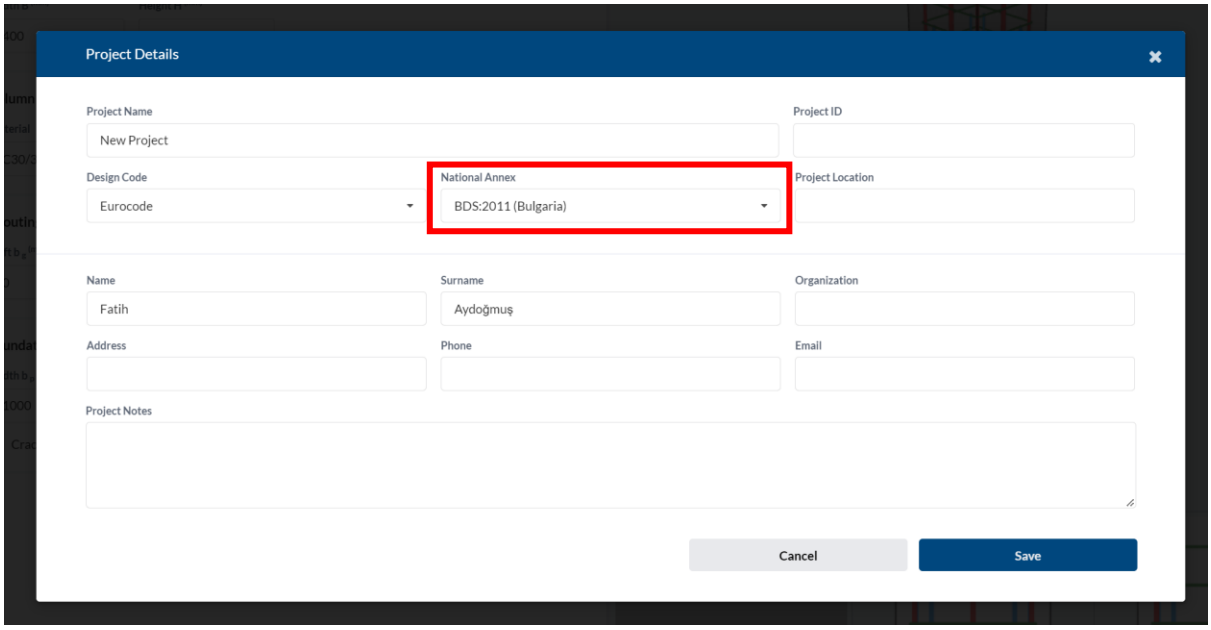
1.3. Create new project page

Create new project page includes three calculation applications. These are column shoe, wall shoe and fastening plate applications. The user name appears on the right top of the screen.

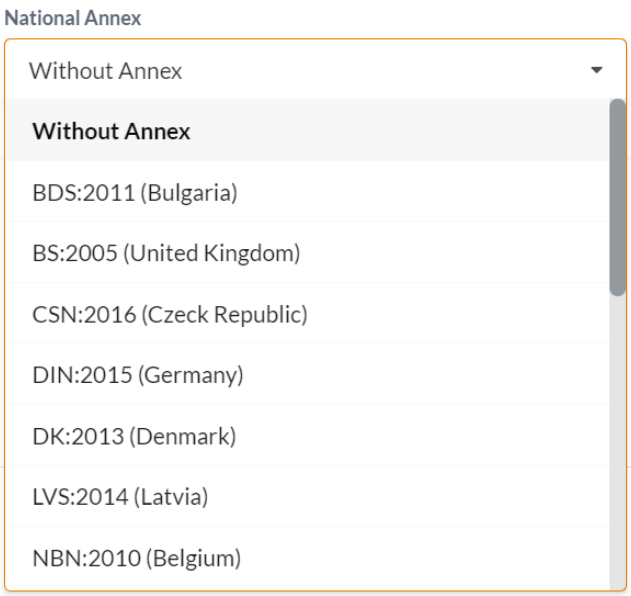


To select the "Column shoe design application", click the marked image.

After that Project Details window appears. You can skip it by clicking the cancel button. But notice that the information you entered here will appear in your report. You can open this window later to complete the missing information or edit the existing information.



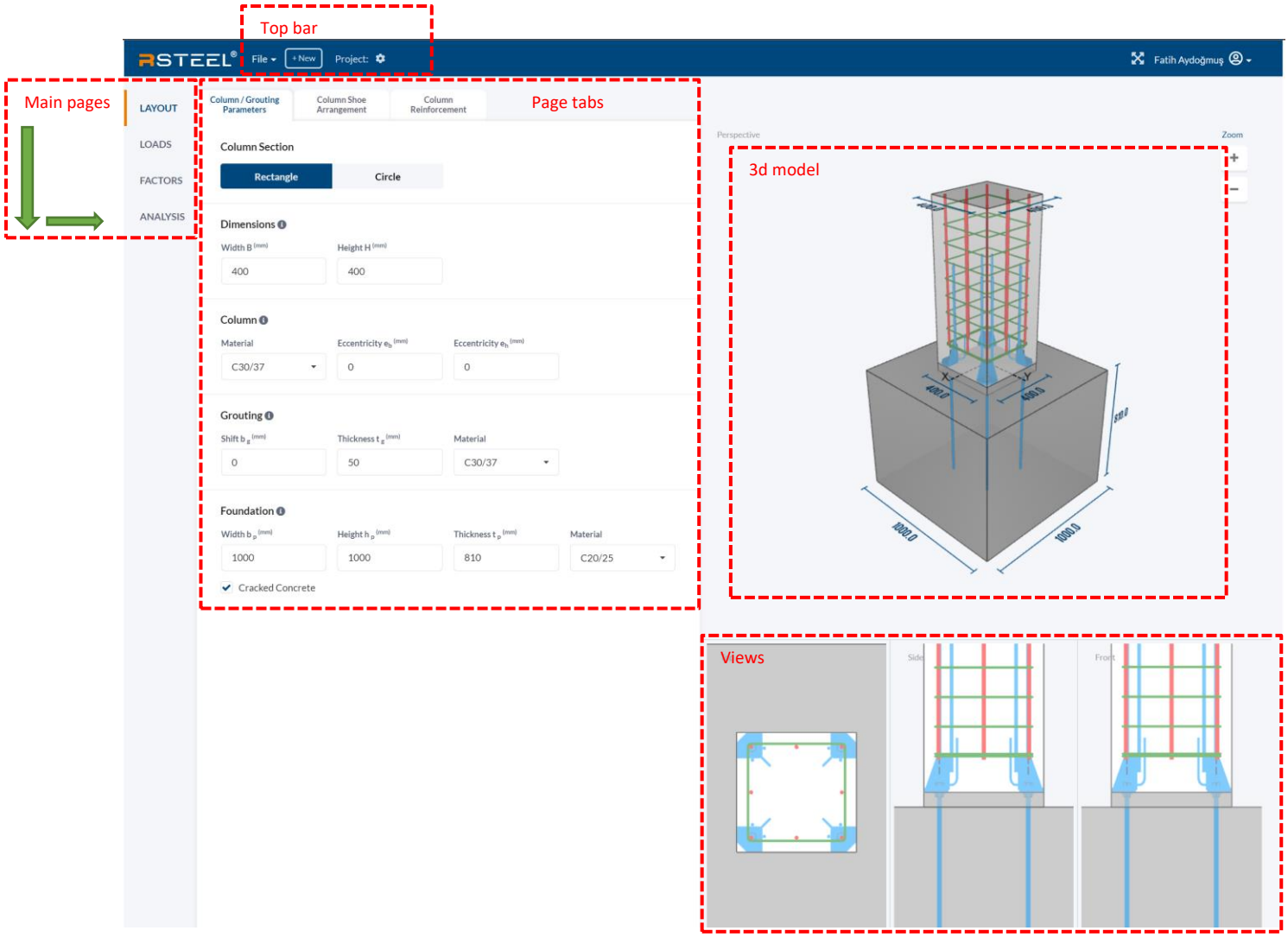
You can select National Annexes you prefer according to your location. For that click the triangle sign and select annexes from pull down menu. This selection will affect "Factor Page" values such as safety factors for concrete, safety factors for steel etc. We will mention them on the Factor page in the next chapter. Also, you can pick Without annex. If you select without Annex, the program will take default values from Eurocode.



To pass this page you can click the save button and the Project Details window will disappear and you will see main program page.

2. Main Application Page

The main application page consists of four main pages and related tabs to the pages. Users will enter the values they desire on the pages by following the order of top to bottom, and for each page, they follow tabs left to right.



Main structure of pages and tabs are given below.

LAYOUT

- Column/ Grouting Parameters
- Column Shoe Arrangement
- Column Reinforcement

LOADS

- Loads Before Grout (Stage I)
- Loads After Grout(Stage II)
- Grouting Fire Resitance

FACTORS

- Column and Anchors

ANALYSIS

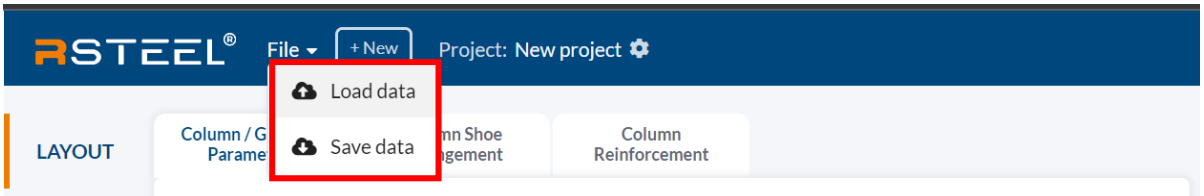
- General Report
- Input Information
- Column Report
- Shoe Report
- Fire Resistance Report

You can find detail explanation about the pages and page related tabs in the next section.

Top bar:

Top bar consists of **File**, **Project Details** and **User information**

When the file menu is clicked, “save data” and Load data” options appear. If you want to save the inputs you have entered in the program, you can select “Save data” and the JSON extension file will be downloaded to your download folder. To reload your data, this time you should select Load data and locate your .json file. RSteel Design Suite doesn’t save any data on the server, that’s why this type of solution is created to solve file sharing issues. The saving option will be handled in the future.

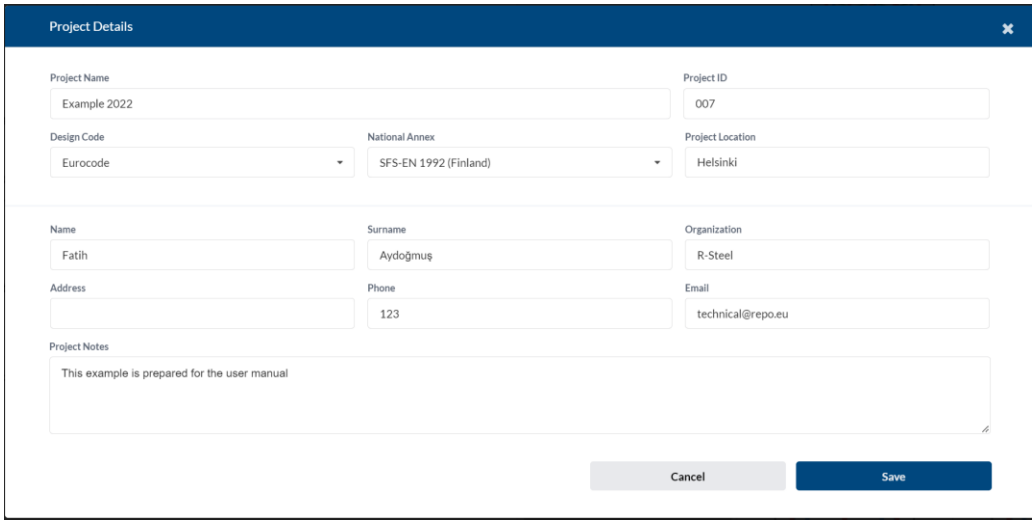


+New command is located right side of the File Menu. This command will create a new empty column shoe file with the default values when it is clicked.

Please be sure that you had downloaded your file or printed your report before create a new file. Also it is highly recommended to check pdf report pages to be sure that there is no issue on printing pdf.

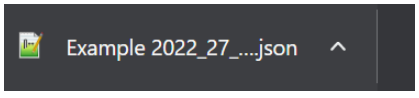
You can re-open “Project Details” by clicking the gear icon on the top bar.

All the information you entered here will appear in your report.



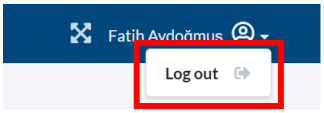
After clicking the save button, the name of the project becomes the same as the name on the Project detail page.

If you use the download option, you will see that the downloaded JSON file has the same name as the project. Also, date information is added to the file name to better organize the files.



You can see .json file extension by using default windows notepad application.

Logout is placed on the right of the top bar.



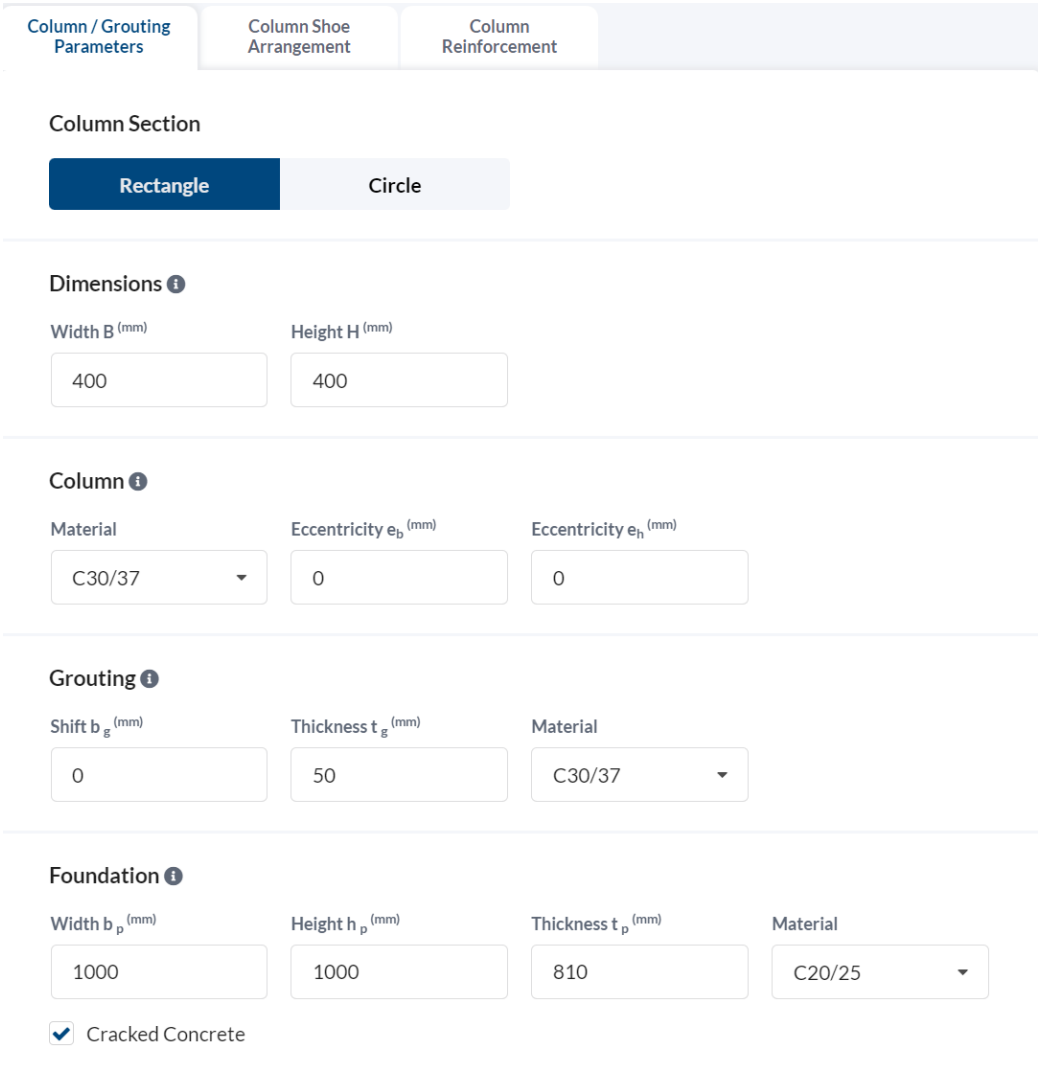
3d model and views:

Users can zoom in and out on the 3d model by rolling the mouse wheel. Right-click on the mouse allows the user to rotate the model. Left-click on the mouse activates the pan option. On view windows, only the zoom option is available. Layout

All main information such as dimensions of columns and foundations, reinforcements, their materials and more importantly Column Shoe types will be defined on the LAYOUT page and on its tabs.

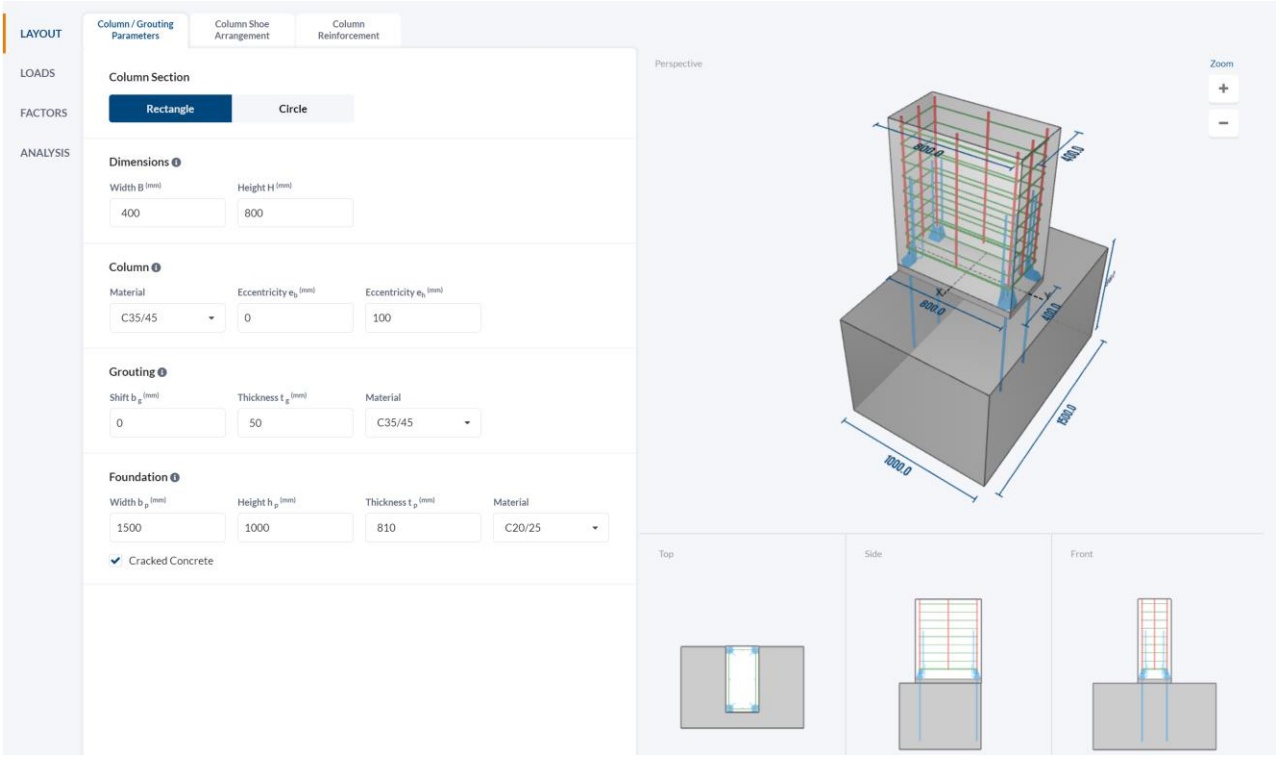
2.1. Column/ Grouting Parameters

In this tab, the user can define the dimensions and material of the column and foundation separately. Column geometry can be arranged as circular or rectangular.



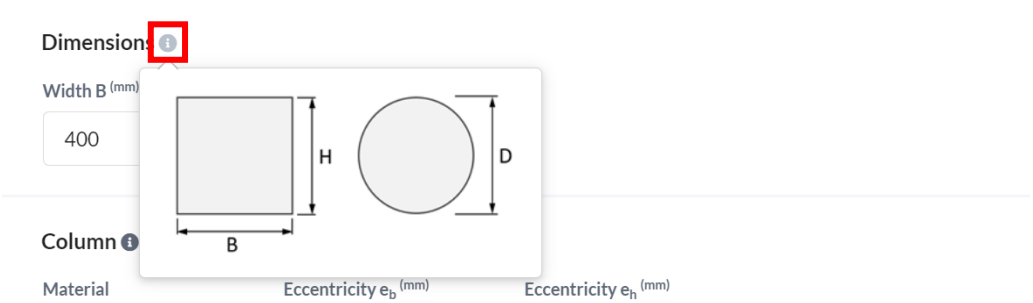
icon as you see on the right side of the Dimension, Column, grouting etc. show that extra explanation for the user. İf you come to the top of this icon , necessary explanation will be appeared.

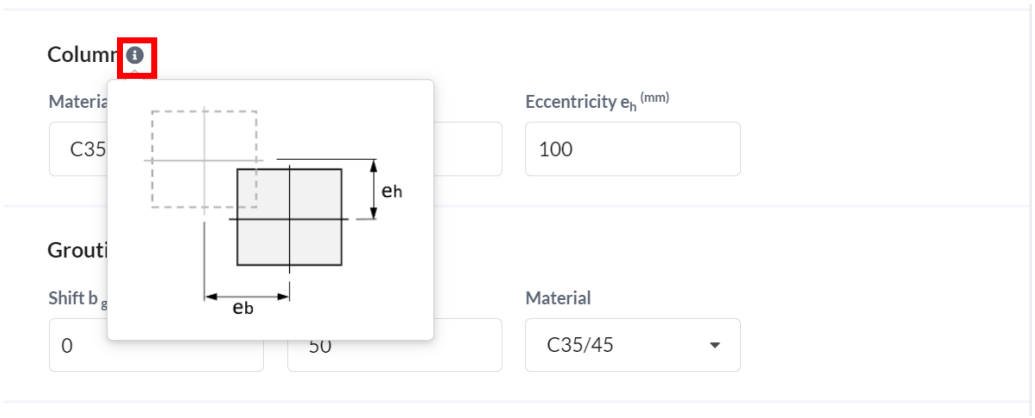
All the changes made by the user will be displayed simultaneously in the 3d model on the right.

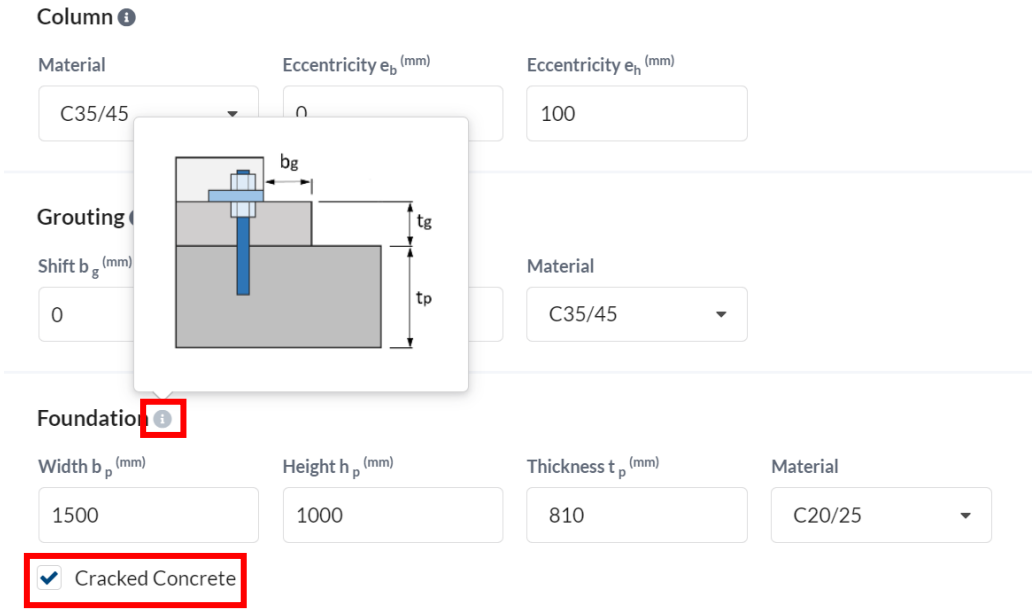


As an example, 400x800 column is defined on the 1500x1000x810 foundation. Column and grouting material selected as C35/45. Column has eccentricity 100 mm on the Y axis. Grouting thickness is 50 mm. Foundation material selected as C20/25.

As we ention earlier if you come to the top of icon , necessary explanation will be appeared.



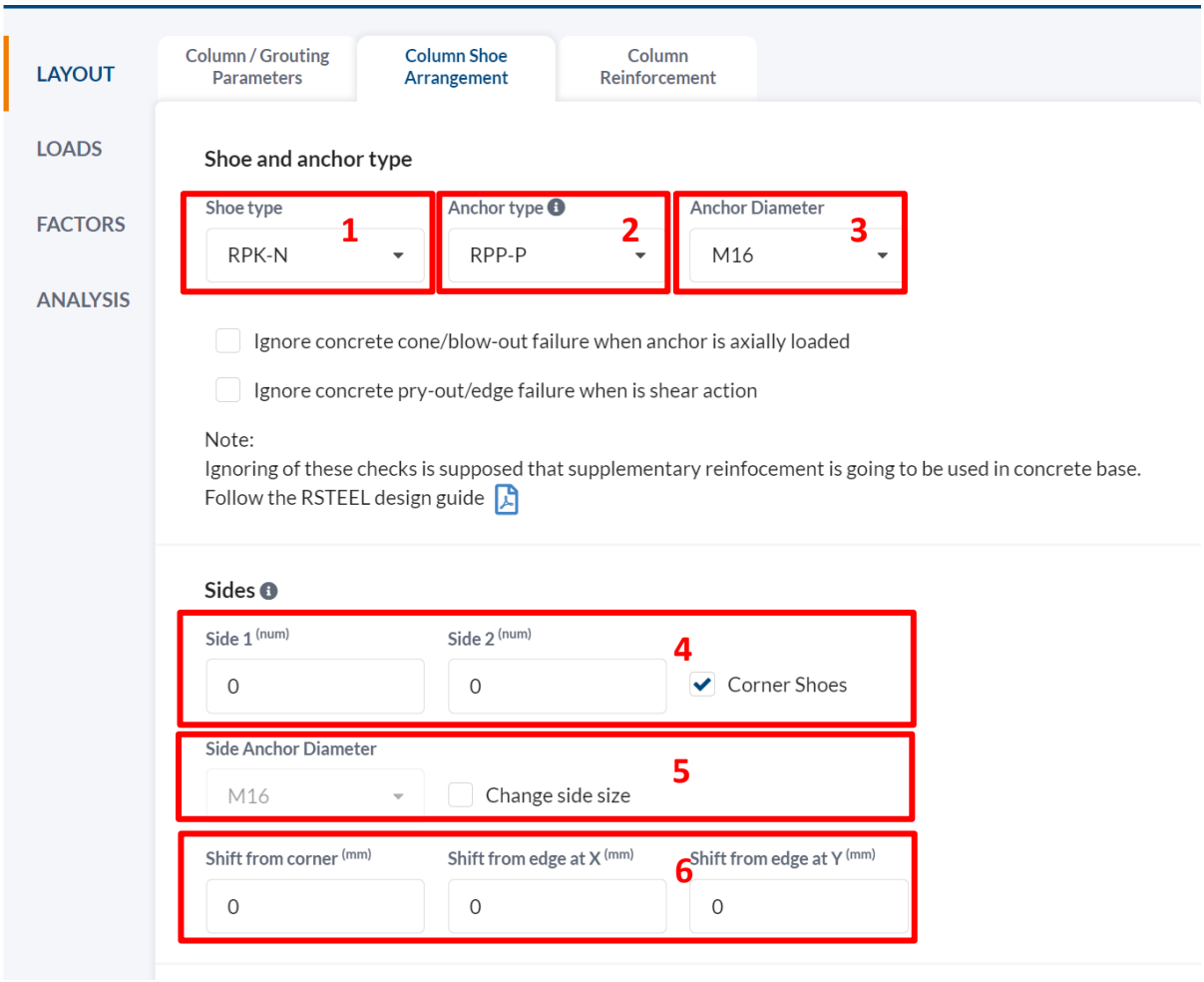




Concrete is accepted as cracked concrete during anchorage length calculations, if you want to run the calculation for non-cracked concrete, the check box should be removed by clicking it.

2.2. Column Shoe Arrangement

Second tab of LAYOUT page is “Column Shoe arrangement” tab.



1 Shoe type can be selected from the Shoe Type menu as RPK-N-type or RPK-E type. According to this selection, the application will select RPP type base bolt for RPK-N type Shoe or RPP-E type base bolt for RPK-Etype shoe automatically.

2 Users can select RPP-P for the long type or RPP-L for the short type bolts according to their desire.

3 Shoe size can be selected from Anchor Diameter

As a default value, all columns have four shoes in the corners. Users can add more shoes to the column.

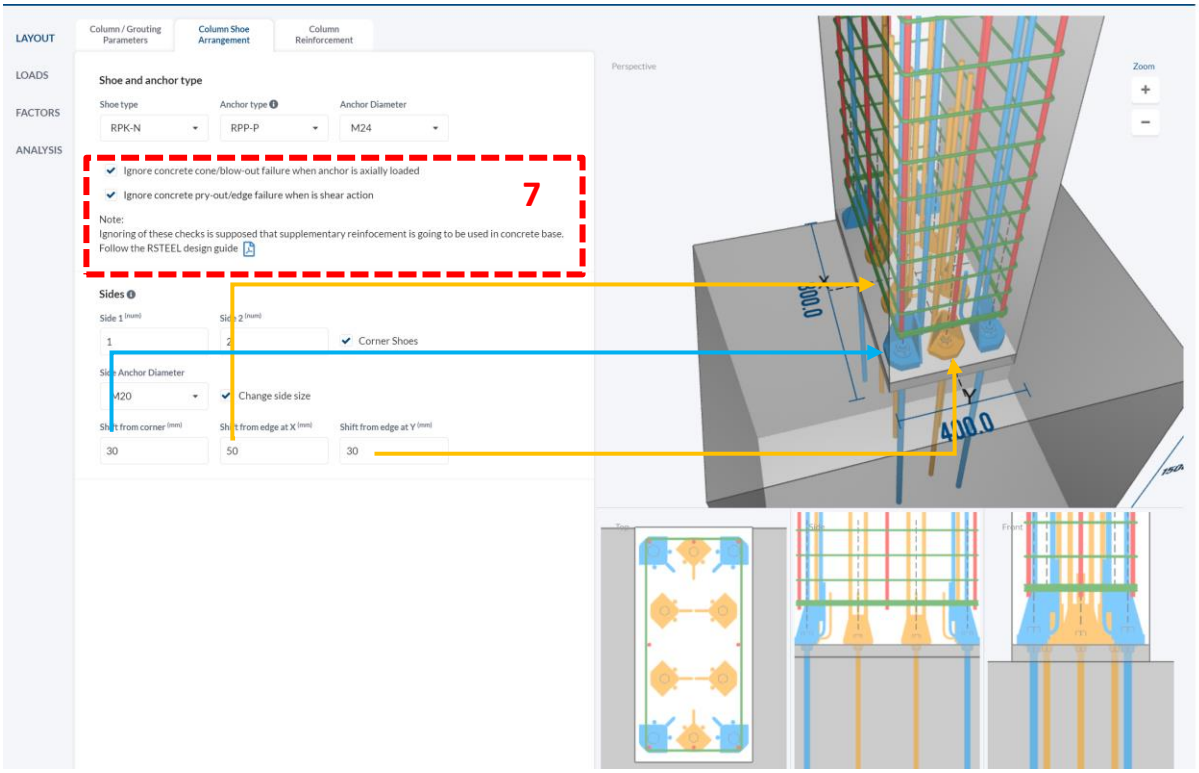
4 Under Sides menu; Side 1 increases number of shoes on Y direction and Side 2 increases number of shoes on X direction. These changes simultaneously affect the 3d model on the right which the user can control the changes.

5 As a default value, all shoe dimensions are the same. Corner shoes and side shoes can have different sizes if the “Change Side Size” box is checked. Side shoe sizes can be the same or less than the corner shoe sizes.

6 The shoe position in the column is arranged by the cover of concrete. For fire protection, users may need more distances. For that reason, users can enter their desired shift distance for corner and side shoes. Cover concrete value effect all reinforcement in the column but this section only affects shoe position. The total shoe distance from the side is equal to the sum of the cover of concrete and shift distance.

In the picture below; the following selection had been made;

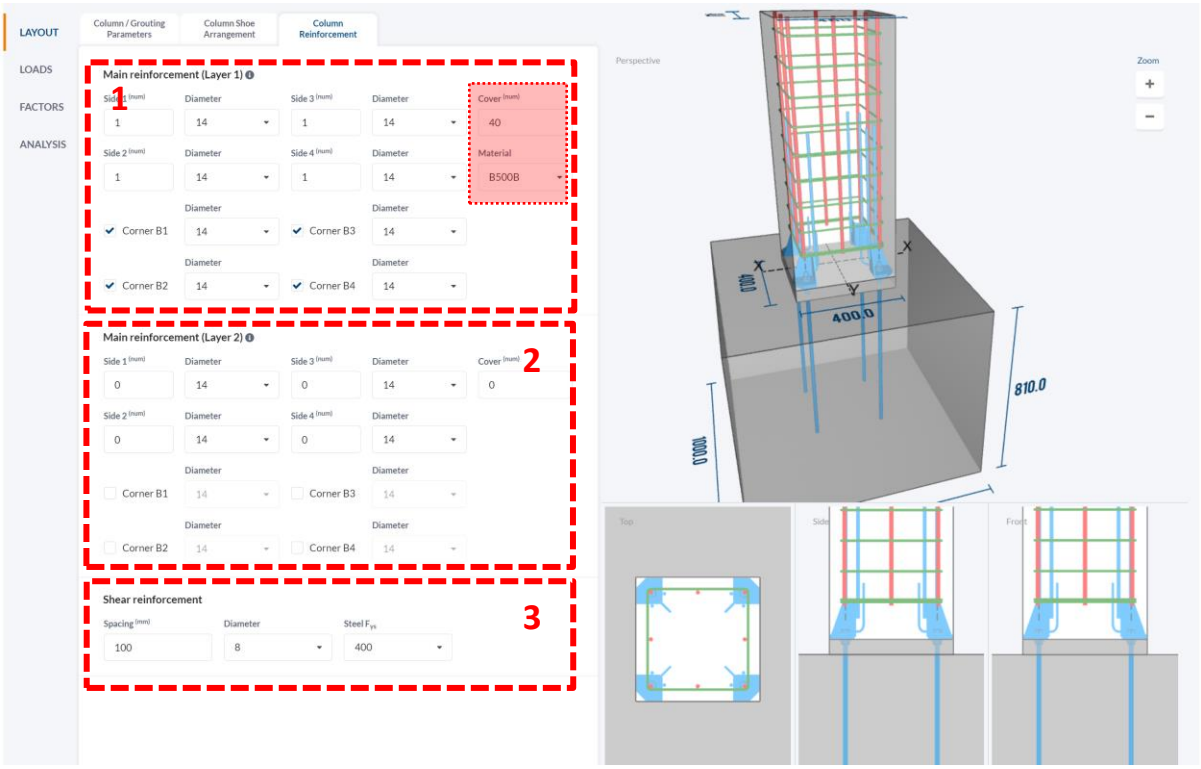
Corner shoes RPK-N M24, side shoes RPK-N M20, corner shoe shift is 30 mm, X side shift is 50 mm, Y side shift is 30 mm.



7 Especially with shallow foundations which use short type of bolts, the foundation may need supplementary reinforcement to handle the loads. Column shoe application is checking cone/blow-out failure and pry-out/edge failure and warns the user if they aren't satisfied. User can skip these checks by selecting check boxes. But ignoring these checks is supposed that supplementary reinforcement is going to be used in a concrete base. User must follow the RSteel design guide for anchor bolts and column shoes.

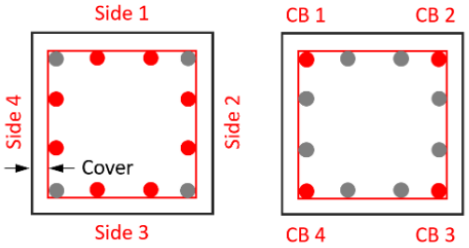
2.3. Column Reinforcement

Users may define the reinforcement in the column or they can skip this tab. Reinforcement definition won't affect the shoe calculation. The column reinforcement tab is prepared to show rebar distribution in the column with the shoe. Also, a column design check can be performed by the application if the user defines all necessary reinforcement. This topic will be explained detailly later under the title of the Analysis page/ Reports (Column).



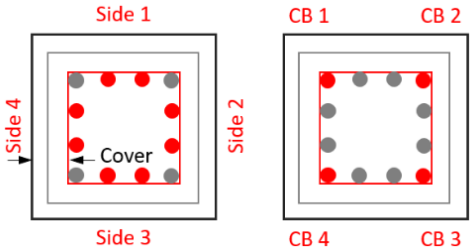
Users can define single layer reinforced column and double layered reinforced column in the program.

1 Users can edit column reinforcement by changing Corner and Side numbers and diameters. The definition of corner and side reinforcements is given in the figure below. The cover of concrete and rebar material is defined under this tab.



As we mention earlier if you come to the top of icon , necessary explanation will be appeared.

2 Users can edit second layer reinforcement by changing Corner and Side numbers and diameters as they do for Layer 1. Related figure is given below.

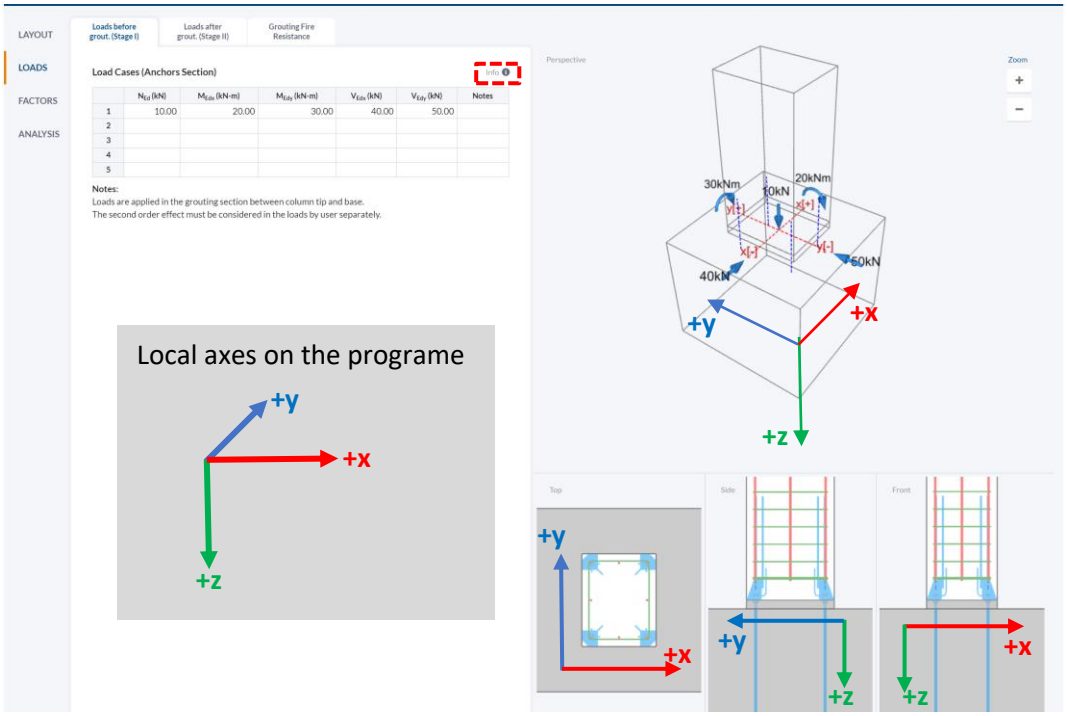


3 Users can edit stirrups by changing stirrups spacing, diameter and material. Changes will appear on the 3d model simultaneously.

3. LOADS

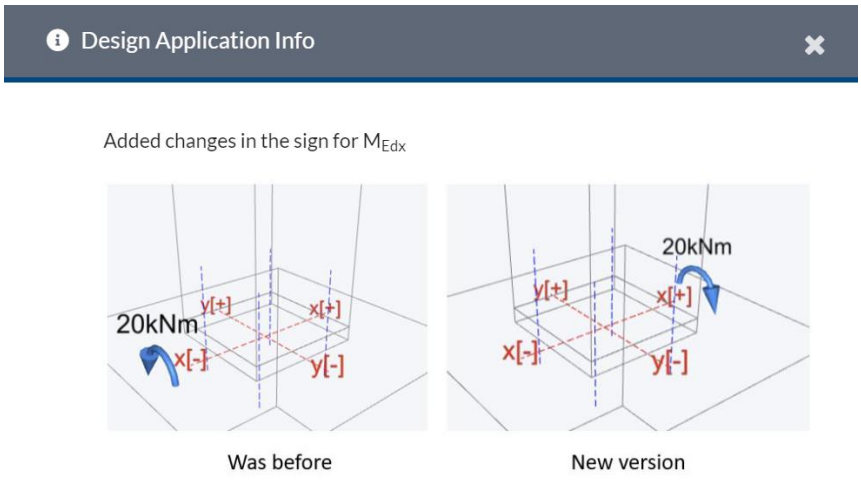
All loading values; Stage I, Stage II and Grouting Fire Resistance loads will be defined in this tab.

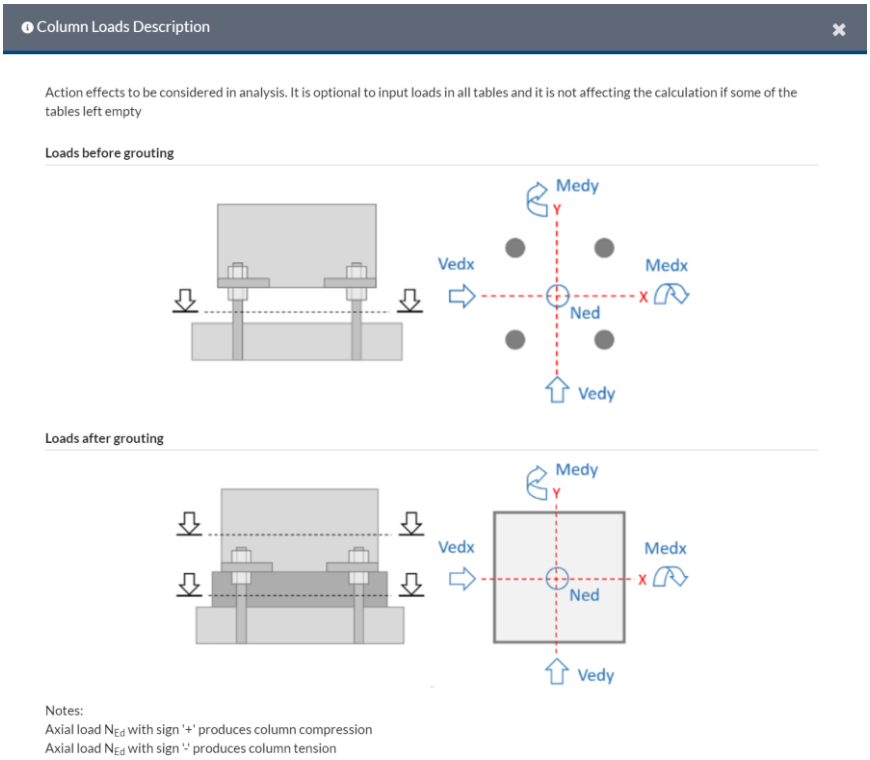
Loads will appear on the 3d model when the defined. Axes have been shown in the figure below. As you see +X and +Y axes are the same with most programs but the +Z axis is downwards. So according to desingn program user might need to change axial force direction negative to positive. Program follows right hand rule to define moment directions(Info sign on the left top opens “Column load description”).



As you see from the table in the figure above, axial forces values are +10 kN, shear force in the x-direction is +40 kN and moment value around the x-axis (Mx) is 20 kN.m. Users can prepare their forces tables in other programs such as Microsoft excel, google sheets or LibreOffice Calc etc and then copy-paste values to the load page.

On the 31.08.2022 update, we corrected the Mx moment direction. If you saved your JSON file before that time, and want to use the same data for other analyses, please check and corrected the Mx direction.



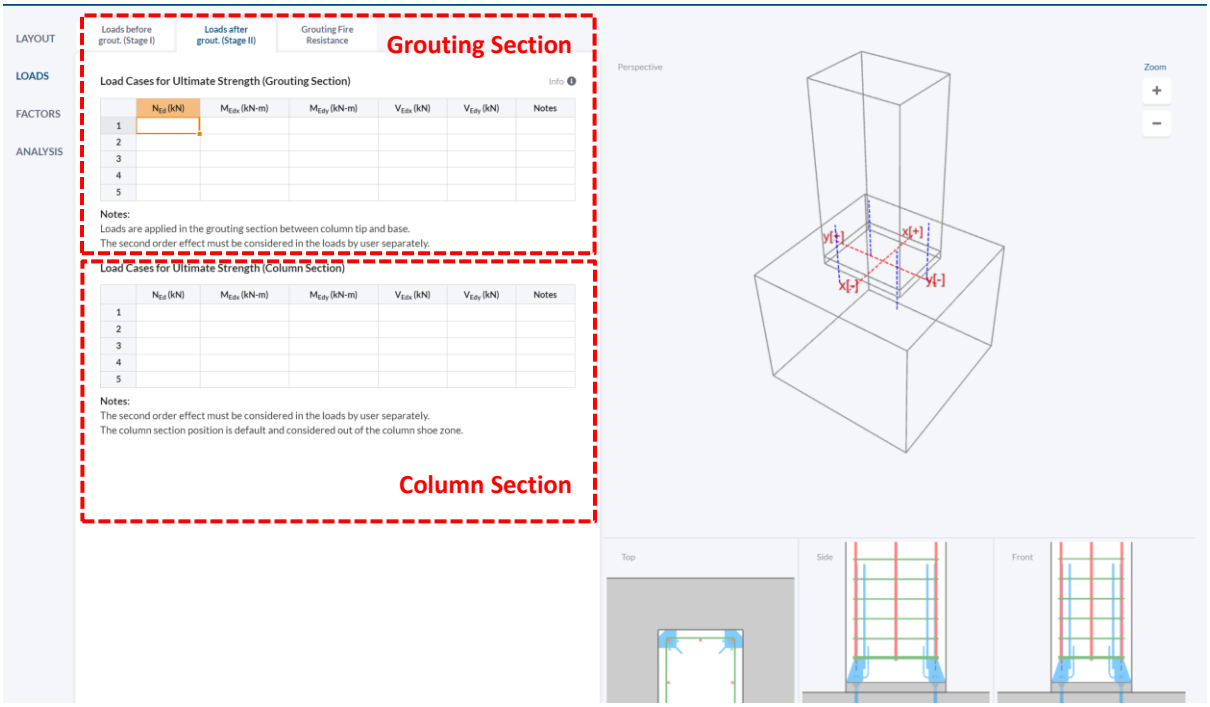


3.1. Loads Before Grout (Stage I)

Stage I includes Load cases during the construction period before grout is poured. So column is standing alone under the effect of wind loads and self weights mostly. The other effect can be considered by the designer according to the project. Users can skip this stage but, it is highly recommended if the columns won't be supported by any other system until grout is poured. Loads are applied in the grouting section between the column tip and base. The second-order effect must be considered in the loads by the user separately.

3.2. Loads After Grout(Stage II)

Stage II includes Load cases during after the construction period which means grout was already poured and cured.



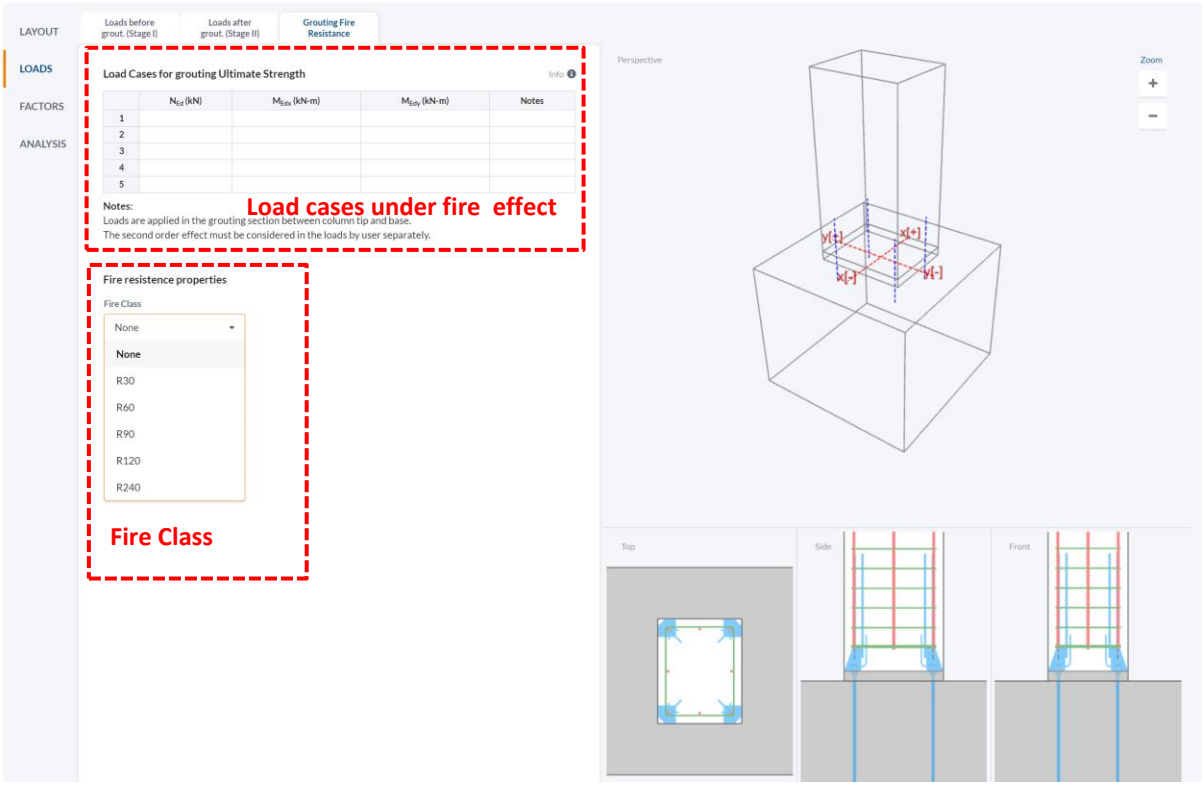
Users can enter their load cases into **Load Cases for Ultimate Strength (Grouting Section)** table. That load cases will be used in the calculation of column shoes. Loads are applied in the grouting section between column tip and base. The second order effect must be considered in the loads by user separately.

Load Cases for Ultimate Strength (Column Section) table has added the application as a bonus. Users can check their column design by adding load cases to this table. Loads will be applied to the column section to check the axial and shear strength of the column. Results can be monitored under the

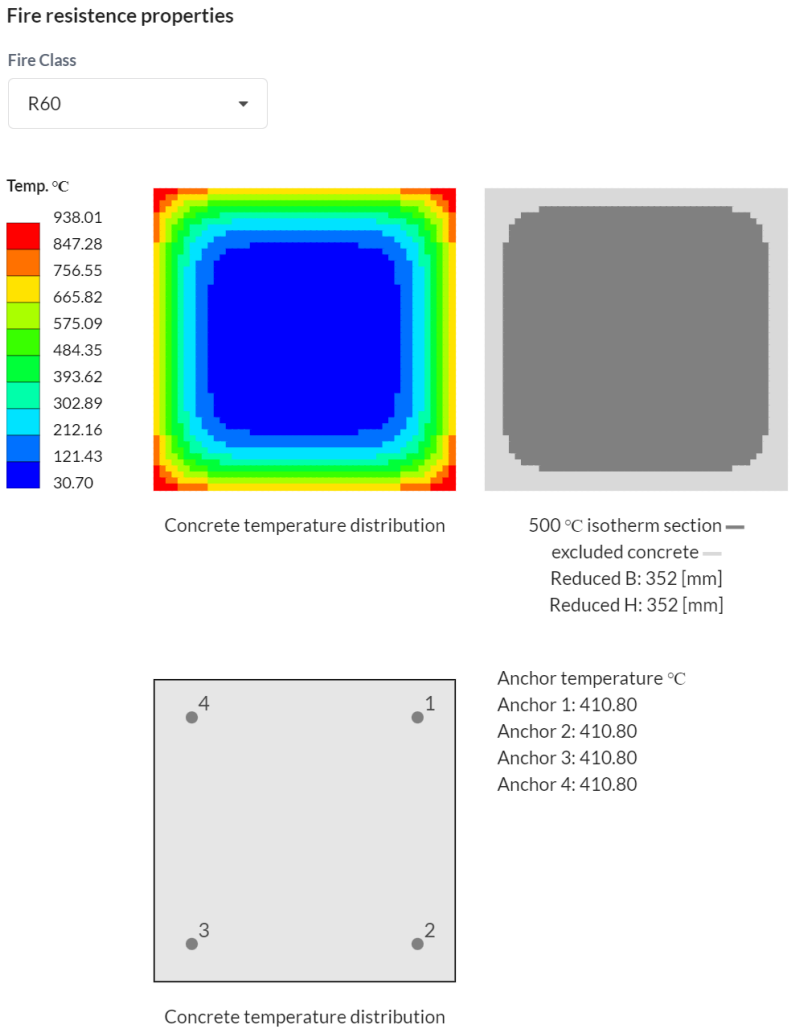
Analysis page, report (Column) tab. These loads won't affect column shoe design, so the grouting section table must be filled if shoe results wanted to be calculated. The second order effect must be considered in the loads by user separately. The column section position is default and considered out of the column shoe zone.

3.3. Grouting Fire Resistance

Users can enter their load cases into the **Load Cases for Ultimate Strength (Grouting Section)** table for fire resistance evaluation. That load cases will be used in the calculation of column shoes under fire effects. Right before doing that, users should select desired Fire class from the pull-down menu. So the application will calculate temperature distribution on the column according to the selected Fire Class and use this data to reduce strength during to shoe calculations.



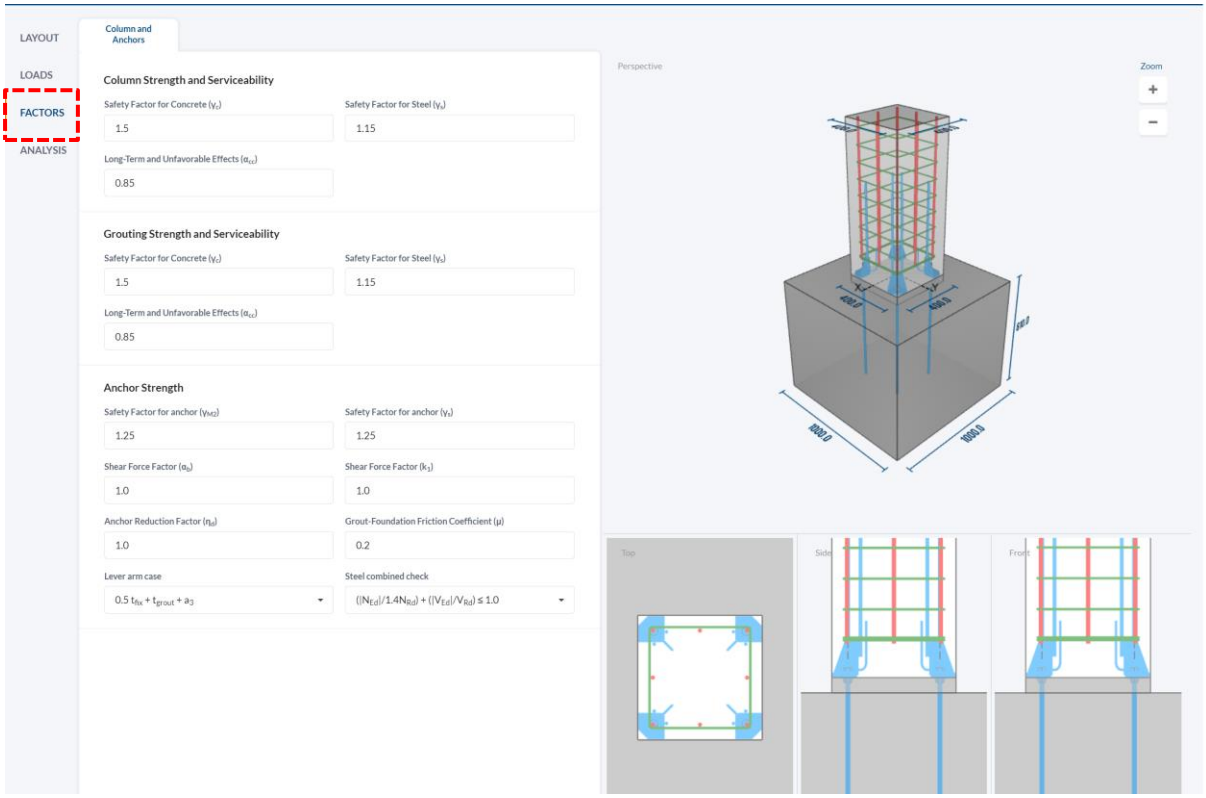
You can see tempeture distrubition of 400 mmx 400mm column under 60 minute fire below.



Loads are applied in the grouting section between column tip and base. The second order effect must be considered in the loads by user separately.

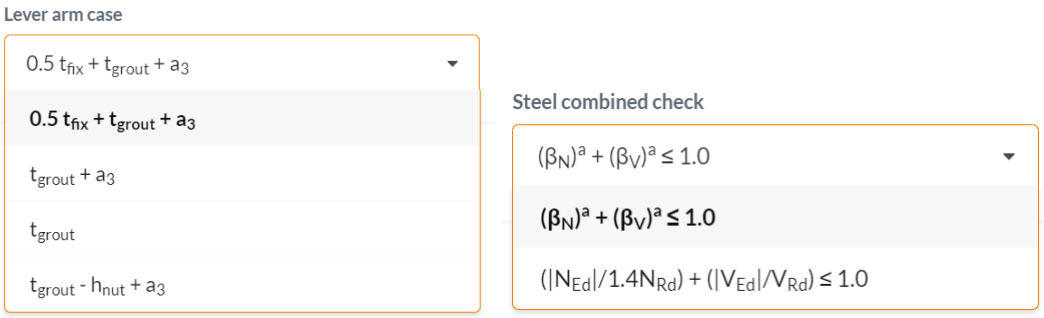
4. FACTORS

Users can see and edit material and force factors under this page. National annexe selection on the **Project detail page** (1.3 Create a new project) will affect the factors. If the user hasn't selected the National annexe according to the project location, the application will have default values from the euro code.



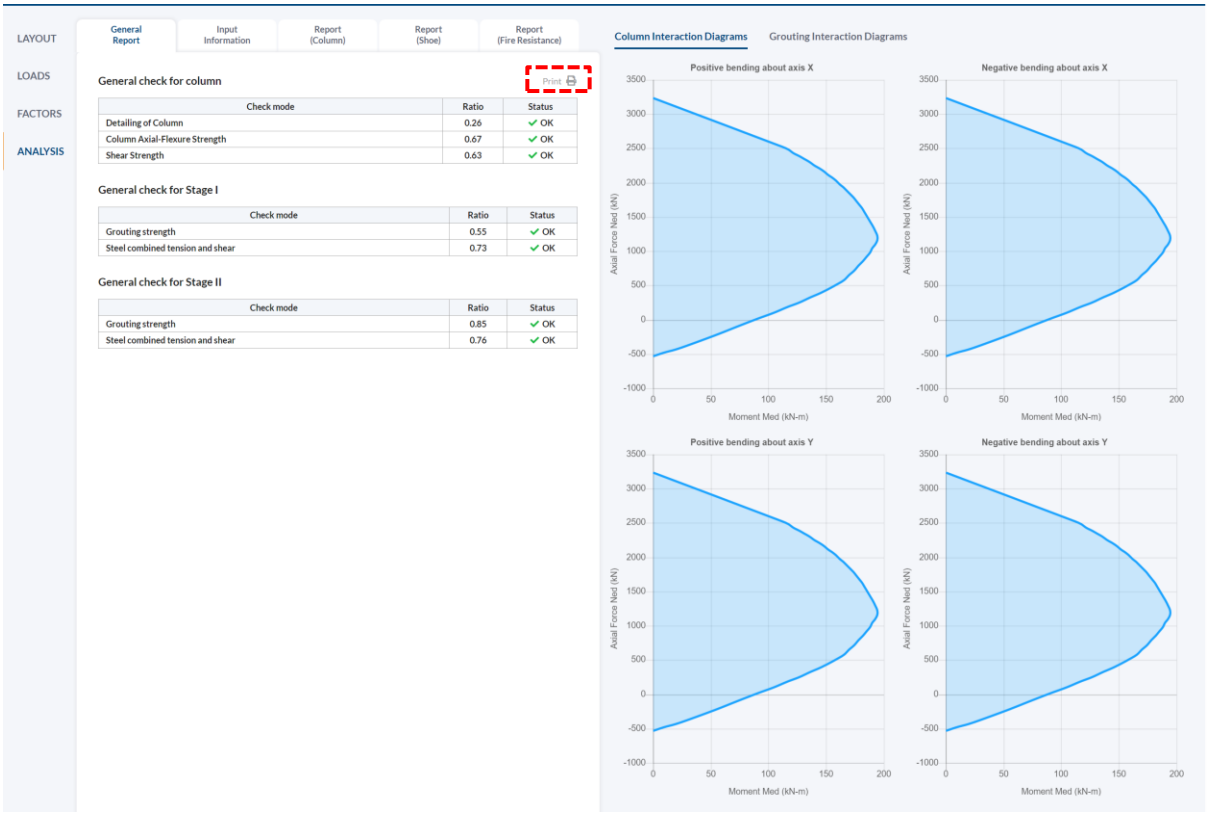
Users can go any time to the Project Detail page and change the National annexe, the application will be affected by this change and bring new values to the factor page.

Application has 4 options in the Lever arm case and two options for Steel combined Check. Recommended formulas are defined as default. Advanced users can select other cases.



5. ANALYSIS

The application doesn't have any run button. It performs calculatıon when the Analysis page is selected. After the calculation is completed analysis summary table appears in the first tab and the interaction diagrams appear on the right. Other tabs are Input information, Column Report, Shoe report and Fire resistance report. Users can print to report by clicking Print icon.



Before we continue, the following loads and dimensions were defined in the application as an example to talk about the analysis page and its tabs.

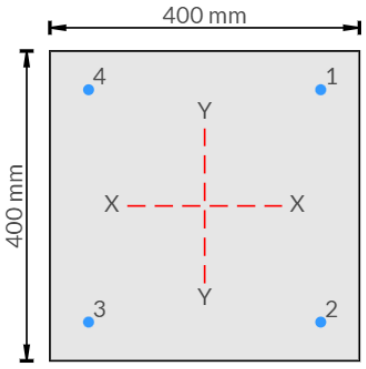
Project Information Print

Engineer Name:	Fatih Aydoğmuş
Organization:	
Address:	
Phone:	
Email:	
Project Name:	Example 2022
Project ID:	
Project Location:	
Project Notes:	

Input Data

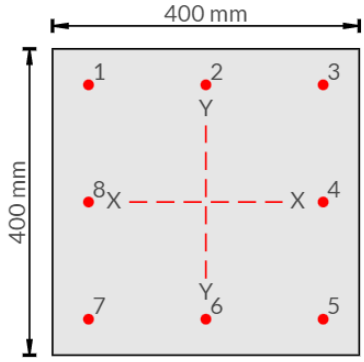
Column Width:	400 mm	Grouting Width:	400 mm
Column Length:	400 mm	Grouting Length:	400 mm
Column Eccentricity (X):	0 mm	Grouting Thickness:	50 mm
Column Eccentricity (Y):	0 mm	Grouting Material:	C30
Column Material:	C30	Shoe Type:	RPK-N3
Foundation Length:	1000 mm	Anchor Type:	RPP-P-M16
Foundation Width:	1000 mm		
Foundation Thickness:	810 mm		
Foundation Material:	C20		

Grouting anchors



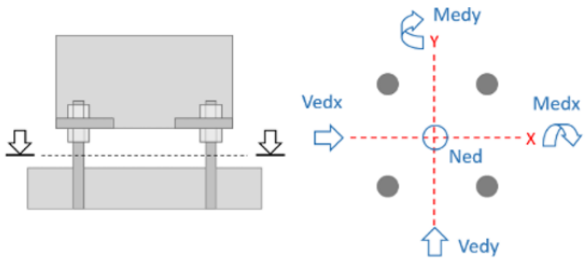
Anchor ID	X, mm	Y, mm	Size, mm
1	150.00	150.00	M16
2	150.00	-150.00	M16
3	-150.00	-150.00	M16
4	-150.00	150.00	M16

Column reinforcement



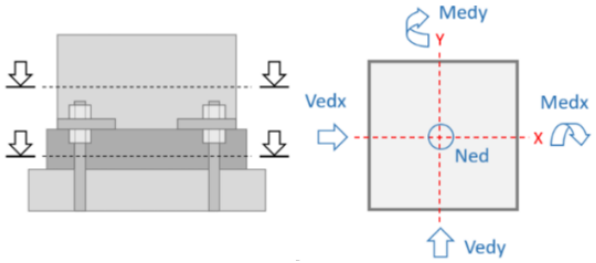
Rebar ID	X, mm	Y, mm	d, mm
1	-153.00	153.00	14
2	0.00	153.00	14
3	153.00	153.00	14
4	153.00	0.00	14
5	153.00	-153.00	14
6	0.00	-153.00	14
7	-153.00	-153.00	14
8	-153.00	0.00	14

Loads before grouting (Stage I) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	15	0	7.5	5	0	
2	15	7.5	0	0	5	

Loads after grouting (Stage II) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	100	50	40	30	20	

Loads at column section

Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	110	60	50	40	30	

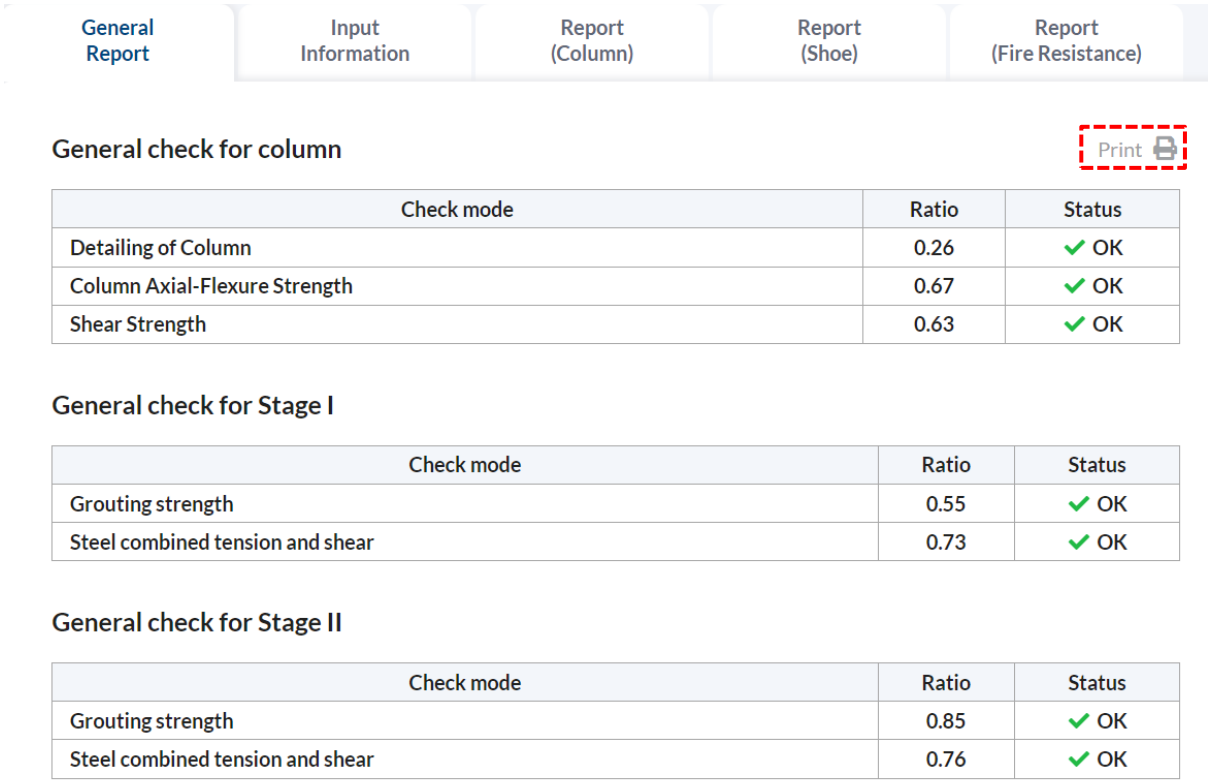
Fire class is R90, load cases for fire resistance given in the table below.

	N_{Ed} (kN)	M_{Edx} (kN-m)	M_{Edy} (kN-m)	Notes
1	80.00	20.00	20.00	

5.1. General Report

In this tab user can see calculation summary with the Ratios, values must be smaller then 1.00.

Users can print to report by clicking Print icon.



5.2. Input Information

Input information shows all values you entered in the application except fire resistance values. Example report is given in the appendix.

5.3. Report (Column)

Column Details which is defined by user are shown. If users entered load cases for Stage II into the column section; Column Axial-Flexure Strength and Shear Strength calculations are shown in the report. Otherwise, only column details are shown. As a reminder, this option is given as a bonus option for the engineers to make a second check on their column design, not for the column shoe design. Example report is given in the appendix.

5.4. Report (Shoe)

Users can see each anchor, axial and shear force results and ratios for both Stages I and Stage II cases. All calculation steps were written in the report clearly to show the calculation method to the engineer. Example report is given in the appendix.

5.5. Report (Fire Resistance)

In the Fire resistance report, users can follow concrete temperature distribution in the column and anchor temperatures according to their fire class. Anchor temperatures will affect anchor strength. The application will calculate new reduced strength according to temperature and shows if the anchor strength is sufficient or not for related load cases. Example report is given in the appendix.

Appendix

- General Report
- Input Information
- Column Report
- Shoe Report
- Fire Resistance Report

NOTES

TECHNICAL MANUAL REVISIONS

01.10.2022 (FA)

- First edition

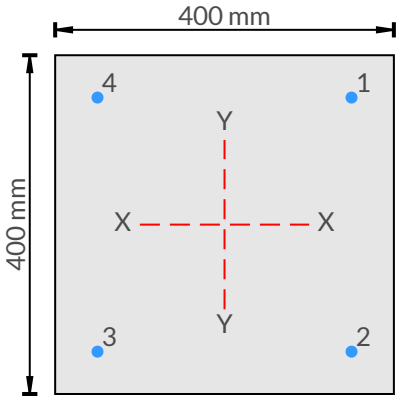
Project Information

Engineer Name:	Fatih Aydoğmuş
Organization:	
Address:	
Phone:	
Email:	
Project Name:	Example 2022
Project ID:	
Project Location:	
Project Notes:	

Input Data

Column Width:	400 mm	Grouting Width:	400 mm
Column Length:	400 mm	Grouting Length:	400 mm
Column Eccentricity (X):	0 mm	Grouting Thickness:	50 mm
Column Eccentricity (Y):	0 mm	Grouting Material:	C30
Column Material:	C30	Shoe Type:	RPK-N3
Foundation Length:	1000 mm	Anchor Type:	RPP-P-M16
Foundation Width:	1000 mm		
Foundation Thickness:	810 mm		
Foundation Material:	C20		

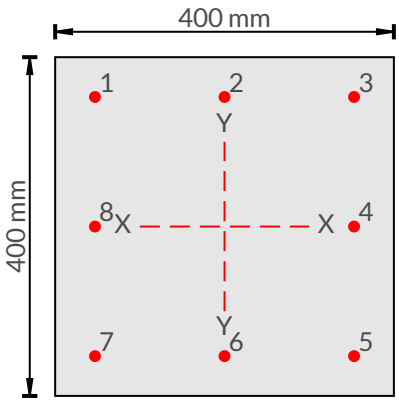
Grouting anchors



Anchor ID	X, mm	Y, mm	Size, mm
1	150.00	150.00	M16
2	150.00	-150.00	M16
3	-150.00	-150.00	M16
4	-150.00	150.00	M16

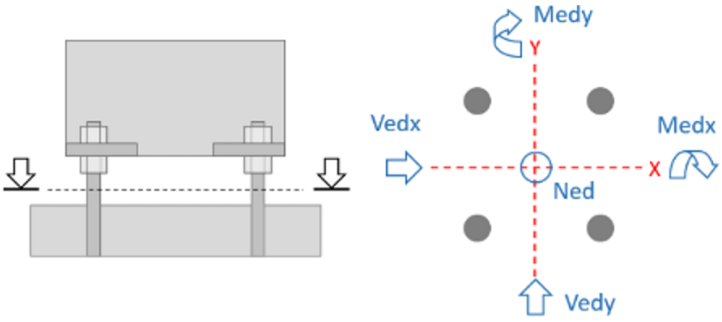
Column reinforcement

Rebar ID	X, mm	Y, mm	d, mm
1	-153.00	153.00	14
2	0.00	153.00	14
3	153.00	153.00	14
4	153.00	0.00	14



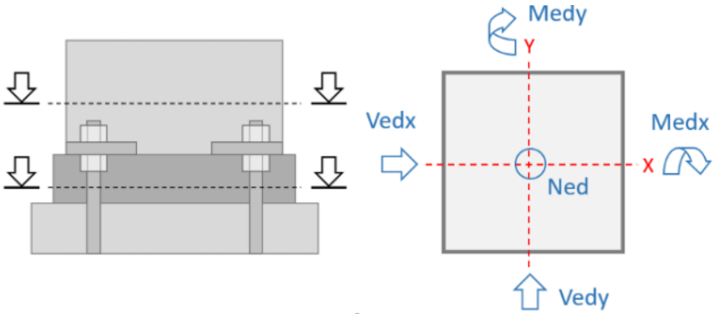
Rebar ID	X, mm	Y, mm	d, mm
5	153.00	-153.00	14
6	0.00	-153.00	14
7	-153.00	-153.00	14
8	-153.00	0.00	14

Loads before grouting (Stage I) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	15	0	7.5	5	0	
2	15	7.5	0	0	5	

Loads after grouting (Stage II) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	100	50	40	30	20	

Loads at column section

Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	110	60	50	40	30	

General check for column

Check mode	Ratio	Status
Detailing of Column	0.26	✔ OK

Check mode	Ratio	Status
Column Axial-Flexure Strength	0.67	✔ OK
Shear Strength	0.63	✔ OK

General check for Stage I

Check mode	Ratio	Status
Grouting strength	0.55	✔ OK
Steel combined tension and shear	0.73	✔ OK

General check for Stage II

Check mode	Ratio	Status
Grouting strength	0.85	✔ OK
Steel combined tension and shear	0.76	✔ OK
Fire resistance	0.41	✔ OK

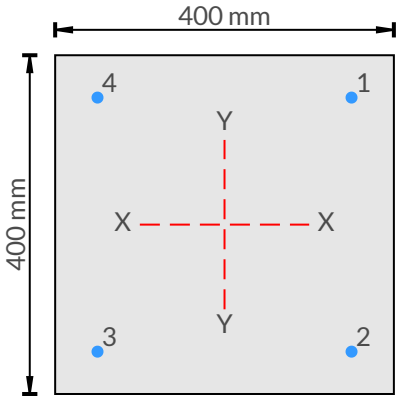
Project Information

Engineer Name:	Fatih Aydoğmuş
Organization:	
Address:	
Phone:	
Email:	
Project Name:	Example 2022
Project ID:	
Project Location:	
Project Notes:	

Input Data

Column Width:	400 mm	Grouting Width:	400 mm
Column Length:	400 mm	Grouting Length:	400 mm
Column Eccentricity (X):	0 mm	Grouting Thickness:	50 mm
Column Eccentricity (Y):	0 mm	Grouting Material:	C30
Column Material:	C30	Shoe Type:	RPK-N3
Foundation Length:	1000 mm	Anchor Type:	RPP-P-M16
Foundation Width:	1000 mm		
Foundation Thickness:	810 mm		
Foundation Material:	C20		

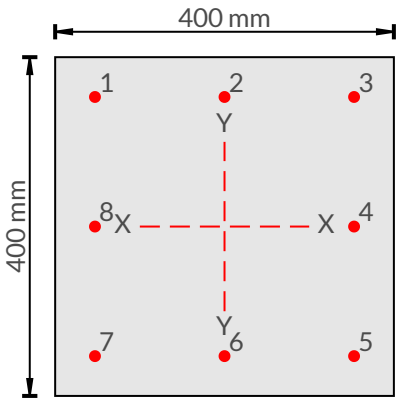
Grouting anchors



Anchor ID	X, mm	Y, mm	Size, mm
1	150.00	150.00	M16
2	150.00	-150.00	M16
3	-150.00	-150.00	M16
4	-150.00	150.00	M16

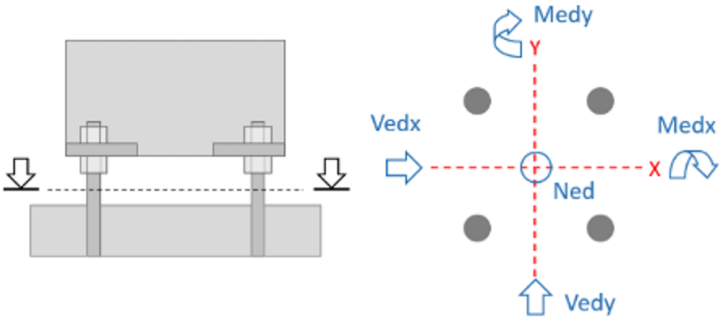
Column reinforcement

Rebar ID	X, mm	Y, mm	d, mm
1	-153.00	153.00	14
2	0.00	153.00	14
3	153.00	153.00	14
4	153.00	0.00	14



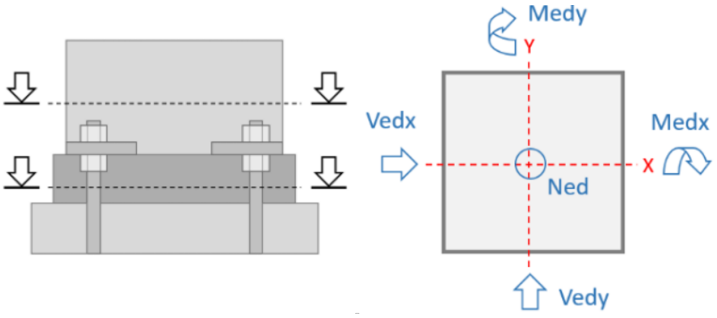
Rebar ID	X, mm	Y, mm	d, mm
5	153.00	-153.00	14
6	0.00	-153.00	14
7	-153.00	-153.00	14
8	-153.00	0.00	14

Loads before grouting (Stage I) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	15	0	7.5	5	0	
2	15	7.5	0	0	5	

Loads after grouting (Stage II) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	100	50	40	30	20	

Loads at column section

Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	110	60	50	40	30	

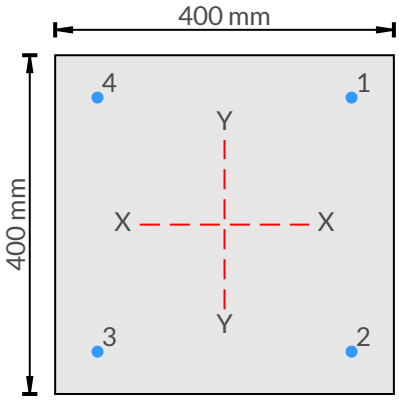
Project Information

Engineer Name:	Fatih Aydoğmuş
Organization:	
Address:	
Phone:	
Email:	
Project Name:	Example 2022
Project ID:	
Project Location:	
Project Notes:	

Input Data

Column Width:	400 mm	Grouting Width:	400 mm
Column Length:	400 mm	Grouting Length:	400 mm
Column Eccentricity (X):	0 mm	Grouting Thickness:	50 mm
Column Eccentricity (Y):	0 mm	Grouting Material:	C30
Column Material:	C30	Shoe Type:	RPK-N3
Foundation Length:	1000 mm	Anchor Type:	RPP-P-M16
Foundation Width:	1000 mm		
Foundation Thickness:	810 mm		
Foundation Material:	C20		

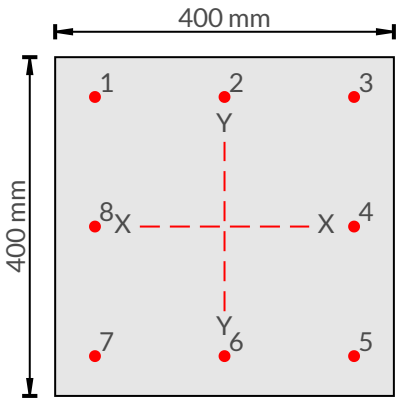
Grouting anchors



Anchor ID	X, mm	Y, mm	Size, mm
1	150.00	150.00	M16
2	150.00	-150.00	M16
3	-150.00	-150.00	M16
4	-150.00	150.00	M16

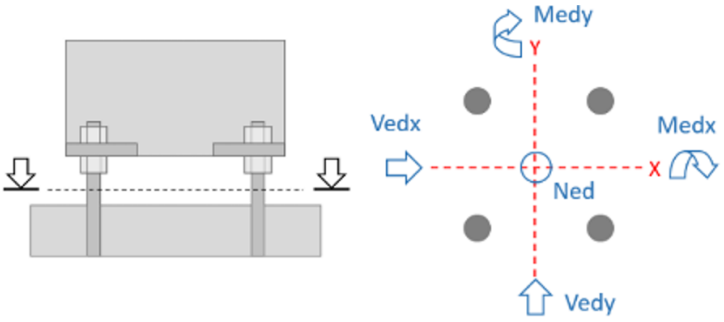
Column reinforcement

Rebar ID	X, mm	Y, mm	d, mm
1	-153.00	153.00	14
2	0.00	153.00	14
3	153.00	153.00	14
4	153.00	0.00	14



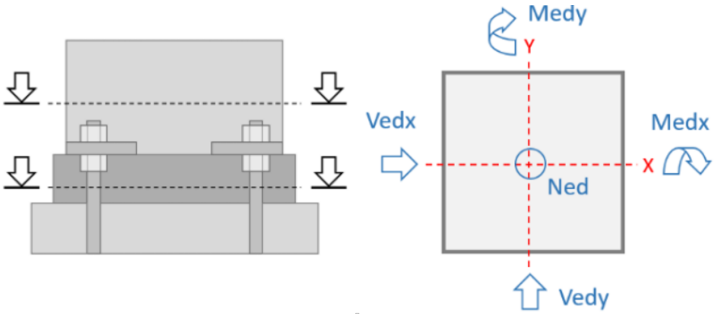
Rebar ID	X, mm	Y, mm	d, mm
5	153.00	-153.00	14
6	0.00	-153.00	14
7	-153.00	-153.00	14
8	-153.00	0.00	14

Loads before grouting (Stage I) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	15	0	7.5	5	0	
2	15	7.5	0	0	5	

Loads after grouting (Stage II) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	100	50	40	30	20	

Loads at column section

Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	110	60	50	40	30	

Detailing of Column

Module of Elasticity E_{cm} = 33000.00 MPa
Characteristic strength of concrete f_{ck} = 30.00 MPa

Design strength of concrete f_{cd} = 17.00 MPa
Characteristic strength of main rebar f_{yk} = 500.00 MPa
Characteristic strength of shear rebar f_{ywk} = 400.00 MPa
Design strength of rebar f_{yd} = 434.78 MPa
Section concrete area A_c = 160000.00 mm^2
Longitudinal rebar area A_{st} = 1231.50 mm^2
Shear links area A_{sw} = 100.53 mm^2
Shear links spacing s = 100.00 mm

Maximum allowed longitudinal reinforcement (EN 1992-1-1, 9.5.2(2), 9.5.2(3)):

$$f_{ctm} = 0.3 \cdot f_{ck}^{2/3} = 0.3 \cdot 30.00^{2/3} = 2.90 \text{ MPa}$$

$$A_{s,max} = 0.04 \cdot A_c = 0.04 \cdot 160000 = 6400.00 \text{ mm}^2$$

Minimum allowed longitudinal reinforcement (EN 1992-1-1, 9.2.1.1)

$$A_{s,min1} = 0.1 \cdot \frac{N_{ed}}{f_{yd}} = 0.1 \cdot \frac{110000.00}{434.78} = 25.30 \text{ mm}^2$$

$$A_{s,min2} = 0.002 \cdot A_c = 0.002 \cdot 160000.00 = 320.00 \text{ mm}^2$$

$$A_{s,min} = max\left[A_{s,min1}, A_{s,min2}\right] = 320.00 \text{ mm}^2$$

Check of allowed longitudinal reinforcement:

$$A_{st} = 1231.50 \text{ mm}^2 \leq A_{s,max} = 6400.00 \text{ mm}^2$$

$$A_{st} = 1231.50 \text{ mm}^2 \geq A_{s,min} = 320.00 \text{ mm}^2$$

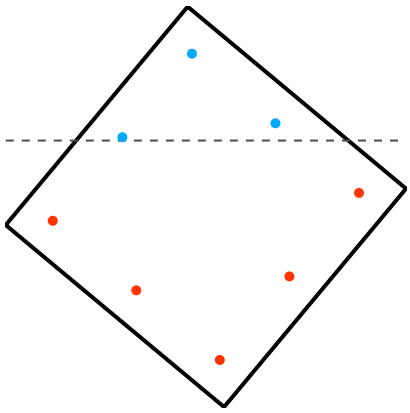
Status: ✔ OK

Column Axial-Flexure Strength

Characteristic strength of concrete f_{ck}: 30.00 MPa
Design strength of concrete f_{cd}: 17.00 MPa
Characteristic strength of rebar f_{yk}: 500.00 MPa
Design strength of rebar f_{yd}: 434.78 MPa

Load Case 1. Axial + Flexure check

Angle of section neutral axis rotation: 140.19 deg.



– NA, ∘Tensioned bar, ∘ Compressed bar

Actual bending moment in section

$$M_{zy} = \sqrt{M_z^2 + M_y^2} = \sqrt{60^2 + 50.00^2} = 78.10 \text{ kN-m}$$

$$e_{xy} = M_{zy} / N_{Edx} = 78.10 / 110.00 = 0.71002$$

Axial load capacity for concentric loading (10.10.4)

$$N_{Rd} = \eta \cdot f_{cd} \cdot (A_c - A_{st}) + f_{yd} \cdot A_{st} = (17.00 \cdot (160000.00 - 1231.50) + 434.78 \cdot 1231.50) \cdot 0.001 = 3234.50 \text{ kN}$$

Axial + flexure capacity

$$N_r = 168.74 \text{ kN}, M_{Rd} = 116.74 \text{ kN-m}$$

$$N_{Edx} = 110.00 \text{ kN} \leq N_r = 168.74 \text{ kN (Ratio: 0.652)}$$

$$M_{zy} = 78.10 \text{ kN-m} \leq M_{Rd} = 116.74 \text{ kN-m (Ratio: 0.669)}$$

$$N_{Edx} = 110.00 \text{ kN} \leq N_{Rd} = 3234.50 \text{ kN (Ratio: 0.034)}$$

Status: ✔ OK

Shear Strength

Load Case: 1

Calculation of design shear resistance of concrete $V_{Rd,c}$ (6.2.2(1))

$$C_{Rd,c} = 0.18 / \gamma_c = 0.18 / 1.5 = 0.12$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{353.00}} = 1.75 \leq 2.0$$

$$\rho_1 = \frac{A_{sl}}{(b_w \cdot d)} = \frac{461.81}{(400 \cdot 353.00)} = 0.0033 \leq 0.02$$

$$\sigma_{cp} = \frac{N_{ed}}{A_c} = \frac{110.00}{160000.00} = 0.00 \text{ MPa} \leq 0.2 \cdot f_{cd} = 0.2 \cdot 17.00 = 3.40 \text{ MPa}$$

$$k_1 = 0.15$$

$$V_{Rd,c1} = \left[C_{Rd,c1} \cdot k \cdot (100 \cdot \rho_1 \cdot f_{ck})^{1/3} + k_1 \cdot \sigma_{cp}\right] \cdot b_w \cdot d =$$

$$= \left[0.12 \cdot 1.75 \cdot (100 \cdot 0.00 \cdot 30)^{1/3} + 0.15 \cdot 0.00\right] \cdot 400 \cdot 353.00 = 63.59 \text{ kN}$$

$$V_{Rd,c2} = \left[0.035 \cdot k^{3/2} \cdot f_{ck}^{1/2} + k_1 \cdot \sigma_{cp}\right] \cdot b_w \cdot d =$$

$$= \left[0.035 \cdot 1.75^{3/2} \cdot 30^{1/2} + 0.15 \cdot 0.00\right] \cdot 400 \cdot 353.00 = 62.82 \text{ kN}$$

$$V_{Rd,c} = max\left\{V_{Rd,c1}, V_{Rd,c2}\right\} = 63.59 \text{ kN}$$

$$V_{Ed} = 40.00 \text{ kN} \leq V_{Rd,c} = 63.59 \text{ kN}$$

No need to consider shear reinforcement

Status: ✔ OK

Calculation of design shear resistance of concrete $V_{Rd,c}$ (6.2.2(1))

$$C_{Rd,c} = 0.18 / \gamma_c = 0.18 / 1.5 = 0.12$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{353.00}} = 1.75 \leq 2.0$$

$$\rho_1 = \frac{A_{sl}}{(b_w \cdot d)} = \frac{461.81}{(400 \cdot 353.00)} = 0.0033 \leq 0.02$$

$$\sigma_{cp} = \frac{N_{ed}}{A_c} = \frac{110.00}{160000.00} = 0.00 \text{ MPa} \leq 0.2 \cdot f_{cd} = 0.2 \cdot 17.00 = 3.40 \text{ MPa}$$

$$k_1 = 0.15$$

$$V_{Rd,c1} = \left[C_{Rd,c1} \cdot k \cdot (100 \cdot \rho_1 \cdot f_{ck})^{1/3} + k_1 \cdot \sigma_{cp}\right] \cdot b_w \cdot d =$$

$$= \left[0.12 \cdot 1.75 \cdot (100 \cdot 0.00 \cdot 30)^{1/3} + 0.15 \cdot 0.00\right] \cdot 400 \cdot 353.00 = 63.59 \text{ kN}$$

$$V_{Rd,c2} = \left[0.035 \cdot k^{3/2} \cdot f_{ck}^{1/2} + k_1 \cdot \sigma_{cp}\right] \cdot b_w \cdot d =$$

$$= \left[0.035 \cdot 1.75^{3/2} \cdot 30^{1/2} + 0.15 \cdot 0.00\right] \cdot 400 \cdot 353.00 = 62.82 \text{ kN}$$

$$V_{Rd,c} = max\left\{V_{Rd,c1}, V_{Rd,c2}\right\} = 63.59 \text{ kN}$$

$$V_{Ed} = 30.00 \text{ kN} \leq V_{Rd,c} = 63.59 \text{ kN}$$

No need to consider shear reinforcement

Status: ✔ OK

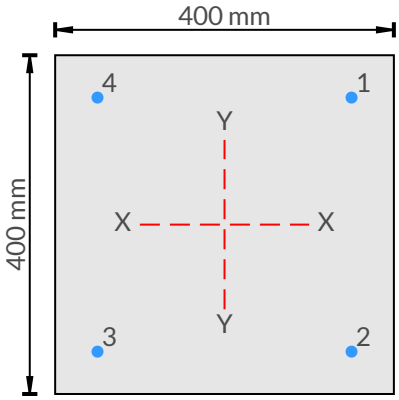
Project Information

Engineer Name:	Fatih Aydoğmuş
Organization:	
Address:	
Phone:	
Email:	
Project Name:	Example 2022
Project ID:	
Project Location:	
Project Notes:	

Input Data

Column Width:	400 mm	Grouting Width:	400 mm
Column Length:	400 mm	Grouting Length:	400 mm
Column Eccentricity (X):	0 mm	Grouting Thickness:	50 mm
Column Eccentricity (Y):	0 mm	Grouting Material:	C30
Column Material:	C30	Shoe Type:	RPK-N3
Foundation Length:	1000 mm	Anchor Type:	RPP-P-M16
Foundation Width:	1000 mm		
Foundation Thickness:	810 mm		
Foundation Material:	C20		

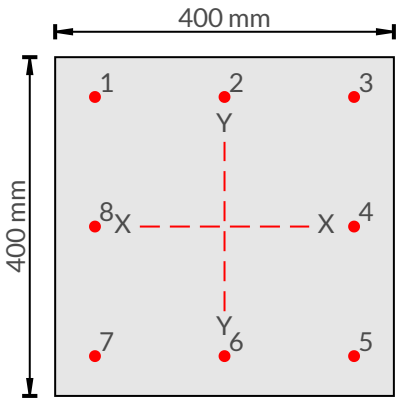
Grouting anchors



Anchor ID	X, mm	Y, mm	Size, mm
1	150.00	150.00	M16
2	150.00	-150.00	M16
3	-150.00	-150.00	M16
4	-150.00	150.00	M16

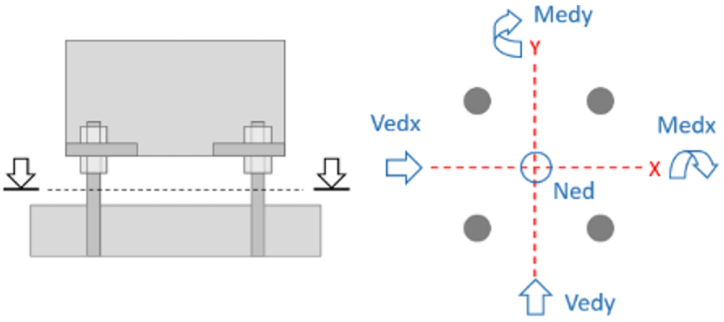
Column reinforcement

Rebar ID	X, mm	Y, mm	d, mm
1	-153.00	153.00	14
2	0.00	153.00	14
3	153.00	153.00	14
4	153.00	0.00	14



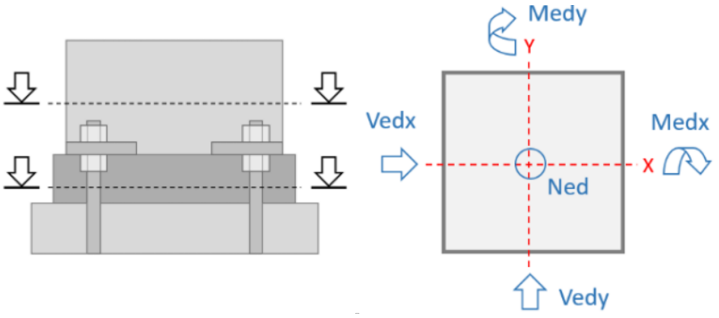
Rebar ID	X, mm	Y, mm	d, mm
5	153.00	-153.00	14
6	0.00	-153.00	14
7	-153.00	-153.00	14
8	-153.00	0.00	14

Loads before grouting (Stage I) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	15	0	7.5	5	0	
2	15	7.5	0	0	5	

Loads after grouting (Stage II) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	100	50	40	30	20	

Loads at column section

Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	110	60	50	40	30	

Column Shoe Resistance (RPK-N3/M16)

Stress area in thread of anchor bolt A_{bolt} = 157.00 mm^2

Thickness of the shoe base plate t_{base} = 15.00 mm

Diameter of nominal stress area in thread of anchor bolt d_b = 14.14 mm

Nominal diameter of anchor bolt d_0 = 16.00 mm

Yield strength of the steel in the anchor bolt $f_{bolt,y}$ = 500.00 MPa

Ultimate strength of the steel in the anchor bolt $f_{bolt,u}$ = 550.00 MPa

Ultimate strength of the foundation $f_{base,u}$ = 510.00 MPa

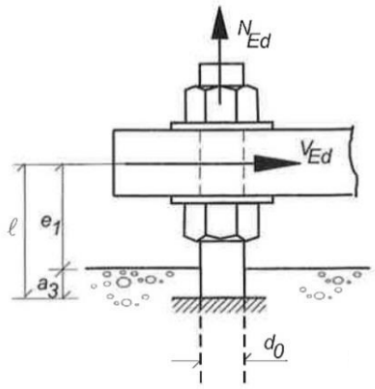
Grouting concrete characteristic strength $f_{grout,ck}$ = 30.00 MPa

Grouting concrete design strength $f_{grout,cd} = \alpha_{cc} \cdot f_{grout,ck} / \gamma_c = 0.85 \cdot 30.00 / 1.50 = 17.00$ MPa

Resistance of a column shoe in tension and compression:

$$N_{Rd} = \eta_d \cdot min \left\{ \frac{f_{bolt,u} \cdot 0.9}{\gamma_{M2}}; \frac{f_{bolt,y}}{1.15} \right\} \cdot A_{bolt} = 1.00 \cdot min \left\{ \frac{550 \cdot 0.9}{1.25}; \frac{500}{1.15} \right\} \cdot 157 \cdot 10^{-3} = 62.17 \text{ kN}$$

Nominal design shear resistance of bolt during installation and prior to grouting of the base (EN 1993-1-8, EN 1993-1-11):



$$e_1 = t_{grout} + 0.5 \cdot t_{base} = 50.00 + 0.5 \cdot 15.00 = 57.50 \text{ mm}$$

$$a_3 = 0.5 \cdot d_b = 0.5 \cdot 14.14 = 7.069 \text{ mm}$$

$$l = e_1 + a_3 = 57.50 + 7.07 = 64.57 \text{ mm}$$

$$W_{el} = \frac{\pi \cdot d_b^3}{32} = \frac{3.14 \cdot 14.14^3}{32} = 277.47 \text{ mm}$$

$$M_{Rk,s}^0 = 1.2 \cdot W_{el} \cdot f_{bolt,u} = 1.2 \cdot 277.47 \cdot 550.00 = 183129.57 \text{ N-mm}$$

$$M_{Rk,s} = M_{Rk,s}^0 \cdot (1 - N_{sd}/N_{Rd,s}) = 183.13 \text{ kN-m (Nsd} = 0\text{; shear only)}$$

$$V_{Rk,s} = \frac{a_m \cdot M_{Rk,s}}{l} = \frac{2.00 \cdot 183.13}{64.57} = 5.67 \text{ kN}$$

$$V_{Rd(stageI)} = \frac{V_{Rk,s}}{\gamma_s} = \frac{5.67}{1.25} = 4.54 \text{ kN}$$

Shear resistance of a column shoe (EN 1993-1-8, 6.2.2):

$$\alpha_b = 0.44 - 0.0003 \cdot f_{bolt,y} = 0.44 - 0.0003 \cdot 500.00 = 0.290$$

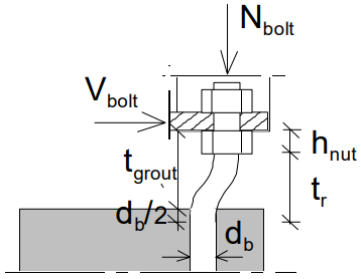
$$F_{1,vb,Rd} = \frac{k_1 \cdot a_b \cdot f_{base,u} \cdot d_b \cdot t_{base}}{\gamma_{M2}} = \frac{1 \cdot 1 \cdot 510 \cdot 14.14 \cdot 15}{1.25} \cdot 10^{-3} = 86.53 \text{ kN}$$

$$F_{2,vb,Rd} = \frac{\alpha_b \cdot f_{bolt,u} \cdot A_{bolt}}{\gamma_{M2}} = \frac{0.290 \cdot 550 \cdot 157}{1.25} \cdot 10^{-3} = 20.03 \text{ kN}$$

$$F_{3,vb,Rd} = \frac{0.5 \cdot f_{bolt,u} \cdot A_{bolt}}{\gamma_{M2}} = \frac{0.5 \cdot 550 \cdot 157}{1.25} \cdot 10^{-3} = 34.54 \text{ kN}$$

$$V_{Rd} = min\left\{F_{1,vb,Rd}; F_{2,vb,Rd}; F_{3,vb,Rd}\right\} = 20.03 \text{ kN}$$

Anchors (Stage I)



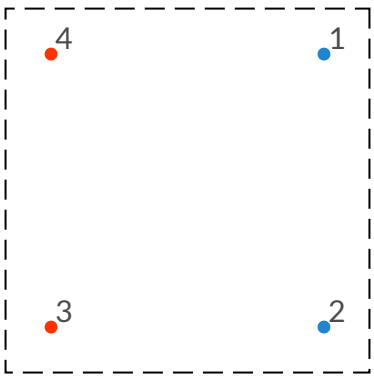
$$\text{Axial Force Criterion: } \frac{N_{Ed,1}}{N_{Rd}} \leq 1.0$$

$$\text{Shear Force Criterion: } \frac{V_{Ed,1}}{V_{Rd}} \leq 1.0$$

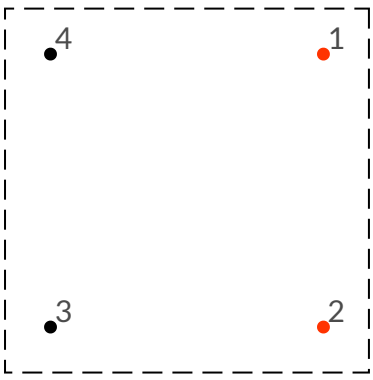
$$\text{Combined Check Criterion: } \frac{16 \cdot |V_{Ed,1}| \cdot t_R}{\pi \cdot d_b^3} + \frac{4 \cdot |N_{Ed,1}|}{\pi \cdot d_b^2} \leq f_{bolt,yd}$$

Load Case 1

N_{Ed}, kN	M_{xEd}, kN-m	M_{yEd}, kN-m	V_{xEd}, kN-m	V_{yEd}, kN-m
15.00	0.00	7.50	5.00	0.00



Axial loading:
- Tensioned (-)
- Compressed (+)



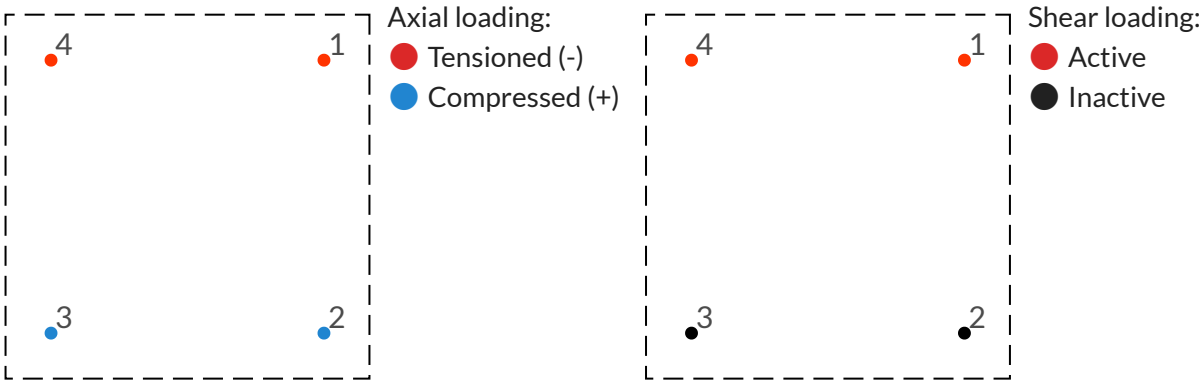
Shear loading:
- Active
- Inactive

Capacity check

ID	$N_{Ed,1}$, kN	N_{Rd}, kN	Axial Ratio	V_{Ed1}, kN	V_{Rd}, kN	Shear Ratio	$\sigma_{Ed,1}$, MPa	$f_{bolt,yd}$, MPa	Combined Ratio	Status
1	16.24	62.17	0.26	2.50	4.54	0.55	288.48	396.00	0.73	✔ OK
2	16.24	62.17	0.26	2.50	4.54	0.55	288.48	396.00	0.73	✔ OK
3	-8.74	62.17	0.14	0.00	4.54	0.00	55.69	396.00	0.14	✔ OK
4	-8.74	62.17	0.14	0.00	4.54	0.00	55.69	396.00	0.14	✔ OK

Load Case 2

N_{Ed}, kN	M_{xEd}, kN-m	M_{yEd}, kN-m	V_{xEd}, kN-m	V_{yEd}, kN-m
15.00	7.50	0.00	0.00	5.00



Capacity check

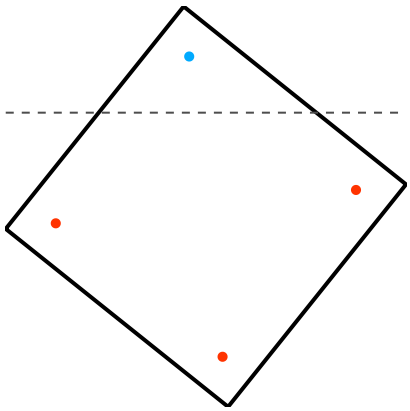
ID	$N_{Ed,1}$, kN	N_{Rd}, kN	Axial Ratio	V_{Ed1}, kN	V_{Rd}, kN	Shear Ratio	$\sigma_{Ed,1}$, MPa	$f_{bolt,yd}$, MPa	Combined Ratio	Status
1	-8.74	62.17	0.14	2.50	4.54	0.55	240.71	396.00	0.61	✔ OK
2	16.24	62.17	0.26	0.00	4.54	0.00	103.46	396.00	0.26	✔ OK
3	16.24	62.17	0.26	0.00	4.54	0.00	103.46	396.00	0.26	✔ OK
4	-8.74	62.17	0.14	2.50	4.54	0.55	240.71	396.00	0.61	✔ OK

Anchors (Stage II)

Characteristic strength of concrete f_{ck}: 30.00 MPa
Design strength of concrete f_{cd}: 17.00 MPa
Characteristic strength of rebar f_{yk}: 500.00 MPa
Design strength of rebar f_{yd}: 396.00 MPa

Load Case 1. Axial + Flexure check

Angle of section neutral axis rotation: 141.34 deg.



– NA, ∘Tensioned bar, ∘ Compressed bar

Actual bending moment in section

$$M_{zy} = \sqrt{M_z^2 + M_y^2} = \sqrt{50^2 + 40.00^2} = 64.03 \text{ kN-m}$$

$$e_{xy} = M_{zy}/N_{Edx} = 64.03/100.00 = 0.64031$$

Axial load capacity for concentric loading (10.10.4)

$$N_{Rd} = \eta \cdot f_{cd} \cdot (A_c - A_{st}) + f_{yd} \cdot A_{st} = (17.00 \cdot (160000.00 - 628.00) + 396.00 \cdot 628.00) \cdot 0.001 = 2958.01 \text{ kN}$$

Axial + flexure capacity

$$N_r = 119.95 \text{ kN}, M_{Rd} = 75.38 \text{ kN-m}$$

$$N_{Edx} = 100.00 \text{ kN} \leq N_r = 119.95 \text{ kN (Ratio: 0.834)}$$

$$M_{zy} = 64.03 \text{ kN-m} \leq M_{Rd} = 75.38 \text{ kN-m (Ratio: 0.849)}$$

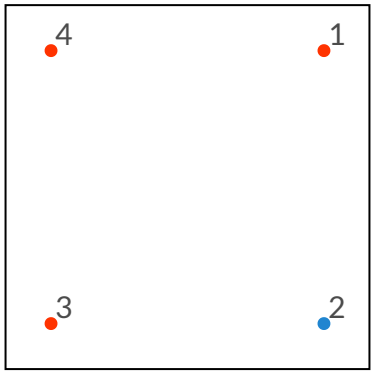
$$N_{Edx} = 100.00 \text{ kN} \leq N_{Rd} = 2958.01 \text{ kN (Ratio: 0.034)}$$

Status: ✔ OK

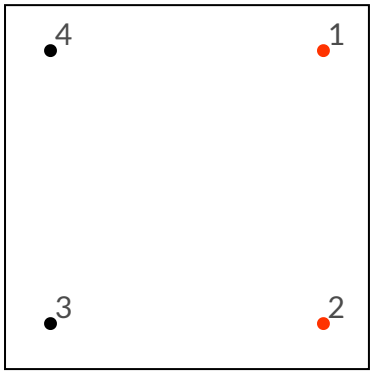
Anchor forces distribution

Load Case 1

N_{Ed}, kN	M_{xEd}, kN-m	M_{yEd}, kN-m	V_{xEd}, kN-m	V_{yEd}, kN-m
100.00	50.00	40.00	30.00	20.00



Axial loading:
- Tensioned (-)
- Compressed (+)



Shear loading:
- Active
- Inactive

Capacity check

$$\text{Combined Force: } \frac{|N_{Ed,1}|}{1.4 \cdot N_{Rd}} + \frac{|V_{Ed,1}|}{V_{Rd}} < 1.0$$

ID	$\sigma_{Ed,1}$, MPa	$N_{Ed,1}$, kN	N_{Rd}, kN	Axial Ratio	V_{Ed1}, kN	V_{Rd}, kN	Shear Ratio	Combined Ratio	Combined Status
1	-198.20	-31.12	62.17	0.50	8.03	20.03	0.40	0.76	✔ OK
2	129.60	20.35	62.17	0.33	8.03	20.03	0.40	0.63	✔ OK
3	-99.46	-15.62	62.17	0.25	0.00	20.03	0.00	0.00	✔ OK
4	-396.00	-62.17	62.17	1.00	0.00	20.03	0.00	0.00	✔ OK

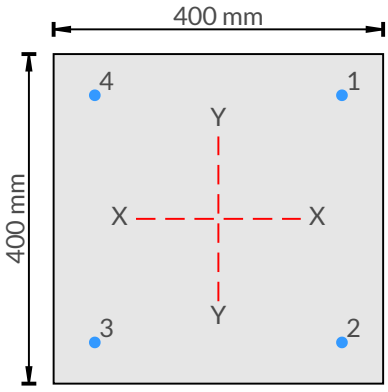
Project Information

Engineer Name:	Fatih Aydoğmuş
Organization:	
Address:	
Phone:	
Email:	
Project Name:	Example 2022
Project ID:	
Project Location:	
Project Notes:	

Input Data

Column Width:	400 mm	Grouting Width:	400 mm
Column Length:	400 mm	Grouting Length:	400 mm
Column Eccentricity (X):	0 mm	Grouting Thickness:	50 mm
Column Eccentricity (Y):	0 mm	Grouting Material:	C30
Column Material:	C30	Shoe Type:	RPK-N3
Foundation Length:	1000 mm	Anchor Type:	RPP-P-M16
Foundation Width:	1000 mm		
Foundation Thickness:	810 mm		
Foundation Material:	C20		

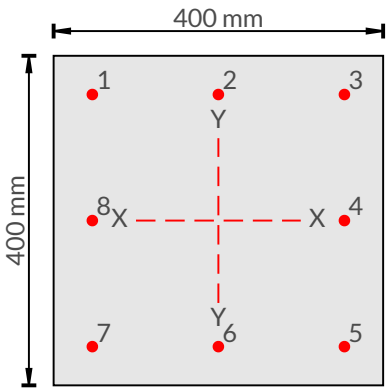
Grouting anchors



Anchor ID	X, mm	Y, mm	Size, mm
1	150.00	150.00	M16
2	150.00	-150.00	M16
3	-150.00	-150.00	M16
4	-150.00	150.00	M16

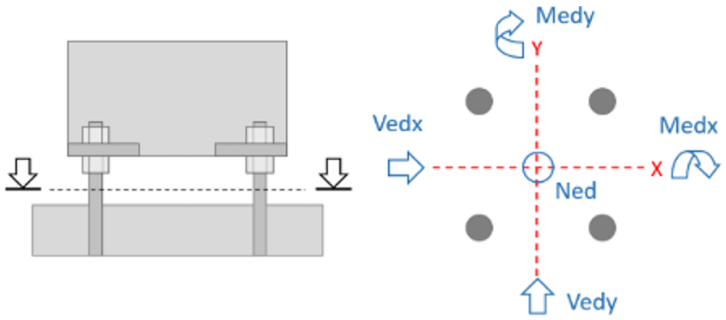
Column reinforcement

Rebar ID	X, mm	Y, mm	d, mm
1	-153.00	153.00	14
2	0.00	153.00	14
3	153.00	153.00	14
4	153.00	0.00	14
5	153.00	-153.00	14



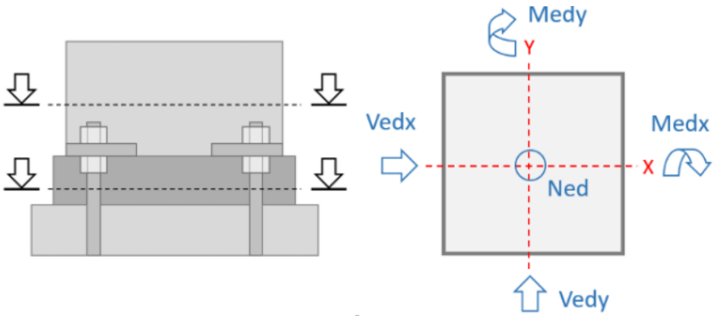
Rebar ID	X, mm	Y, mm	d, mm
6	0.00	-153.00	14
7	-153.00	-153.00	14
8	-153.00	0.00	14

Loads before grouting (Stage I) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	15	0	7.5	5	0	
2	15	7.5	0	0	5	

Loads after grouting (Stage II) - Anchors section



Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	100	50	40	30	20	

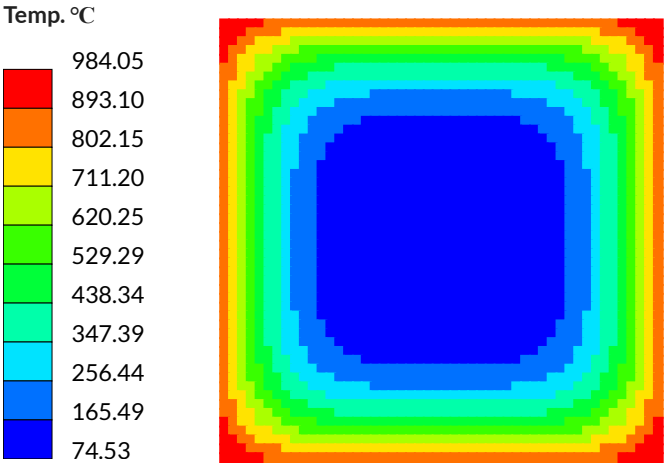
Loads at column section

Load Case	N_{Ed}, kN	M_{Edx}, kN-m	M_{Edy}, kN-m	V_{Edx}, kN	V_{Edy}, kN	Notes
1	110	60	50	40	30	

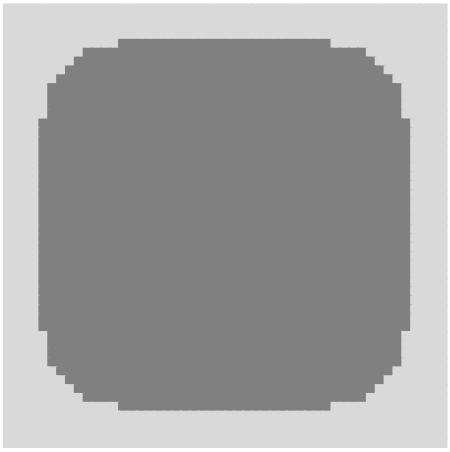
Fire Resistance

Grouting section thermal properties for Fire Class R90

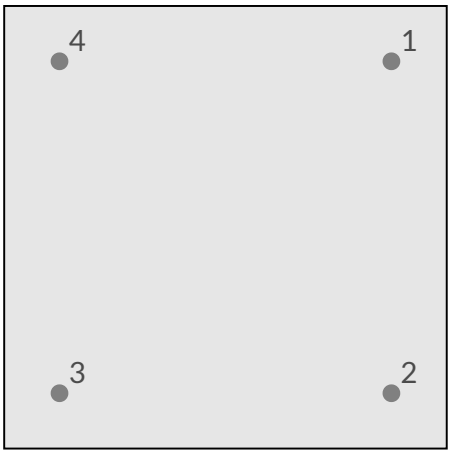
Eurocode 2 EN 1992-1-2:2004. ANNEX B. B.1 500°C isotherm method



Concrete temperature distribution



500 ℃ isotherm section
excluded concrete
Reduced B: 336 [mm]
Reduced H: 336 [mm]



Concrete temperature distribution

Anchor temperature ℃
Anchor 1: 564.60
Anchor 2: 564.60
Anchor 3: 564.60
Anchor 4: 564.60

Load Case 1

N_{Ed}, kN	M_{xEd}, kN-m	M_{yEd}, kN-m
80.00	20.00	20.00

Characteristic strength of concrete f_{ck}: 30.00 MPa
Design strength of concrete f_{cd}: 17.00 MPa
Characteristic strength of anchor bar f_{yk}: 500.00 MPa
Design strength of anchor bar f_{yd}: 396.00 MPa
Section Rotation due to load acting: 135.0 deg.
Section plastic centroid from top: 282.84 mm
Isotherm concrete section concrete area Ag: 0.1060 m^2

Anchor bar area Ast: 0.000628 m^2
Ag - Ast: 0.1054 m^2

Axial + Flexure check

Actual bending moment in section

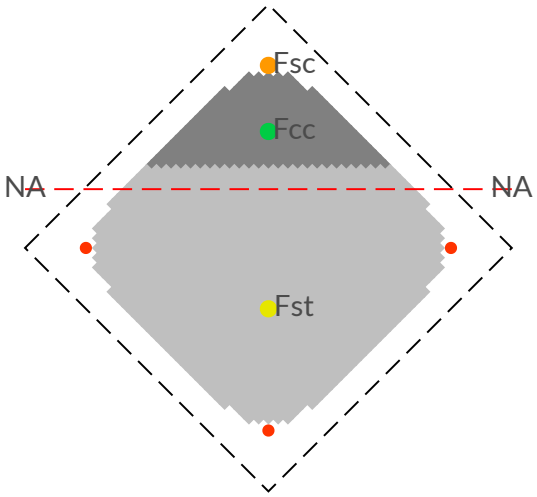
$$M_{zy} = \sqrt{M_z^2 + M_y^2} = \sqrt{20^2 + 20.00^2} = 28.28 \text{ kN-m}$$

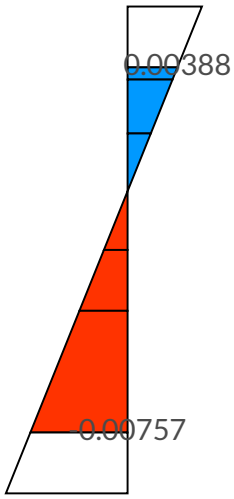
$$e_{xy} = M_{zy}/N_{Edx} = 28.28/80.00 = 0.35355$$

$$N_{Rd} = \eta \cdot f_{cd} \cdot (A_c - A_{st}) + f_{yd} \cdot A_{st} = 1933.77 \text{ kN}$$

Axial + flexure capacity

Depth x: 129.68 mm





$$N_r = 201.71 \text{ kN}, M_{Rd} = 69.58 \text{ kN-m}$$

$$N_{Edx} = 80.00 \text{ kN} \leq N_r = 201.71 \text{ kN (Ratio: 0.397)}$$

$$M_{zy} = 28.28 \text{ kN-m} \leq M_{Rd} = 69.58 \text{ kN-m (Ratio: 0.406)}$$

$$N_{Edx} = 80.00 \text{ kN} \leq N_{Rd} = 1933.77 \text{ kN (Ratio: 0.041)}$$