

Fire resistance of RC column

Introduction

This tutorial shows a design of reinforced concrete (RC) column subjected to fire. The column has rectangular crosssection with dimensions 400x300 mm and length 3000 mm. The column is subjected to axial compressive force, biaxial bending and lateral forces from both directions. The internal forces in the Ultimate Limit State (ULS) are shown in the table below and were calculated based on the basic combination. The column is located inside of an office building and is considered to be rigid at the bottom and hinged at the top. The material of the column is concrete C35/45 and steel reinforcement B550B.

section [m]	N [kN]	My [kNm]	Mz [kNm]	Vy [kN]	Vz [kN]	combination	η [-]
3	-685	140	135	-70	-80	basic	0.7
2.25	-687.25	70	67.5	-70	-80	basic	0.7
1.5	-689.5	0	0	-70	-80	basic	0.7
0.75	-691.75	-70	-67.5	-70	-80	basic	0.7
0	-694	-140	-135	-70	-80	basic	0.7

The internal forces in the column

Starting a new project

The following screen appears after running the software "Concrete Fire":

B FIN EC 2021 - Concrete Fire [Untitled.c	e]	-		Х
File Edit Mass inputs Data Options	Help			
. 🗋 🗗 - 🔚 - 💆				
Add section -	General project data			
🖶 Add member	4 Edit Date : 04/03/2021			
🗙 Remove				
Project	Standard Standard EN 1992-1-2/Czech Rep Concrete compressive strength : α _{ccc} = 1.000 Reliability of concrete and reinforcement in fire : γ _{M,5} = 1.000 Minimal reinforcement ration according to CSN 73 1201			
	Fire resistance parameters			
				_
	Edit Required fire resistance chosen 60.0 min			
-	Calculation options			
	Check bar spacing Check of detailing only informative (does not set check result) Imperfection and minimum eccentricity considered in the direction of the bending moment vector; Minimum eccentricity considered	before I	buckling	,
☆ Up & Down	Program options			
EN 1992-1-2/Czech Rep.	Use wizard for new input			

The start window of the software "Concrete Fire"

The software allows to asses unlimited number of tasks per one project. The supported tasks are, the assessment of cross section ("Section") or the whole member ("Member"). The "Section" may be used for simple verification of RC cross-sections subjected to fire, where the "Member" is usually used for the design of structures created in "Fin 2D" and "Fin 3D". This example shows the use of "Section" analysis. The start screen contains a part "General project data", where the job name, description and other project identification data can be entered. After clicking the "Edit" button, we first enter the job name and other project details:



General project data			×
Job name:	Concrete fire example	Author:	John Smith 💌
Part:	Columns	Date:	04/03/2021
Description:		Project ID:	
Client:	Concrete structures Ltd.	Archive ID:	
Comment:			^
			Y
Copy	Paste		<u>✓ O</u> K <u>X</u> Cancel

"General project data" dialog box

These data is displayed in the header or footer of the final documentation. Next, click the **"Edit"** button in the **"Standard"** frame and select the appropriate national annex. The supported national annexes are listed in the drop-down list. In case, the proper national annex is not listed, it is possible to choose *User defined* and set up custom coefficients.

andard selection			>
National annex:			
Czech Rep.			
User defined Default EC			
Czech Rep.			
Slovakia			
Poland			
Bulgaria			
United Kingdom			
Minimal reinforcement ration according to ČSN 73 1.			
Default -		√ <u>0</u> K	X Cancel

Selection of the standards

Last, the fire resistance properties are set in the "**Fire resistance parameters**" part. This project data can be edited any time during the analysis.

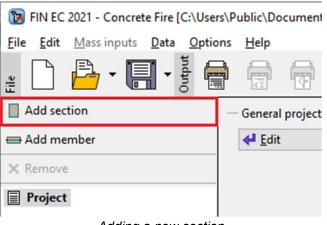
Before any data is assigned to the project, it is highly recommended to save the file. This can be done either using "



Save As					×
$\leftarrow \rightarrow \ \cdot \ \uparrow$. Os	(C:) > Users > Public > Public Docu	ments > Fine > FIN EC 2020 Př	íklady 🗸 🖑		EC 2020 Příklady
Organise 👻 New folde	r				E== ▼ ?
🖈 Quick access	Name	Date modified	Туре	Size	
	Sconcrete_fire_example	05/11/2020 13:24	FIN EC Concrete Fire applic	at 4 KB	
OneDrive - Vysoké uč					
This PC					
💣 Network					
File <u>n</u> ame: Concr	ete_fire_example				~
Save as type: Files C	oncrete Fire (*.cfe)				~
∧ Hide Folders				<u>S</u> ave	Cancel

Saving the project

Now we can proceed to entering a new task by clicking the "Add Section" button in the upper part of the program's tree menu.



Adding a new section

The following dialog box appears, in which we can enter the section's name ("**Column**") into the "**Section description**" field, confirming by clicking the "**OK**" button.

Add Section	×
Create new section	
O Copy existing section	n
Section description:	Column C1
	✓ <u>O</u> K X Cancel

Dialog box for adding a new section

The new task "**Column C1**" has been created in the tree menu, every time a new "**Section**" or "**Member**" is created, it will appear in the tree menu. The software has automatically selected the "**Column C1**", therefore it is possible to directly edit this task. In the right bottom corner, it shows what is required in order to run the analysis.



Difference Fire [C:\User	s\Public\Documents\Fine\Engineering manuals\Concrete_fire_example.cfe	1 – 🗆 X
<u>File Edit Mass inputs</u> Data Optio		
📲 🗋 📥 - 🔚 - 🖥 🗑		
Add section		ULS check : NO CHECK
📾 Add member		Interaction diagram 3D Interaction diagram My-Mz Interaction diagram N-My 🔹 🕨
× Remove		Mz: 0.00 [kNm]
Project		🗘 View
	- Section, Material, Reinforcement	Loads
	Member type : Select kind	Number Name 2nd order N [kN] M _y [kNm] M _z [kNm] V _z [kN] V _y [kN] T [kNm]
	Section: no input	
	Longitudinal reinf.: no input	
	Transverse reinf.: no input Environment: X0	
	 Include reinf. in compression 	Add 🖓 Edit X Remove 🛄 Import 🔻 💽 In detail
	- Imperfection, Buckling	- Results
	Add imperfection I ₀ / 400 I ₀ = [m]	Cross-section form is not set. Cannot run calculation!
	Calculate buck. Y Calculate buck. Z	Cross-section material is not set. Cannot run calculation! Reinforcement material is not set. Cannot run calculation!
	Mem. length Y: [m] III L _{0y} = [m]	
	Mem. length Z: [m] [m] [m]	
	- Fire	-
	Limit fire resistance period: [min]	
	T	
	Standard temperature curve	
☆ Up ↓ Down	Exposed to fire on all sides	
Check all	Exposed to fire of an sides	
EN 1992-1-2/Czech Rep.		

Main screen for "Section" task type

Section, Material, Reinforcement

In the beginning it is necessary to enter the dimensions of the geometrical and material characteristics of the considered RC column in the "Section, Material, Reinforcement" frame. First select the type of the member in "Member type" dropdown list. Available types are "beam", "slab", "column" or "wall".

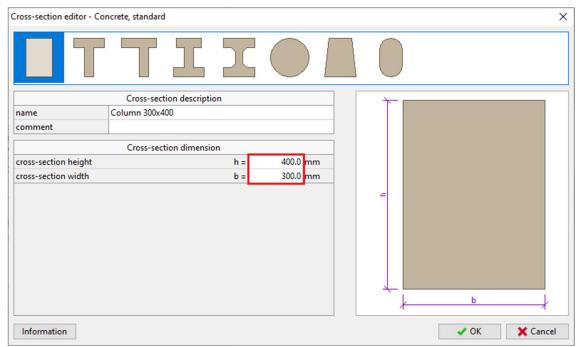
Member type :	Select kind			
Section: no in	beam slab	 <u>■</u> ² Material	∰} <u>M</u> aterial	
Concrete: no			100	
Longitudinal	wall	Reinforcement	1733	
Transverse rei	nf.: no input			
Environment:	X0	Shear reinforcem	ent	

Defining the member type

In our example we select member type "**column**". This selection affects the analysis and verifications of the reinforcement arrangement.

By clicking the "**Section**" button, the cross-section can be defined by the first suggested rectangular shape. The dimensions of the cross-section are simply defined by changing it's height and depth. The software allows to use custom user-defined shapes, however for the purpose of this example it is not needed.





Geometry of the column

We proceed with defining the material properties in "**Materials**" dialog box which is run by clicking the "**Material**" button in the "**Section**, **Materials**, **Reinforcement**" part. Assuming the column is located inside of the structure we select "**X1**" for "**Exposure class**", as the column is not in contact with outside environment. Subsequently we define the material properties of concrete and longitudinal and transversal reinforcement. We can select standardized materials from the library of pre-defined materials by clicking the "**Catalogue**" button at relevant lines.

Materials			×
Environment:	X0	4	<u>E</u> dit
Concrete:	No input	Catalogue	User defined
Longitudinal reinf .:	No input	Catalogue	User defined
Shear reinf.:	No input	Catalogue	User defined
— Indicative strength class —			
Aeration > 4%	Desig	n lifetime 100 yea	rs
C8/10 (EN 1992-1-1)			
C12/15 (ČSN EN 206+A1;Č	SN P 73 2404)		
Ductility class of longitudin	al reinforcement	○ A ● B	⊖ c
— Fire —			
	CTT		
Aggregates type:	Siliceous aggregates		•
Reinforcement type:	Hot rolled		-
Concrete moisture:		u = 1	.5 [%]
Parameter of thermal conductivity 0.000 [-]			00 [-]
Limits of the	ermal conductivity (chap. 3.3	3.3 of standard): 0	- min, 1 - max
		√ <u>0</u> K	X Cancel
Window "Materials"			

For column environment select the corrosion induced by carbonation "XC1" and close the dialog box by clicking "OK".



nvironment	×
- Corrosion	
Corrosion induced by carbonation:	
XC1 - Dry or permanently wet	•
Concrete inside buildings with low air humidity; Concrete permanently submerged in water	
Corrosion induced by chlorides:	
X0 - No risk of corrosion or attack	•
Concrete inside buildings with very low air humidity	
Corrosion induced by chlorides from sea water:	
X0 - No risk of corrosion or attack	•
Concrete inside buildings with very low air humidity	
Concrete	
Freeze/Thaw attack:	
X0 - No risk of corrosion or attack	•
Concrete inside buildings with very low air humidity	
Chemical attack:	
X0 - No risk of corrosion or attack	•
Concrete inside buildings with very low air humidity	_
Concrete inside buildings with very low an humany	
Other influences	
Abbrasion class:	
X0 - No abrasion	•
✓ <u>O</u> K ¥ <u>C</u> ano	el

Selection of the column environment

For concrete select the strength class "C35/45" and close the dialog box by clicking "OK".



Materials catalogue - Concrete		×
C 8/10 C 12/15 C 16/20 C 20/25		
C 25/30 C 28/35 C 30/37 C 32/40		
C 35/45 C 40/50 C 45/55 C 50/60		-
Information	🗸 OK 🔀 Can	cel

The strength classes of the concrete

Proceeding to definition of the steel properties, select the grade "**B550**" for both longitudinal and transversal reinforcement and close the dialog box by clicking "**OK**".

Materials catalogue - Longitudinal rei	nf.	×
10505 (R) 10425 (V) KARI wire (W) Nets (SZ) B420 B450 B500 B550		
Information	√ 0K	X Cancel

The steel grade classes

When returning to the "**Materials**" dialog box, the selected materials are checked with the predefined standard and displayed whether the material requirements on the "**Indicative strength class**" are fulfilled. At the bottom of the "**Materials**" dialog box, the material properties influencing the fire resistance properties can be changed. Finally, exit the window by clicking "**OK**".

Materials			×
Environment:	XC1	ب	<u>E</u> dit
Concrete:	C 35/45	Catalogue	User defined
Longitudinal reinf.:	B550	Catalogue	User defined
Shear reinf.:	B550	Catalogue	User defined
- Indicative strength class -			
Aeration > 4%	De	sign lifetime 100 yea	rs
C16/20 ⇒ strength class pa	ss (EN 1992-1-1)		
C16/20 ⇒ strength class pa		P 73 2404)	
Ductility class of longitudi	nal reinforcement	○ A ● B	⊖ c
- Fire			
Aggregates type:	Siliceous aggregates		-
Reinforcement type:	Hot rolled		-
Concrete moisture:		u = 1	.5 [%]
Parameter of thermal conc	luctivity	0.00	00 [-]
Limits of th	ermal conductivity (chap	. 3.3.3 of standard): 0	- min, 1 - max
		√ <u>O</u> K	X Cancel

Indicative strength class check in "Materials" window

Loads

After defining the geometry of the section and material properties, either the loads or the reinforcement may be defined. In this example, the load is defined first, then the reinforcement can be assessed immediately during its definition. The load case is created by clicking the **"Add**" button located under the **"Loads"** table.

Inserting the new load

In the "**New load**" window select a "**Combination type**". This type should be selected according to the type of combination, which was used for determination of the forces and moments. This input affects the type of verification. The following options are available:



(ULS) •Forces and bending moments have been obtained from the basic combination for persistent and transient design situations according to EN 1990, equations *6.10* resp. *6.10a* and *6.10b*. These loads are used for basic assessment of cross-section's capacity in the ultimate limit state.

Accidental • design (ULS)

Forces and bending moments have been obtained from the combination for accidental design situations according to EN 1990, equation *6.11*. These loads are used for assessment of cross-section's capacity in accidental design situations in the ultimate limit state (partial safety and material factors for accidental design situations are used).

In this example, the internal forces were calculated based on basic design combination, therefore pick the **"Basic design (ULS)"**. Now in the dialog window add the internal forces on section 3m according to the table in the introduction. The axial force is N= -685kN (negative value denotes compression), the bending moments are M_y = 140Nm, M_z = 135kNm and the lateral forces are V_z = -80kN and V_y = -70kN (negative value denotes they act in the same direction as the moments). Next, define **"Reduction coefficient"**, the procedure to determine this coefficient is in the chapter 2.4.2 of the standard EN 1992-1-2. As a simplification, the standard suggests to use η_{fi} with value of 0,7.

The **"Load duration coefficient**", i.e. the ratio of quasi-permanent and total loads for calculation of the creep coefficient. If the exact value is not available, the conservative value is *1.00*, which means that the total load is considered quasi-permanent in the calculations. The new load is confirmed by clicking the **"Add"** button and **"Cancel"** to exit the dialog box.

New load				×
- Load				
Load 1				
Combination type:		basic design (ULS)	•
Forces calculated using 2nd	order the	basic design (accidental des		
- Force on cross-section	l	accidentarides	sigii (OES	
Axial force:	N =	-685.00	[kN]	N > 0 : tension ; N < 0 : compression
Bending moment:	M _v =	140.00	[kNm]	M _v > 0 : bottom fibres in tension
				M _z > 0 : left fibres in tension
Bending moment:	M _z =	135.00	[kNm]	
Shear force:	V _z =	-80.00	[kN]	V _z :↓↑
Shear force:	V _y =	-70.00	[kN]	V_y : \leftrightarrow
Torsional moment:	T =	0.00	[kNm]	
- Reduction coefficient for design	load —			
Reduction coefficient:	η _{fi} =	0.700	[-]	
- Load duration coefficient				
			1	
Load duration coefficient:		1.000	[-]	
	nd entere			ending moment, values range from 0 to 1; or calculation of buckling (creep
				♣ <u>A</u> dd X Cancel

Defining the loads

As a result, the table summarizing all defined load cases is generated in the dialog box.



- basic design (ULS)	-479.50(-685.00)	98.00(140.00)	94.50(135.00)	-56.00(-80.00)	-49.00(-70.00)	
						*

Overview of the loads

However, adding all the load cases one by one is quite time consuming, therefore the load cases can be imported in a batch using **.txt, *.xslx, *.csv* file (button **"Import**"). The number of loads is not limited in the software.

rganise 🔻 New folder					T
	Name	Date modified	Туре	Size	
Quick access OneDrive - Vysoké uč	Concrete_fire_example_Loads	05/11/2020 13:08	Text Document	1 KB	
This PC					
🕨 Network					
File <u>n</u> ame	e: Concrete_fire_example_Loads			Known files (*.txt;*.xlsx;	*,csv;*,

Load the *.txt file table data

The dialog box **"Import of table data**" will appear after loading the source file. In this dialog box it is possible to align the data from the source file to the group of data, that are recognized by the software. When the data is formatted in the same manner as in the table in the introduction chapter, the dialog box "**Import of table data**" will look similar as the picture below. Next, it is necessary to align the columns in the source file (4) with the columns of the imported data (5). Check the imported data in the result of import preview (6) and make sure the imported data are aligned with the source file.

А			В	С	D		E	F	G		н
(123.45)			(123.45)	(123)	(123.4		(123)	(123)	(ABCDEFG)		(123.45)
section [n	m]		N [kN]	My [kNm]	Mz [kʰ		Vy [kN]	Vz [kN]	combination	1	?[-]
	2.	3	-6 -687.		40 70	135 67.5	-70 -70	-80 ba -80 ba			0.7
		.5	-687.		0	07.3	-70	-80 5a -80 5a			0.7
Name	Axia	l force	Bending M, [kNm]	moment M ₇ [kNm]	Shea V _z [kN]	r force V _y [kN]	Torsional moment M _x [kNm]	According to seco	nd Combination ty	pe Reduction coefficie η _{fi} [-]	[-]
	N										
	N B: N [kN]	(Y	C: My [kNm] 🔻	Constant of Constant of Constant				(unspecified)	- G: combination	100 100 EVEN	(unspecified)
ection [m] 🔻	B: N [kN] kN	1.000E+00	C: My [kNm] + 1.000E+00	Constant of Constant of Constant	1.000E+00	and the second sec	00	(unspecified)	G: combination Assignment	100 100 EVEN	
ection [m] 👻	B: N [kN] kN	1.000E+00 •	C: My [kNm] + 1.000E+00 kNm +	1.000E+00 kNm ▼	1.000E+00	0 1.000E+			Assignment	1.000E+1	10
ection [m] 🔻	B: N [kN] kN	1.000E+00 * * * * * * * *	C: My [kNm] + 1.000E+00	1.000E+00 kNm ▼	1.000E+00	0 1.000E+ kN	Shear for		Assignment	1.000E+1	
ection [m] 👻	B: N [kN] kN	1.000E+00 * * * * * * * *	C: My [kNm] + 1.000E+00 cNm +	1.000E+00 kNm ▼ Bendin	1.000E+00 kN • g moment M ₂ [kNm]	0 1.000E+ kN		rce V _y [kN]	Assignment	1.000E+1	ction coefficient
ection [m] 👻	B: N [kN] kN	1.000E+00 * * * * * * * *	C: My [kNm]	1.000E+00 kNm My (kNm) My (kNm) 140.0 70.0	g moment 0 0	1.000E+ kN 135.00 67.50	0 Shear for -80.00 -80.00	rce V _y [kN]	Assignment Combin 70.00 basic 70.00 basic	ation type Redu design design	0 ction coefficient η _E [-] 0.70 0.70
ection [m] -	B: N [kN] kN	1.000E+00 * * * * * * * *	C: My [kNm]	1.000E+00 kNm Bendin M _y [kNm] 140.0 70.0 0.0	1.000E+0C kN g moment M ₂ [kNm; 0 0 0	1.000E+ kN 135.00 67.50 0.00	0 V_ [kN] -80.00 -80.00 -80.00	rce V _y [kN]	Assignment Combin 70.00 basic 70.00 basic 70.00 basic	ation type Redu design design design	20 ction coefficient η _n [-] 0.70 0.70 0.70
ection [m] vertical vertical vertica	B: N [kN] kN	1.000E+00 * * * * * * * *	C: My [kNm]	1.000E+00 kNm My [kNm] 140.0 70.0	g moment M 0 0 0 0	1.000E+ kN 135.00 67.50	0 Shear for -80.00 -80.00	rce V _y [kN]	Assignment Combin 70.00 basic 70.00 basic 70.00 basic 70.00 basic	ation type Redu design design	0 ction coefficient η _E [-] 0.70 0.70



Import the data from the file

When clicking the button "**OK**" the load cases will appear in the dialog box "**Loads**". If the import of the load cases was done correctly, the first imported load case should match with the load case defined manually.

- Loads -										
Number	Name	2nd order	N [kN]	M _v [kNm]	M _z [kNm]	V _z [kN]	V _v [kN]	T [kNm]	Utilization	
1	Load 1 - basic design (ULS)		-479.50(-685.00)	98.00(140.00)	94.50(135.00)	-56.00(-80.00)	-49.00(-70.00)			-
2	3 - basic design (ULS)		-479.50(-685.00)	98.00(140.00)	94.50(135.00)	-56.00(-80.00)	-49.00(-70.00)			
3	2.25 - basic design (ULS)		-481.07(-687.25)	49.00(70.00)	47.25(67.50)	-56.00(-80.00)	-49.00(-70.00)			
4	1.5 - basic design (ULS)		-482.65(-689.50)			-56.00(-80.00)	-49.00(-70.00)			
5	0.75 - basic design (ULS)		-484.22(-691.75)	-49.00(-70.00)	-47.25(-67.50)	-56.00(-80.00)	-49.00(-70.00)			
6	0 hasis design (ULS)		495 90/ 604 00)	09.00/ 140.00)	04 50(125 00)	56.00/ 20.00)	40.00(70.00)			•

Overview of the loads with after the data import

Longitudinal reinforcement

When returning to the main dialog box, the longitudinal reinforcement is defined in the "Edit reinforcement" dialog that is accessed by the "Reinforcement" button in the "Section, Material, Reinforcement" frame. The upper part of the window allows to select calculation method for the cover. Keep the predefined method for now.

Edit reinfo	rcement													×
 Min Use 	imum cover cover and stir r defined cove			Cover:		32.0 [m		nimum cover neck of cover	Ţ	0	0	0	0	
— Upper i	reinforcement Diameter [mm]	Type Input	Distance [mm]	Count [-]	Positi Type	ion [mm]	A _s [mm ²]							
✓ 1	22	Number 🔻		4	Min. cvr. 🔻	32.0	1520.5	▲	400.0	\bigcirc			0	
2	22	Number -		2	Position •	150.0	760.3	ΣAs	6	0			0	
✓ 3	22	Number 👻		2	Position •	250.0	760.3	[mm ²]					Ŭ	
- Bottom	n reinforcemen Diameter [mm]	Type Input	Distance [mm]	Count [-]	Positi Type	ion [mm]	A _s [mm ²]		+		30	0.0	0	
✓ 1	22	Number 🔻		4	Min. cvr. 🔻	32.0	1520.5	*		4				
2 3 4	ation	• • • •			• • •			Σ A _s [mm ²]) Ger	orcement nerate iden s as much	ntical bar	spacing	le	
Check c Column $\rho_s = 0.0$	of min and ma (total reinford $0.38 \ge \rho_{s,min} =$	rea: 4561.6 mm ² x reinforme tement): e 0.002 ⇒ Pass e 0.04 ⇒ Pass	nt level											
Utilization	by bending :		63.3 % PASS								√ <u>O</u> K		🗙 <u>C</u> ancel	

Defining the longitudinal reinforcement

When the reinforcement is defined, click " button and the software will check whether the cross-section has sufficient capacity in bending. It shows that the defined cross-section passes the design criteria with 63.3% utilization in bending. In the section "Information on reinforcement" it shows that the detailing requirements given by the code are satisfied. Next, check the minimum cover requirements by clicking the "Minimum cover" button:



Reinforcement cover				×			
- Environment							
Environment:	XC1	<mark>∉</mark> dit					
Indicative strength class	$C16/20 \Rightarrow$ strength class	pass (EN 1992-1-1)					
	$C16/20 \Rightarrow$ strength class	pass (ČSN EN 206+A1;ČSN	I P 73 2404)			
- Structure class							
Class :		S4		•			
Residential, civil and other comr management	mon structures, industrial st	ructures, structures for min	ing, reserv	oirs, wather			
Design lifetime 80 years		Design lifeti	ime 100 yea	ars			
Slab geometry		Special qua	Special quality control				
Deputting structure laters		\$3					
Resulting structural class:		53					
Other influences Abbrasion class:							
Abbiasion class.		X0 - No abrasio	n	-			
Max aggregate diameter is g Uneven surface	greater than 32mm		0.0	[mm]			
Additive safety element		Δc _{dur,γ}	0.0	[mm]			
Stainless steel		$\Delta c_{dur,st}$	0.0	[mm]			
Additional protection		Δc _{dur,add}	0.0	[mm]			
Allowance in design for devi	iation	Δc_{dev}	10.0	[mm]			
Ground:	O prepared	soil					
- Minimal cover							
Min longitudinal reinf. cover : cmin = max(cmin.b; cmin.dur; 10) = max(22; 10; 10) = 22 mm	1					
$c_{nom} = c_{min} + \Delta c_{dev} = 22 + 10$							
Min stirrup cover: c _{min} = max(c _{min,b} ; c _{min,dur} ; 10) = max(8; 10; 10) = 10 mm						
$c_{nom} = c_{min} + \Delta c_{dev} = 10 + 10$ Longitudinal reinforcement cover							
$c_{nom} = max(32; 20 + 8) = max(32; 20 + 8)$		= 32 mm					
			✓ <u>O</u> k	Cancel			

The minimal reinforcement cover

The minimum required cover may change, when the stirrups are defined. Therefore, you should always look into this dialog box, after the stirrups are defined.

Shear reinforcement

The shear reinforcement is defined by clicking the "Shear reinforcement" button. The column is subjected to lateral

forces, therefore the calculation for the shear resistance must be made. Define the shear reinforcement and click " button, the software will check whether the cross-section has sufficient capacity in shear. It shows that the defined crosssection passes the design criteria with *49.3%* utilization in shear.



🔞 Edit reinforcement						-	- □) ×
─✔ Boundary stirrups								
Diameter d :	8 [mm]							
Spacing s :	150.0 [mm]		царана С					
Torsion :	Consired only to shear	resistance	•					
Ratio of stirrup area used f	for torsion resistance :			[%]				
— Ties, inner stirrups v	ertical	— — Ties, inner stirre	ups horizontal					
Same as boundary stir	rups	Same as boundar	y stirrups					
Diameter d :	[mm]	Diameter d :	[mm]				
Spacing s :	[mm]	Spacing s :	[mm]				
Count of shears:	[-]	Count of shears:		-]				
	Te to the test of test				400.0			
Bent-up bars vertica	1	Bent-up bars h	orizontal					
Diameter d :	[mm]	Diameter d :	[mm]				
Pitch α :	[°]	Pitch α :	[•]				
Count of shears:	[-]	Count of shears:	[-]				
As row of bent-up bar	'S	As row of bent-u	p bars			300.0)	
Spacing s :	[mm]	Spacing s :	[[mm]	1			1
	4	Ę						
- Inner lever arm		— — Angle of compress	ion struts					
Define by calculation		 Iterate 						
O Define as	× d	O User defined	[°]]				
- Information								
$\begin{array}{lll} f_{sd,fi} &= k_{s(\theta)} \times f_{yk} / \gamma_{l} \\ V_{Rds} &= A_{sw} / s \times z \times \\ V_{Rd} &= max(V_{Rdc};m) \end{array}$		0.9 MPa × 257.4 × 349.9 × 2.5 = 1 103.9; min(227.3; 150.9)) =	50.9 kN					•
								•
Utilization in shear :	49.3 % PASS					✓ <u>O</u> K	×	<u>C</u> ancel

Defining the shear reinforcement

Buckling

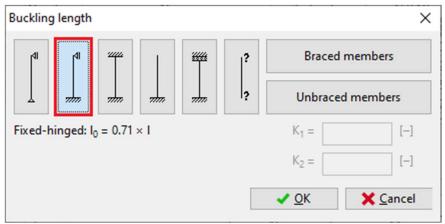
The next step is defining the buckling parameters. First tick "**Calculate buck. Y/Z**" boxes followed by entering the nominal lengths of the column for both directions, based on which the effective buckling lengths will be calculated. For a column rigid at the bottom and simply supported at the top, the effective buckling length is reduced.

- Imperfection, Bud	ckling				
Add imperfect	tion I	₀ / 400	I ₀ =	3.000 [m]	
✓ Calculate buc	k. Y	✓ Cale	culate	buck. Z	Buckling
Mem. length Y:		3.000 [[m]	L _{0y} =	2.130 [m]
Mem. length Z:		3.000 [[m]	L _{0z} =	2.130 [m]

Defining buckling parameters



Define the boundary conditions by clicking the " 🖩 " buttons for each direction.



Setting the buckling length

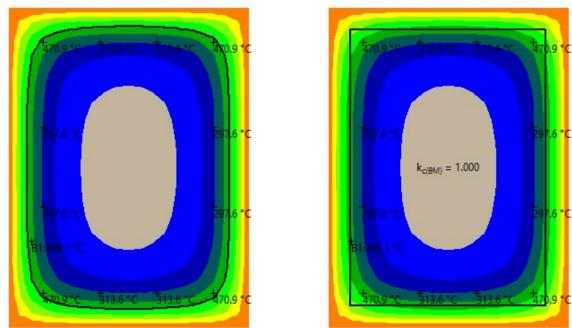
Fire

Last, the parameters for the fire assessment are defined at the bottom of the main dialog box in the "**Fire**" frame. The software allows to do the calculations based on the "**500°C isotherm method**" or the "**Zone method**". For the column it is recommended to use the "**Zone method**".

Limit fire resistance period:	60.0 [min]
Zone method	•
Standard temperature curve	Temperature curve
Exposed to fire on all sides	A Fire detail

Fire calculation parameters

The picture of the temperature distribution is shown at the top of the main dialog box, under the **"Temperature distribution"** bookmark.



500°C isotherm method (left) and Zone method (right)



The position, where the fire is acting on the column is displayed in the "**Fire detail button**". The column is considered to stand alone, thus select the first fire detail.



Fire detail

Results

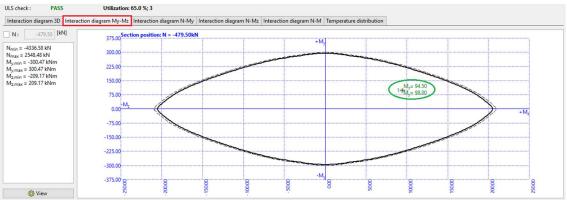
When all the input has been defined, the results are shown in the main dialog box. If the defined element satisfies the software shows "**PASS**" at the top of the main dialog box.

section				ULS check : PASS	Utilizatio	n: 67.4 %; 3							
member				Interaction diagram 3D In	teraction diagram My-M	Iz Interaction diagram	N-My Interaction diagram	m N-Mz Interaction dia	gram N-M Temperati	ire distribution			
ove			4x22-cov.32.0	N _{min} = -4304.82 kN	1								
ect mm.Cl	0	O 2	2x22-cov.139.0	N _{max} = 2404.48 kN N _{grain} = -317.82 kNm M _{grain} = -317.82 kNm M _{grain} = -221.61 kNm M _{grain} = -221.61 kNm	0 0 0				-N				
	\$ •	0 2	2x22-cov.139.0		+ + ™ ©			+My -		+Mz			
			4x22-cov.32.0		ي م لا				V	TIVIZ			
	- Section. Material. Reinforcement			🔅 View	Ŷ								
	- Section, Material, Reinforcement -	Section		An and a second s	Name	2nd order	N [kN]	M _e [kNm]	M ₂ [kNm]	V _z [kN]	V. [kN]	T [kNm]	Utili
	Member type : column			Loads Number^ 1 3 - basic design (I	Name ULS)	2nd order	-479.50(-685.00)	98.00(140.00)	94.50(135.00)	-56.00(-80.00)	-49.00(-70.00)	T [kNm]	67
	Member type : column Cross-section: Column 300x400	Section		Loads Number 1 3 - basic design (l 2 225 - basic design	Name ULS) n (ULS)	2nd order	-479.50(-685.00) -481.07(-687.25)			-56.00(-80.00) -56.00(-80.00)	-49.00(-70.00) -49.00(-70.00)	T [kNm]	67 49
	Member type : column Cross-section: Column 300x400 Concrete: C 35/45 Longitudinal reinf: 85508		ent 500	Loads Number 1 3 - basic design (l 2 225 - basic design 3 1.5 - basic design	Name ULS) n (ULS) i (ULS)	2nd order	-479.50(-685.00) -481.07(-687.25) -482.65(-689.50)	98.00(140.00) 49.00(70.00)	94.50(135.00) 47.25(67.50)	-56.00(-80.00) -56.00(-80.00) -56.00(-80.00)	-49.00(-70.00) -49.00(-70.00) -49.00(-70.00)	T [khim]	67 49 49
	Member type : column Cross-section: Column 300x400 Concrete: C 33/45 Longitudinal reinfr: B550B Transverse reinfr: B550	Aterial	ent 🐌	Loads Number+ 1 3 - basic design (1 2 2.25 - basic design 3 1.5 - basic design 4 0.75 - basic design	Name ULS) n (ULS) i (ULS) n (ULS)	2nd order	-479.50(-685.00) -481.07(-687.25) -482.65(-689.50) -484.22(-691.75)	98.00(140.00) 49.00(70.00) -49.00(-70.00)	94.50(135.00) 47.25(67.50) -47.25(-67.50)	-56.00(-80.00) -56.00(-80.00) -56.00(-80.00) -56.00(-80.00)	-49.00(-70.00) -49.00(-70.00) -49.00(-70.00) -49.00(-70.00)	T[khm]	6 4 4
	Member type : column Cross-section: Column 300x400 Concrete: C 35/45 Longitudinal reinf: 85508	Aterial		Loads Number 1 3 - basic design (l 2 225 - basic design 3 1.5 - basic design	Name ULS) n (ULS) i (ULS) n (ULS)	2nd order	-479.50(-685.00) -481.07(-687.25) -482.65(-689.50)	98.00(140.00) 49.00(70.00)	94.50(135.00) 47.25(67.50)	-56.00(-80.00) -56.00(-80.00) -56.00(-80.00)	-49.00(-70.00) -49.00(-70.00) -49.00(-70.00)	T [khim]	6 4 4
	Member type : column Cross-section: Column 300x400 Concrete: C 33/45 Longitudinal reinfr: B550B Transverse reinfr: B550	Beinforceme		Loads Number+ 1 3 - basic design (1 2 2.25 - basic design 3 1.5 - basic design 4 0.75 - basic design	Name ULS) n (ULS) i (ULS) n (ULS)	2nd order	-479.50(-685.00) -481.07(-687.25) -482.65(-689.50) -484.22(-691.75)	98.00(140.00) 49.00(70.00) -49.00(-70.00)	94.50(135.00) 47.25(67.50) -47.25(-67.50)	-56.00(-80.00) -56.00(-80.00) -56.00(-80.00) -56.00(-80.00)	-49.00(-70.00) -49.00(-70.00) -49.00(-70.00) -49.00(-70.00)	T [khim]	61 44 41 41 61
	Member type : column Cross-section: Column 300x400 Concrete: C 33/43 Longtudinal reint: 85508 Transvess: reint 8550 Environment: XC1 C Include reinf. In compression Imperfection, Buckling	Material	rcement	Loads Number^ 1 3 - basic design (1 2 2.25 - basic design 3 1.5 - basic design 4 0.75 - basic design (1 5 0 - basic design (1	Name ULS) n (ULS) (ULS) n (ULS) ULS)		-479.50(-685.00) -481.07(-687.25) -482.65(-689.50) -484.22(-691.75)	98.00(140.00) 49.00(70.00) -49.00(-70.00)	94.50(135.00) 47.25(67.50) -47.25(-67.50)	-56.00(-80.00) -56.00(-80.00) -56.00(-80.00) -56.00(-80.00)	-49.00(-70.00) -49.00(-70.00) -49.00(-70.00) -49.00(-70.00)	T [kNm]	6 4 4 4 6
	Member type: column Cross-section: Column 300x400 Concrete: 33/45 Lengtudinal reint: 85308 Transverse reinf: 8530 Environment: XC1 Include reinf. in compression	Material Beinforceme	3.000 [m]	Loads Number+ 1 3 - basic design (1 2 225 - basic design 4 0.75 - basic design 4 0.75 - basic design 4 0.75 - basic design (1 ♠ Add 4 Esit	Name ULS) n (ULS) n (ULS) n (ULS) ULS) X Bernove	Import V	-479.50(-685.00) -481.07(-687.23) -482.65(-669.50) -484.22(-691.75) -485.80(-694.00)	98.00(140.00) 49.00(70.00) -49.00(-70.00) -98.00(-140.00)	94.50(135.00) 47.25(67.50) -47.25(-67.50) -94.50(-135.00)	-56.00(-80.00) -56.00(-80.00) -56.00(-80.00) -56.00(-80.00) -56.00(-80.00)	-49.00(-70.00) -49.00(-70.00) -49.00(-70.00) -49.00(-70.00) -49.00(-70.00)	T (khim)	61 44 41 41 61
	Member type : column Cross-section: Column 300x400 Concrete: C 33/43 Longtudinal reint: 85508 Transvess: reint 8550 Environment: XC1 C Include reinf. In compression Imperfection, Buckling	Beinforceme	rcement	Loads Number 1 3 - basic design (1 2 - 255 - basic design 3 - 1.5 - basic design 4 - 0.75 - basic design 5 - 0 - basic design 6 - basic design 1 - basic des	Name ULS) n (ULS) n (ULS) n (ULS) ULS) X Bernove	Import •	-479.50(-685.00) -481.07(-687.25) -482.65(-689.50) -484.22(-691.75) -485.80(-694.00) Mtoy	98.00(140.00) 49.00(70.00) -49.00(-70.00) -98.00(-140.00) Mtdx	94.50(135.00) 47.25(67.50) -47.25(-67.50) -94.50(-135.00) Veo	- 56.00(-80.00) - 56.00(-80.00) - 56.00(-80.00) - 56.00(-80.00) - 56.00(-80.00)	-49.00(-70.00) -49.00(-70.00) -49.00(-70.00) -49.00(-70.00) -49.00(-70.00) -49.00(-70.00)	T [khm]	67 49 49 67 67
	Member type : Column Conservedine Column 300440 Concrete C3049 Longbuildinal reint : B5508 Environment : 2014 Innover en reint : B5508 Environment : 2014 Innover en reint : B5508 Environment : 2014 Innover en reint : B508 Environment : 2014 Innover en reint : B508 Environment : 2014 Innover en reint : 2014 Innover en	lo =	3.000 [m] Buckling	Coads Number- 1 3 - basic design (1 2 225 - basic design 4 0.75 - basic design 4 0.75 - basic design (1 4 0.75 - basic design (1 4 0.75 - basic design (1 7 - bas	Name ULS) n (ULS) n (ULS) n (ULS) ULS) X Bernove	NEd Mag [KN]	-479.50(-685.00) -481.07(-687.23) -482.65(-669.50) -484.22(-691.75) -485.80(-694.00)	98.00(140.00) 49.00(70.00) -49.00(-70.00) -98.00(-140.00)	94.50(135.00) 47.25(67.50) -47.25(-67.50) -94.50(-135.00) VEd Vac	- 56.00(-80.00) - 56.00(-80.00) - 56.00(-80.00) - 56.00(-80.00) - 56.00(-80.00) - 56.00(-80.00)	-49.00(-70.00) -49.00(-70.00) -49.00(-70.00) -49.00(-70.00) -49.00(-70.00) -49.00(-70.00)		67 49 49 49 67
	Member type i column Conserve 100-400 Converte 104-00500 Converte 104-05500 Environment XC1 Interfaction, Buckling Chald imperfection, Buckling Chald interfection by 700 Chald buck V. 2000 (m)	line buck. Z	3.000 [m]) Buckling 2.130 [m]	Loads Number 1 3 - basic design (1 2 225- basic design 3 15 - basic design 4 0.75 - basic design 5 0 - basic design 5 0 - basic design 7 Results ULTIMATE LIMIT no. Name	Name ULS) n (ULS) (ULS) (ULS) ULS) X Bemove STATE	Import • NEd Nag [kki] - -475.50 -	-479.50(-685.00) -481.07(-687.25) -482.65(-685.50) -484.22(-691.75) -484.22(-691.75) -485.80(-694.00) 	98.00(140.00) 49.00(70.00) -49.00(-70.00) -98.00(-140.00) -98.00(-140.00) -98.00(-140.00) -98.00(-140.00) -98.00(-140.00) -98.00(-140.00) -98.00(-140.00)	94.50(135.00) 47.23(67.50) -47.23(-67.50) -94.50(-135.00) VEd VRg [NN	-56.00(-80.00) -56.00(-80.00) -56.00(-80.00) -56.00(-80.00) -56.00(-80.00) -56.00(-80.00) -56.00(-80.00)	-49,00(-70,00) -49,00(-70,00) -49,00(-70,00) -49,00(-70,00) -49,00(-70,00) -49,00(-70,00) -49,00(-70,00)	Utilization [56]	67 49 49 67 67 67 67
	Member type i column Conserve 100-400 Converte 104-00500 Converte 104-05500 Environment XC1 Interfaction, Buckling Chald imperfection, Buckling Chald interfection by 700 Chald buck V. 2000 (m)	lo =	3.000 [m] Buckling	Loads Number 1 3 - basic design (1 2 - 255 - basic design 3 - 1.5 - basic design 4 - 0.75 - basic design 5 - 0 - basic design 6 - basic design 1 - basic des	Name ULS) n (ULS) (ULS) (ULS) ULS) X Bemove STATE	NEd w Nitd (kN) (kN) -475.50 -4304.62 -4304.62	-479.50(-685.00) -481.07(-687.25) -482.65(-685.50) -484.22(-691.75) -485.80(-694.00) 	98.00(140.00) 49.00(70.00) -49.00(-70.00) -98.00(-140.00) -98.00(-140.00) Meas Meas [kHm] 94.50 - 97.04 144.06	94.50(135.00) 47.25(67.50) -47.25(-67.50) -94.50(-135.00) VEG VEG VEG VEG VEG VEG VEG VEG	-56.00(-80.00) -56.00	-49,00(-70,00) -49,00(-70,00) -49,00(-70,00) -49,00(-70,00) -49,00(-70,00) -49,00(-70,00) -49,00(-70,00) -49,00(-70,00)	Utilization	67 49 49 67 67
	Member type: Column Create-sectors: Calumn: Stock Concrete: Stock Stock Concrete: Stock Stock Invicational: All system Stock On cluber training: Add imperfection, Buckling Add imperfection, Model On Cluber training: Calculate buck; V Calculate buck; Mem. length 2: 3.000 [m] Mem. length 2: 3.000 [m]	line buck. Z	3.000 [m]) Buckling 2.130 [m]	Loads Number 1 3 - basic design (1 2 225- basic design 3 15 - basic design 4 0.75 - basic design 5 0 - basic design 5 0 - basic design 7 Results ULTIMATE LIMIT no. Name	Name ULS) n (ULS) n (ULS) n (ULS) ULS) X Bemore	Ng Ng (M)	- 479:50(-685:00) - 481:071:687:25) - 482:63(-686:50) - 484:22(-691:75) - 485:80(-694:00)	98.00(140.00) 49.00(70.00) -49.00(-70.00) -98.00(-140.00) Mg/s Mg/s (84m) 94.50 - 97.04 144.06 47.25 - 49.75	94.50(135.00) 47.25(67.50) -47.25(67.50) -94.50(-135.00) Vice	-56.00(-80.00) -56.00	-49,00(-70,00) -40,00(-70,00) -40,00	Utilization [56]	
	Member type i column Conserve 100-400 Converte 104-00500 Converte 104-05500 Environment XC1 Interfaction, Buckling Chald imperfection, Buckling Chald interfection by 700 Chald buck V. 2000 (m)	line buck. Z	3.000 [m]) Buckling 2.130 [m]	Loads Number 1 3-baic design (1 2 225-baic design (1 2 225-baic design (1 2 25-baic design (1 5 0-baic design (1 4 0.75-baic design (1 4 0.64 64 64 64 7 Esuits UITIMATE LIMIT no. Name 1 2 2 225	Name ULS) n (ULS) n (ULS) n (ULS) ULS) X Bemore	Nig Nig Nig [1:4] -479:50 -4304.82 -4304.82 -4304.82	-479,50;465,00) -481,07(-687,29) -482,67(-685,50) -482,87(-685,50) -485,80;469,50) -485,80;469,400) -485,80;469,400) -485,80;469,400 -485,80;460,400 -485,80;460,400 -485,80;460,400 -485,80;460,400 -485,80;460,400 -485,80;460,400 -485,80;460,400 -485,80;460,400 -485,80;460,400 -485,80;400,400 -485,80;400,400 -485,80;400,400 -485,80;400,400 -485,80;400,400 -485,80;400,400 -485,80;400,400 -485,80;400,400 -485,80;400,400 -485,80;400,400 -485,80;400,400 -485,80;400,400 -485,800 -485	98.00(40.00) 48.00(70.00) -49.00(-70.00) -98.00(-140.00) M ₆₄₂ (klwm) 94.59 - 97,04 144.05 47.25 - 497,7 144.03	94.50(135.00) 47.25(67.50) -47.25(67.50) -94.50(-135.00) Vieto Viet	-56.00(-80.00) -56.00	-49.00(-70.00) -40.00(-70.00) -40.00	Utilization [55] 67.4 49.3	67 49 49 49 67 67 67 67 67 67 67 67 67 67 67 67 67
	Member type: Column Create-sectors: Calumn: Stock Concrete: Stock Stock Concrete: Stock Stock Invicational: All system Stock On cluber training: Add imperfection, Buckling Add imperfection, Model On Cluber training: Calculate buck; V Calculate buck; Mem. length 2: 3.000 [m] Mem. length 2: 3.000 [m]	lo = lo constante	3.000 [m]) Buckling 2.130 [m]	Loads Number 225-basic design (1 2.25-basic design 4. 0.75-basic design	Name ULS) n (ULS) n (ULS) n (ULS) ULS) STATE	Import • Nta • Nta • •	-475 552 (485.0) -481.07(487.2) -482.65(-680.50) -482.42(-691.73) -485.80(-694.00) -485.80(98.00(140.00) 49.00(70.00) -49.00(-70.00) -98.00(-140.00) Mass [kim] 9.50 -97.00 141.00 141.00 142.5 -49.75 141.03 0.003.82	94.50(135.00) 47.25(87.50) -47.25(67.50) -94.50(-135.00) -94.50(-135.00) -94.50(-135.00) -94.50(-135.00) -94.50(-135.00)	-56.00(-80.00) -56.00	-49.00(-70.00) -40.00(-70.00) -40.00	Utilization [%] 67.4	67 49 49 67 67 67 67 67 67 98 58 9855
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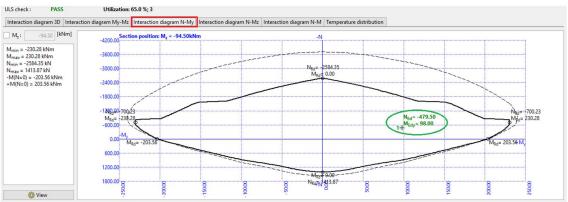
The main dialog box with the 3D representation of the interaction diagram



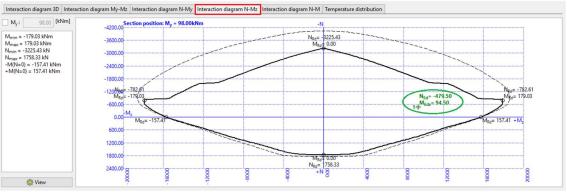
The results may be shown in terms of interaction diagram in the bookmarks at the top of the main dialogue box. The defined loads are shown as points in the interaction diagram. If the load lies inside of the solid line of the diagram, the cross-section satisfies the fire assessment. The dashed line shows the iteration diagram of the column without buckling.



The M_v - M_z interaction diagram

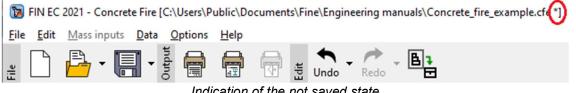


The N - M_v interaction diagram



The N - M₇ interaction diagram

When the project is finished, it is highly recommended to save the file by clicking "🔚 " button, or in the main menu clicking on "File" - "Save As", or using the "Ctrl+S" shortcut. The indication of not saved state is "*" in the program window header. In such case it is advisable to save the state.

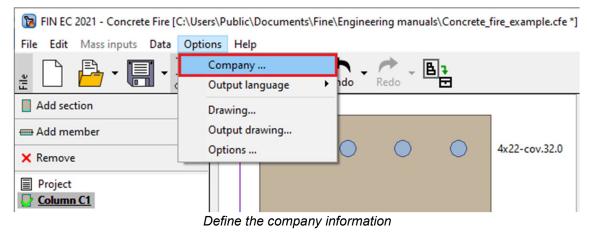


Indication of the not saved state



Outputs

In order to show the information about the company in the output files, the information must be defined in the project. Click the button **"Company"** in the Options drop-down menu.



The window "**About the company**" will appear, where the information about the company can be defined. It is also possible to import the company logo, that will show at the header of the exported documentation.



Set the company data and import the logo

If all the settings finished and saved, the output documentation can be composed. First print out a single title page summarizing all the input data and the check results. This is done by clicking the "**File**" and "**Graphic output**" or "^{Contemposed}" in the toolbar.



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The graphic output

At the top part of this window, there are buttons "**Page setup**" and "**Header and footer**". Click the button "**Page setup**" and a window for editing the paper size, margins or a colour of the output document will appear. Pick the preferred colour based on your liking and continue.



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Page appearance settings

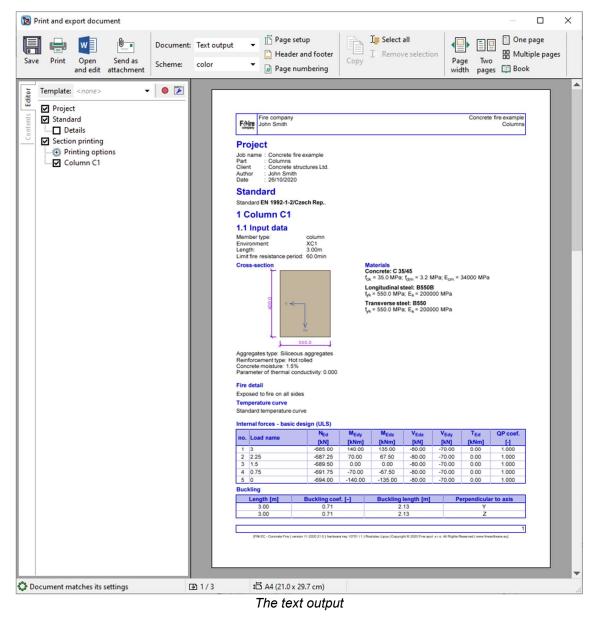
When clicking the button "**Header and footer**" the window for adding information about the project to the header or footer of the output documentation will appear. Check the "**insert company logo**" box in order to show the company logo in the header. The other information about the project can be also added to the footer or header by clicking the button "**Insert**".

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Header and footer settings

Apart from this title document, the detail text output can be composed by clicking the """ button in the toolbar or selecting "File" and "Text output" in the main menu. If the print and export document dialog box is still opened, the document type can be changed in the toolbar's "Document" drop-down list.





After switching to the "Text output" mode, the parts of the documentation can be added or excluded in the "Editor".



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	Interaction diagram
	Column C1

Add or exclude the output parts

The software will immediately re-generate the output to reflect each change made in the settings in the tree on the lefthand side. Once the output contains all required information, the document can be again saved on disk.



The document can be printed directly by clicking " 🖶 " button or save it on disk as *.pdf or *.rtf file by clicking " 🗐 "



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Saving file in *.pdf format

Completing the outputs generation, the work is done.