NEMETSCHEK
Scia

Stade des Alpes - Grenoble
Etudes et Techniques Internationales (ETI)

Tutorial: Concrete 1D members – setting overview, concrete solver and checks acc. to EC2

Scia
Engineer

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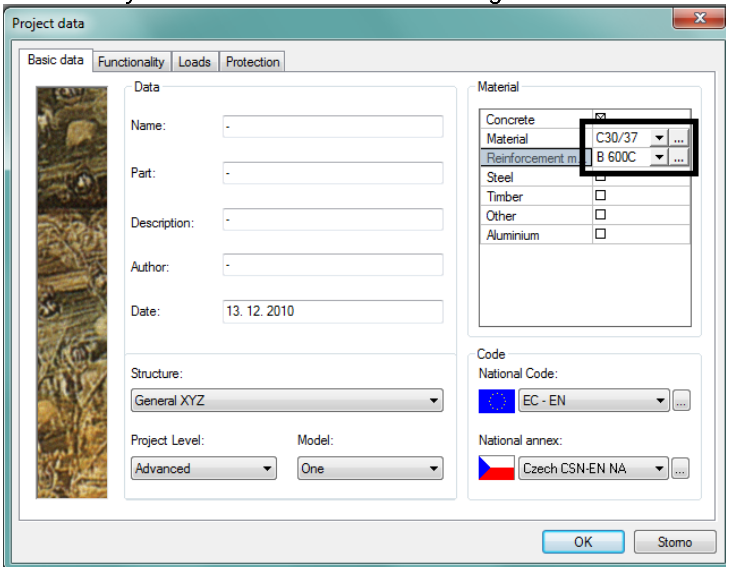
Contents:

1. Introduction

The aim of this publication is to show the main relations of the setting for 1D concrete members and to explain the most frequent question that users ask technical support. All the setting is linked to Eurocodes and to software version 2010.1. But some of the explained features can be related to other codes and older versions of Scia Engineer.

2. Material setting for concrete structures:

a) for the whole structure you set the concrete and steel grade as follows:



Data

Name:	-
Part:	-
Description:	-
Author:	-
Date:	13. 12. 2010

Structure: General XYZ

Project Level: Advanced

Model: One

Material

Concrete	☒
Material	C30/37
Reinforcement m...	B 600C
Steel	☐
Timber	☐
Other	☐
Aluminium	☐

Code

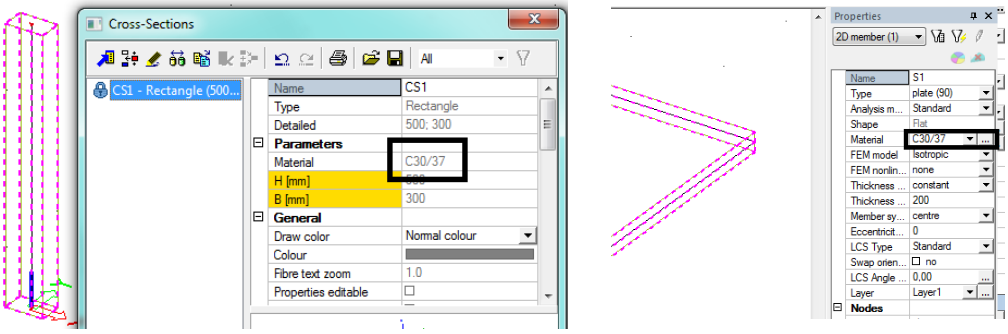
National Code: EC - EN

National annex: Czech CSN-EN NA

Pics.1 - Material setting for all construction

b) for particular members

- concrete grade can be chosen in the properties window

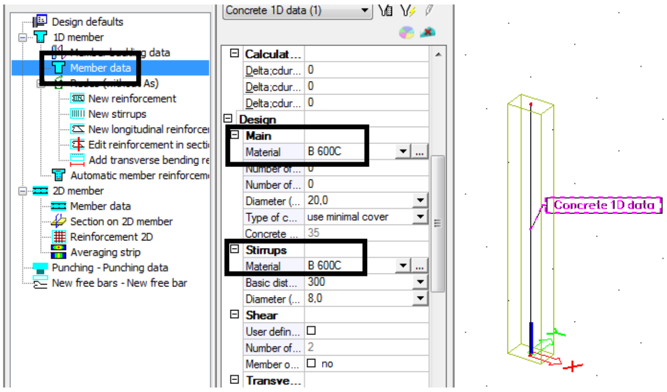


Name	CS1
Type	Rectangle
Detailed	500; 300
Parameters	
Material	C30/37
H [mm]	500
B [mm]	300
General	
Draw color	Normal colour
Colour	
Fibre text zoom	1.0
Properties editable	☐

Name	S1
Type	plate (90)
Analysis m...	Standard
Shape	Flat
Material	C30/37
FEM model	Isotropic
FEM nonlin...	none
Thickness ...	constant
Thickness ...	200
Member sy...	centre
Eccentricit...	0
LCS Type	Standard
Swap orien...	☐ no
LCS Angle ...	0,00
Layer	Layer1
Nodes	

Pics.2 – Concrete grade setting for each member individually

- steel grade can be set in the member data for beam or slab in the concrete service



Calculat...	
Delta;cdur...	0
Delta;cdur...	0
Delta;cdur...	0
Design	
Main	
Material	B 600C
Number of...	0
Number of...	0
Diameter (...	20,0
Type of c...	use minimal cover
Concrete ...	35
Stirrups	
Material	B 600C
Basic dist...	300
Diameter (...	8,0
Shear	
User defin...	☐
Number of...	2
Member o...	☐ no
Transve...	

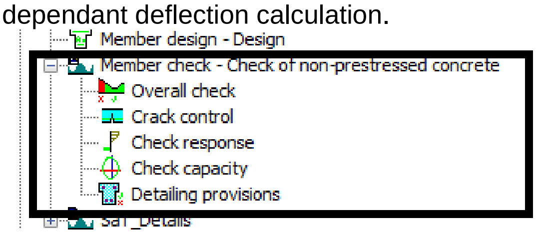
Pics.3 – Setting grade of reinforcement through member data

3. Types of reinforcement used in the program

Scia Engineer uses for checks two basic types of reinforcement:

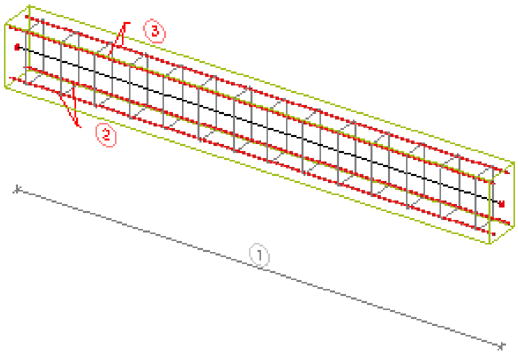
a) **User defined reinforcement** – this is a real reinforcement that you have set and where actual shape can be seen

User definer (real) reinforcement can be used for all check in the frame below (Pic. 4) and for code dependant deflection calculation.



- Member design - Design
- Member check - Check of non-prestressed concrete
  - Overall check
  - Crack control
  - Check response
  - Check capacity
  - Detailing provisions
- Sa1_Details

Pics.4 – Member check for user defined reinforcement

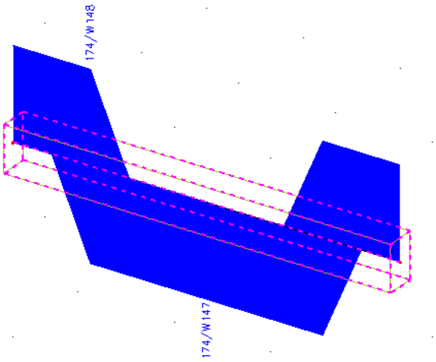


Pics.5 – User defined reinforcement

b) **Required reinforcement** – (total reinf.) this is only required amount of reinforcement (area) which is designed in particular sections of the structure.

You can use total required reinforcement for crack control check and for code dependant deflection calculation.

Which of this reinforcement is used depends on particular check and calculation setting. Details will follow.



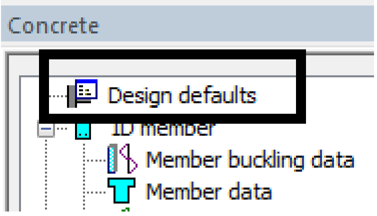
Pics.6 – Required reinforcement (total reinf.)

4. Concrete settings sorting

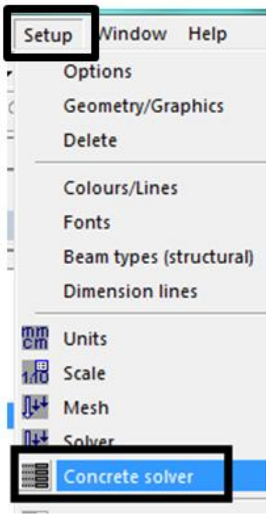
Program uses three settings that influence concrete structures. These settings are related to the whole structure and can be found here:

a) Setting which relates to steel bars (diameters, ...) and reinforcement (cover, ...) can be entered from the main tree of concrete service as **Design defaults**.

b) All the adjustment affecting reinforcement design and all types of checks is located in Setup – **Concrete solver**.

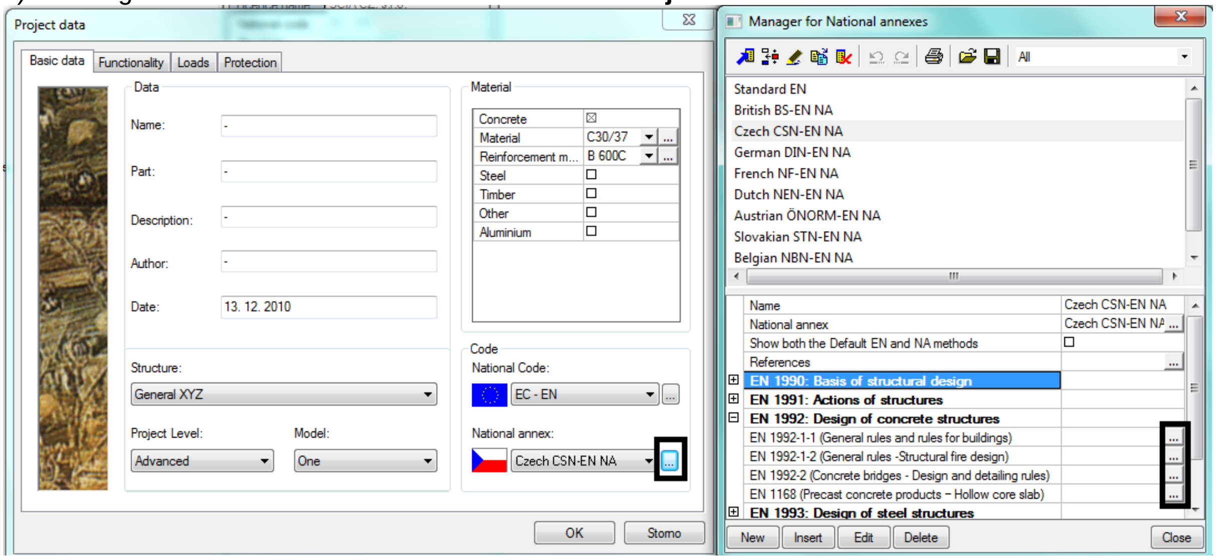


Pics.7 – Design defaults



Pics.8 – Concrete solver

c) Setting related to national annex can be seen in **Project data.**



Name: -
Part: -
Description: -
Author: -
Date: 13. 12. 2010
Structure: General XYZ
Project Level: Advanced
Model: One

Concrete	☒
Material	C30/37
Reinforcement m...	B 600C
Steel	☐
Timber	☐
Other	☐
Aluminium	☐

National Code: EC - EN
National annex: Czech CSN-EN NA

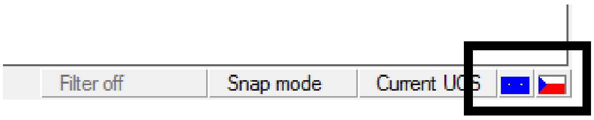
Standard EN
British BS-EN NA
Czech CSN-EN NA
German DIN-EN NA
French NF-EN NA
Dutch NEN-EN NA
Austrian ÖNORM-EN NA
Slovakian STN-EN NA
Belgian NBN-EN NA

Name	Czech CSN-EN NA
National annex	Czech CSN-EN NA
Show both the Default EN and NA methods	☐
References	
EN 1990: Basis of structural design	
EN 1991: Actions of structures	
EN 1992: Design of concrete structures	
EN 1992-1-1 (General rules and rules for buildings)	...
EN 1992-1-2 (General rules -Structural fire design)	...
EN 1992-2 (Concrete bridges - Design and detailing rules)	...
EN 1168 (Precast concrete products – Hollow core slab)	...
EN 1993: Design of steel structures	

Pics.9 – Setting of national annexes

Trick:

The fastest way how to open national annex dialogue from any place of the program is through these two buttons:



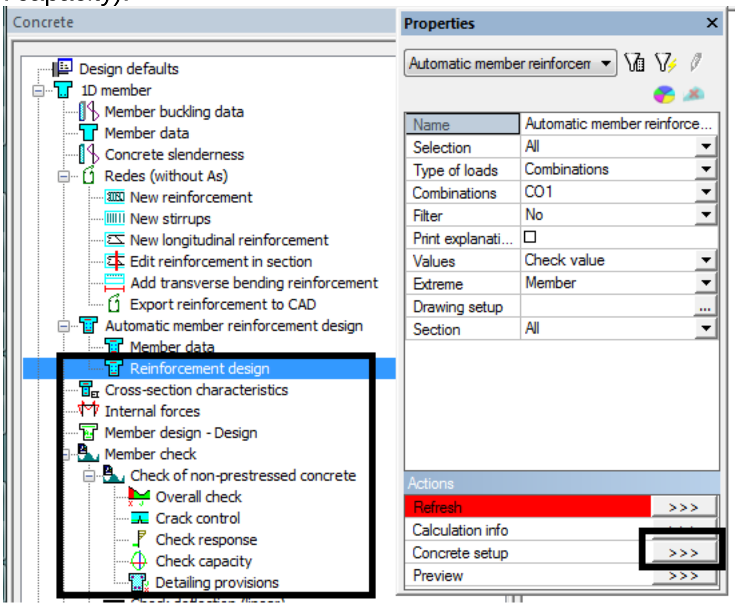
Pics.10 – Short cut to national annex

Note:

National application documents don’t need to be created by the user from version 2010.1. They are implemented in the software for certain countries.

Trick:

All these settings can be entered by just one mouse-click. To be precise, all the highlighted functions (from pic. 11) has got the action button **Concrete setup**. Dialogue with relevant setting is opened by clicking on this button. The setting includes only filtered items according to individual functions (e.g. check capacity).



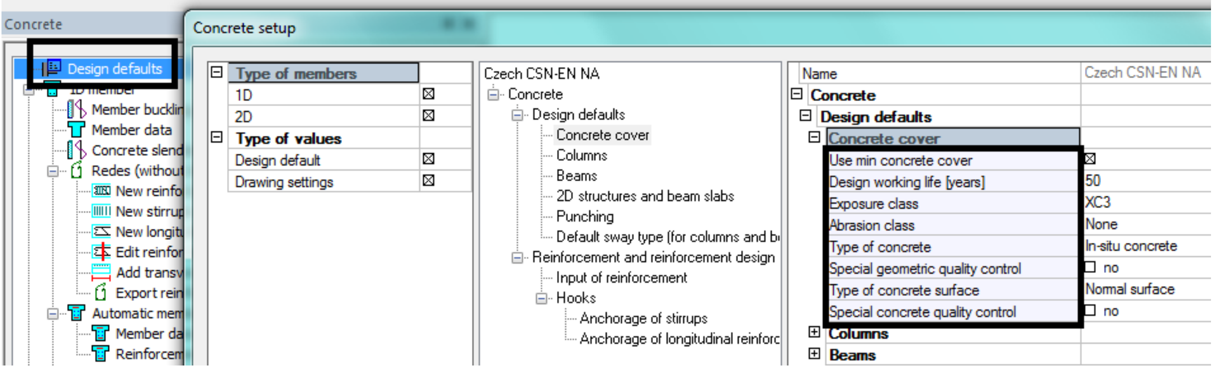
Name	Automatic member reinforce...
Selection	All
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Values	Check value
Extreme	Member
Drawing setup	...
Section	All

Pics.11 – Action button Concrete setup

Note:

All the settings (*Design defaults, Concrete solver, National annexes*) are related to the whole model. If you open any of it you can notice following graphical differentiation:

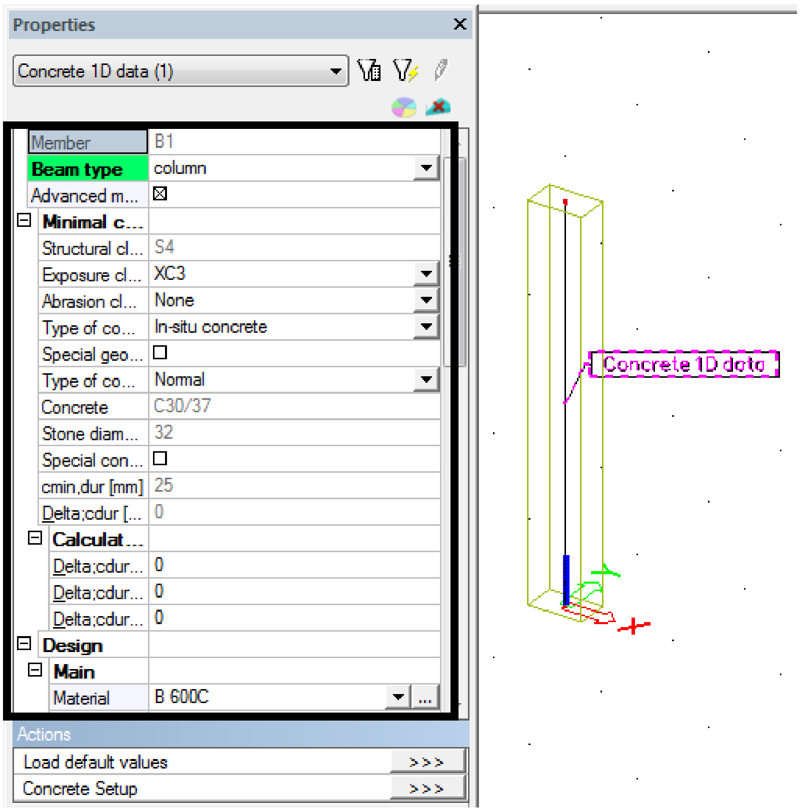
- **blue items** can be overtrumphed by member data and be set for selected member only



Type of members	
1D	☒
2D	☒
Type of values	
Design default	☒
Drawing settings	☒

Name	Czech CSN-EN NA
Concrete	
Design defaults	
Concrete cover	
Use min concrete cover	☒
Design working life [years]	50
Exposure class	XC3
Abrasion class	None
Type of concrete	In-situ concrete
Special geometric quality control	☐ no
Type of concrete surface	Normal surface
Special concrete quality control	☐ no
Columns	
Beams	

Pics.12 – Parameters in blue colour



Properties

Concrete 1D data (1)

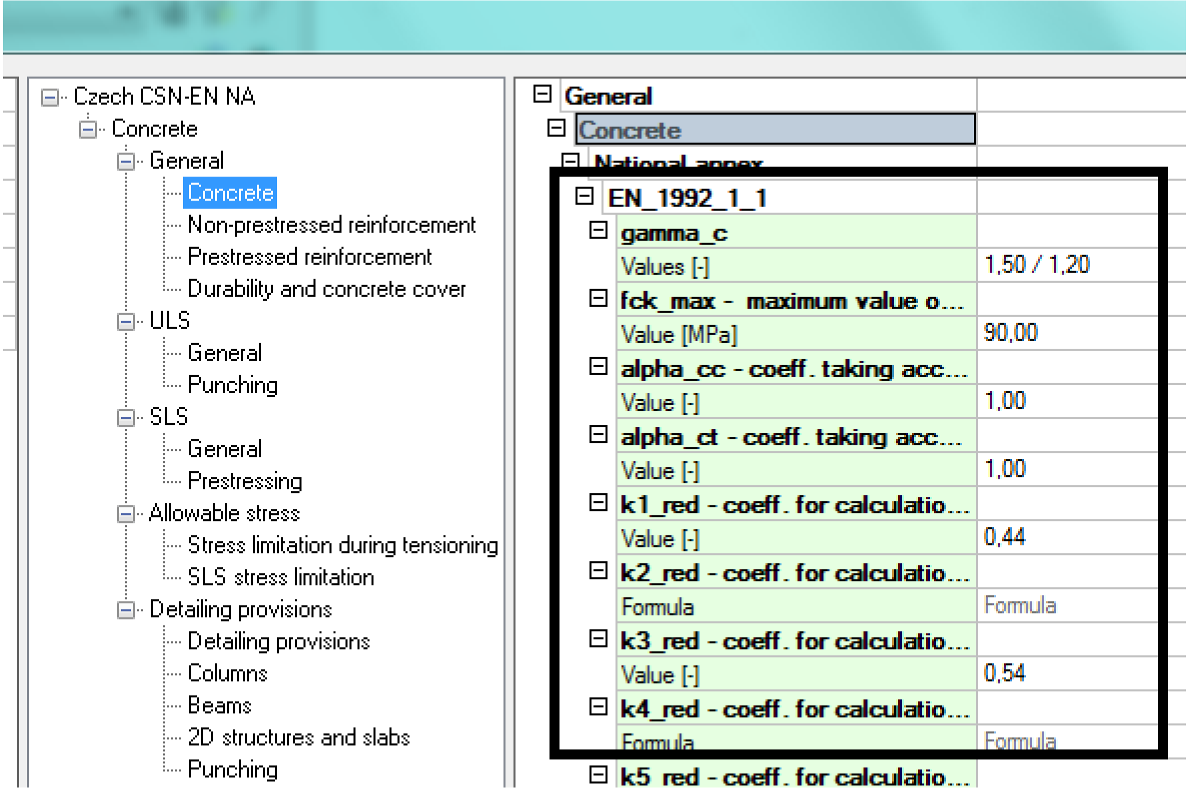
Member	B1
Beam type	column
Advanced m...	☒
Minimal c...	
Structural cl...	S4
Exposure cl...	XC3
Abrasion cl...	None
Type of co...	In-situ concrete
Special geo...	☐
Type of co...	Normal
Concrete	C30/37
Stone diam...	32
Special con...	☐
cmin,dur [mm]	25
Delta;cdur [...	0
Calculat...	
Delta;cdur...	0
Delta;cdur...	0
Delta;cdur...	0
Design	
Main	
Material	B 600C

Actions

Load default values	>>>
Concrete Setup	>>>

Pics.13 – Concrete 1D data and individual setting for member

- **green items** are taken from the national annex



- Czech CSN-EN NA
  - Concrete
    - General
      - Concrete
      - Non-prestressed reinforcement
      - Prestressed reinforcement
      - Durability and concrete cover
    - ULS
      - General
      - Punching
    - SLS
      - General
      - Prestressing
    - Allowable stress
      - Stress limitation during tensioning
      - SLS stress limitation
    - Detailing provisions
      - Detailing provisions
      - Columns
      - Beams
      - 2D structures and slabs
      - Punching

General	
Concrete	
National annex	
EN_1992_1_1	
gamma_c	
Values [-]	1,50 / 1,20
fck_max - maximum value o...	
Value [MPa]	90,00
alpha_cc - coeff. taking acc...	
Value [-]	1,00
alpha_ct - coeff. taking acc...	
Value [-]	1,00
k1_red - coeff. for calculatio...	
Value [-]	0,44
k2_red - coeff. for calculatio...	
Formula	Formula
k3_red - coeff. for calculatio...	
Value [-]	0,54
k4_red - coeff. for calculatio...	
Formula	Formula
k5_red - coeff. for calculatio...	

Pics.14 – National annex in green colour

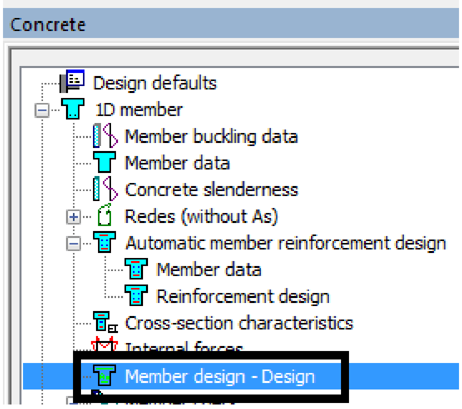
5. Member design - Design

You can use this function:

a) before you enter some real reinforcement, program is able to calculate longitudinal reinforcement area, shear reinforcement area etc. provisionally. It is also able to show you the proper locations of bars so that the member satisfies the check.

b) when you want to assess a member at SLS and find out whenther you pass crack width criteria. No real reinforcement is needed, simply execute this design and use the designed reinforcement for the check.

c) during reconstruction when you usually know how much reniforcement there is in the member. Program is able to tell you how much steel area you need to add so that the member can take the new load.

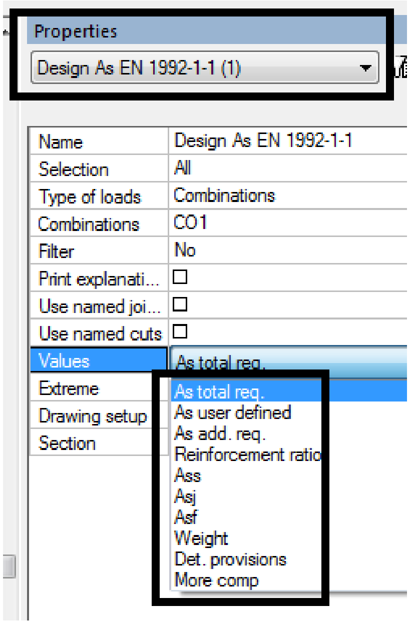


Pics.15 – Member design – Design

d) for calculation of **Code dependant deflections**, so called nonlinear deformations with creep, and you don't want to input reinforcement into the whole model.

You can use following options during the design:

a) **As total reguired** – program designs necessary area of a longitudinal reinforcement.
b) **As user defined** – use for inputted reinforcement representation.
c) **As additional required** – use for calculation of how much reinforcement is needed to add to satisfy member check.
d) **Reinforcement ratio** – program designs reinforcement according to reinf. ratio.
e) **Ass** – program designs total shear reinforcement.
f) **Asj** - program designs shear reinforcement in the horizontal joint, e.g. when using phased cross-section.

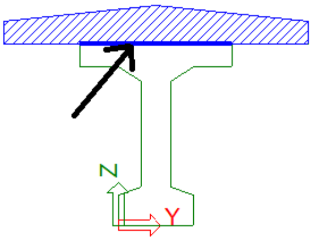


Properties

Design As EN 1992-1-1 (1)

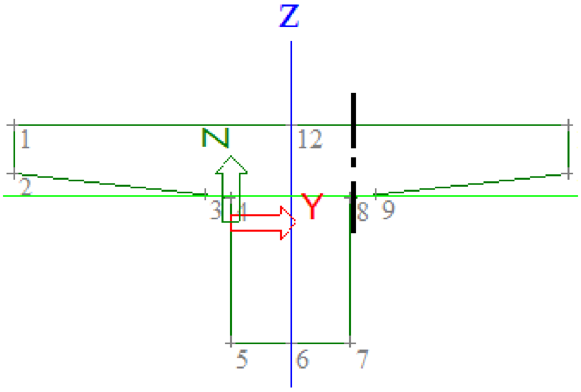
Name	Design As EN 1992-1-1
Selection	All
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As total req.
Extreme	
Drawing setup	
Section	

Pics.16 – Options for design



Pics.17 – Asj shear in the horizontal joint

g) **Asf** – program designs shear reinforcement in the vertical joint

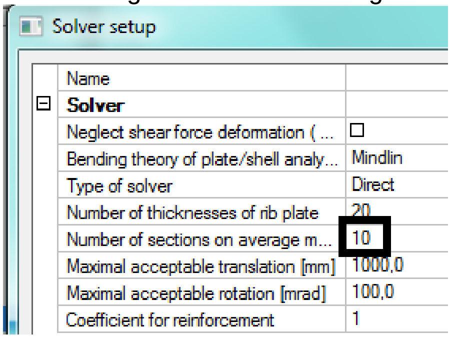


Pics.18 – Asf - shear in the vertical joint

h) **Wight** – design of a longitudinal and shear reinforcement. It shows the amount of it in kilograms in section.

5.1. Design As – total required

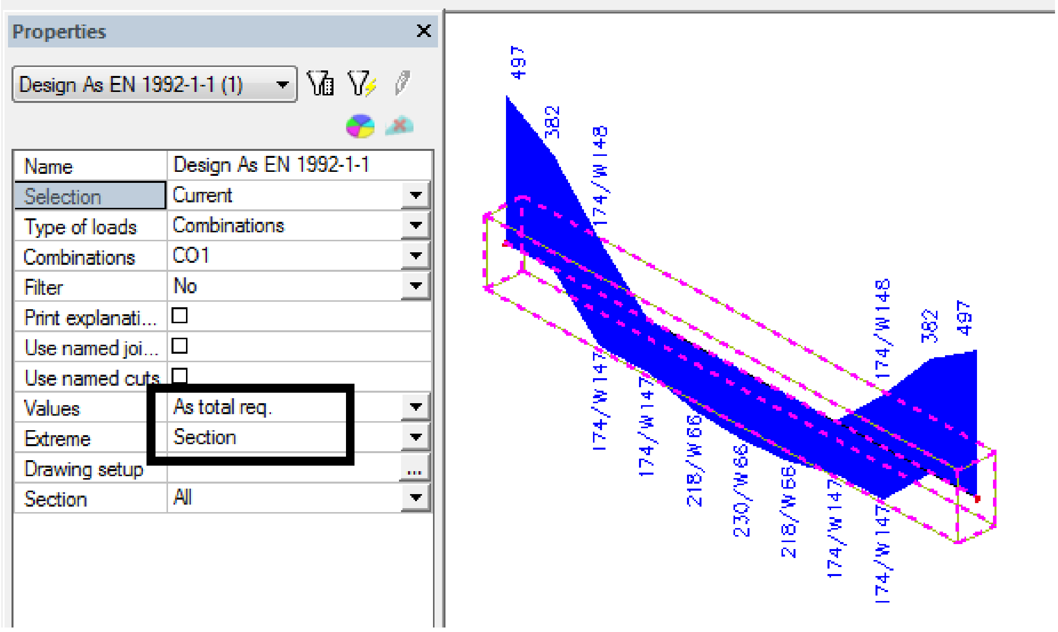
Design is made in 10 sections along the beam according to this parameter:



Name	
⊟ **Solver**	
Neglect shear force deformation (...	☐
Bending theory of plate/shell analy...	Mindlin
Type of solver	Direct
Number of thicknesses of rib plate	20
Number of sections on average m...	10
Maximal acceptable translation [mm]	1000,0
Maximal acceptable rotation [mrad]	100,0
Coefficient for reinforcement	1

Pics.19 – Solver setup

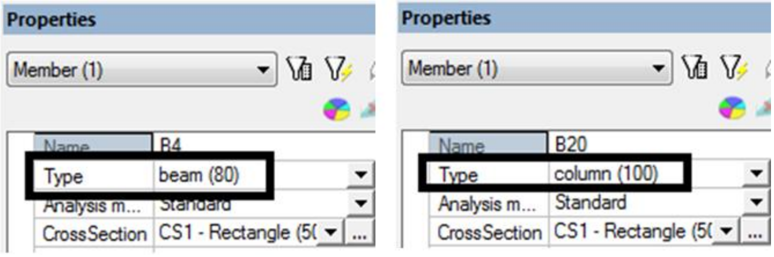
Another sections are automatically added in the critical points of every beam (e.g.end sections, openings, haunches etc.)



Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As total req.
Extreme	Section
Drawing setup	...
Section	All

Pics.20 – Sections for design As

The method of design conforms to the type of particular member:



Name	B4
Type	beam (80)
Analysis m...	Standard
CrossSection	CS1 - Rectangle (5(

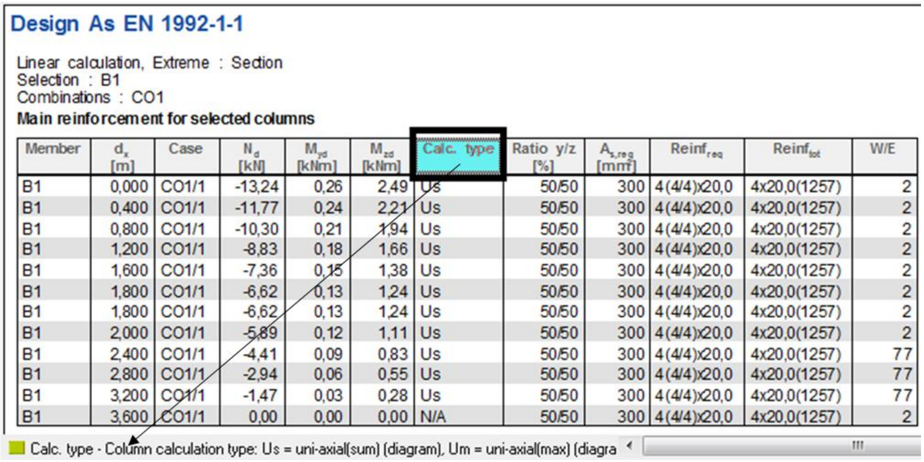
Name	B20
Type	column (100)
Analysis m...	Standard
CrossSection	CS1 - Rectangle (5(

Pics.21 – Properties of member

a) If the member type is **column** and you don't change anything in the Concrete solver program recognizes automatically whether the task is one-axis or two-axes bending and designs the reinforcement in compliance with this. You can read which method and in which section was used in the output.

Trick:

Every time you put a mouse pointer on the table heaser you can see the prompter. The user always knows what was calculated. All tables in concrete service have got this property.



Design As EN 1992-1-1

Linear calculation, Extreme : Section
Selection : B1
Combinations : CO1
Main reinforcement for selected columns

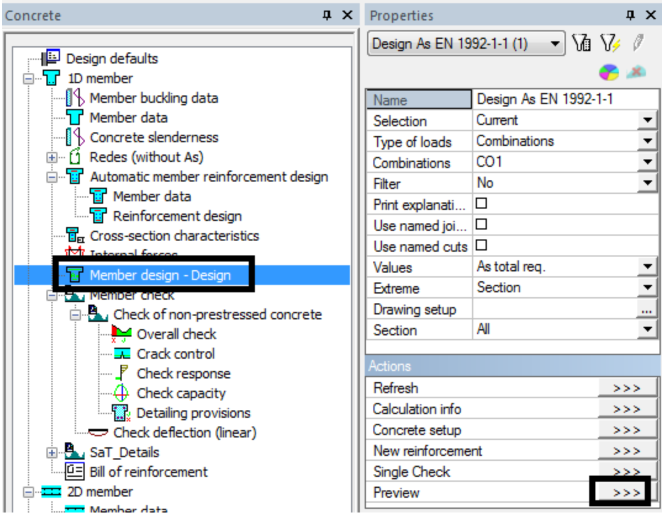
Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	Ratio y/z [%]	$A_{s,req}$ [mm^2]	$Reinf_{req}$	$Reinf_{tot}$	W/E
B1	0,000	CO1/1	-13,24	0,26	2,49	Us	50/50	300	4(4/4)x20,0	4x20,0(1257)	2
B1	0,400	CO1/1	-11,77	0,24	2,21	Us	50/50	300	4(4/4)x20,0	4x20,0(1257)	2
B1	0,800	CO1/1	-10,30	0,21	1,94	Us	50/50	300	4(4/4)x20,0	4x20,0(1257)	2
B1	1,200	CO1/1	-8,83	0,18	1,66	Us	50/50	300	4(4/4)x20,0	4x20,0(1257)	2
B1	1,600	CO1/1	-7,36	0,15	1,38	Us	50/50	300	4(4/4)x20,0	4x20,0(1257)	2
B1	1,800	CO1/1	-6,62	0,13	1,24	Us	50/50	300	4(4/4)x20,0	4x20,0(1257)	2
B1	1,800	CO1/1	-6,62	0,13	1,24	Us	50/50	300	4(4/4)x20,0	4x20,0(1257)	2
B1	2,000	CO1/1	-5,89	0,12	1,11	Us	50/50	300	4(4/4)x20,0	4x20,0(1257)	2
B1	2,400	CO1/1	-4,41	0,09	0,83	Us	50/50	300	4(4/4)x20,0	4x20,0(1257)	77
B1	2,800	CO1/1	-2,94	0,06	0,55	Us	50/50	300	4(4/4)x20,0	4x20,0(1257)	77
B1	3,200	CO1/1	-1,47	0,03	0,28	Us	50/50	300	4(4/4)x20,0	4x20,0(1257)	77
B1	3,600	CO1/1	0,00	0,00	0,00	N/A	50/50	300	4(4/4)x20,0	4x20,0(1257)	2

🟩 Calc. type - Column calculation type: Us = uni-axial(sum) (diagram), Um = uni-axial(max) (diagra

Pics.22 – The help in preview tables

Trick:

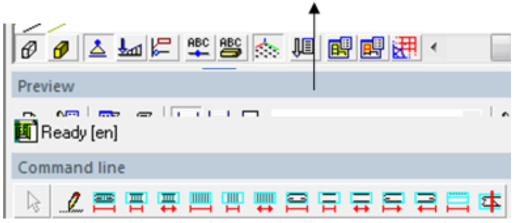
The table is opened by the action button **Preview**.



Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As total req.
Extreme	Section
Drawing setup	...
Section	All

Pics.23 – Action button Preview

Sometimes happen that the table is hidden. Then you need to pull it up with a mouse.



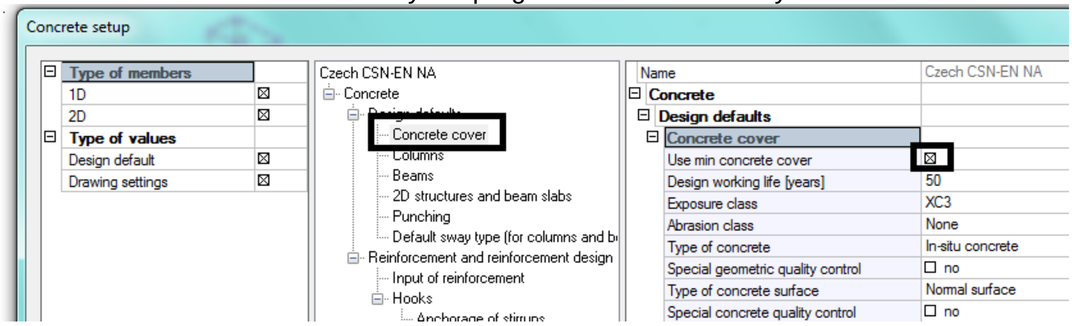
Pics.24 – Pull up of table preview

b) If the member type is **beam** program performs design with the response check.

Reinforcement cover is also taken into account in the design; values are taken from **Design defaults** or from **member data**.

Cover

a) Concrete cover can be chosen by the program from the currently used code:



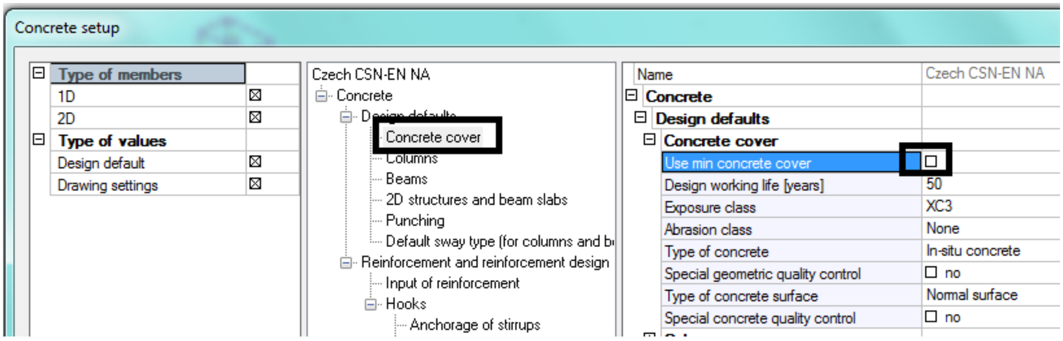
Type of members	
1D	☒
2D	☒
Type of values	
Design default	☒
Drawing settings	☒

Czech CSN-EN NA
- Concrete
  - Design defaults
    - Concrete cover
    - Columns
    - Beams
    - 2D structures and beam slabs
    - Punching
    - Default sway type (for columns and b
  - Reinforcement and reinforcement design
    - Input of reinforcement
    - Hooks
      - Anchorage of stirrups

Name	Czech CSN-EN NA
Concrete	
Design defaults	
Concrete cover	
Use min concrete cover	☒
Design working life [years]	50
Exposure class	XC3
Abrasion class	None
Type of concrete	In-situ concrete
Special geometric quality control	☐ no
Type of concrete surface	Normal surface
Special concrete quality control	☐ no

Pics.25 – The calculation of cover according to code

b) Or you can define your own cover, independently on the code, if you deactivate the check box Use min. concrete cover.



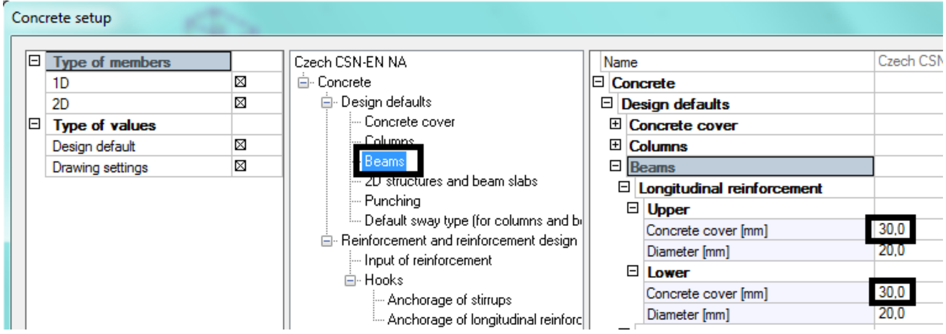
Type of members	
1D	☒
2D	☒
Type of values	
Design default	☒
Drawing settings	☒

Czech CSN-EN NA
- Concrete
  - Design defaults
    - Concrete cover
    - Columns
    - Beams
    - 2D structures and beam slabs
    - Punching
    - Default sway type (for columns and b
  - Reinforcement and reinforcement design
    - Input of reinforcement
    - Hooks
      - Anchorage of stirrups

Name	Czech CSN-EN NA
Concrete	
Design defaults	
Concrete cover	
Use min concrete cover	☐
Design working life [years]	50
Exposure class	XC3
Abrasion class	None
Type of concrete	In-situ concrete
Special geometric quality control	☐ no
Type of concrete surface	Normal surface
Special concrete quality control	☐ no

Pics.26 – Concrete cover independent to code

Next, it depends on the member type, you can set the cover value for all member types independently. Values for upper and lower surface of a beam can also differ.



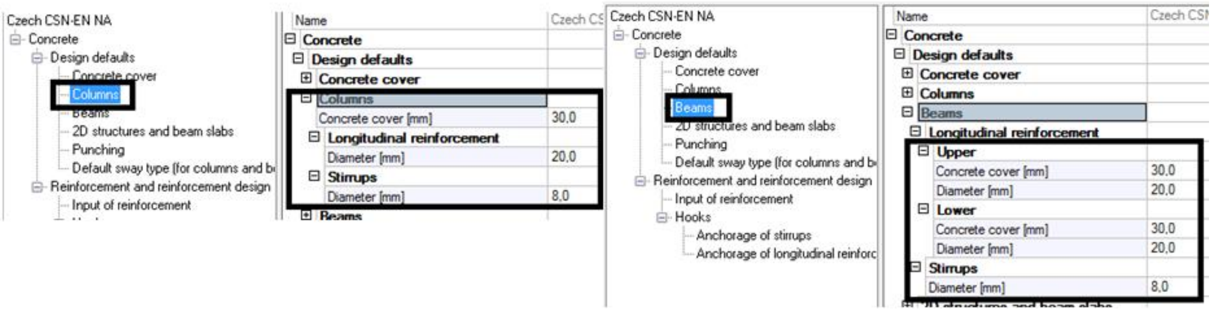
Type of members	
1D	☒
2D	☒
Type of values	
Design default	☒
Drawing settings	☒

Czech CSN-EN NA
- Concrete
  - Design defaults
    - Concrete cover
    - Columns
    - Beams
    - 2D structures and beam slabs
    - Punching
    - Default sway type (for columns and b
  - Reinforcement and reinforcement design
    - Input of reinforcement
    - Hooks
      - Anchorage of stirrups
      - Anchorage of longitudinal reinforc

Name	Czech CSN
Concrete	
Design defaults	
Concrete cover	
Columns	
Beams	
Longitudinal reinforcement	
Upper	
Concrete cover [mm]	30,0
Diameter [mm]	20,0
Lower	
Concrete cover [mm]	30,0
Diameter [mm]	20,0

Pics.27 – Setting of cover for beams

Program also takes bar diameters from the **Design defaults** (or from **member data**) and according to the member type relevant value is applied in the design



Concrete
Design defaults
Concrete cover
Columns
Concrete cover [mm] 30,0
Longitudinal reinforcement
Diameter [mm] 20,0
Stirrups
Diameter [mm] 8,0
Beams

Concrete
Design defaults
Concrete cover
Columns
Beams
Longitudinal reinforcement
Upper
Concrete cover [mm] 30,0
Diameter [mm] 20,0
Lower
Concrete cover [mm] 30,0
Diameter [mm] 20,0
Stirrups
Diameter [mm] 8,0

Pics.28 – Setting of reinforcement profiles for all construction

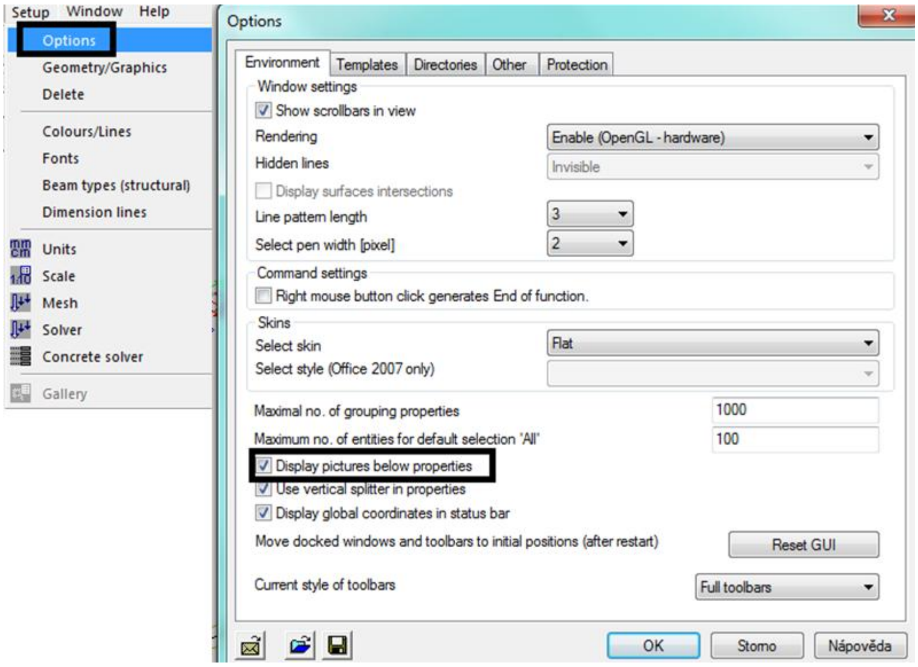
Program also evaluates the setting from Setup/**Concrete solver**. Its components and how they influence the design or the check will be explained below.

Note:

Program designs reinforcement to only one layer. It can´t design reinforcement in more layers but you can go around this problem in a following way: you can set bigger cover which will corresponds to the centre of gravity of multi-layer reinforcement and calculate bar positions individually.

Trick:

New interactive help was implemented into 2010 version, this is available for all concrete setting. Tick this box for utilization:



Window settings
☑ Show scrollbars in view
Rendering: Enable (OpenGL - hardware)
Hidden lines: Invisible
☐ Display surfaces intersections
Line pattern length: 3
Select pen width [pixel]: 2

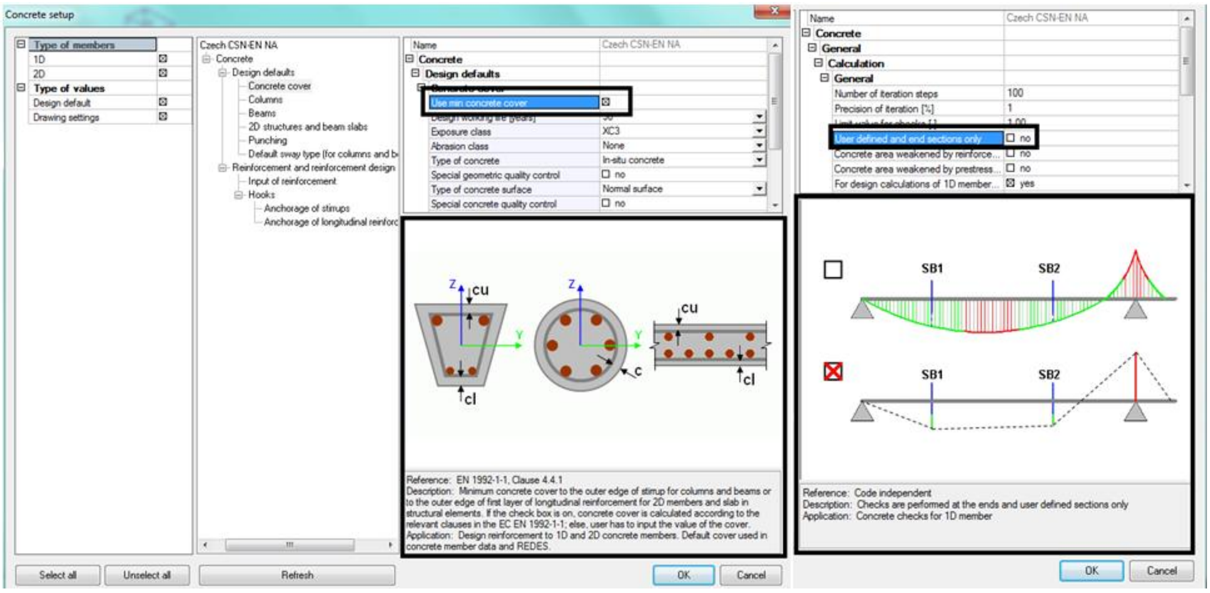
Command settings
☐ Right mouse button click generates End of function.

Skins
Select skin: Flat
Select style (Office 2007 only)

Maximal no. of grouping properties: 1000
Maximum no. of entities for default selection 'All': 100
☑ Display pictures below properties
☑ Use vertical splitter in properties
☑ Display global coordinates in status bar
Move docked windows and toolbars to initial positions (after restart)
Current style of toolbars: Full toolbars

Pics.29 – Display pictures below properties

Restart of Scia Engineer is necessary after ticking this check box. Afterwards you will be able to see helping pictures and explanations for each item from Design defaults and Concrete solver.



Name	Czech CSN-EN NA
Concrete	
Design defaults	
Use min concrete cover	☒
Exposure class	XC3
Abrasion class	None
Type of concrete	In-situ concrete
Special geometric quality control	☐ no
Type of concrete surface	Normal surface
Special concrete quality control	☐ no

Reference: EN 1992-1-1, Clause 4.4.1
Description: Minimum concrete cover to the outer edge of stirrup for columns and beams or to the outer edge of first layer of longitudinal reinforcement for 2D members and slab in structural elements. If the check box is on, concrete cover is calculated according to the relevant clauses in the EC EN 1992-1-1; else, user has to input the value of the cover.
Application: Design reinforcement to 1D and 2D concrete members. Default cover used in concrete member data and REDES.

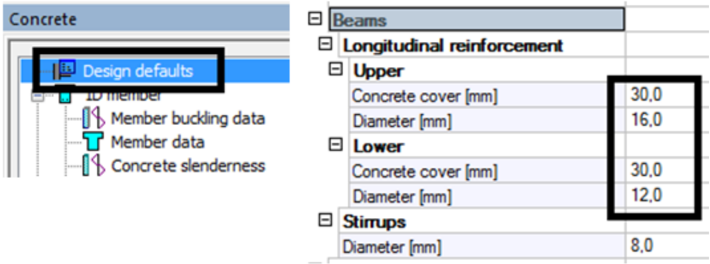
Name	Czech CSN-EN NA
Concrete	
General	
Calculation	
General	
Number of iteration steps	100
Precision of iteration [%]	1
User defined and end sections only	☐ no
Concrete area weakened by reinforce...	☐ no
Concrete area weakened by prestress...	☐ no
For design calculations of 1D member...	☒ yes

Reference: Code independent
Description: Checks are performed at the ends and user defined sections only
Application: Concrete checks for 1D member

Pics.30 – Displaying on-line helps

5.1.1. As total required – design control

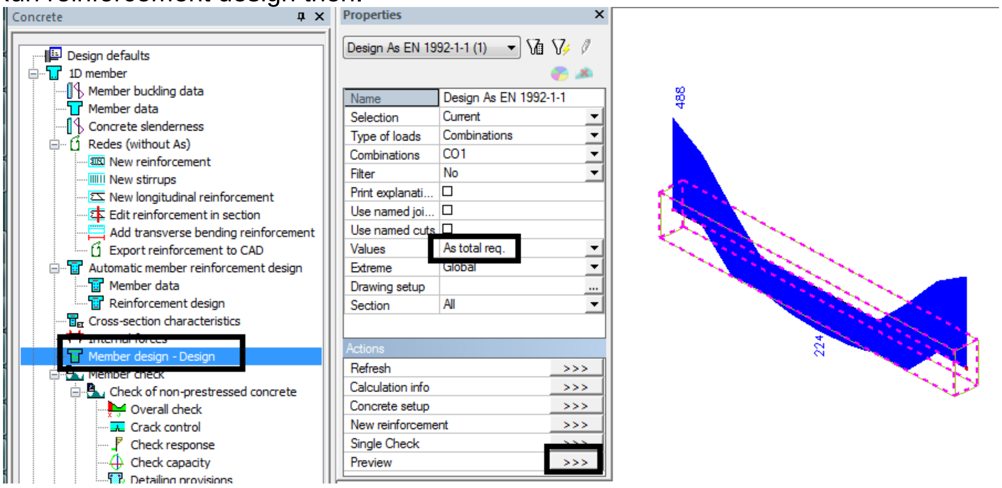
a) In the Design defaults can be set that program should use bars of a diameter 16 mm for upper layer and diameter 12 mm for lower layer for all beams.



Beams	
Longitudinal reinforcement	
Upper	
Concrete cover [mm]	30,0
Diameter [mm]	16,0
Lower	
Concrete cover [mm]	30,0
Diameter [mm]	12,0
Stirrups	
Diameter [mm]	8,0

Pics.31 – Setting diameters of reinforcement for beams

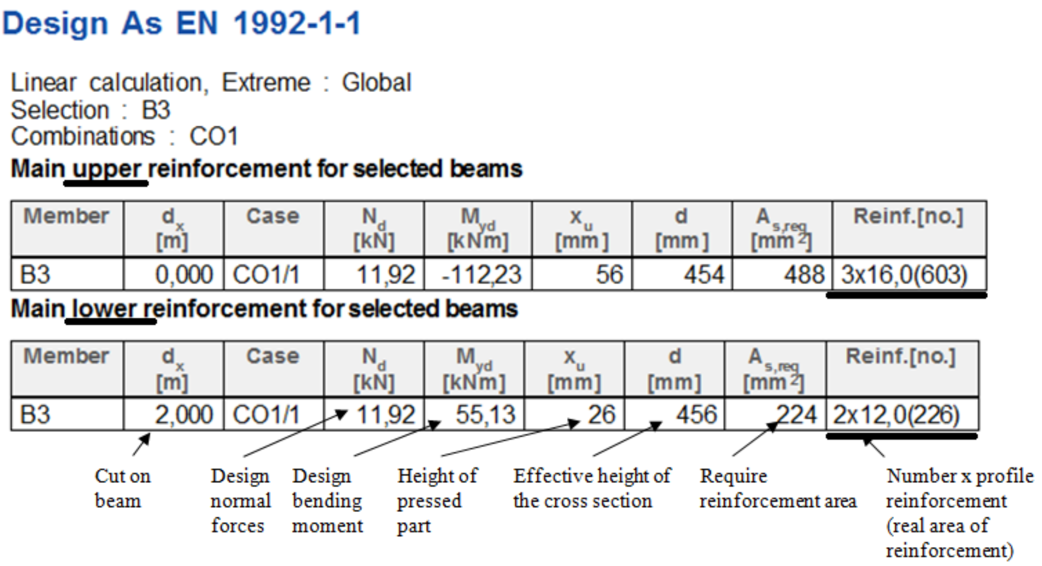
Run reinforcement design then.



Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As total req.
Extreme	Global
Drawing setup	...
Section	All

Pics.32 – Member design – Desing

Three bars with diameter 16mm to the upper surface and 2 bars with diameter 12mm to the lower surface were designed. Following values were calculated:



Design As EN 1992-1-1

Linear calculation, Extreme : Global
Selection : B3
Combinations : CO1

Main upper reinforcement for selected beams

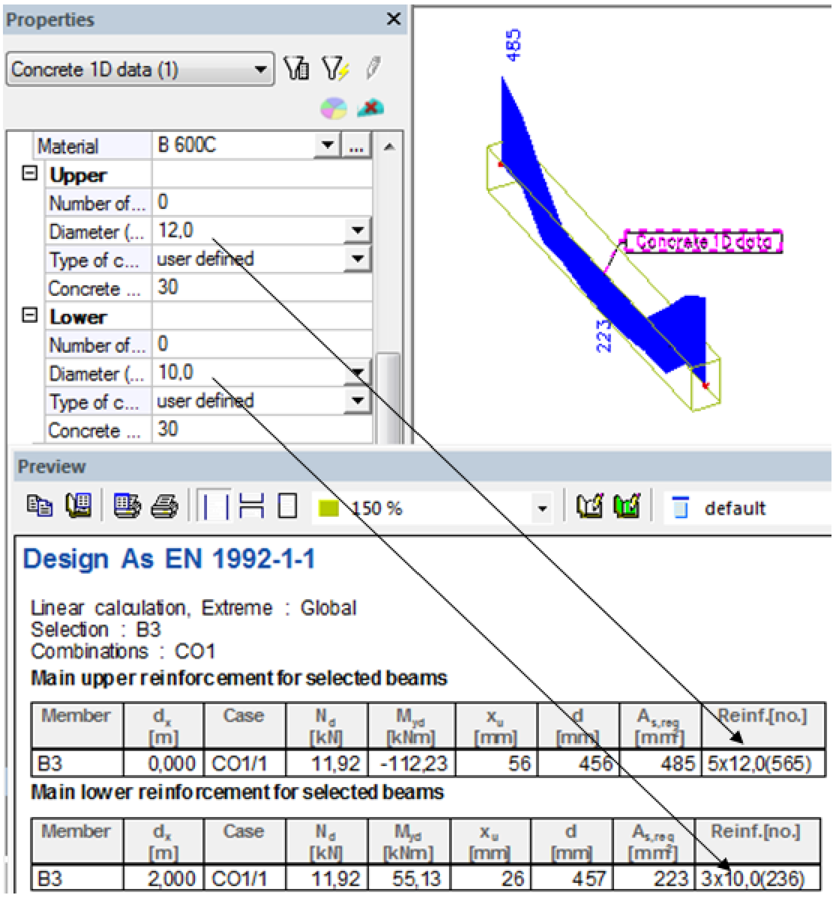
Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{s,req}$ [mm^2]	Reinf.[no.]
B3	0,000	CO1/1	11,92	-112,23	56	454	488	3x16,0(603)

Main lower reinforcement for selected beams

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{s,req}$ [mm^2]	Reinf.[no.]
B3	2,000	CO1/1	11,92	55,13	26	456	224	2x12,0(226)

Pics.33 – Member design – Design. Diameters of bars are taken from design defaults.

b) You can also design each member individually, with different reinforcement. Set member data to beams where you specify different bar diameters. The program automatically picks out those properties that belong to the particular member with member data and the rest is taken from Design defaults. Member data were set such that upper reinforcement is of diameter 10mm and lower reinforcement of diameter 12mm.



Material: B 600C

Upper

Number of...: 0
Diameter (...: 12,0
Type of c...: user defined
Concrete ...: 30

Lower

Number of...: 0
Diameter (...: 10,0
Type of c...: user defined
Concrete ...: 30

Design As EN 1992-1-1

Linear calculation, Extreme : Global
Selection : B3
Combinations : CO1

Main upper reinforcement for selected beams

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{s,req}$ [mm^2]	Reinf.[no.]
B3	0,000	CO1/1	11,92	-112,23	56	456	485	5x12,0(565)

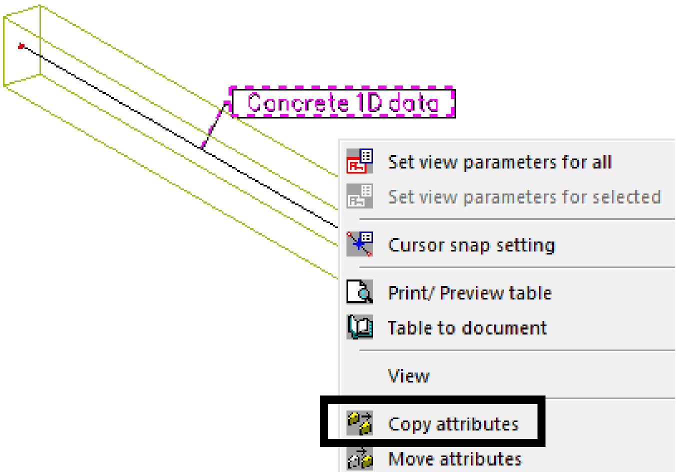
Main lower reinforcement for selected beams

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{s,req}$ [mm^2]	Reinf.[no.]
B3	2,000	CO1/1	11,92	55,13	26	457	223	3x10,0(236)

Pics.34 – Member design – Design. Diameters of bars are taken from member data.

Trick:

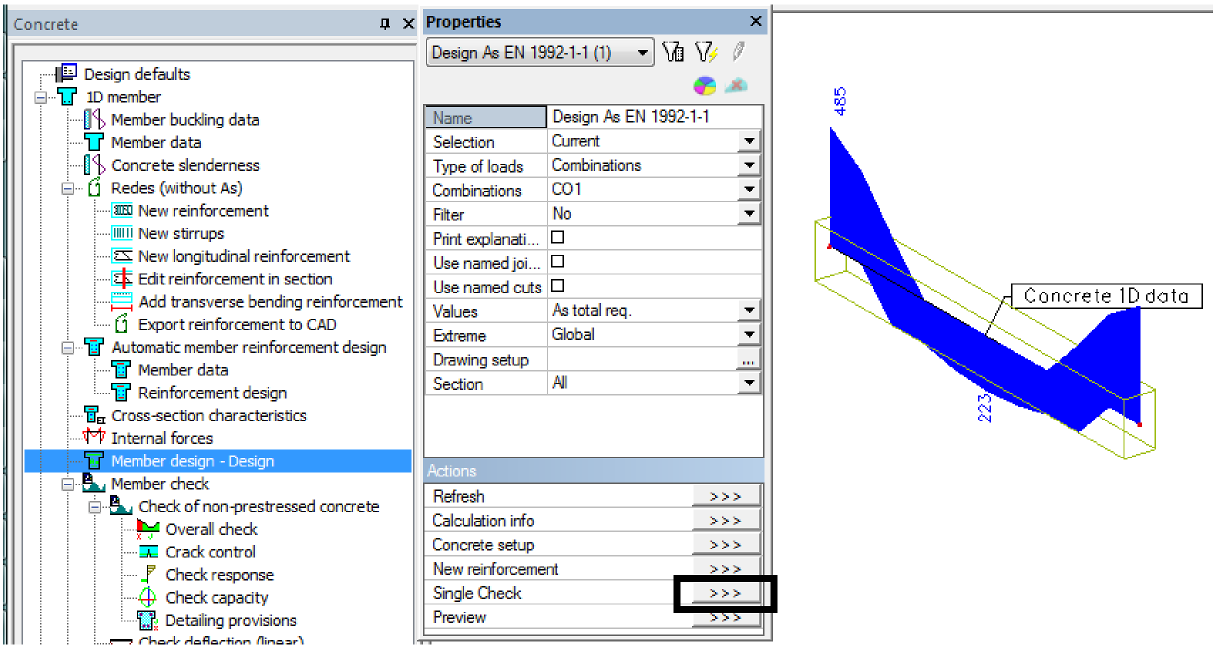
When you want to define identical member data to more members you can simply copy the flag. The flag is coppied as an attribute (additional data in older versions).



Pics.35 – Copy of member data

Trick:

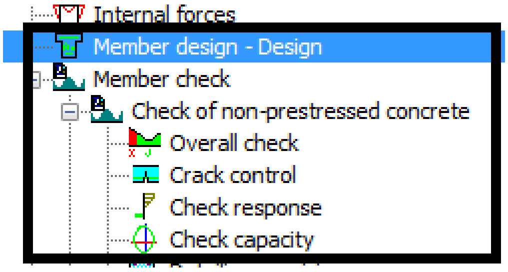
If you are not sure where and how much reinforcement is designed you can use Member check action button.



Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As total req.
Extreme	Global
Drawing setup	...
Section	All

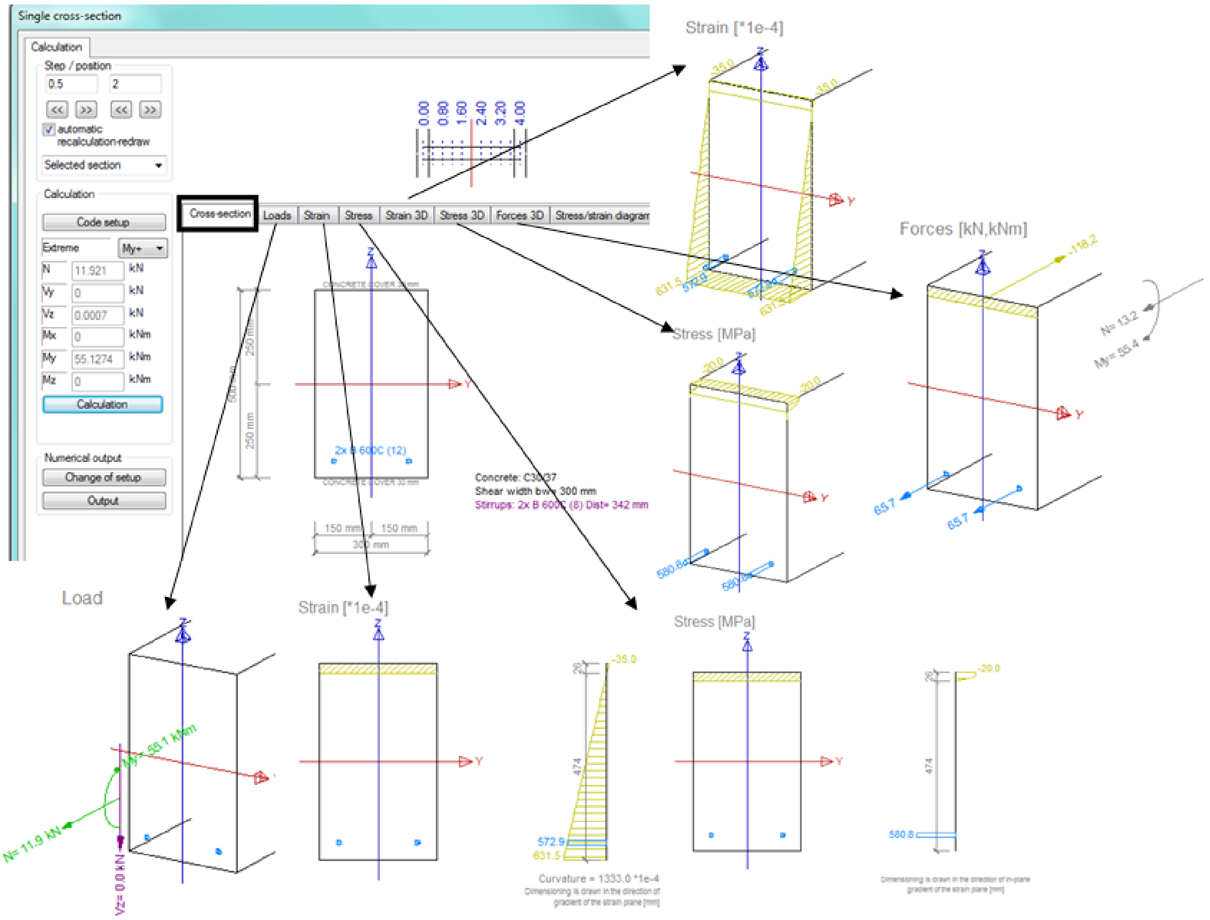
Pics.36 – Action button – Single check

This button can be used for all of these functions:



Pics.37 – Using action button – Single check

This button shows details of a design in particular section with reinforcement position.



Single cross-section

Step / position: 0.5 2

☑ automatic recalculation-redraw

Selected section

Extreme: My+

N 11.921 kN

Vy 0 kN

Vz 0.0007 kN

Mx 0 kNm

My 55.1274 kNm

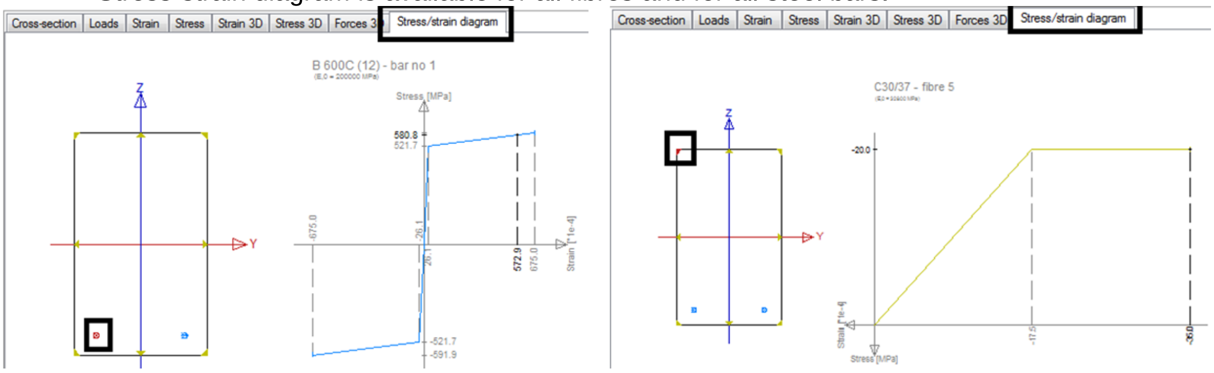
Mz 0 kNm

Concrete: C30/37
Shear width bw= 300 mm
Stirrups: 2x B 600C (8) Dist= 342 mm

Curvature = 1333.0 *1e-4

Pics.38 – Design details

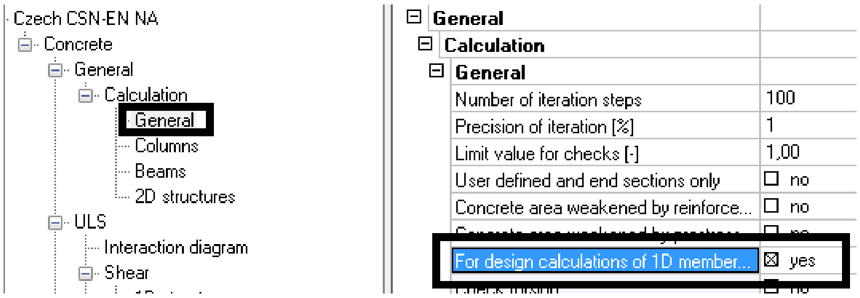
Stress-strain diagram is available for all fibres and for all steel bars.



Pics.39 – Stress-strain diagram

5.2. How to consider longitudinal user reinforcement

This function along with description can be found in Setup/**Concrete solver**.



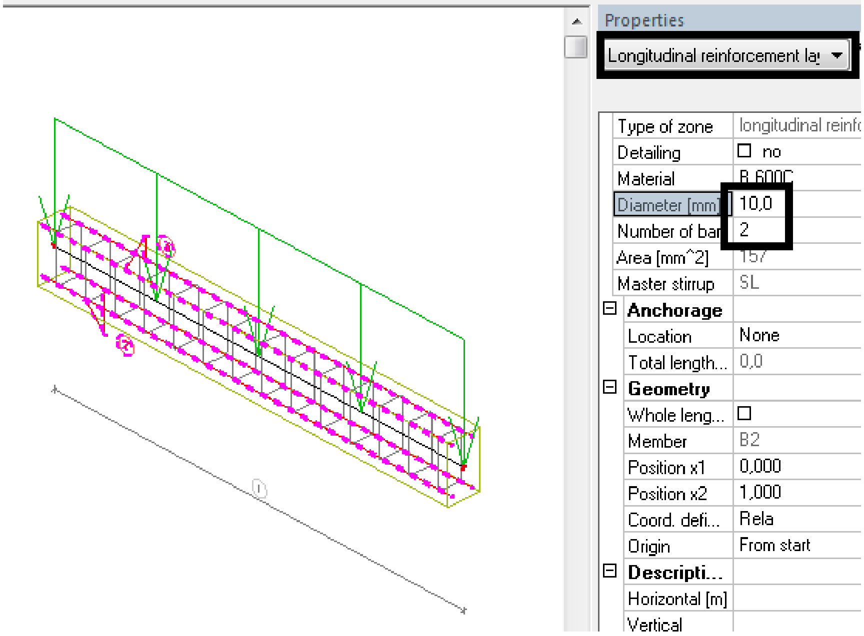
- Czech CSN-EN NA
  - Concrete
    - General
      - Calculation
        - General
        - Columns
        - Beams
        - 2D structures
    - ULS
      - Interaction diagram
      - Shear

General	
Calculation	
General	
Number of iteration steps	100
Precision of iteration [%]	1
Limit value for checks [-]	1,00
User defined and end sections only	☐ no
Concrete area weakened by reinforce...	☐ no
For design calculations of 1D member...	☒ yes

Pics.40 – For design calculation of 1D member consider longitudinal user reinforcement

When activated it can be used as follows:

a) A member has got real longitudinal reinforcement – 2 bars of a diameter 10 mm on both surfaces.



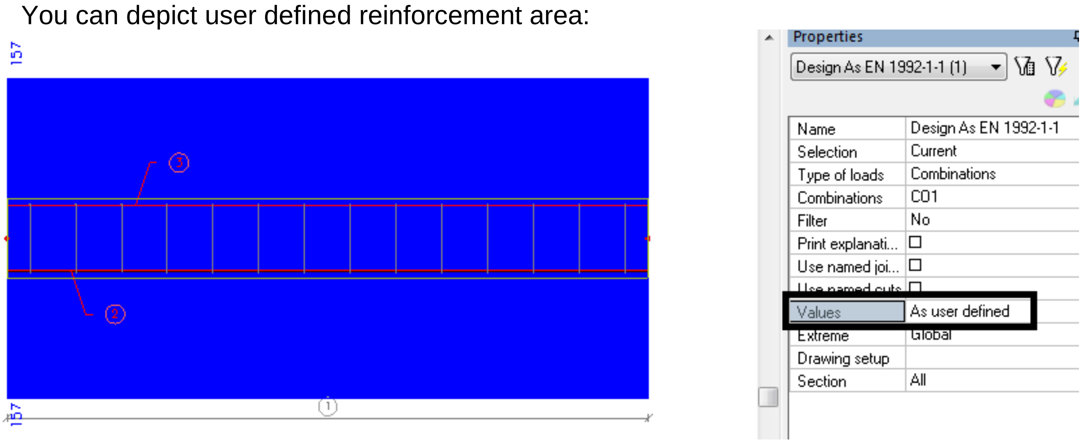
Properties

Longitudinal reinforcement la

Type of zone	longitudinal reinfo
Detailing	☐ no
Material	B 600C
Diameter [mm]	10,0
Number of bar	2
Area [mm^2]	157
Master stirrup	SL
Anchorage	
Location	None
Total length...	0,0
Geometry	
Whole leng...	☐
Member	B2
Position x1	0,000
Position x2	1,000
Coord. defi...	Rela
Origin	From start
Descripti...	
Horizontal [m]	
Vertical	

Pics.41 – User defined bars of reinforcement of diameter 10 mm

You can depict user defined reinforcement area:



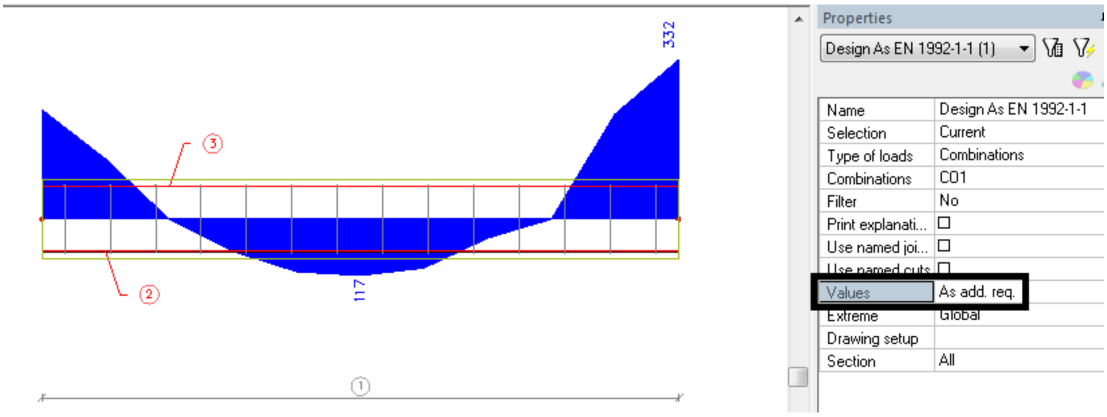
Properties

Design As EN 1992-1-1 (1)

Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	C01
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As user defined
Extreme	Global
Drawing setup	
Section	All

Pics.42 – User defined areas of reinforcement in section

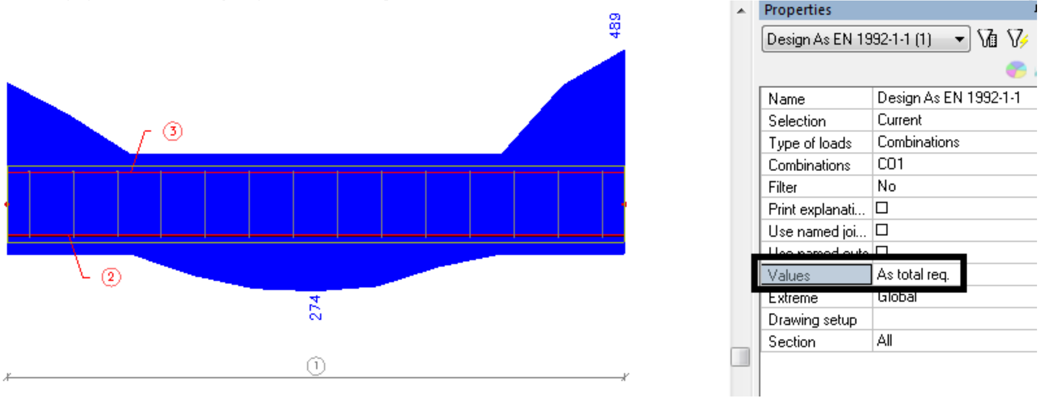
As well as additional reinforcement area which is necessary to add. Diameter values are taken from Design defaults of from Member data.



Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As add. req.
Extreme	Global
Drawing setup	
Section	All

Pics.43 – Additional required reinforcement area

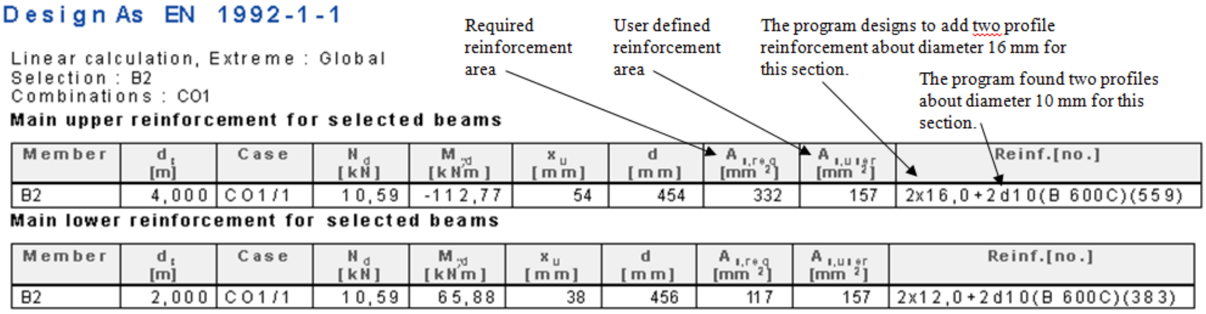
Finally you can display **Total required reinforcement = user defined + additional required.**



Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As total req.
Extreme	Global
Drawing setup	
Section	All

Pics.44 –Total required reinforcement area

More values will be included in the table:



Design As EN 1992-1-1

Linear calculation, Extreme : Global
Selection : B2
Combinations : CO1

Main upper reinforcement for selected beams

Member	d_t [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{1,req}$ [mm ^{2}]	$A_{1,user}$ [mm ^{2}]	Reinf.[no.]
B2	4,000	CO1/1	10,59	-112,77	54	454	332	157	2x16,0+2d10(B 600C)(559)

Main lower reinforcement for selected beams

Member	d_t [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{1,req}$ [mm ^{2}]	$A_{1,user}$ [mm ^{2}]	Reinf.[no.]
B2	2,000	CO1/1	10,59	65,88	38	456	117	157	2x12,0+2d10(B 600C)(383)

Required reinforcement area

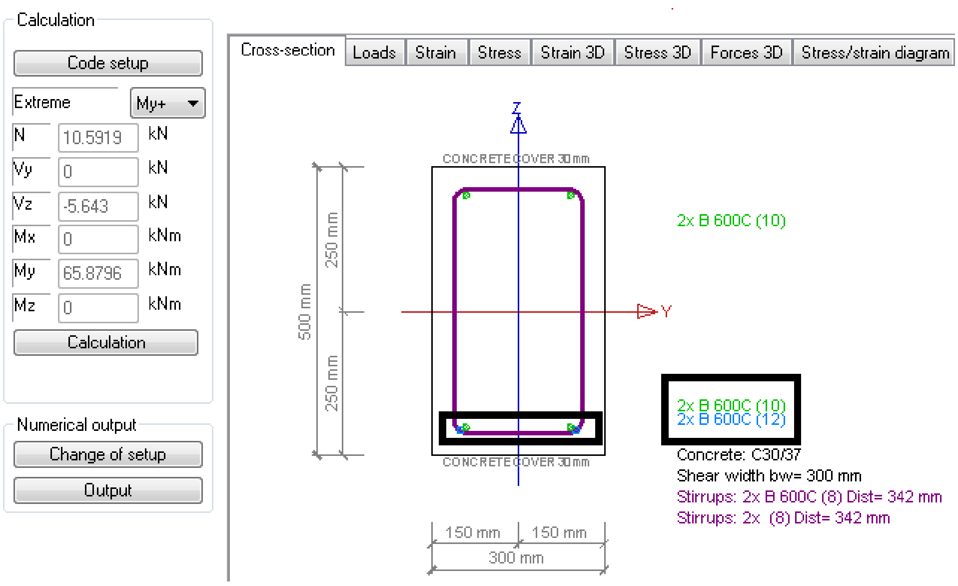
User defined reinforcement area

The program designs to add two profile reinforcement about diameter 16 mm for this section.

The program found two profiles about diameter 10 mm for this section.

Pics.45 – Table of total required reinforcement

Control is available by the action button **Member check**. Green bars are real reinforcement set by the user, blue bars are additional required.



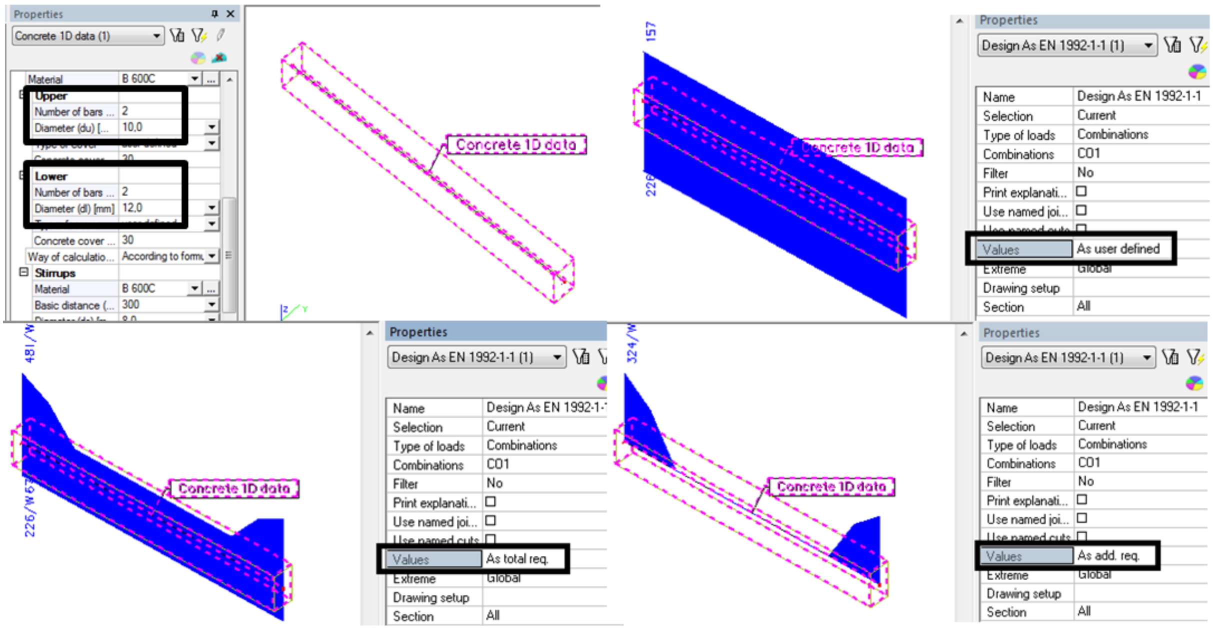
Extreme: My+

N	10.5919	kN
Vy	0	kN
Vz	-5.643	kN
Mx	0	kNm
My	65.8796	kNm
Mz	0	kNm

2x B 600C (10)
2x B 600C (12)
Concrete: C30/37
Shear width bw= 300 mm
Stirrups: 2x B 600C (8) Dist= 342 mm
Stirrups: 2x (8) Dist= 342 mm

Pics.46 – Detailed check of reinforcement position

b) Another utilisation can be made by member data where you can take into account supposed reinforcement.



Properties: Concrete 1D data (1)

Material	B 600C
Upper	
Number of bars ...	2
Diameter (du) [...	10,0
Concrete cover ...	30
Lower	
Number of bars ...	2
Diameter (dl) [mm]	12,0
Concrete cover ...	30
Way of calculatio...	According to form
Stirrups	
Material	B 600C
Basic distance (...	300

Properties: Design As EN 1992-1-1 (1)

Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As user defined
Extreme	Global
Drawing setup	
Section	All

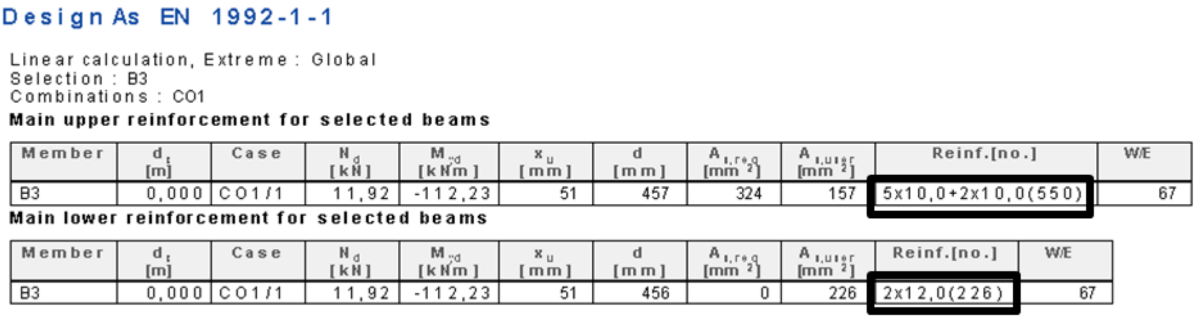
Properties: Design As EN 1992-1-1 (1)

Name	Design As EN 1992-1-
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As total req.
Extreme	Global
Drawing setup	
Section	All

Properties: Design As EN 1992-1-1 (1)

Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As add. req.
Extreme	Global
Drawing setup	
Section	All

Pics.47 – Member design – Design through member data



Design As EN 1992-1-1

Linear calculation, Extreme : Global
Selection : B3
Combinations : CO1

Main upper reinforcement for selected beams

Member	d_t [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{I,req}$ [mm ^{2}]	$A_{I,user}$ [mm ^{2}]	Reinf.[no.]	W/E
B3	0,000	CO1/1	11,92	-112,23	51	457	324	157	5x10,0+2x10,0(550)	67

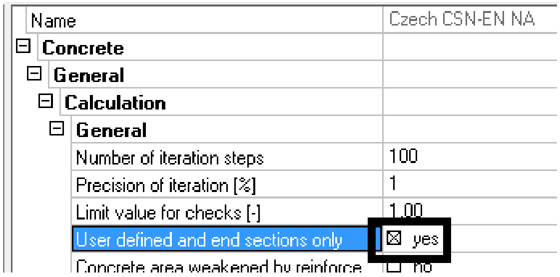
Main lower reinforcement for selected beams

Member	d_t [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{I,req}$ [mm ^{2}]	$A_{I,user}$ [mm ^{2}]	Reinf.[no.]	W/E
B3	0,000	CO1/1	11,92	-112,23	51	456	0	226	2x12,0(226)	67

Pics.48 – Table of reinforcement desing using member data.

6. Assessment in selected sections

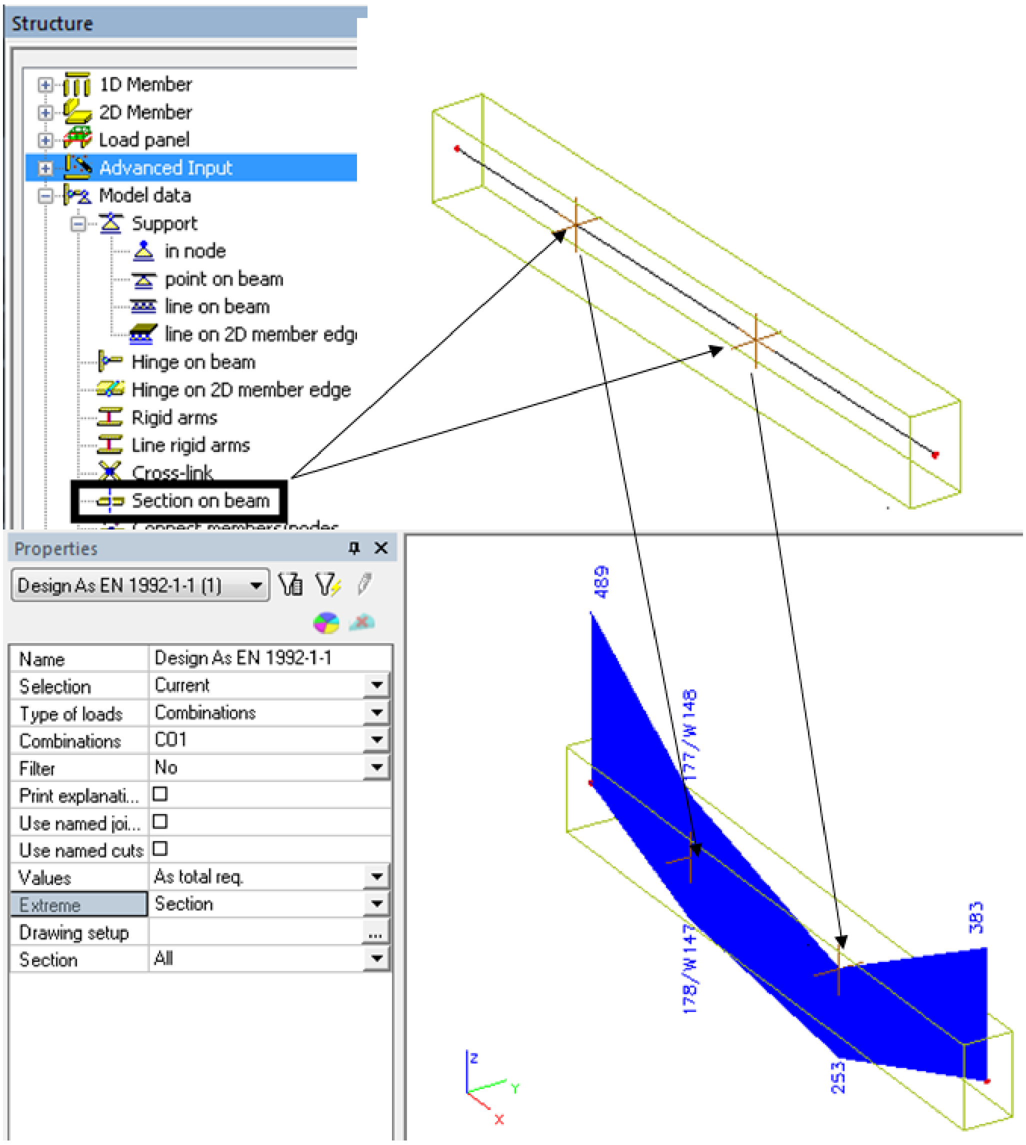
This function can be found in Setup/**Concrete solver**. If it is ticked checks will be executed in end and user defined sections only, meaning that you can choose any arbitrary position along the beam where to design and check reinforcement.



Name	Czech CSN-EN NA
⊟ **Concrete**	
⊟ **General**	
⊟ **Calculation**	
⊟ **General**	
Number of iteration steps	100
Precision of iteration [%]	1
Limit value for checks [-]	1.00
User defined and end sections only	☒ yes
Concrete area weakened by reinforce	☐ no

Pics.49 – Check and reinforcement design in selected sections.

Sections are defined in the structure service.



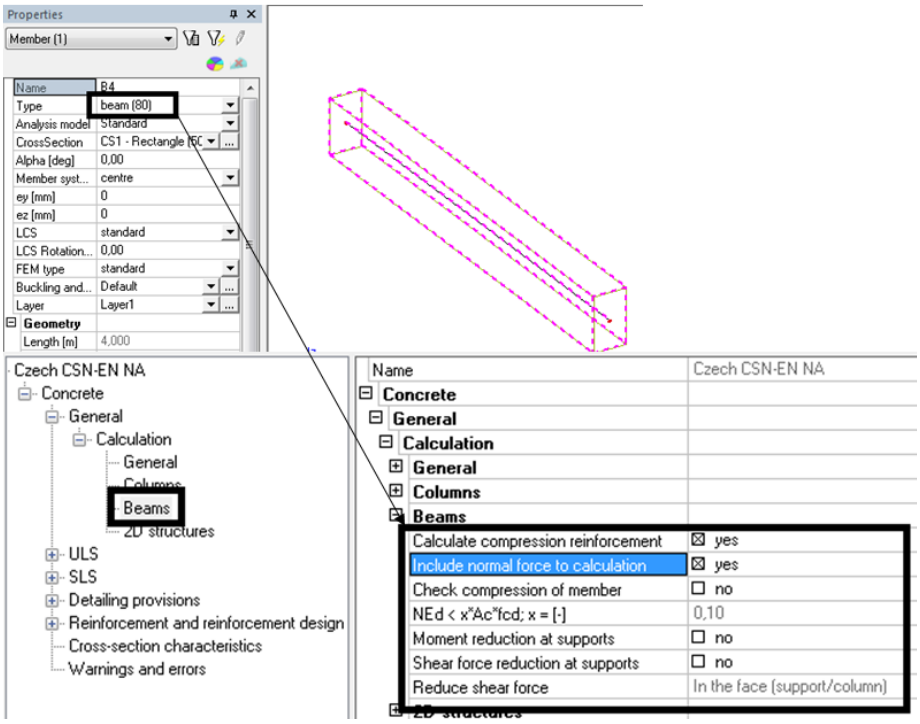
Design As EN 1992-1-1 (1)

Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As total req.
Extreme	Section
Drawing setup	...
Section	All

Pics.50 – Reinforcement design in selected sections.

7. Functions for reinforcement design and beam checks

All these settings are accessible through Setup/**Concrete solver.**



Properties

Member (1)

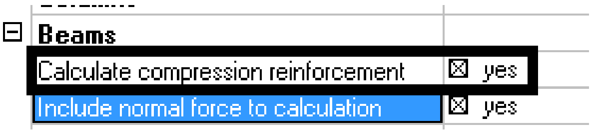
Name	B4
Type	beam (80)
Analysis model	Standard
CrossSection	CS1 - Rectangle (50
Alpha [deg]	0,00
Member syst...	centre
ey [mm]	0
ez [mm]	0
LCS	standard
LCS Rotation...	0,00
FEM type	standard
Buckling and...	Default
Layer	Layer1
Geometry	
Length [m]	4,000

Name	Czech CSN-EN NA
Concrete	
General	
Calculation	
General	
Columns	
Beams	
Calculate compression reinforcement	☒ yes
Include normal force to calculation	☒ yes
Check compression of member	☐ no
NEd < x*Ac*fcd; x = [-]	0,10
Moment reduction at supports	☐ no
Shear force reduction at supports	☐ no
Reduce shear force	In the face (support/column)
2D structures	

Pics.51 – Setting for beam

7.1. Calculate compression reinforcement

We advise to have this option always ticked. It means that the program designs compression reinforcement if necessary. It should also not happen that no internal forces equilibrium is found and no reinforcement designed when this function is ticked.

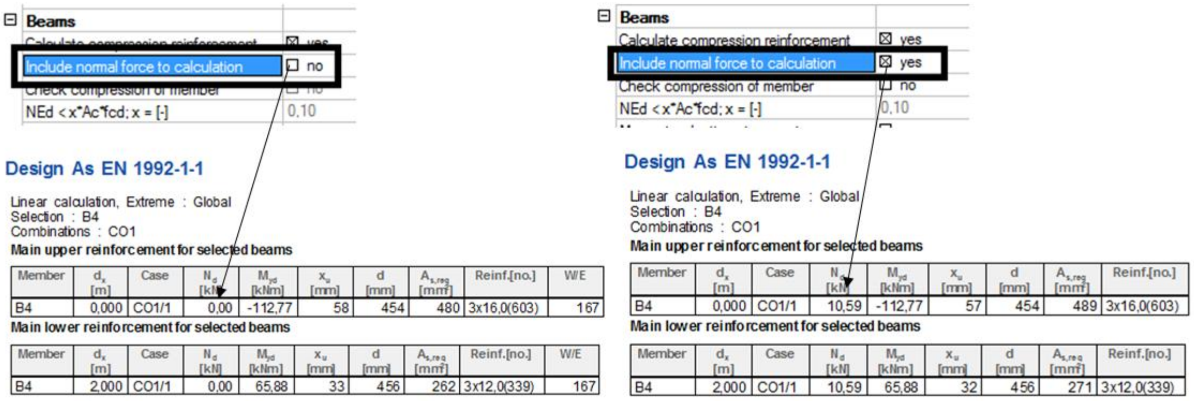


Beams	
Calculate compression reinforcement	☒ yes
Include normal force to calculation	☒ yes

Pics.52 – Calculate compression reinforcement

7.2. Include normal force to calculation

If you want to design a beam with only bending actions you should mark this check box.



Beams	
Calculate compression reinforcement	☒ yes
Include normal force to calculation	☐ no
Check compression of member	☐ no
NEd < x*Ac*fcd; x = [-]	0,10

Design As EN 1992-1-1

Linear calculation, Extreme : Global
Selection : B4
Combinations : CO1

Main upper reinforcement for selected beams

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{s,req}$ [mm²]	Reinf.[no.]	W/E
B4	0,000	CO1/1	0,00	-112,77	58	454	480	3x16,0(603)	167

Main lower reinforcement for selected beams

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{s,req}$ [mm²]	Reinf.[no.]	W/E
B4	2,000	CO1/1	0,00	65,88	33	456	262	3x12,0(339)	167

Beams	
Calculate compression reinforcement	☒ yes
Include normal force to calculation	☒ yes
Check compression of member	☐ no
NEd < x*Ac*fcd; x = [-]	0,10

Design As EN 1992-1-1

Linear calculation, Extreme : Global
Selection : B4
Combinations : CO1

Main upper reinforcement for selected beams

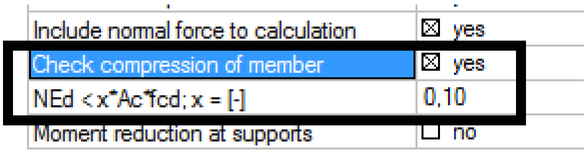
Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{s,req}$ [mm²]	Reinf.[no.]
B4	0,000	CO1/1	10,59	-112,77	57	454	489	3x16,0(603)

Main lower reinforcement for selected beams

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	x_u [mm]	d [mm]	$A_{s,req}$ [mm²]	Reinf.[no.]
B4	2,000	CO1/1	10,59	65,88	32	456	271	3x12,0(339)

Pics.53 – Design of reinforcement for bending moment only

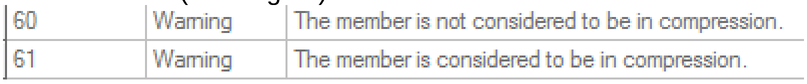
7.3. Check compression of member



Include normal force to calculation	☒ yes
Check compression of member	☒ yes
NEd < x*Ac*fcd; x = [-]	0,10
Moment reduction at supports	☐ no

Pics.54 – Check compression of member

With this option set to yes program looks whether the member is mainly unde bending or under compression. If compression is dominant following message is shown during reinforcement design or during member check (warning 61):



60	Warning	The member is not considered to be in compression.
61	Warning	The member is considered to be in compression.

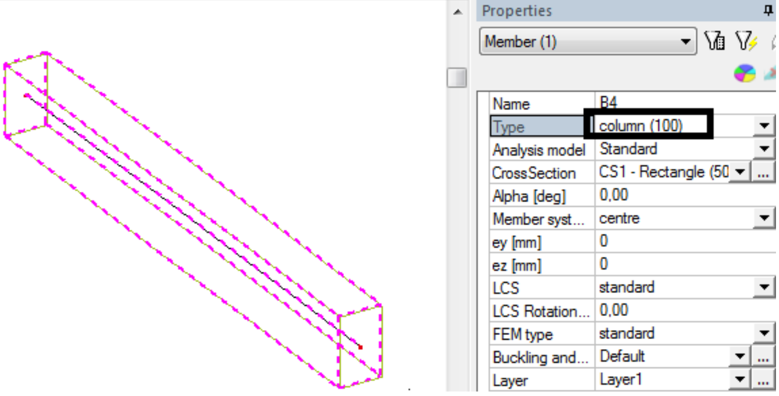
Pics.55 – Warning 61

Trick:

Eurocode doesn't specify exact limits for member mainly under compression and mainly under bending. Thus the user have an opportunity to specify this limit as a percentage of multiple A_c*f_{cd}.

A_c – area of concrete
f_{cd}- concrete design strength in compression

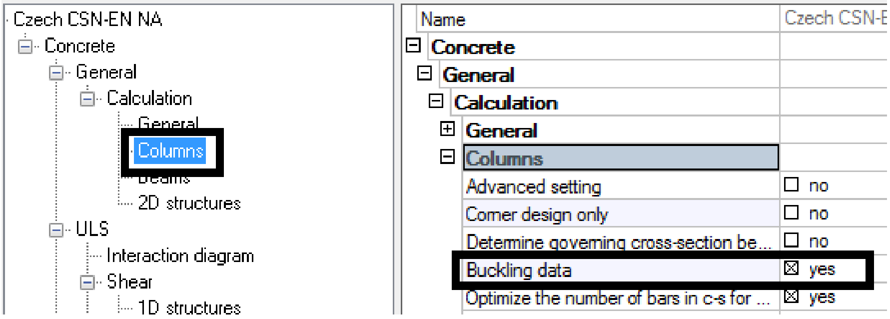
When this limit is reached the member should not be considered as a beam but as a column. The member type in the properties window should be changed.



Name	B4
Type	column (100)
Analysis model	Standard
CrossSection	CS1 - Rectangle (50
Alpha [deg]	0,00
Member syst...	centre
ey [mm]	0
ez [mm]	0
LCS	standard
LCS Rotation...	0,00
FEM type	standard
Buckling and...	Default
Layer	Layer1

Pics.56 – Change setting of element type

Thic change enables to consider the influence of buckling for the compressed member.



Name	Czech CSN-E
⊟ Concrete	
⊟ General	
⊟ Calculation	
⊞ General	
⊟ Columns	
Advanced setting	☐ no
Corner design only	☐ no
Determine governing cross-section be...	☐ no
Buckling data	☒ yes
Optimize the number of bars in c-s for ...	☒ yes

Pics.57 – Buckling date

Note:

The influence of buckling should be considered by the user if the limit slenderness λ_{lim} was exceeded. Details can be found in **chapter 8**.

7.4. Moment reduction at supports

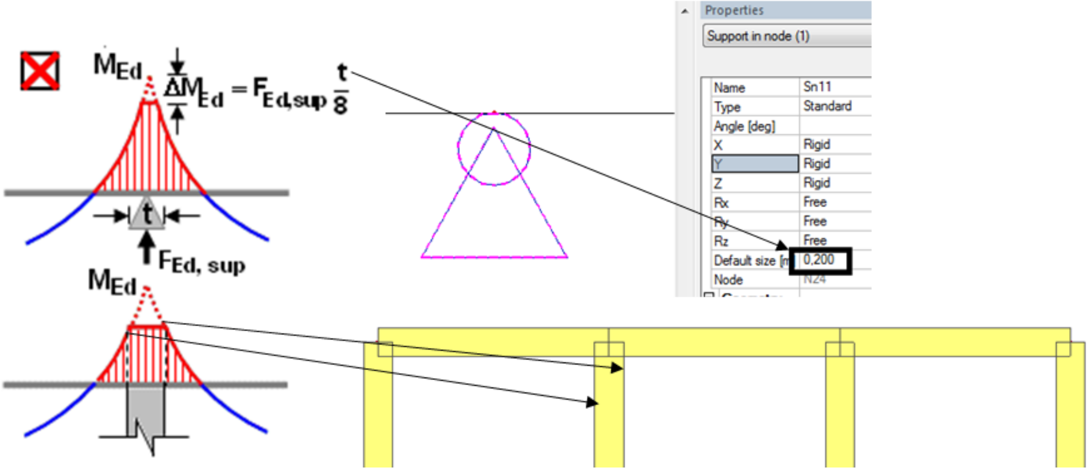
Moment reduction can be done:

a) in the column face (under beams) which are automatically recognized by the program

b) according to formula on the **picture 58**, if there is a support under the beam.

Note:

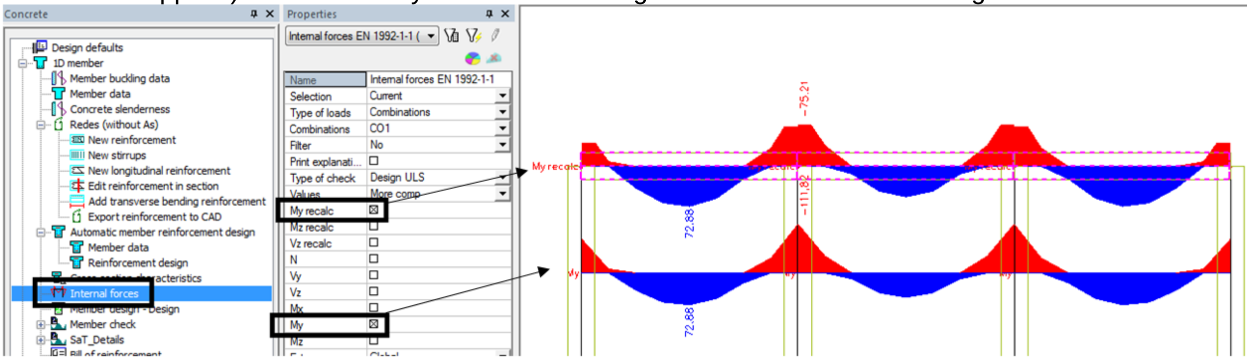
Each support has his own size, total size is to be set.



Name	Sn11
Type	Standard
Angle [deg]	
X	Rigid
Y	Rigid
Z	Rigid
Rx	Free
Ry	Free
Rz	Free
Default size [m]	0,200
Node	N24

Pics.58 – Reduction of bending moments in supports

Reduction control is available in the concrete service in the fold Internal forces. You can view both original bending moments **My** (the same values as in results) and **recalculated My** (where reduction is applied) simultaneously. Reduced bending moments are used for design and checks.

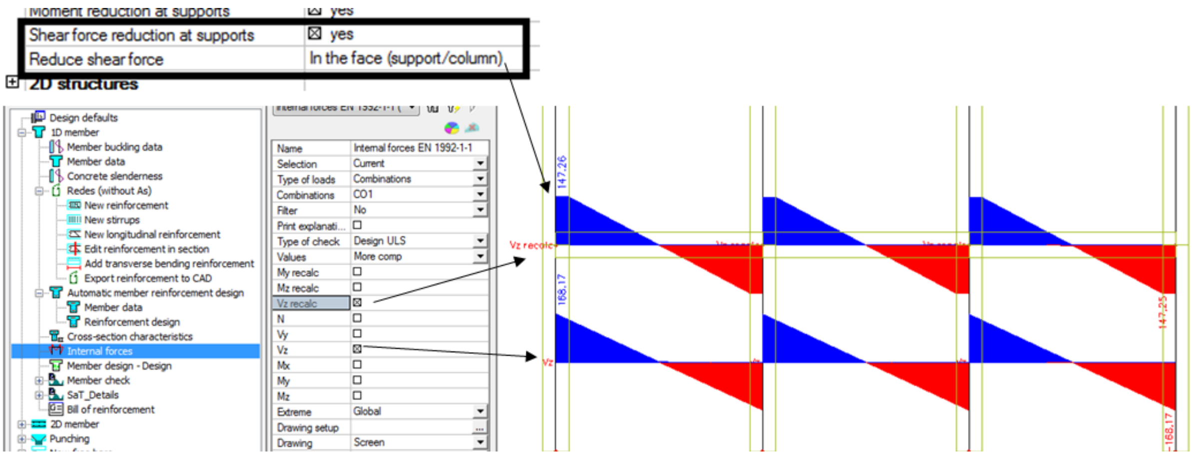


Name	Internal forces EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Type of check	Design ULS
Values	More comp
My recalc	☒
Mz recalc	☐
Vz recalc	☐
N	☐
Vy	☐
Vz	☐
Mx	☐
My	☒
Mz	☐

Pics.59 – Reduction of bending moments in supports

7.5. Shear forces reduction at supports

a) in the face (support/column)

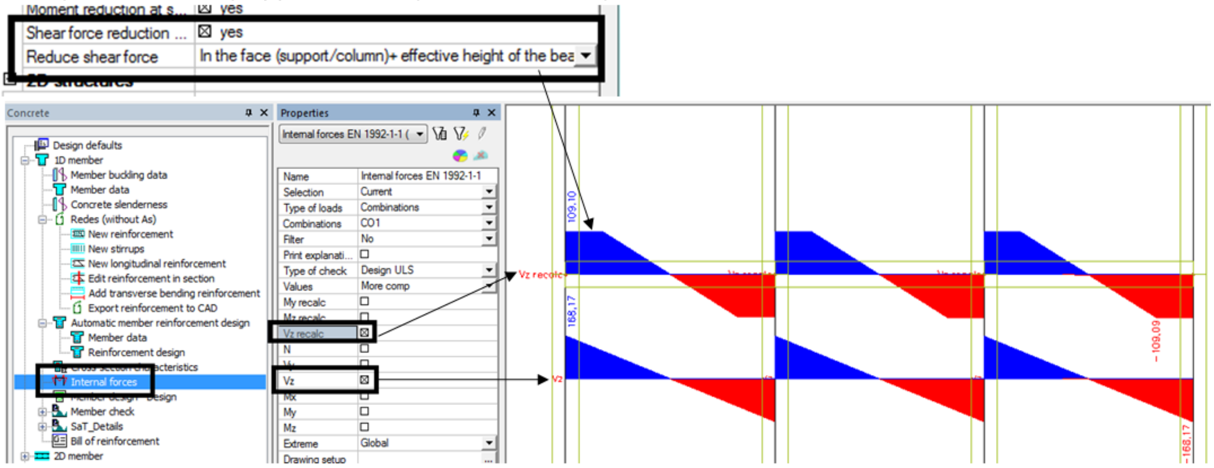


Moment reduction at supports	☒ yes
Shear force reduction at supports	☒ yes
Reduce shear force	In the face (support/column)

Name	Internal forces EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Type of check	Design ULS
Values	More comp
My recalc	☐
Mz recalc	☐
Vz recalc	☒
N	☐
Vy	☐
Vz	☒
Mx	☐
My	☐
Mz	☐
Extreme	Global
Drawing setup	
Drawing	Screen

Pics.60 – Reduction of shear forces in the face support/column

b) in the face (support/column) + effective height of the beam



Moment reduction at s...	☒ yes
Shear force reduction ...	☒ yes
Reduce shear force	In the face (support/column)+ effective height of the bea

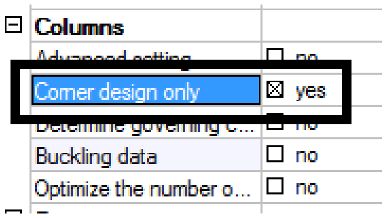
Name	Internal forces EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Type of check	Design ULS
Values	More comp
My recalc	☐
Mz recalc	☐
Vz recalc	☒
N	☐
Vy	☐
Vz	☒
Mx	☐
My	☐
Mz	☐
Extreme	Global
Drawing setup	

Pics.61 – Reduction of shear force in the face support/column + effective height of the beam

8. Functions for reinforcement design and column check

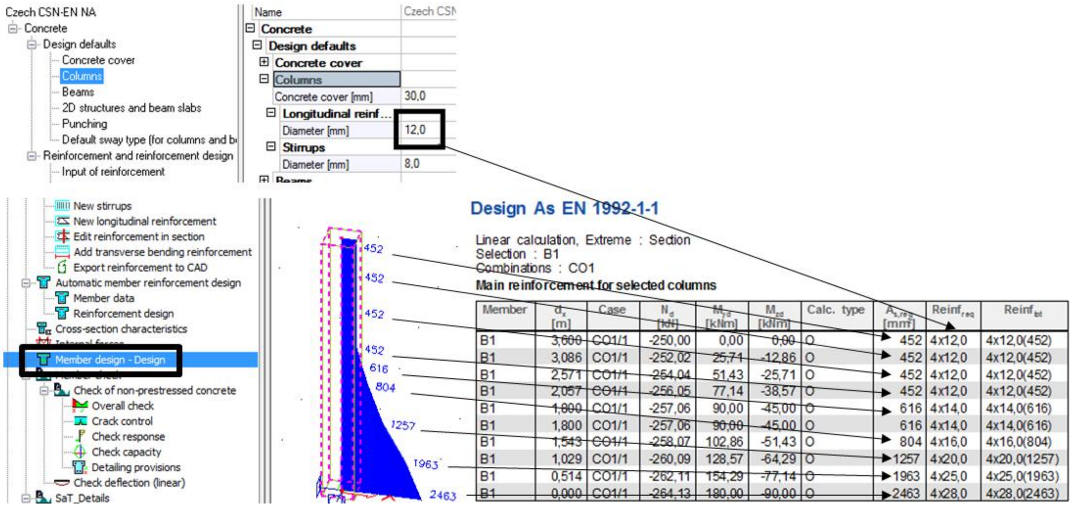
8.1. Corner design only

This function behaves like this: the program takes default values of reinforcement diameters from the Design defaults or member data and chooses only corner positions of the cross-section, in our case bars of 12 mm width. Then it tries to find optimal diameter so that the member satisfies the check in every section.



Columns
Advanced setting ☐ no
Corner design only ☒ yes
Determine governing c... ☐ no
Buckling data ☐ no
Optimize the number o... ☐ no

Pics.62 – Corner design only



Concrete
Design defaults
Concrete cover
Columns
Concrete cover [mm] 30,0
Longitudinal reinf...
Diameter [mm] 12,0
Stirrups
Diameter [mm] 8,0
Beams

Design As EN 1992-1-1

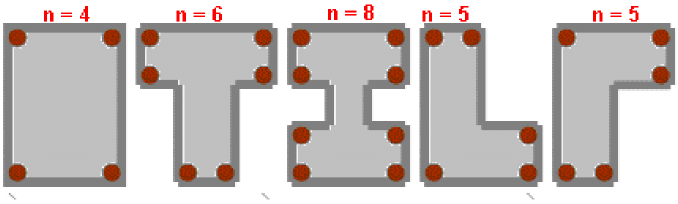
Linear calculation, Extreme : Section
Selection : B1
Combinations : CO1

Main reinforcement for selected columns

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	$A_{s,req}$ [mm²]	Reinf_{req}	Reinf_{tot}
B1	3,600	CO1/1	-250,00	0,00	0,00	O	452	4x12,0	4x12,0(452)
B1	3,086	CO1/1	-252,02	25,71	-12,86	O	452	4x12,0	4x12,0(452)
B1	2,571	CO1/1	-254,04	51,43	-25,71	O	452	4x12,0	4x12,0(452)
B1	2,057	CO1/1	-256,05	77,14	-38,57	O	452	4x12,0	4x12,0(452)
B1	1,800	CO1/1	-257,06	90,00	-45,00	O	616	4x14,0	4x14,0(616)
B1	1,800	CO1/1	-257,06	90,00	-45,00	O	616	4x14,0	4x14,0(616)
B1	1,543	CO1/1	-258,07	102,86	-51,43	O	804	4x16,0	4x16,0(804)
B1	1,029	CO1/1	-260,09	128,57	-64,29	O	1257	4x20,0	4x20,0(1257)
B1	0,514	CO1/1	-262,11	154,29	-77,14	O	1963	4x25,0	4x25,0(1963)
B1	0,000	CO1/1	-264,13	180,00	-90,00	O	2463	4x28,0	4x28,0(2463)

Pics 63 – Check only design into corner

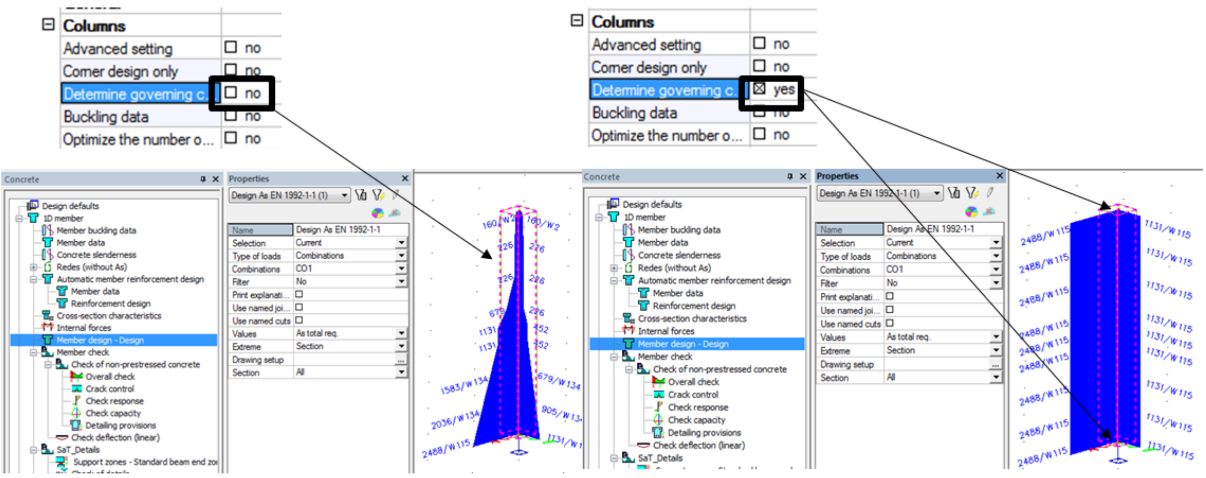
Following cross-section can be used for described method:



Pics.64 – Cross sections, which you can use for corner design only

8.2. Determine governing cross-section beforehand

This method can speed up the reinforcement design of columns. Maximal strain is usually in the head and foot of column. With this function only these two sections are considered for design. The larger amount of reinforcement is applied to the whole column.



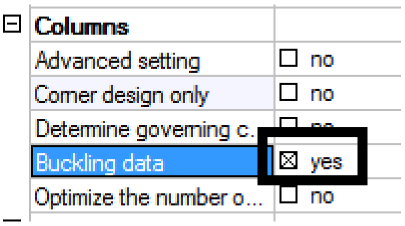
Columns	
Advanced setting	☐ no
Corner design only	☐ no
Determine governing c.	☐ no
Buckling data	☐ no
Optimize the number o...	☐ no

Columns	
Advanced setting	☐ no
Corner design only	☐ no
Determine governing c.	☒ yes
Buckling data	☐ no
Optimize the number o...	☐ no

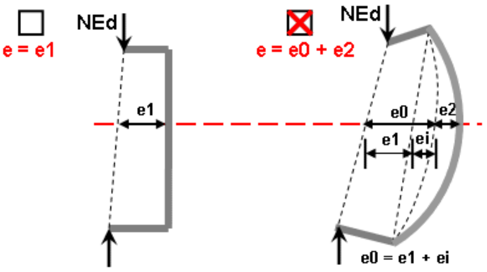
Pics.65 – Compare of reinforcement designs when using function Determine governing cross section beforehand.

8.3. Buckling data

This function takes into account article 5.8.8 from the code EN 1992-1-1 – second order eccentricity (method based on the nominal curvature) and the eccentricity caused by geometric imperfection.

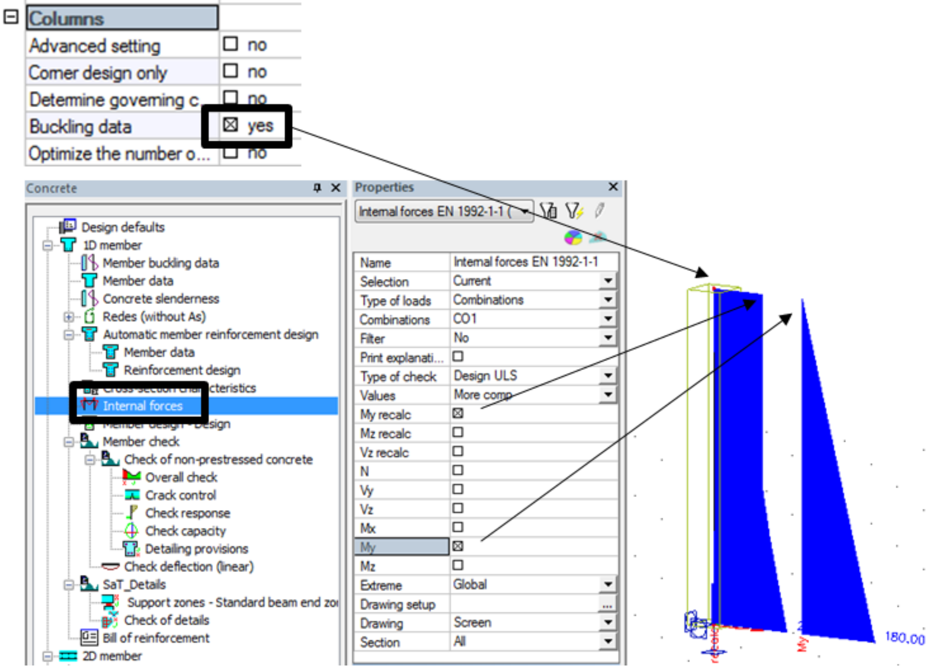


Columns	
Advanced setting	☐ no
Corner design only	☐ no
Determine governing c.	☐ no
Buckling data	☒ yes
Optimize the number o...	☐ no



Pics.66 – Buckling data **Pics.67 – Eccentricity**

This setting influence recalculated internal forces.



Columns	
Advanced setting	☐ no
Corner design only	☐ no
Determine governing c.	☐ no
Buckling data	☒ yes
Optimize the number o...	☐ no

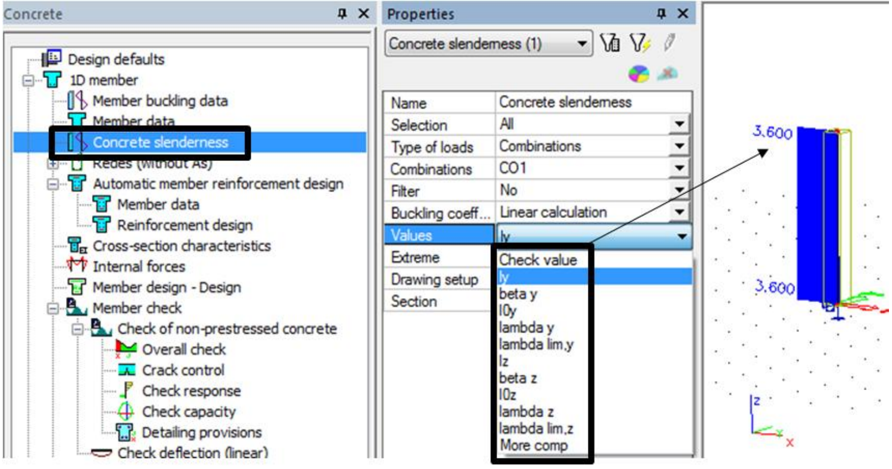
Name	Internal forces EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Type of check	Design ULS
Values	More comp
My recalc	☒
Mz recalc	☐
Vz recalc	☐
N	☐
Vy	☐
Vz	☐
Mx	☐
My	☒
Mz	☐
Extreme	Global
Drawing setup	...
Drawing	Screen
Section	All

Pics.68 – Check of internal forces with buckling data

Note:

Buckling data should be used when the limit slenderness of a cross-section is exceeded. Concrete slenderness can be seen in the concrete service:

a) All the values for slenderness check can be represented graphically for better transparency.



Concrete

- Design defaults
- 1D member
  - Member buckling data
  - Member data
  - Concrete slenderness
  - Redes (without As)
  - Automatic member reinforcement design
    - Member data
    - Reinforcement design
  - Cross-section characteristics
  - Internal forces
  - Member design - Design
  - Member check
    - Check of non-prestressed concrete
      - Overall check
      - Crack control
      - Check response
      - Check capacity
      - Detailing provisions
    - Check deflection (linear)

Properties

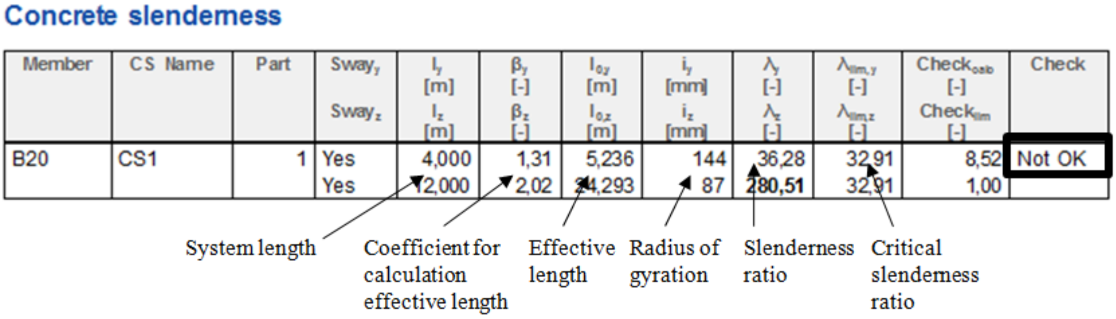
Concrete slenderness (1)

Name	Concrete slenderness
Selection	All
Type of loads	Combinations
Combinations	CO1
Filter	No
Buckling coeff...	Linear calculation
Values	ly
Extreme	
Drawing setup	
Section	

Check value
ly
beta y
l0y
lambda y
lambda lim,y
lz
beta z
l0z
lambda z
lambda lim,z
More comp

Pics.69 – Displaying concrete slenderness

b) In the table



Concrete slenderness

Member	CS Name	Part	$Sway_y$ $Sway_z$	l_y [m] l_z [m]	β_y [-] β_z [-]	l_{0y} [m] l_{0z} [m]	i_y [mm] i_z [mm]	λ_y [-] λ_z [-]	$\lambda_{lim,y}$ [-] $\lambda_{lim,z}$ [-]	$Check_{calc}$ [-] $Check_{lim}$ [-]	Check
B20	CS1	1	Yes Yes	4,000 12,000	1,31 2,02	5,236 24,293	144 87	36,28 280,51	32,91 32,91	8,52 1,00	Not OK

Pics.70 – Concerete slenderness preview

If the check is not OK the influence of slenderness should be introduced. Calculation of a limit slendernees can be done as follows. The articles are taken from EN 1992-1-1.

5.8.3.1 Slenderness criterion for isolated members

(1) As an alternative to 5.8.2 (6), second order effects may be ignored if the slenderness λ (as defined in 5.8.3.2) is below a certain value λlim.

Note: The value of λlim for use in a Country may be found in its National Annex. The recommended value follows from**:**

$\lambda lim = 20 \cdot A \cdot B \cdot C/\sqrt{n}$ (5.13N)

where $A = 1 / (1+0,2\varphi ef)$ (if-li φef is not known, A = 0,7 may be used);

$B = \sqrt{1+2\omega}$ (if ω is not known, B = 1,1 may be used);

$C = 1,7 - rm$ (if rm is not known, C = 0,7 may be used);

φef	effective creep ratio; see 5.8.4;
ω = Asfyd / (Acfcd)	mechanical reinforcement ratio;
As	is the total area of longitudinal reinforcement;
n = NEd / (Acfcd)	relative normal force;
rm = M01/M02	moment ratio;
M01, M02	are the first orded end moments, $|M02| \geq |M01|$.

5.8.3.2 Slenderness and effective length of isolated members

(1) The slenderness ratio is defined as follows:

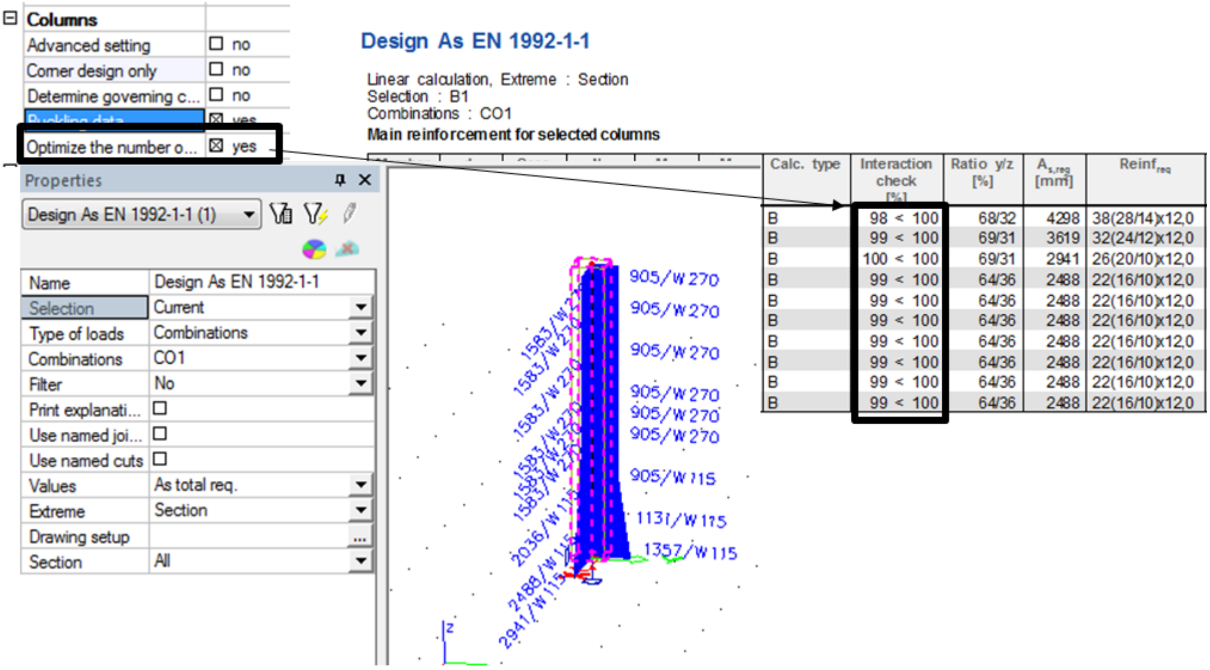
$\lambda = l0 / i$ (5.14)

where l0 is the effective length, see 5.8.3.2 (2) to (7);
i is the radius of gyration of the uncracked concrete section

Detailed information about the calculation and buckling length coefficients in Scia Engineer can be found in tutorial **Buckling lengths.**

8.4. Optimize the number of bars in c-s for biaxial calculation

The program calculates and checks all possible arrangements of bars in the cross-section, independently on the y/z ratio (details below) ans chooses the optimal arrangement where the result of interaction equation is smaller then, but the closest to 1. It searches for the best ulitisation of the cross-section.



Columns	
Advanced setting	☐ no
Corner design only	☐ no
Determine governing c...	☐ no
Buckling data	☒ yes
Optimize the number o...	☒ yes

Properties

Design As EN 1992-1-1 (1)

Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As total req.
Extreme	Section
Drawing setup	...
Section	All

Design As EN 1992-1-1

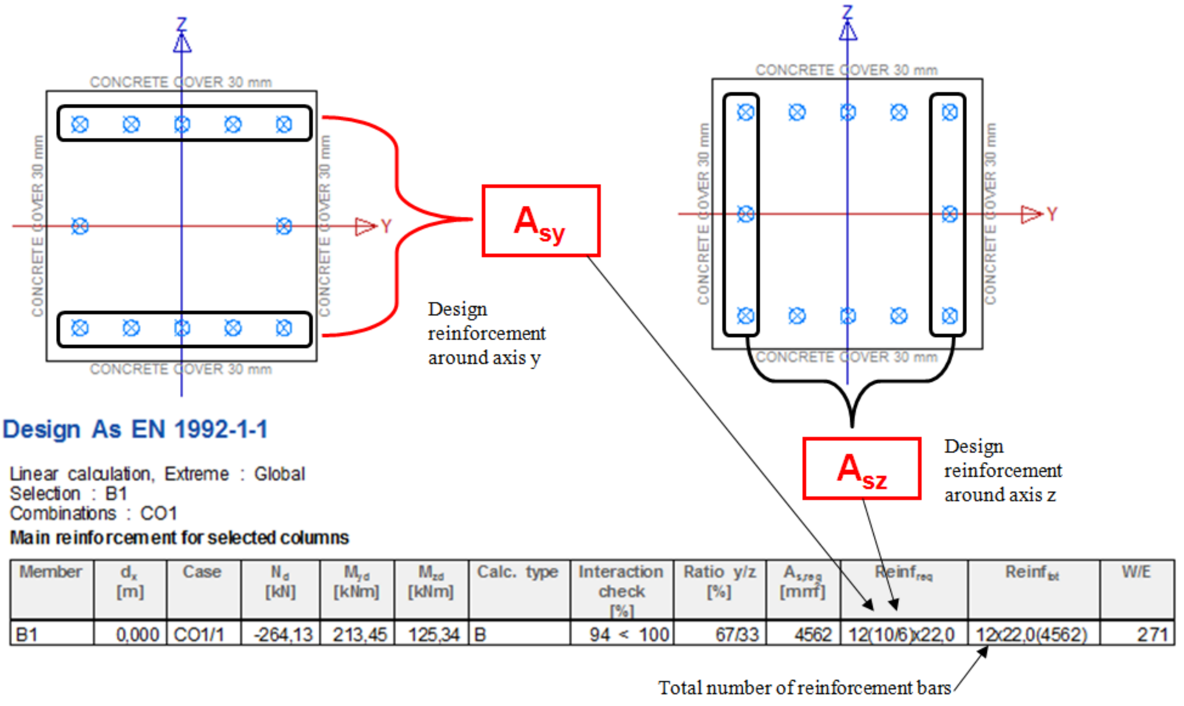
Linear calculation, Extreme : Section
Selection : B1
Combinations : CO1
Main reinforcement for selected columns

Calc. type	Interaction check [%]	Ratio y/z [%]	$A_{s,req}$ [mm²]	$Reinf_{req}$
B	98 < 100	68/32	4298	38(28/14)x12,0
B	99 < 100	69/31	3619	32(24/12)x12,0
B	100 < 100	69/31	2941	26(20/10)x12,0
B	99 < 100	64/36	2488	22(16/10)x12,0
B	99 < 100	64/36	2488	22(16/10)x12,0
B	99 < 100	64/36	2488	22(16/10)x12,0
B	99 < 100	64/36	2488	22(16/10)x12,0
B	99 < 100	64/36	2488	22(16/10)x12,0
B	99 < 100	64/36	2488	22(16/10)x12,0
B	99 < 100	64/36	2488	22(16/10)x12,0

Pics.71 – Optimize the number of bars for biaxial calculation

Note:

Explanation of a table with reinforcement design results is following. The design says that 8 bars in one direction and 4 bars in the other direction are necessary. Alltogether 8 pieces because the corner bars are calculated twice (separately for each direction).



Design As EN 1992-1-1

Linear calculation, Extreme : Global
Selection : B1
Combinations : CO1

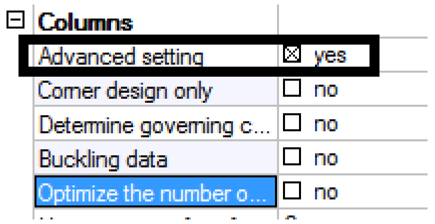
Main reinforcement for selected columns

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	Interaction check [%]	Ratio y/z [%]	$A_{s,req}$ [mm²]	$Reinf_{req}$	$Reinf_{tot}$	W/E
B1	0,000	CO1/1	-264,13	213,45	125,34	B	94 < 100	67/33	4562	12(10/6)x22,0	12x22,0(4562)	271

Pics.72 – Explanation of table for reinforcement design

8.5. Advanced setting

Advanced design setting for column reinforcement is suitable for skilled users. In 80% of cases it is not necessary to change this setting.



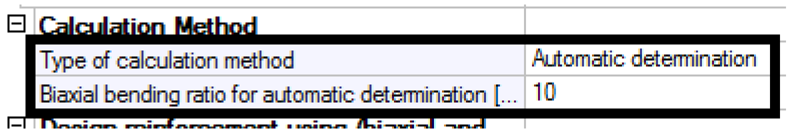
⊟ **Columns**

Advanced setting	☒ yes
Corner design only	☐ no
Determine governing c...	☐ no
Buckling data	☐ no
Optimize the number o...	☐ no

Pics.73 – Advanced setting for columns

8.5.1. Calculation method

With advanced setting ticked the user have the possibility to choose type of calculation method for column reinforcement design.



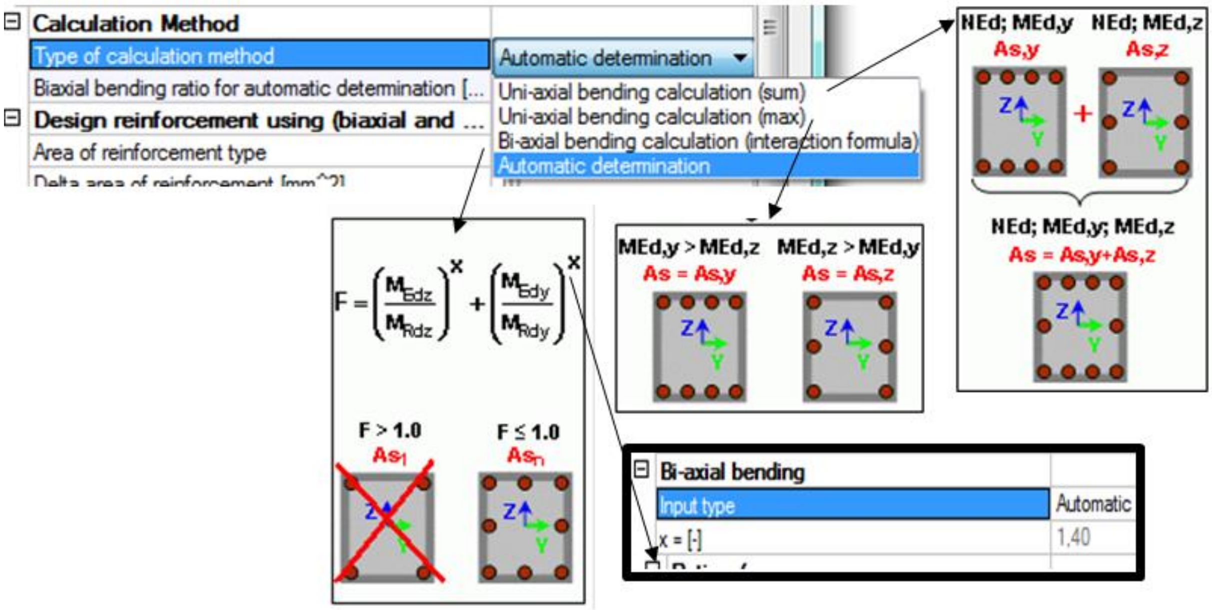
⊟ **Calculation Method**

Type of calculation method	Automatic determination
Biaxial bending ratio for automatic determination [...	10

Pics.74 – Type of calculation method

When Automatic determination is used, the program decides whether it is the case of uni-axial or bi-axial bending calculation. This decision is made according to the bending moments proportion, limit value is 10.

Or you can select from the following methods (which will be used for the design of all columns). The reliability coefficient for interaction equation can be also set or you can leave it up to the program to calculate it according to EN 1992-1-1, 5.8.9(4).



Type of calculation method: Automatic determination

Input type: Automatic

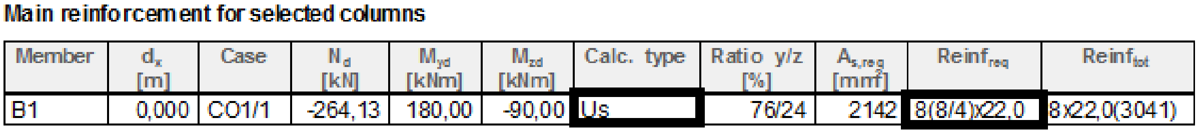
x = [-]: 1,40

Pics.75 – Types of calculation methods

Comparison and explanation of methods:

- There is a column with identical loading and we will demonstrate how the design changes

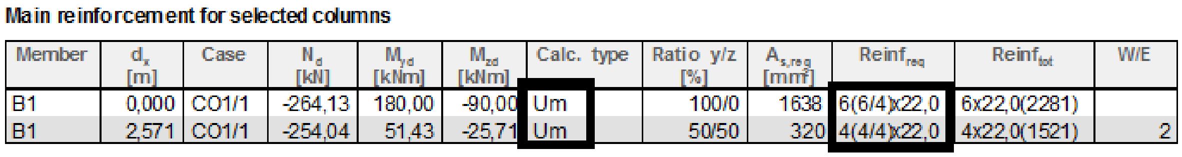
a) **Uni-axial bending calculation (sum)** – reinforcement design is done in one direction for internal forces **NEd + MEdy** and reinforcement area **As,y** is calculated. Next the design for other direction is done (internal forces **NEd + MEdz)** and reinforcement area **As,z** is calculated. **These areas are summed**.


Main reinforcement for selected columns

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	Ratio y/z [%]	$A_{s,req}$ [mm^2]	$Reinf_{req}$	$Reinf_{tot}$
B1	0,000	CO1/1	-264,13	180,00	-90,00	Us	76/24	2142	8(8/4)x22,0	8x22,0(3041)

Pics.76 – Uni-axial bending calculation (sum)

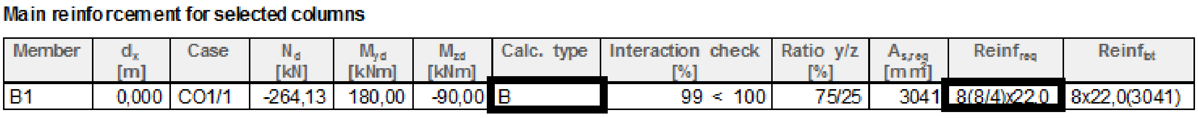
b) **Uni-axial bending calculation (max)** – reinforcement design is done in one direction for internal forces **NEd + MEdy** and reinforcement area **As,y** is calculated. Next the design for other direction is done (internal forces **NEd + MEdz)** and reinforcement area **As,z** is calculated. **The bigger area from these two values As,y and As,z is chosen.**


Main reinforcement for selected columns

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	Ratio y/z [%]	$A_{s,req}$ [mm^2]	$Reinf_{req}$	$Reinf_{tot}$	W/E
B1	0,000	CO1/1	-264,13	180,00	-90,00	Um	100/0	1638	6(6/4)x22,0	6x22,0(2281)	
B1	2,571	CO1/1	-254,04	51,43	-25,71	Um	50/50	320	4(4/4)x22,0	4x22,0(1521)	2

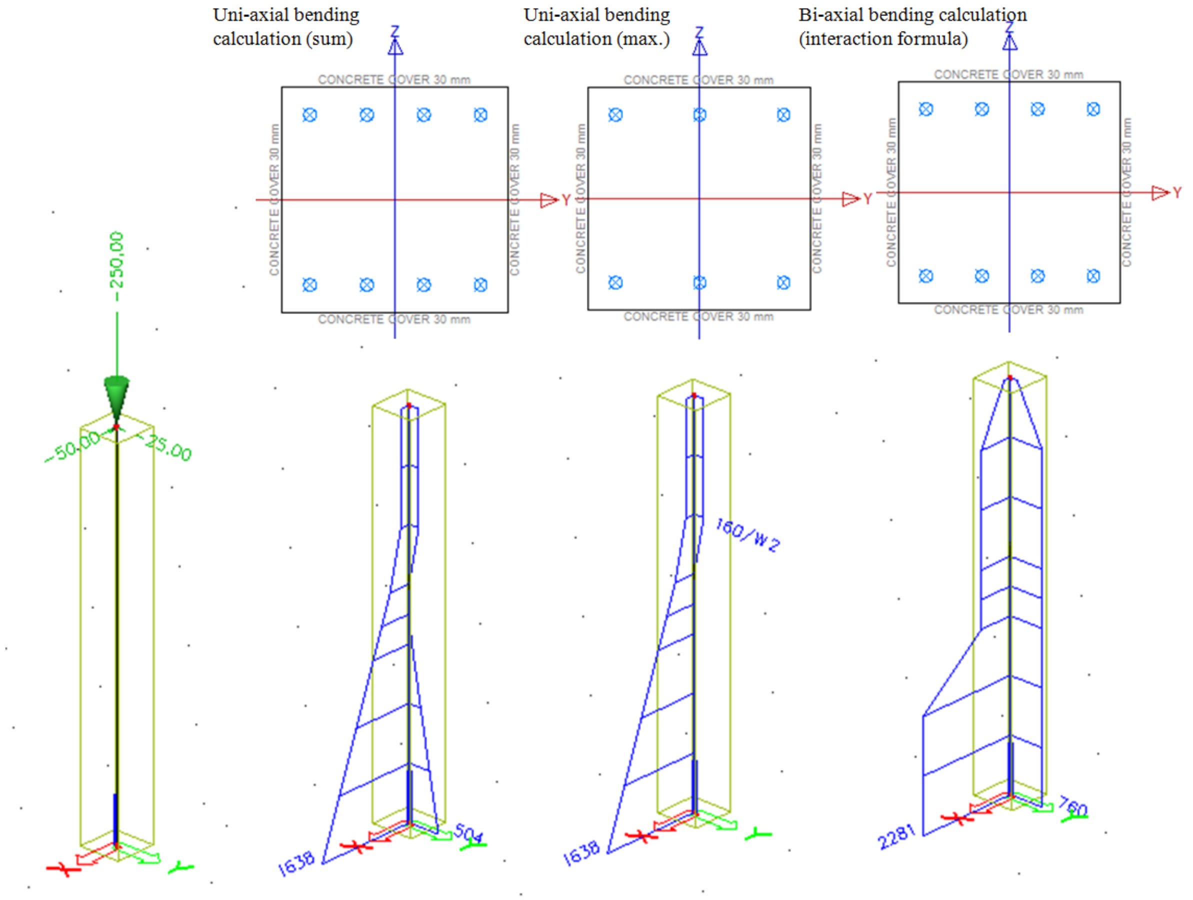
Pics.77 Uni-axial bending calculation (max)

c) **Bi-axial bending calculation (interaction formula)** – reinforcement distribution is made in accordance with the y/z ratio setting. Calculation according to interaction formula.


Main reinforcement for selected columns

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	Interaction check [%]	Ratio y/z [%]	$A_{s,req}$ [mm^2]	$Reinf_{req}$	$Reinf_{tot}$
B1	0,000	CO1/1	-264,13	180,00	-90,00	B	99 < 100	75/25	3041	8(8/4)x22,0	8x22,0(3041)

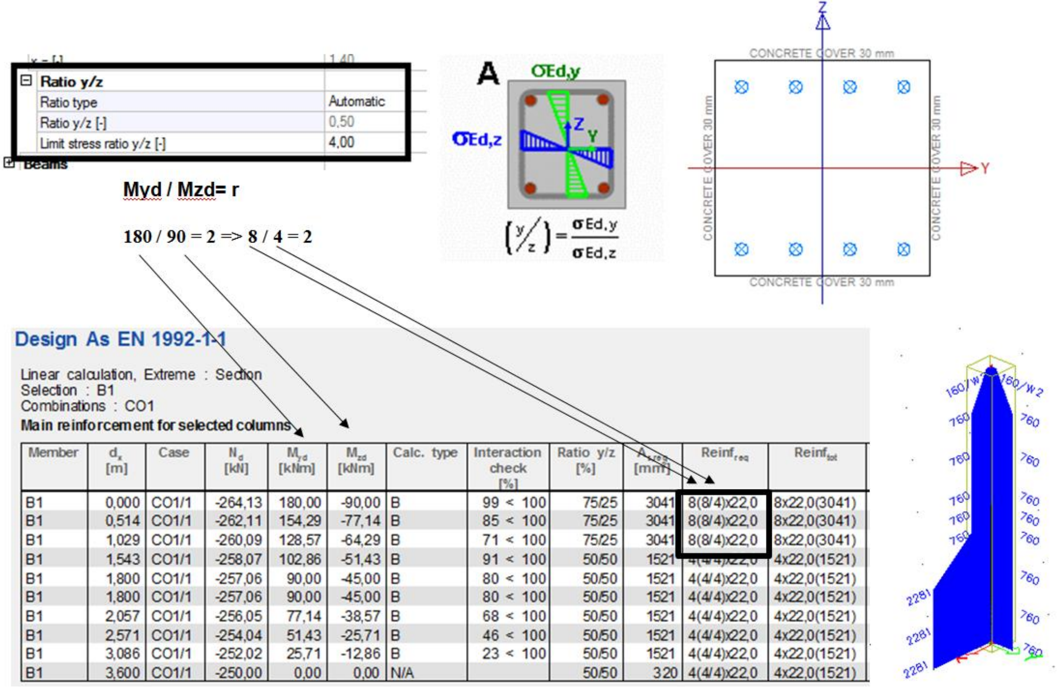
Pics.78 – Bi-axial bending calculation (interaction formula)



Pics.79 – Compare of reinforcement design in steel column for each method

Reinforcement distribution ratio:

c1) The ratio can be set to **Automatic** – then the stress in the first and the second direction is calculated. These stresses are divided and reinforcement is located on the basis of this ratio. For bi-axially symmetric cross-section it is the ratio of bending moments.



Ratio y/z	
Ratio type	Automatic
Ratio y/z [-]	0,50
Limit stress ratio y/z [-]	4,00

Myd / Mzd= r

180 / 90 = 2 => 8 / 4 = 2

$$\left\{ \frac{y}{z} \right\} = \frac{\sigma Ed,y}{\sigma Ed,z}$$

Design As EN 1992-1-1

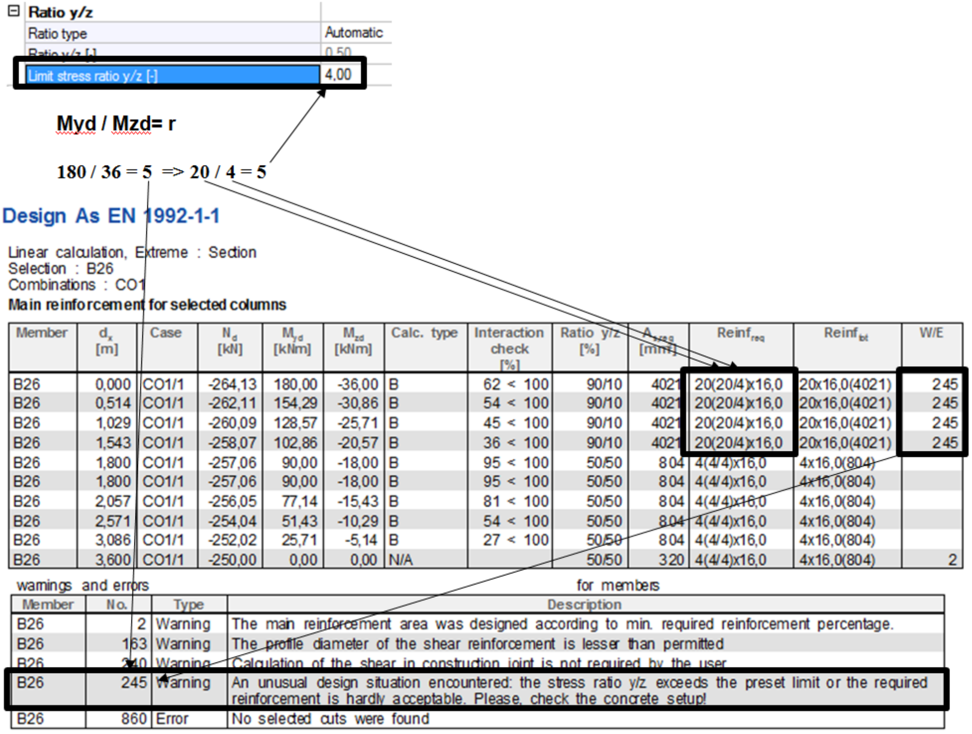
Linear calculation, Extreme : Section
Selection : B1
Combinations : CO1
Main reinforcement for selected columns

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	Interaction check [%]	Ratio y/z [%]	$A_{s,req}$ [mm²]	$Reinf_{req}$	$Reinf_{tot}$
B1	0,000	CO1/1	-264,13	180,00	-90,00	B	99 < 100	75/25	3041	8(8/4)x22,0	8x22,0(3041)
B1	0,514	CO1/1	-262,11	154,29	-77,14	B	85 < 100	75/25	3041	8(8/4)x22,0	8x22,0(3041)
B1	1,029	CO1/1	-260,09	128,57	-64,29	B	71 < 100	75/25	3041	8(8/4)x22,0	8x22,0(3041)
B1	1,543	CO1/1	-258,07	102,86	-51,43	B	91 < 100	50/50	1521	4(4/4)x22,0	4x22,0(1521)
B1	1,800	CO1/1	-257,06	90,00	-45,00	B	80 < 100	50/50	1521	4(4/4)x22,0	4x22,0(1521)
B1	1,800	CO1/1	-257,06	90,00	-45,00	B	80 < 100	50/50	1521	4(4/4)x22,0	4x22,0(1521)
B1	2,057	CO1/1	-256,05	77,14	-38,57	B	68 < 100	50/50	1521	4(4/4)x22,0	4x22,0(1521)
B1	2,571	CO1/1	-254,04	51,43	-25,71	B	46 < 100	50/50	1521	4(4/4)x22,0	4x22,0(1521)
B1	3,086	CO1/1	-252,02	25,71	-12,86	B	23 < 100	50/50	1521	4(4/4)x22,0	4x22,0(1521)
B1	3,600	CO1/1	-250,00	0,00	0,00	N/A		50/50	320	4(4/4)x22,0	4x22,0(1521)

Pics.80 – The ratio for reinforcement design and automatic setting

Note:

If the limit stress ratio is reached you will get a warning in the calculation informations.



Ratio y/z	
Ratio type	Automatic
Ratio y/z [-]	0,50
Limit stress ratio y/z [-]	4,00

Myd / Mzd= r

180 / 36 = 5 => 20 / 4 = 5

Design As EN 1992-1-1

Linear calculation, Extreme : Section
Selection : B26
Combinations : CO1

Main reinforcement for selected columns

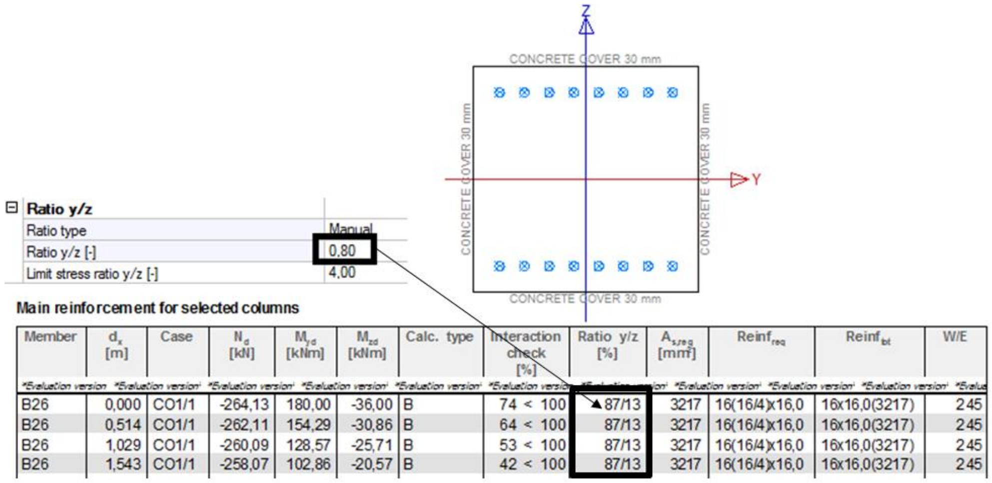
Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	Interaction check [%]	Ratio y/z [%]	$A_{s,req}$ [mm²]	$Reinf_{req}$	$Reinf_{tot}$	W/E
B26	0,000	CO1/1	-264,13	180,00	-36,00	B	62 < 100	90/10	4021	20(20/4)x16,0	20x16,0(4021)	245
B26	0,514	CO1/1	-262,11	154,29	-30,86	B	54 < 100	90/10	4021	20(20/4)x16,0	20x16,0(4021)	245
B26	1,029	CO1/1	-260,09	128,57	-25,71	B	45 < 100	90/10	4021	20(20/4)x16,0	20x16,0(4021)	245
B26	1,543	CO1/1	-258,07	102,86	-20,57	B	36 < 100	90/10	4021	20(20/4)x16,0	20x16,0(4021)	245
B26	1,800	CO1/1	-257,06	90,00	-18,00	B	95 < 100	50/50	804	4(4/4)x16,0	4x16,0(804)	
B26	1,800	CO1/1	-257,06	90,00	-18,00	B	95 < 100	50/50	804	4(4/4)x16,0	4x16,0(804)	
B26	2,057	CO1/1	-256,05	77,14	-15,43	B	81 < 100	50/50	804	4(4/4)x16,0	4x16,0(804)	
B26	2,571	CO1/1	-254,04	51,43	-10,29	B	54 < 100	50/50	804	4(4/4)x16,0	4x16,0(804)	
B26	3,086	CO1/1	-252,02	25,71	-5,14	B	27 < 100	50/50	804	4(4/4)x16,0	4x16,0(804)	
B26	3,600	CO1/1	-250,00	0,00	0,00	N/A		50/50	320	4(4/4)x16,0	4x16,0(804)	2

warnings and errors for members

Member	No.	Type	Description
B26	2	Warning	The main reinforcement area was designed according to min. required reinforcement percentage.
B26	163	Warning	The profile diameter of the shear reinforcement is lesser than permitted
B26	240	Warning	Calculation of the shear in construction joint is not required by the user
B26	245	Warning	An unusual design situation encountered: the stress ratio y/z exceeds the preset limit or the required reinforcement is hardly acceptable. Please, check the concrete setup!
B26	860	Error	No selected cuts were found

Pics.81 – The ratio for reinf. design and automatic setting and crossing limit value for ratio

c2) The ratio can be set **manually**. The program tries to fulfill the ratio condition. If this is not possible program designs new ratio which is as close as possible but which satisfies the check.



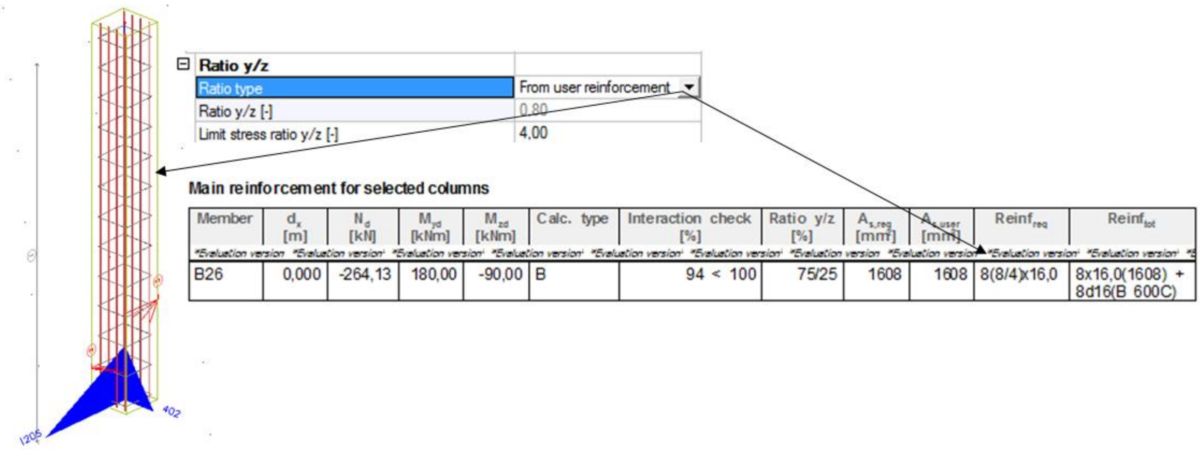
Ratio y/z	
Ratio type	Manual
Ratio y/z [-]	0,80
Limit stress ratio y/z [-]	4,00

Main reinforcement for selected columns

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	Interaction check [%]	Ratio y/z [%]	$A_{s,req}$ [mm²]	$Reinf_{req}$	$Reinf_{tot}$	W/E
Evaluation version	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evalua*
B26	0,000	CO1/1	-264,13	180,00	-36,00	B	74 < 100	87/13	3217	16(16/4)x16,0	16x16,0(3217)	245
B26	0,514	CO1/1	-262,11	154,29	-30,86	B	64 < 100	87/13	3217	16(16/4)x16,0	16x16,0(3217)	245
B26	1,029	CO1/1	-260,09	128,57	-25,71	B	53 < 100	87/13	3217	16(16/4)x16,0	16x16,0(3217)	245
B26	1,543	CO1/1	-258,07	102,86	-20,57	B	42 < 100	87/13	3217	16(16/4)x16,0	16x16,0(3217)	245

Pics.82 – The ratio for reinforcement design and manual setting

c3) **From user reinforcement** – usable for example in the case of additional reinforcement design when there is some real reinforcement in the member already and you want to use the same ratio.



⊟ **Ratio y/z**

Ratio type	From user reinforcement
Ratio y/z [-]	0,80
Limit stress ratio y/z [-]	4,00

Main reinforcement for selected columns

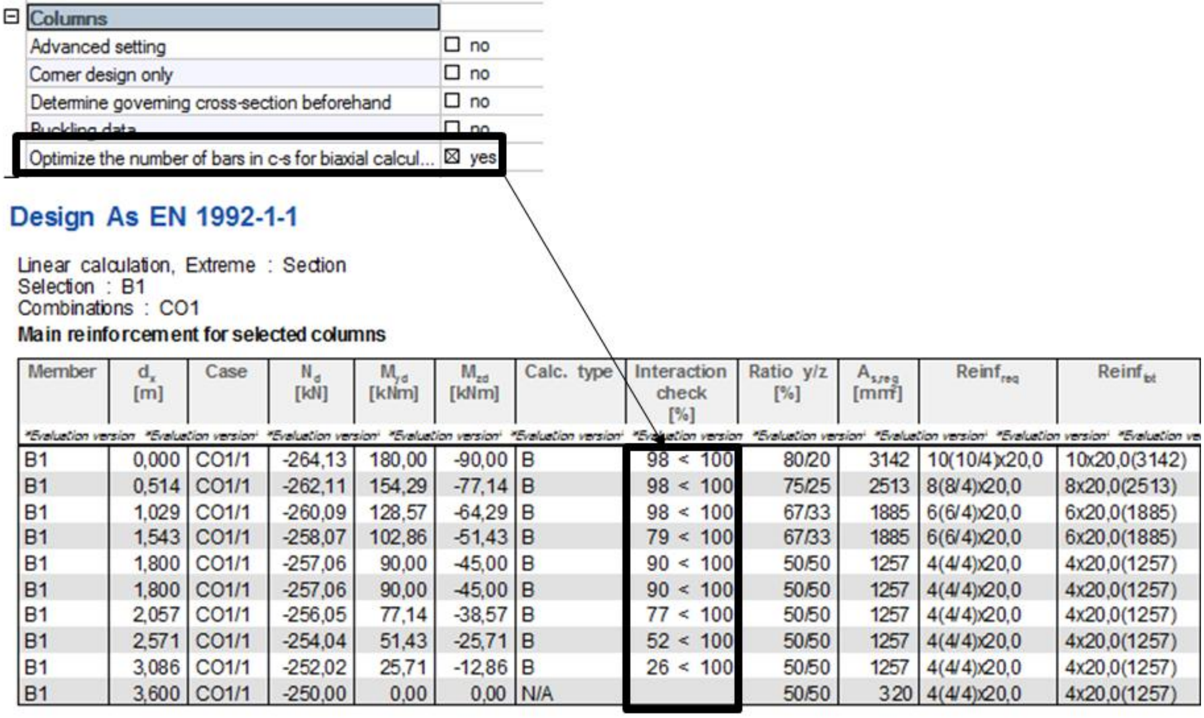
Member	d_x [m]	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	Interaction check [%]	Ratio y/z [%]	$A_{s,req}$ [mm²]	$A_{s,user}$ [mm²]	$Reinf_{req}$	$Reinf_{tot}$
B26	0,000	-264,13	180,00	-90,00	B	94 < 100	75/25	1608	1608	8(8/4)x16,0	8x16,0(1608) + 8d16(B 600C)

Pics.83 – The reinforcement ratio and manual setting

Comparison:

The function of reinforcement amount optimization and design according to bi-axial bending (interactive formula) with automatic y/z ratio.

With optimisation the program tries to find 100% utilization of the cross-section.



⊟ Columns

Advanced setting	☐ no
Corner design only	☐ no
Determine governing cross-section beforehand	☐ no
Buckling data	☐ no
Optimize the number of bars in c-s for biaxial calcul...	☒ yes

Design As EN 1992-1-1

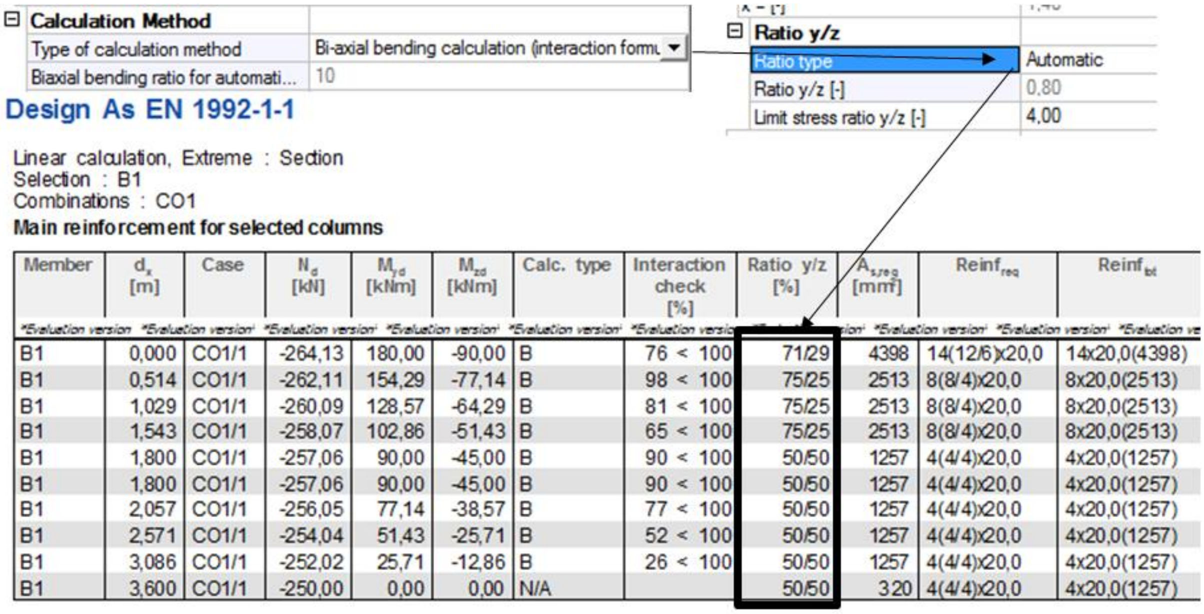
Linear calculation, Extreme : Section
Selection : B1
Combinations : CO1

Main reinforcement for selected columns

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	Interaction check [%]	Ratio y/z [%]	$A_{s,req}$ [mm²]	$Reinf_{req}$	$Reinf_{tot}$
B1	0,000	CO1/1	-264,13	180,00	-90,00	B	98 < 100	80/20	3142	10(10/4)x20,0	10x20,0(3142)
B1	0,514	CO1/1	-262,11	154,29	-77,14	B	98 < 100	75/25	2513	8(8/4)x20,0	8x20,0(2513)
B1	1,029	CO1/1	-260,09	128,57	-64,29	B	98 < 100	67/33	1885	6(6/4)x20,0	6x20,0(1885)
B1	1,543	CO1/1	-258,07	102,86	-51,43	B	79 < 100	67/33	1885	6(6/4)x20,0	6x20,0(1885)
B1	1,800	CO1/1	-257,06	90,00	-45,00	B	90 < 100	50/50	1257	4(4/4)x20,0	4x20,0(1257)
B1	1,800	CO1/1	-257,06	90,00	-45,00	B	90 < 100	50/50	1257	4(4/4)x20,0	4x20,0(1257)
B1	2,057	CO1/1	-256,05	77,14	-38,57	B	77 < 100	50/50	1257	4(4/4)x20,0	4x20,0(1257)
B1	2,571	CO1/1	-254,04	51,43	-25,71	B	52 < 100	50/50	1257	4(4/4)x20,0	4x20,0(1257)
B1	3,086	CO1/1	-252,02	25,71	-12,86	B	26 < 100	50/50	1257	4(4/4)x20,0	4x20,0(1257)
B1	3,600	CO1/1	-250,00	0,00	0,00	N/A		50/50	320	4(4/4)x20,0	4x20,0(1257)

Pics.84 – Optimize the number of bars in cross section for biaxial calculation

When bi-axial bending calculation (interactive formula) with automatic y/z ratio is to be used and optimization is turned off, the program tries to fulfil only bars distribution ratio condition.



Calculation Method

Type of calculation method	Bi-axial bending calculation (interaction formu
Biaxial bending ratio for automati...	10

Ratio y/z

Ratio type	Automatic
Ratio y/z [-]	0,80
Limit stress ratio y/z [-]	4,00

Design As EN 1992-1-1

Linear calculation, Extreme : Section
Selection : B1
Combinations : CO1

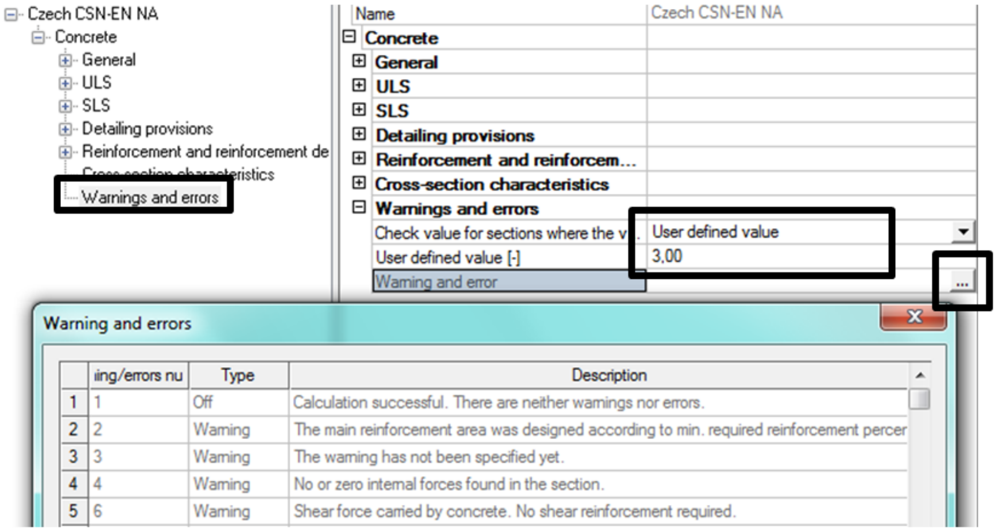
Main reinforcement for selected columns

Member	d_x [m]	Case	N_d [kN]	M_{yd} [kNm]	M_{zd} [kNm]	Calc. type	Interaction check [%]	Ratio y/z [%]	$A_{s,req}$ [mm²]	$Reinf_{req}$	$Reinf_{tot}$
B1	0,000	CO1/1	-264,13	180,00	-90,00	B	76 < 100	71/29	4398	14(12/6)x20,0	14x20,0(4398)
B1	0,514	CO1/1	-262,11	154,29	-77,14	B	98 < 100	75/25	2513	8(8/4)x20,0	8x20,0(2513)
B1	1,029	CO1/1	-260,09	128,57	-64,29	B	81 < 100	75/25	2513	8(8/4)x20,0	8x20,0(2513)
B1	1,543	CO1/1	-258,07	102,86	-51,43	B	65 < 100	75/25	2513	8(8/4)x20,0	8x20,0(2513)
B1	1,800	CO1/1	-257,06	90,00	-45,00	B	90 < 100	50/50	1257	4(4/4)x20,0	4x20,0(1257)
B1	1,800	CO1/1	-257,06	90,00	-45,00	B	90 < 100	50/50	1257	4(4/4)x20,0	4x20,0(1257)
B1	2,057	CO1/1	-256,05	77,14	-38,57	B	77 < 100	50/50	1257	4(4/4)x20,0	4x20,0(1257)
B1	2,571	CO1/1	-254,04	51,43	-25,71	B	52 < 100	50/50	1257	4(4/4)x20,0	4x20,0(1257)
B1	3,086	CO1/1	-252,02	25,71	-12,86	B	26 < 100	50/50	1257	4(4/4)x20,0	4x20,0(1257)
B1	3,600	CO1/1	-250,00	0,00	0,00	N/A		50/50	320	4(4/4)x20,0	4x20,0(1257)

Pics.85 – Bi-axial calculation and ratio bars of reinforcement is set to automatic

Trick:

The list of all warnings can be found in Setup/**Concrete solver**.



Name	Czech CSN-EN NA
Concrete	
General	
ULS	
SLS	
Detailing provisions	
Reinforcement and reinforcem...	
Cross-section characteristics	
Warnings and errors	
Check value for sections where the v	User defined value
User defined value [-]	3,00
Warning and error	...

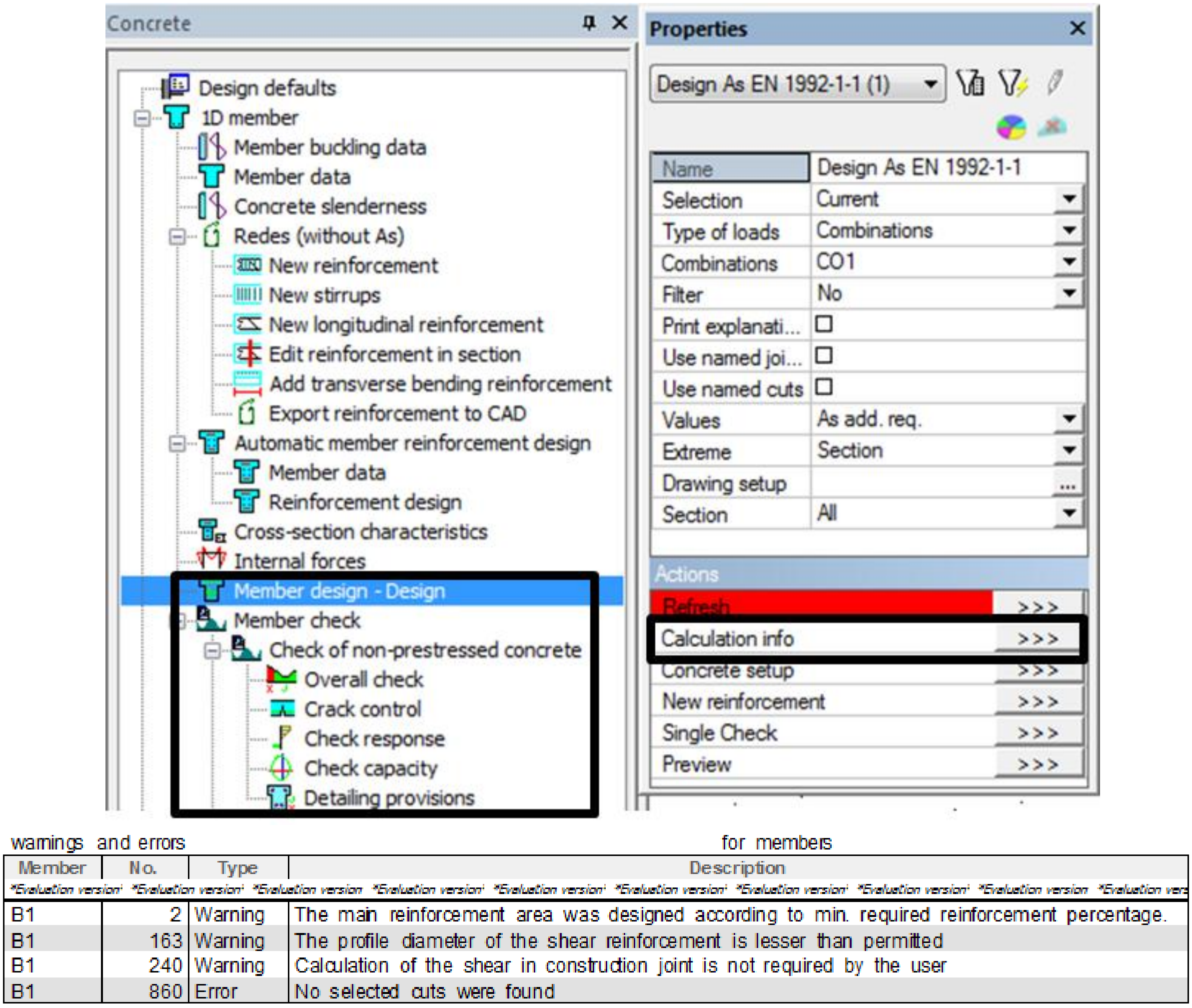
Warning and errors

	ning/errors nu	Type	Description
1	1	Off	Calculation successful. There are neither warnings nor errors.
2	2	Warning	The main reinforcement area was designed according to min. required reinforcement percer
3	3	Warning	The warning has not been specified yet.
4	4	Warning	No or zero internal forces found in the section.
5	6	Warning	Shear force carried by concrete. No shear reinforcement required.

Pics.86 – List of warning and errors

When warning arises design or member check is done anyway and the warning is displayed at the end. When error arises design or member check is interrupted and user defined value is marked red.

Every warning or error can be displayed by action button Calculation info. This button is available for all below highlighted checks and designs **Pic.87.**



Design As EN 1992-1-1 (1)

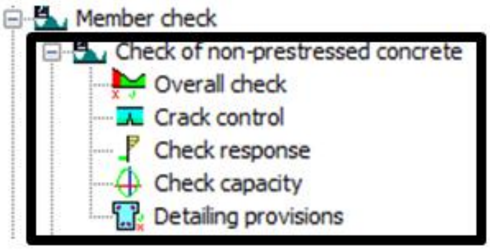
Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As add. req.
Extreme	Section
Drawing setup	
Section	All

warnings and errors for members

Member	No.	Type	Description
B1	2	Warning	The main reinforcement area was designed according to min. required reinforcement percentage.
B1	163	Warning	The profile diameter of the shear reinforcement is lesser than permitted
B1	240	Warning	Calculation of the shear in construction joint is not required by the user
B1	860	Error	No selected cuts were found

Pics.87 – Information about calculation

9. Check of non-prestressed concrete

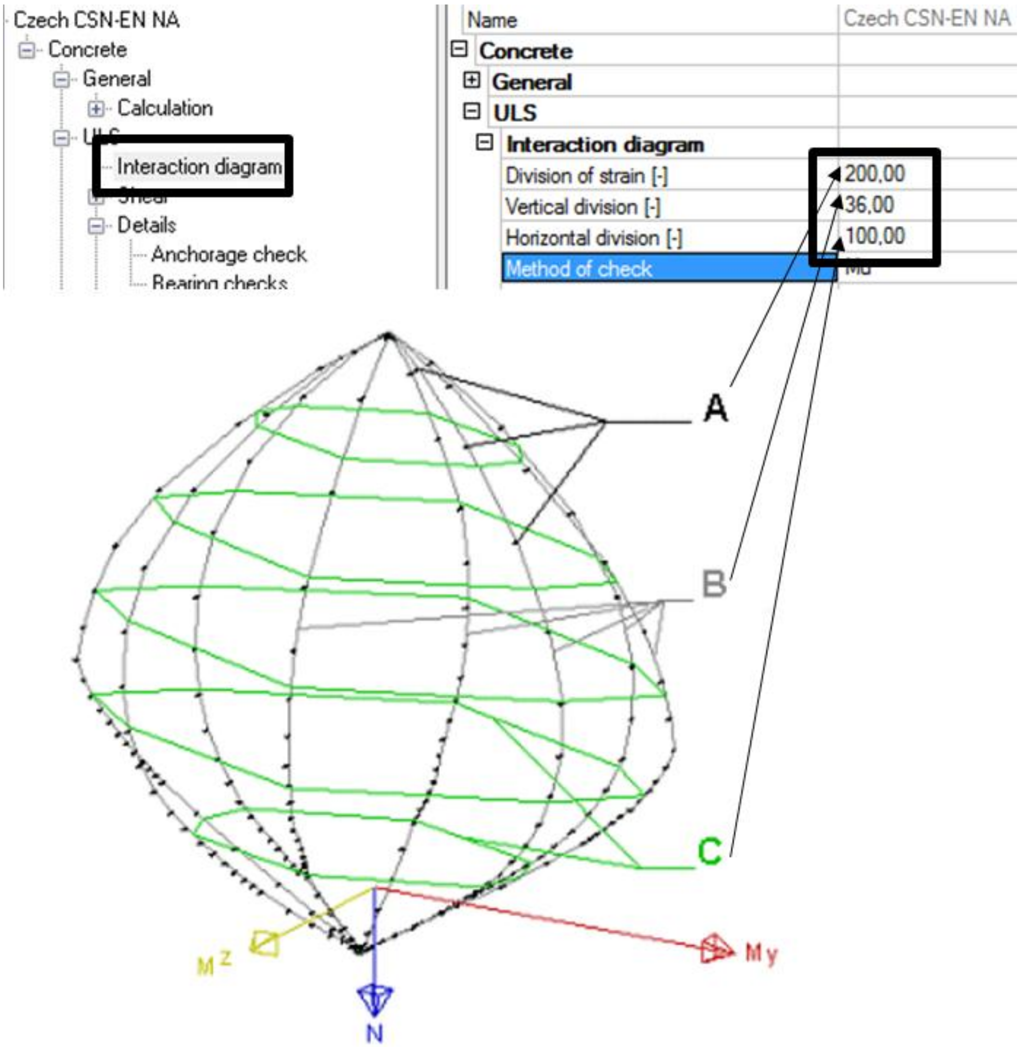


- Member check
  - Check of non-prestressed concrete
    - Overall check
    - Crack control
    - Check response
    - Check capacity
    - Detailing provisions

Pics.88 – All checks for 1D member

9.1. Check capacity (interaction diagram)

For this check real reinforcement in the member is necessary.
Settings that influence this check are present in Setup/**Concrete solver**.



- Czech CSN-EN NA
  - Concrete
    - General
      - Calculation
    - ULS
      - Interaction diagram
      - Shear
    - Details
      - Anchorage check
      - Bearing checks

Name	Czech CSN-EN NA
Concrete	
General	
ULS	
Interaction diagram	
Division of strain [-]	200,00
Vertical division [-]	36,00
Horizontal division [-]	100,00
Method of check	Md

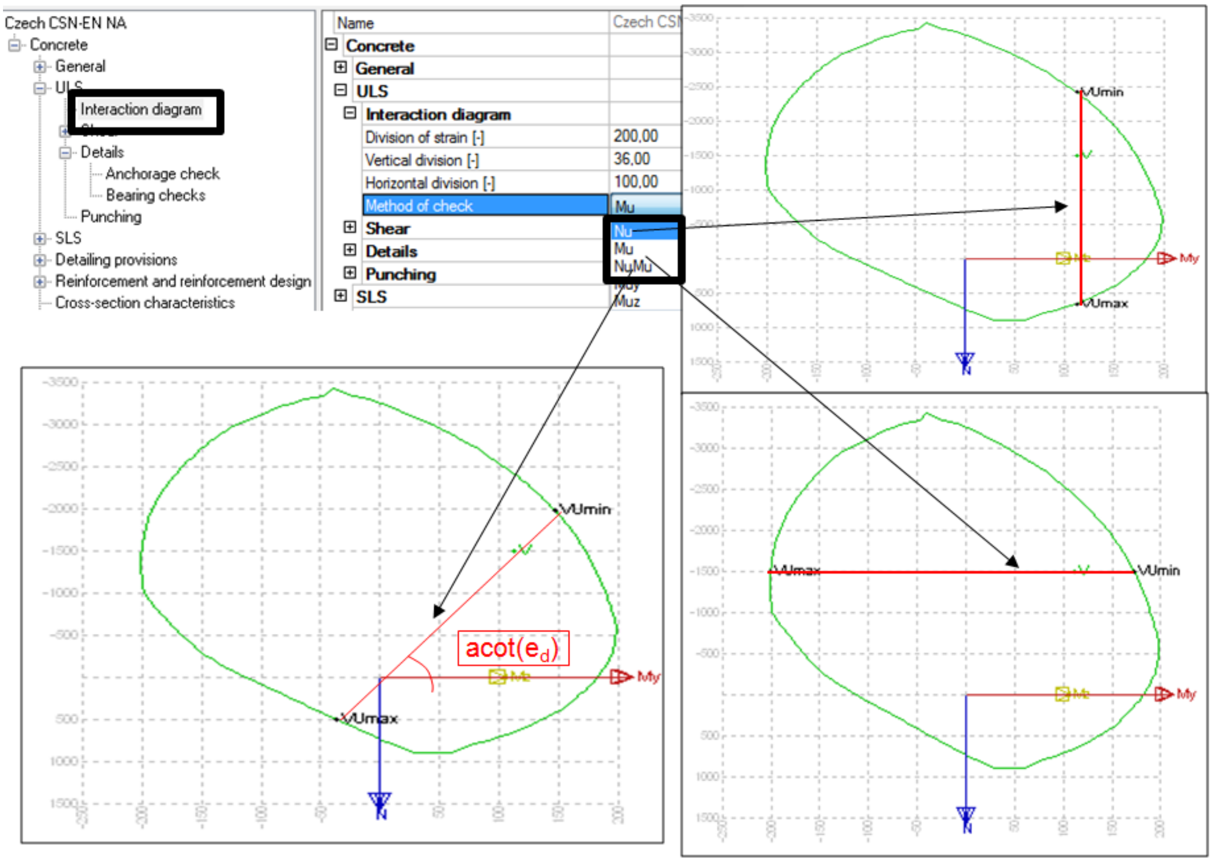
Pics.89 – Division of interaction diagram

Division of strain – calculation precision for one diagram branch. The value means how many times the strain plane is readjusted from the position of section under full compression to the position of section under full tension.

Vertical division - number of directions in which the diagram is calculated.

Horizontal division – the value affecting the accuracy of vertical sections; because branches of the diagram are not generally planar the calculation of vertical sections is based on horizontal sections.

There are 5 methods for check capacity- First three **(Nu, Mu, NuMu)** concern vertical section of the diagram. Methods **Muy** and **Muz** concern horizontal section of the diagram.



Czech CSN-EN NA
- Concrete
  - General
  - ULS
    - Interaction diagram
    - Shear
    - Details
      - Anchorage check
      - Bearing checks
    - Punching
  - SLS
  - Detailing provisions
  - Reinforcement and reinforcement design
  - Cross-section characteristics

Name	Czech CSN
Concrete	
General	
ULS	
Interaction diagram	
Division of strain [-]	200,00
Vertical division [-]	36,00
Horizontal division [-]	100,00
Method of check	Mu
Shear	
Details	
Punching	
SLS	

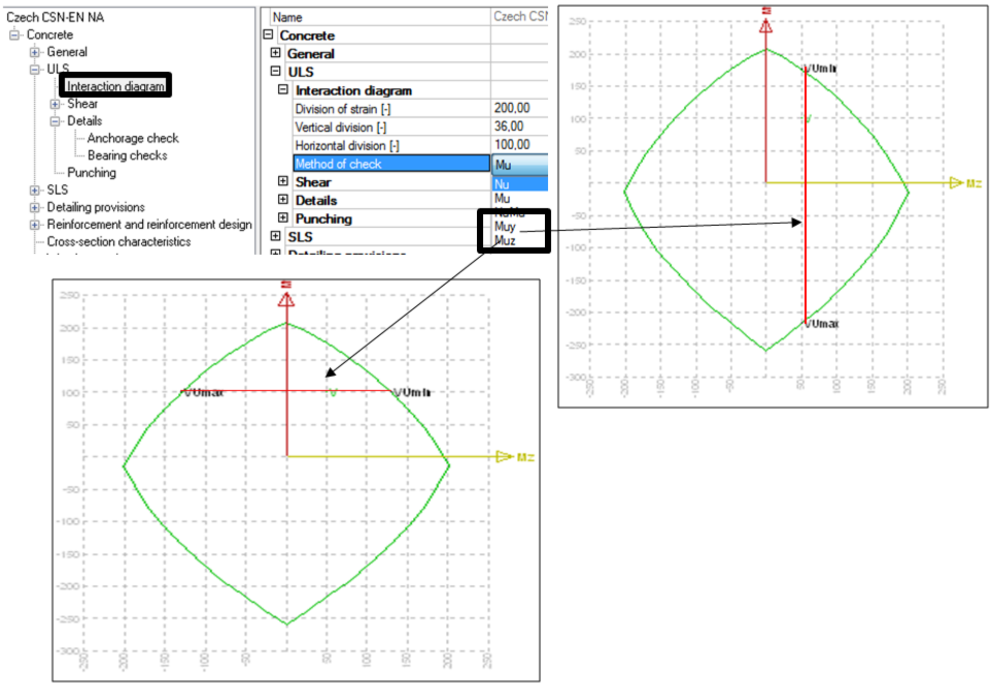
Pics.90 – Vertical methods for check capacity Nu, Mu, NuMu

Methods description:

Method Nu – we assume that **Md** is constant and thus search for normal forces at ultimate limit state parallel to normal force axis.

Method Mu – we assume that Nd is constant and thus search for bending moment at ultimate limit state parallel to moment axis.

Method NuMu – we assume constant eccentricity, a straight line is drawn from the origin and we search for internal forces at ultimate limit state on this line.



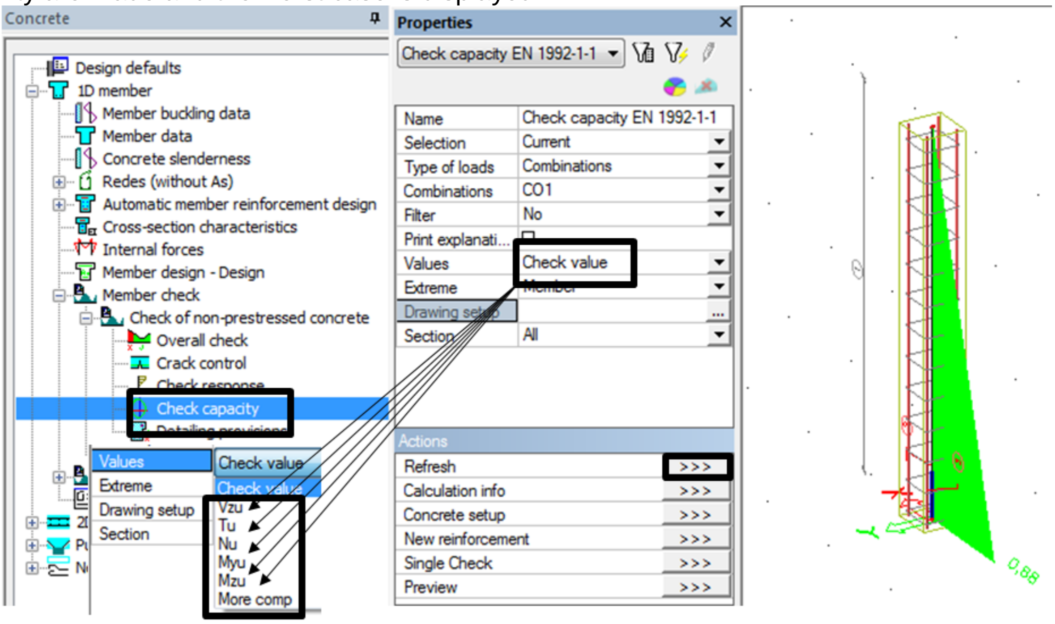
Name	Czech CSN
Division of strain [-]	200,00
Vertical division [-]	36,00
Horizontal division [-]	100,00
Method of check	Mu

Pics.91 – Horizontal methods for check capacity Nu, Mu, NuMu

Method Muy – we assume constant **Mdz** and search for limit bending moments horizontally with y axis.

Method Muz – we assume constant **Mdy** and search for limit bending moments horizontally with z axis.

If you choose the value for check capacity as “Check value” all of checks hidden under this possibility are made and the worst case is displayed.

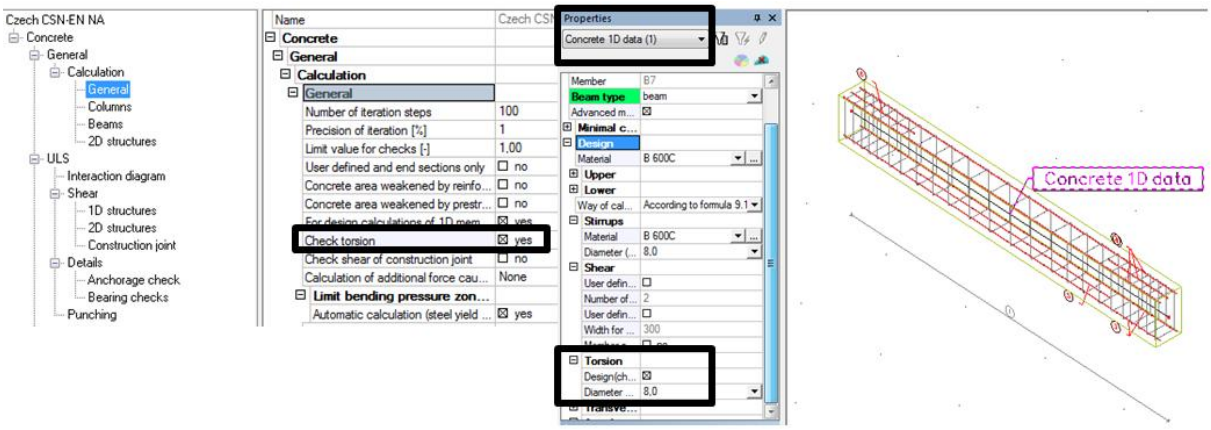


Name	Check capacity EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Values	Check value
Extreme	Member
Drawing setup	
Section	All

Pics.92 – Checking interaction diagram

Vzu – shear check. Shear check is not implemented for columns, details are in chapter 9.2.2.

Tu – torsion check for beams. This check is turned off as default because it takes much calculation time. You can activate it for each individual member in member data. Details about torsion check are in chapter 9.2.3.



Czech CSN-EN NA
- Concrete
  - General
    - Calculation
      - General
      - Columns
      - Beams
      - 2D structures
  - ULS
    - Interaction diagram
    - Shear
      - 1D structures
      - 2D structures
      - Construction joint
    - Details
      - Anchorage check
      - Bearing checks
    - Punching

Name	Czech CSN
Concrete	
General	
Calculation	
General	
Number of iteration steps	100
Precision of iteration [%]	1
Limit value for checks [-]	1,00
User defined and end sections only	☐ no
Concrete area weakened by reinfo...	☐ no
Concrete area weakened by prestr...	☐ no
For design calculations of 1D mem...	☒ yes
Check torsion	☒ yes
Check shear of construction joint	☐ no
Calculation of additional force cau...	None
Limit bending pressure zon...	
Automatic calculation (steel yield ...	☒ yes

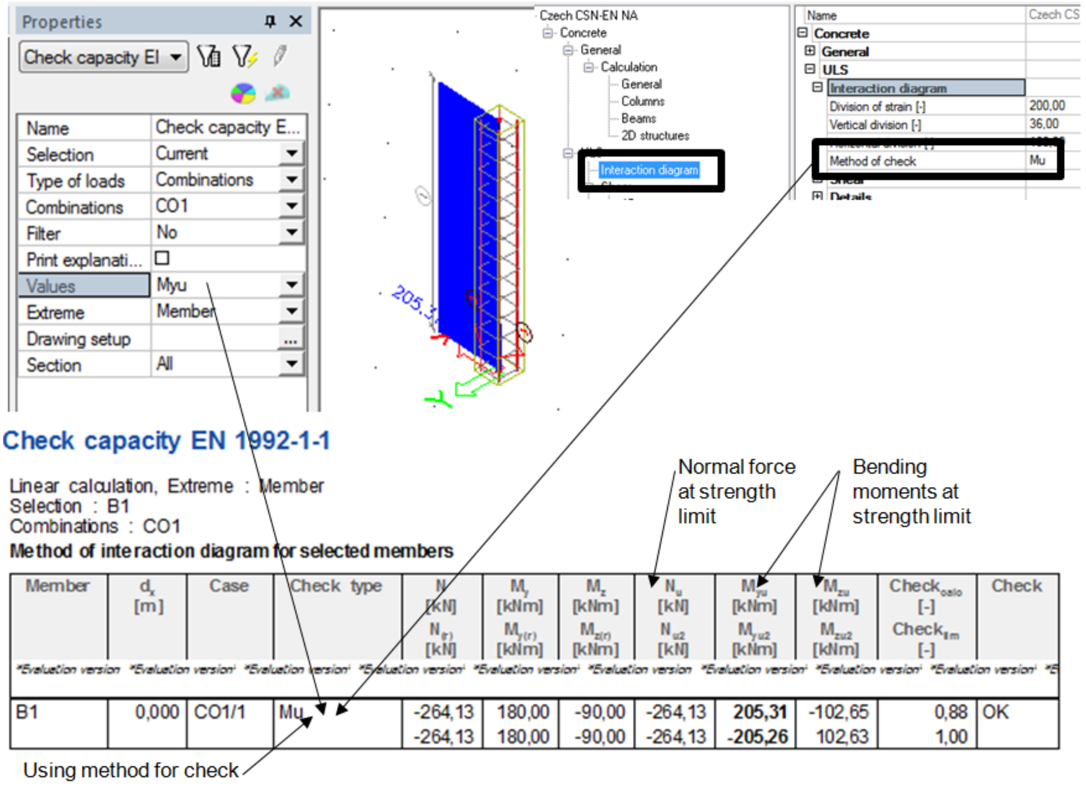
Properties

Concrete 1D data (1)

Member	B7
Beam type	beam
Advanced m...	☒
Minimal c...	
Design	
Material	B 600C
Upper	
Lower	
Way of cal...	According to formula 9.1
Stirrups	
Material	B 600C
Diameter (...	8,0
Shear	
User defin...	☐
Number of...	2
User defin...	☐
Width for ...	300
Torsion	
Design(ch...	☒
Diameter ...	8,0
Transve...	

Pics.93 – Switch on the torsion check

Nu, Muy, Muz – output changes according to your chosen method, for example setting for Mu method is following:



Properties

Check capacity El	
Name	Check capacity E...
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Values	Myu
Extreme	Member
Drawing setup	...
Section	All

Czech CSN-EN NA
- Concrete
  - General
    - Calculation
      - General
      - Columns
      - Beams
      - 2D structures
  - ULS
    - Interaction diagram

Name	Czech CS
Concrete	
General	
ULS	
Interaction diagram	
Division of strain [-]	200,00
Vertical division [-]	36,00
Method of check	Mu
Shear	
Details	

Check capacity EN 1992-1-1

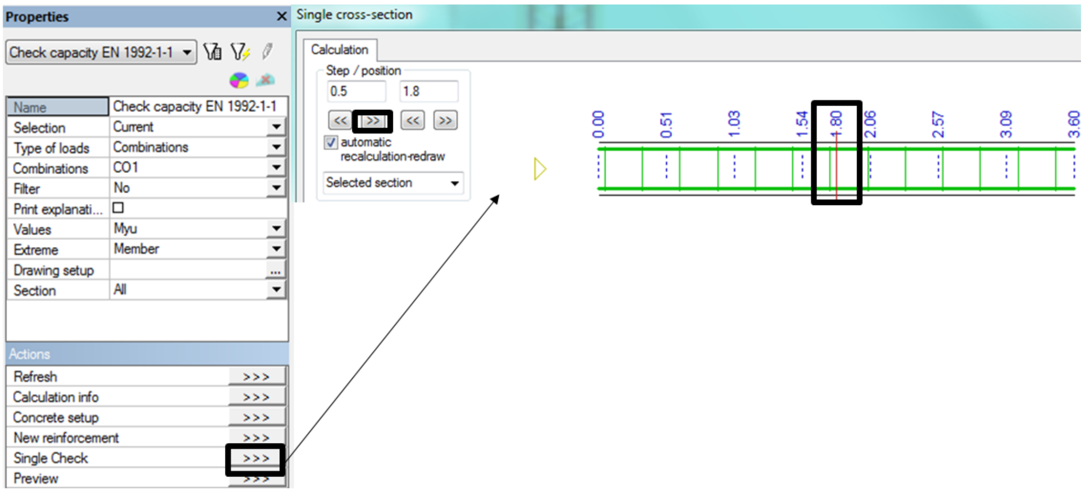
Linear calculation, Extreme : Member
Selection : B1
Combinations : CO1

Method of interaction diagram for selected members

Member	d_x [m]	Case	Check type	N [kN] $N_{(r)}$ [kN]	M_y [kNm] $M_{y(r)}$ [kNm]	M_z [kNm] $M_{z(r)}$ [kNm]	N_u [kN] N_{u2} [kN]	M_{yu} [kNm] M_{yu2} [kNm]	M_{zu} [kNm] M_{zu2} [kNm]	$Check_{calc}$ [-] $Check_{lim}$ [-]	Check
*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*E
B1	0,000	CO1/1	Mu	-264,13 -264,13	180,00 180,00	-90,00 -90,00	-264,13 -264,13	**205,31** **-205,26**	-102,65 102,63	0,88 1,00	OK

Pics.94 – Check capacity for whole member

For detailed check action button **Single check** is suitable. You will be asked to select a member. Any section along the beam can be viewed and checked, selection is made either by double-click on the requested position or by buttons with arrows.



Name	Check capacity EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Values	Myu
Extreme	Member
Drawing setup	...
Section	All

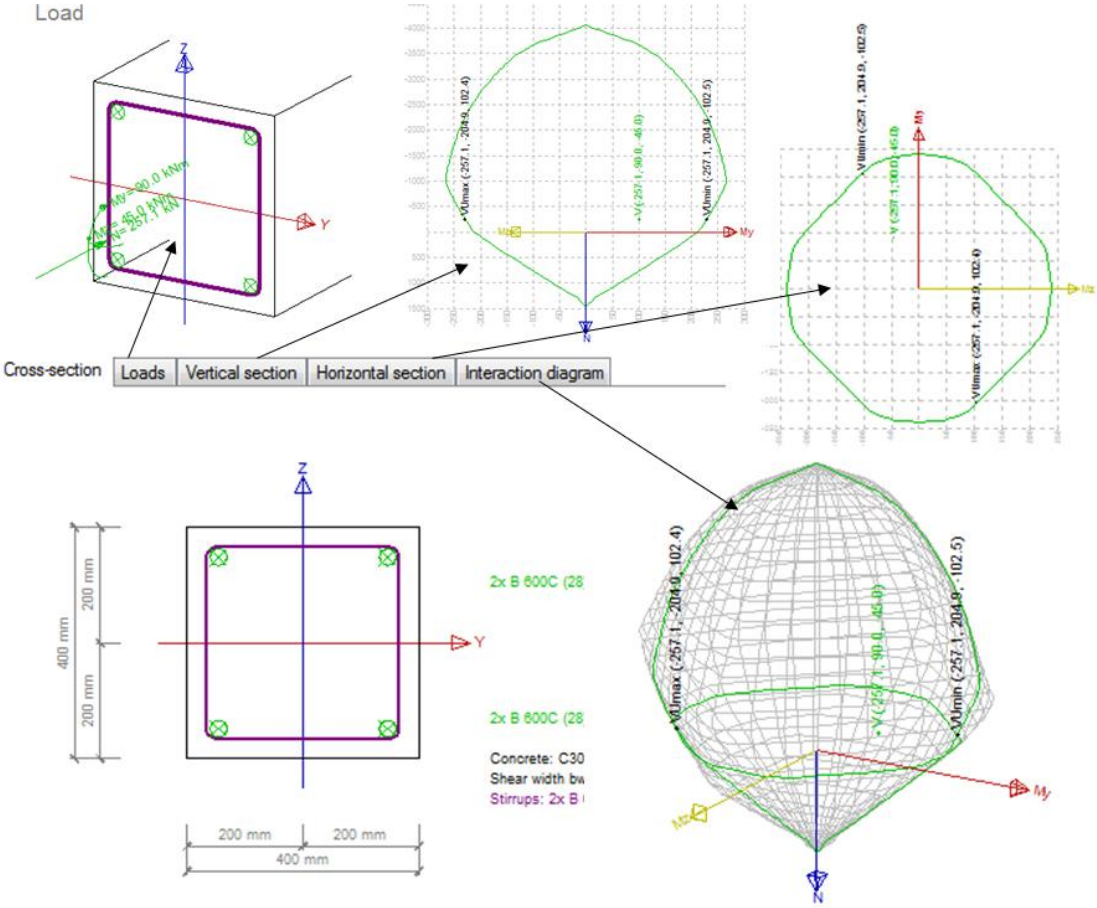
Step / position: 0.5 1.8

☑ automatic recalculation-redraw

Selected section

Pics.95 – Controls for single check

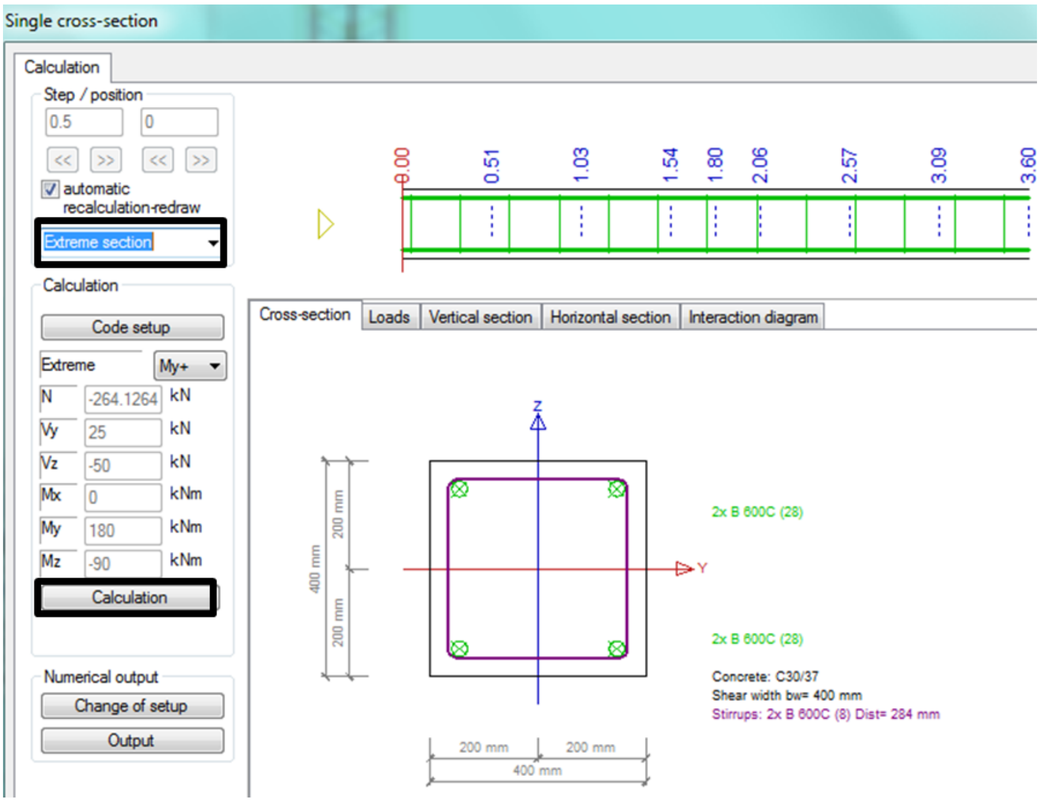
Then you can display detailed values of the check.



Pics.96 – Single check for check capacity

Trick:

If you want to find an extreme value on the member, select “Extreme section” in the combo box and press Clalculation button. Program fits the check into the most exposed section automatically. This feature is available for all kind of single checks.



Single cross-section

Step / position: 0.5 | 0

☑ automatic recalculation-redraw

Extreme section

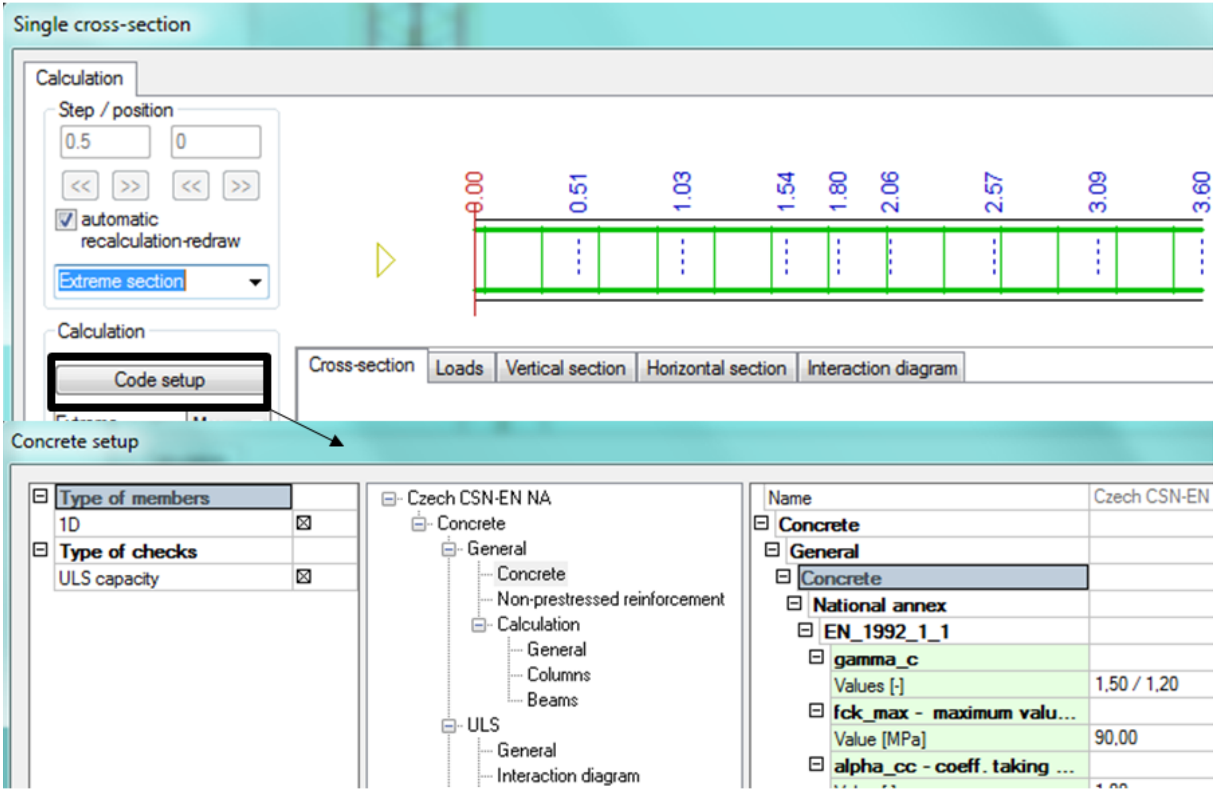
Extreme: My+

N: -264.1264 kN
Vy: 25 kN
Vz: -50 kN
Mx: 0 kNm
My: 180 kNm
Mz: -90 kNm

Pics.97 – Extreme section

Trick:

If you want to change any parameter that is involved in the check during the assessment click on Code setup button. Dialogue with all code parameters applied in particular assessment only appears.



Single cross-section

Step / position: 0.5 | 0

☑ automatic recalculation-redraw

Extreme section

Concrete setup

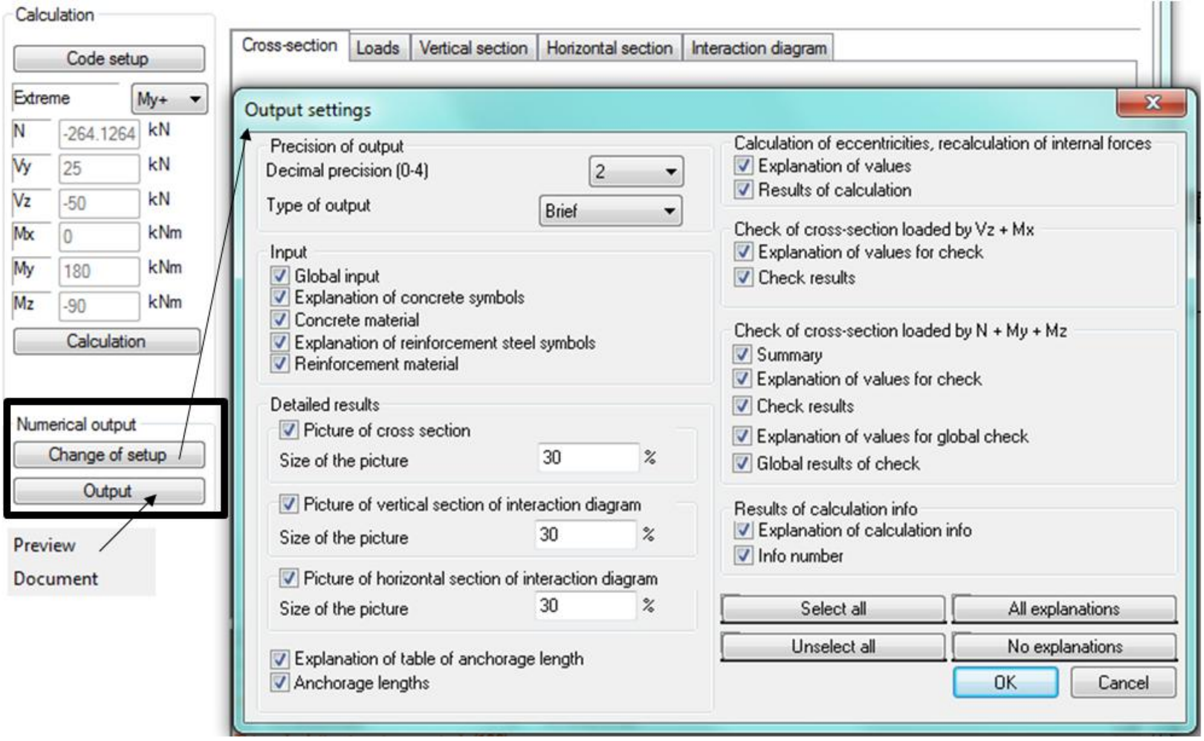
⊟ **Type of members**	
1D	☒
⊟ **Type of checks**	
ULS capacity	☒

Name	Czech CSN-EN
⊟ **Concrete**	
⊟ **General**	
⊟ Concrete	
⊟ **National annex**	
⊟ **EN_1992_1_1**	
⊟ **gamma_c**	
Values [-]	1,50 / 1,20
⊟ **fck_max - maximum valu...**	
Value [MPa]	90,00
⊟ **alpha_cc - coeff. taking ...**	

Pics.98 – Code setup

Trick:

Another interesting option is output setting (**Change of setup** button). You can arrange what exactly you do need in the output here. Again, this option is available for all kind of single checks.



Extreme: My+
N: -264.1264 kN
Vy: 25 kN
Vz: -50 kN
Mx: 0 kNm
My: 180 kNm
Mz: -90 kNm

Precision of output
Decimal precision (0-4): 2
Type of output: Brief

Input
☑ Global input
☑ Explanation of concrete symbols
☑ Concrete material
☑ Explanation of reinforcement steel symbols
☑ Reinforcement material

Detailed results
☑ Picture of cross section
Size of the picture: 30 %
☑ Picture of vertical section of interaction diagram
Size of the picture: 30 %
☑ Picture of horizontal section of interaction diagram
Size of the picture: 30 %

☑ Explanation of table of anchorage length
☑ Anchorage lengths

Calculation of eccentricities, recalculation of internal forces
☑ Explanation of values
☑ Results of calculation

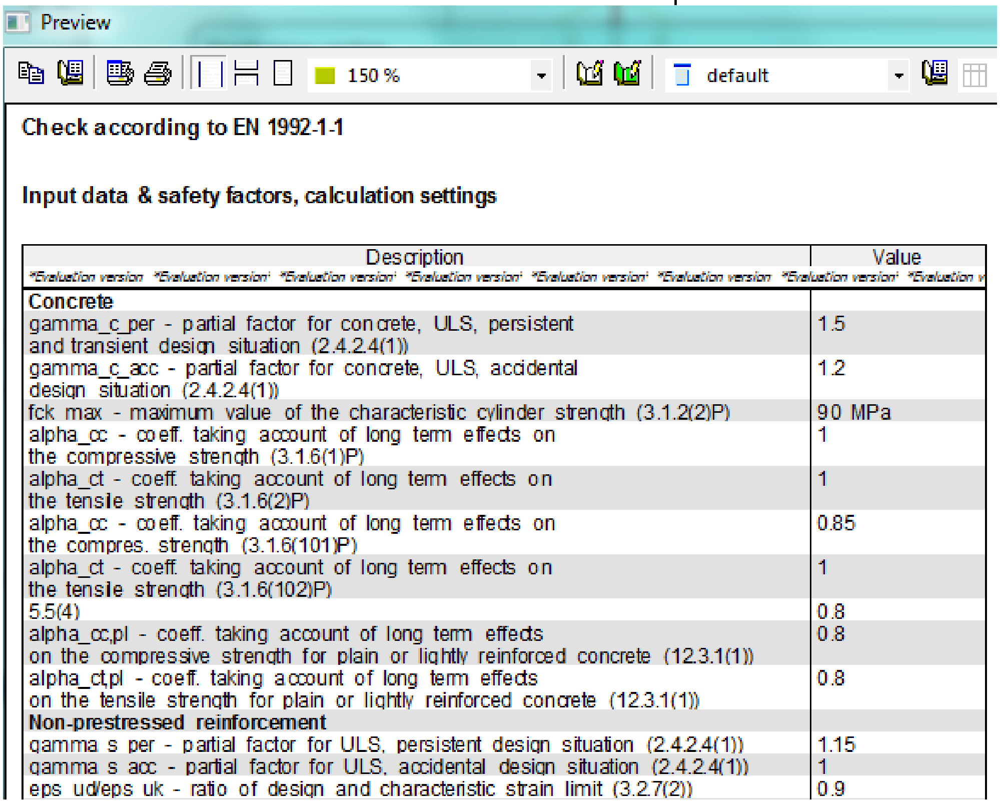
Check of cross-section loaded by Vz + Mx
☑ Explanation of values for check
☑ Check results

Check of cross-section loaded by N + My + Mz
☑ Summary
☑ Explanation of values for check
☑ Check results
☑ Explanation of values for global check
☑ Global results of check

Results of calculation info
☑ Explanation of calculation info
☑ Info number

Pics.99 – Setting of the output

References to code articles are also shown in detailed output.



Check according to EN 1992-1-1

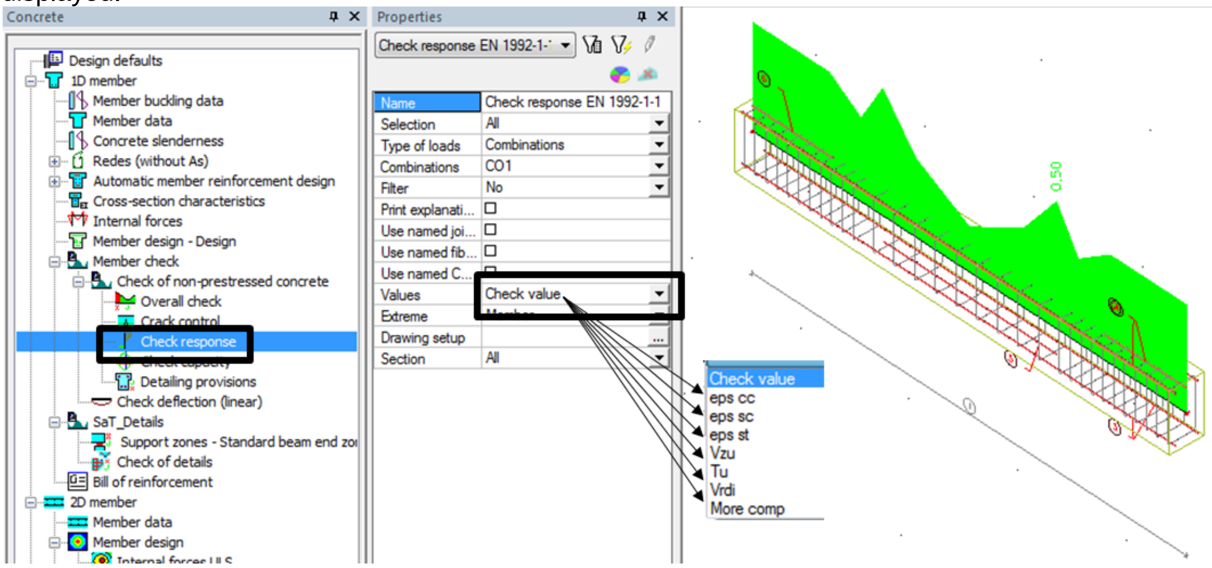
Input data & safety factors, calculation settings

Description	Value
Concrete	
gamma_c_per - partial factor for concrete, ULS, persistent and transient design situation (2.4.2.4(1))	1.5
gamma_c_acc - partial factor for concrete, ULS, accidental design situation (2.4.2.4(1))	1.2
fck max - maximum value of the characteristic cylinder strength (3.1.2(2)P)	90 MPa
alpha_cc - coeff. taking account of long term effects on the compressive strength (3.1.6(1)P)	1
alpha_ct - coeff. taking account of long term effects on the tensile strength (3.1.6(2)P)	1
alpha_cc - coeff. taking account of long term effects on the compres. strength (3.1.6(101)P)	0.85
alpha_ct - coeff. taking account of long term effects on the tensile strength (3.1.6(102)P)	1
5.5(4)	0.8
alpha_cc,pl - coeff. taking account of long term effects on the compressive strength for plain or lightly reinforced concrete (12.3.1(1))	0.8
alpha_ct,pl - coeff. taking account of long term effects on the tensile strength for plain or lightly reinforced concrete (12.3.1(1))	0.8
Non-prestressed reinforcement	
gamma s per - partial factor for ULS, persistent design situation (2.4.2.4(1))	1.15
gamma s acc - partial factor for ULS, accidental design situation (2.4.2.4(1))	1
eps ud/eps uk - ratio of design and characteristic strain limit (3.2.7(2))	0.9

Pics.100 – Details of output

9.2. Check response

For this check real reinforcement in the member is necessary. If you choose the value for check response as “Check value” all of checks hidden under this possibility are made and the worst case is displayed.



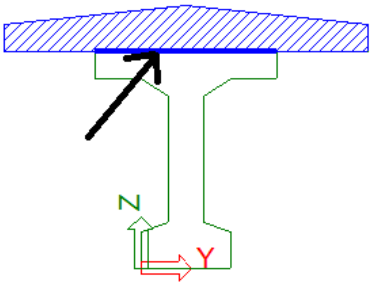
Check response EN 1992-1-1

Name	Check response EN 1992-1-1
Selection	All
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named fib...	☐
Use named C...	☐
Values	Check value
Extreme	Member
Drawing setup	...
Section	All

Check value
eps cc
eps sc
eps st
Vzu
Tu
Vrdi
More comp

Pics.101 – Check response

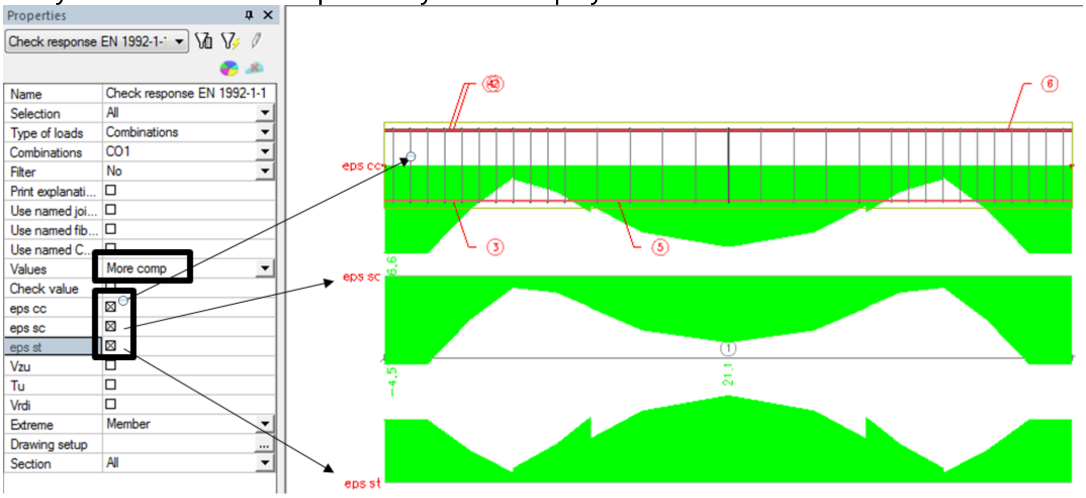
eps cc	- compressive strain in concrete check
eps sc	- compressive strain in reinforcement bars check
eps st	- tensile strain in reinforcement bars check
Vzu	- shear check
Tu	- tosion check
Vrdi	- shear check at the interface



Pics.102 – Horizontal joint

9.2.1 Strain check

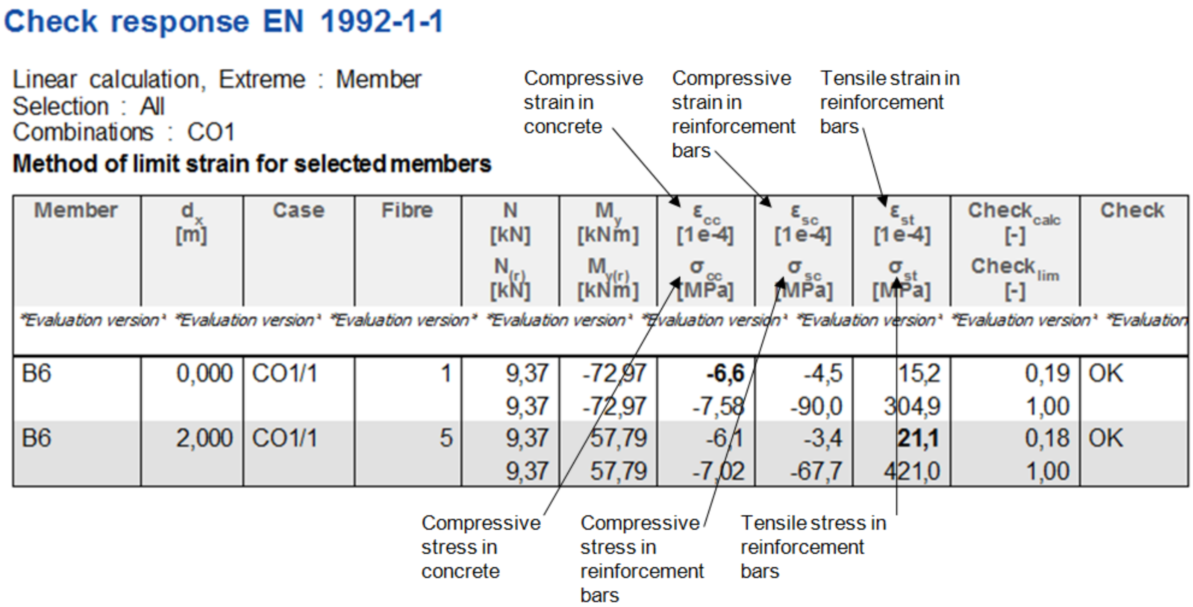
If you choose more components you can display more check in the same time.



Check response EN 1992-1-1

Name	Check response EN 1992-1-1
Selection	All
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named fib...	☐
Use named C...	☐
Values	More comp
Check value	☐
eps cc	☒
eps sc	☒
eps st	☒
Vzu	☐
Tu	☐
Vrdi	☐
Extreme	Member
Drawing setup	...
Section	All

Pics.103 – Displaying of strains for concrete and reinforcement.



Check response EN 1992-1-1

Linear calculation, Extreme : Member
Selection : All
Combinations : CO1

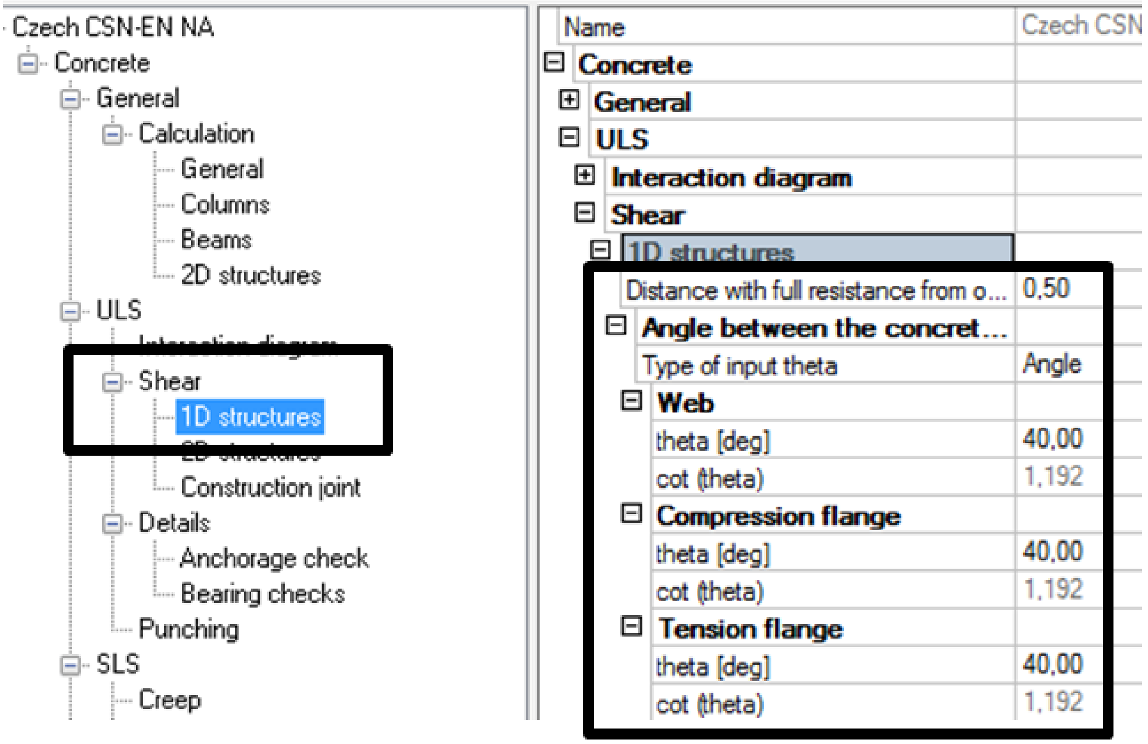
Method of limit strain for selected members

Member	d_x [m]	Case	Fibre	N [kN] $N_{(r)}$ [kN]	M_y [kNm] $M_{y(r)}$ [kNm]	ε_{cc} [1e-4] σ_{cc} [MPa]	ε_{sc} [1e-4] σ_{sc} [MPa]	ε_{st} [1e-4] σ_{st} [MPa]	$Check_{calc}$ [-] $Check_{lim}$ [-]	Check
Evaluation version	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation			
B6	0,000	CO1/1	1	9,37 9,37	-72,97 -72,97	**-6,6** -7,58	-4,5 -90,0	15,2 304,9	0,19 1,00	OK
B6	2,000	CO1/1	5	9,37 9,37	57,79 57,79	-6,1 -7,02	-3,4 -67,7	**21,1** 421,0	0,18 1,00	OK

Pics.104 – Table of strain for concrete and reinforcement

9.2.2. Shear check

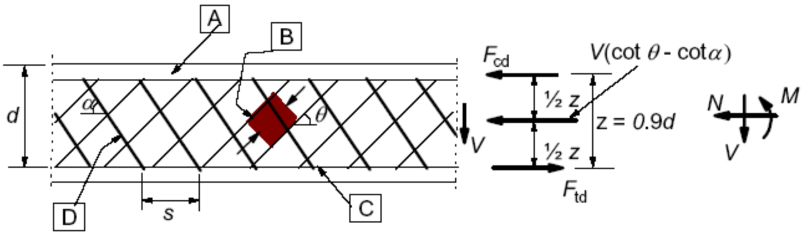
Shear check is affected by the setting in **Concrete solver**.



Name	Czech CSN
Concrete	
General	
ULS	
Interaction diagram	
Shear	
1D structures	
Distance with full resistance from o...	0.50
Angle between the concret...	
Type of input theta	Angle
Web	
theta [deg]	40.00
cot (theta)	1.192
Compression flange	
theta [deg]	40.00
cot (theta)	1.192
Tension flange	
theta [deg]	40.00
cot (theta)	1.192

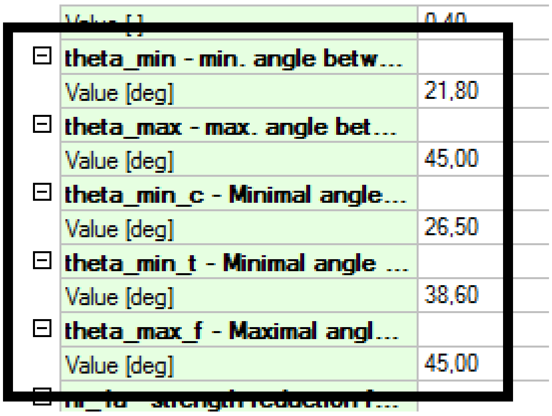
Pics.105 – Angle theta

Design shear force calculation is influenced by angle theta. This is an angle between the concrete compression strut and the beam axis perpendicular to the shear force. It can be defined in degrees or as a contangent.Angle theta may be variable with the height of the I-profile beam, therefore you can set different values for web, compression and tension flange. Design force is calculated according to formula 6.8 from EN 1992-1-1.



Pics.106 – Parameters for shear calculation

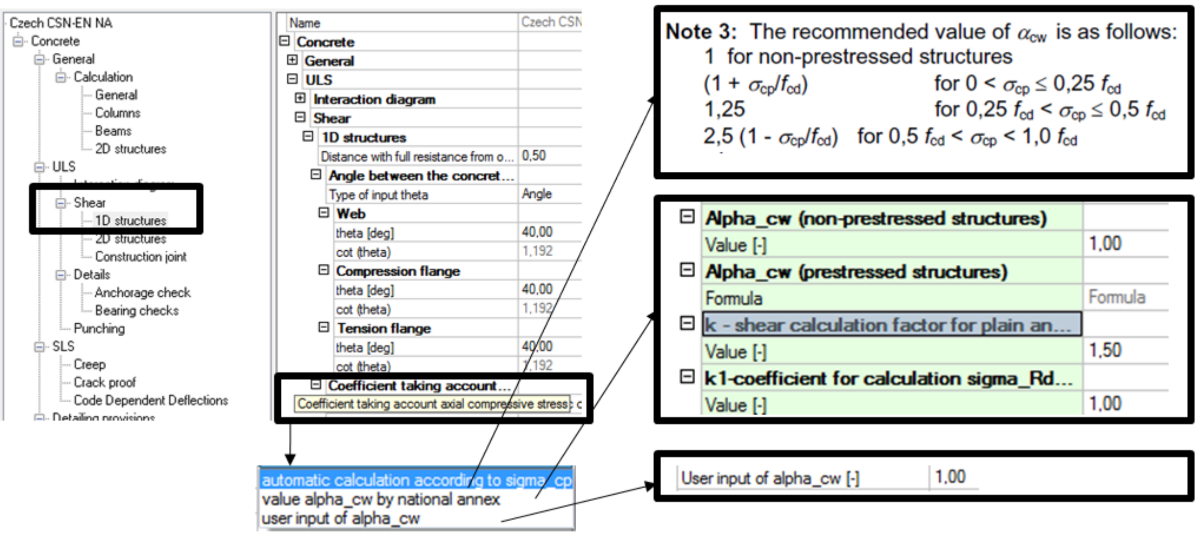
Limit values of this angle can be found in the national annex.



⊟ **theta_min - min. angle betw...**	
Value [deg]	21,80
⊟ **theta_max - max. angle bet...**	
Value [deg]	45,00
⊟ **theta_min_c - Minimal angle...**	
Value [deg]	26,50
⊟ **theta_min_t - Minimal angle ...**	
Value [deg]	38,60
⊟ **theta_max_f - Maximal angl...**	
Value [deg]	45,00

Pics.107 – Limit for angle theta according to national annex

Another coefficient that affects shear check is a coefficient taking account axial compressive stress. It influences the calculation of maximal shear force which is the element able to resist. The value can be specified as follows:



- Czech CSN-EN NA
  - Concrete
    - General
      - Calculation
        - General
        - Columns
        - Beams
        - 2D structures
    - ULS
      - Shear
        - 1D structures
        - 2D structures
        - Construction joint
      - Details
        - Anchorage check
        - Bearing checks
      - Punching
    - SLS
      - Creep
      - Crack proof
      - Code Dependent Deflections

Name	Czech CSN
⊟ **Concrete**	
⊞ **General**	
⊟ **ULS**	
⊞ **Interaction diagram**	
⊟ **Shear**	
⊟ **1D structures**	
Distance with full resistance from o...	0,50
⊟ **Angle between the concret...**	
Type of input theta	Angle
⊟ **Web**	
theta [deg]	40,00
cot (theta)	1,192
⊟ **Compression flange**	
theta [deg]	40,00
cot (theta)	1,192
⊟ **Tension flange**	
theta [deg]	40,00
cot (theta)	1,192
⊟ **Coefficient taking account...**	
Coefficient taking account axial compressive stress	

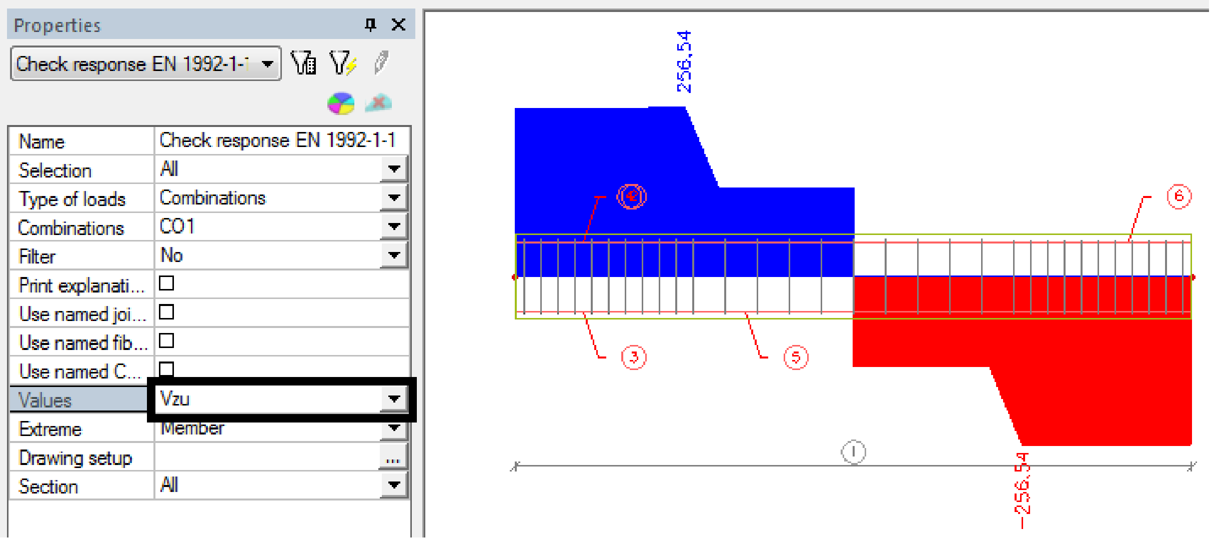
automatic calculation according to sigma_cp
value alpha_cw by national annex
user input of alpha_cw

Note 3: The recommended value of α_{cw} is as follows:
1 for non-prestressed structures
$(1 + \sigma_{cp}/f_{cd})$ for $0 < \sigma_{cp} \leq 0{,}25\ f_{cd}$
1,25 for $0{,}25\ f_{cd} < \sigma_{cp} \leq 0{,}5\ f_{cd}$
$2{,}5\ (1 - \sigma_{cp}/f_{cd})$ for $0{,}5\ f_{cd} < \sigma_{cp} < 1{,}0\ f_{cd}$

⊟ **Alpha_cw (non-prestressed structures)**	
Value [-]	1,00
⊟ **Alpha_cw (prestressed structures)**	
Formula	Formula
⊟ k - shear calculation factor for plain an...	
Value [-]	1,50
⊟ **k1-coefficient for calculation sigma_Rd...**	
Value [-]	1,00

User input of alpha_cw [-]	1,00

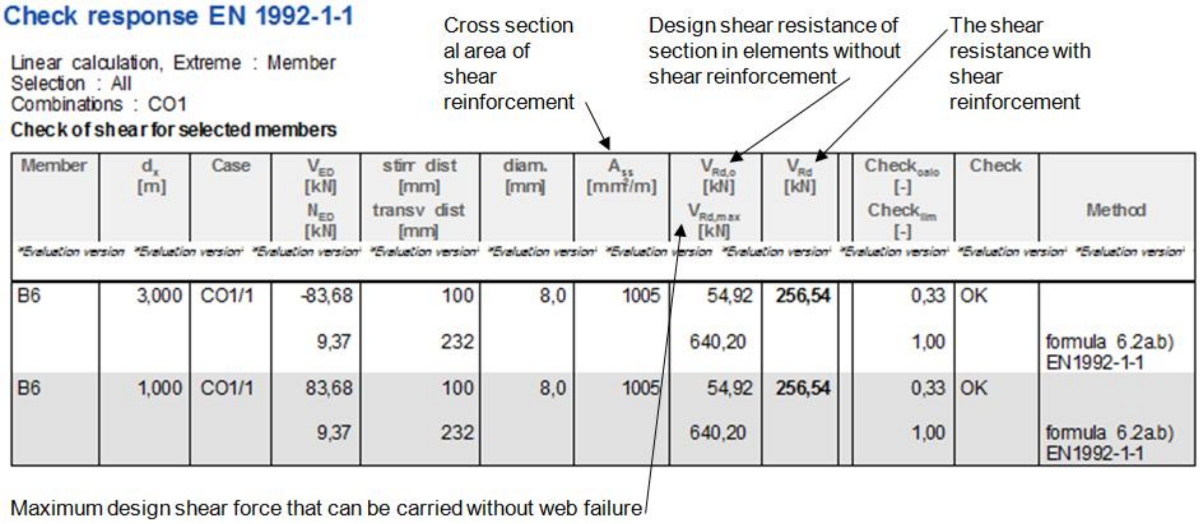
Pics.108 – Options for calculation coefficient, which takes axial compressive stress



Properties

Name	Check response EN 1992-1-1
Selection	All
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named fib...	☐
Use named C...	☐
Values	Vzu
Extreme	Member
Drawing setup	...
Section	All

Pics.109 – Displaying check of shear



Check response EN 1992-1-1

Linear calculation, Extreme : Member
Selection : All
Combinations : CO1

Check of shear for selected members

Member	d_x [m]	Case	V_{ED} [kN] N_{ED} [kN]	stirr dist [mm] transv dist [mm]	diam. [mm]	A_{ss} [mm²/m]	$V_{Rd,c}$ [kN] $V_{Rd,max}$ [kN]	V_{Rd} [kN]	$Check_{calc}$ [-] $Check_{lim}$ [-]	Check	Method
*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version		
B6	3,000	CO1/1	-83,68 9,37	100 232	8,0	1005	54,92 640,20	**256,54**	0,33 1,00	OK	formula 6.2a.b) EN1992-1-1
B6	1,000	CO1/1	83,68 9,37	100 232	8,0	1005	54,92 640,20	**256,54**	0,33 1,00	OK	formula 6.2a.b) EN1992-1-1

Cross sectional area of shear reinforcement

Design shear resistance of section in elements without shear reinforcement

The shear resistance with shear reinforcement

Maximum design shear force that can be carried without web failure

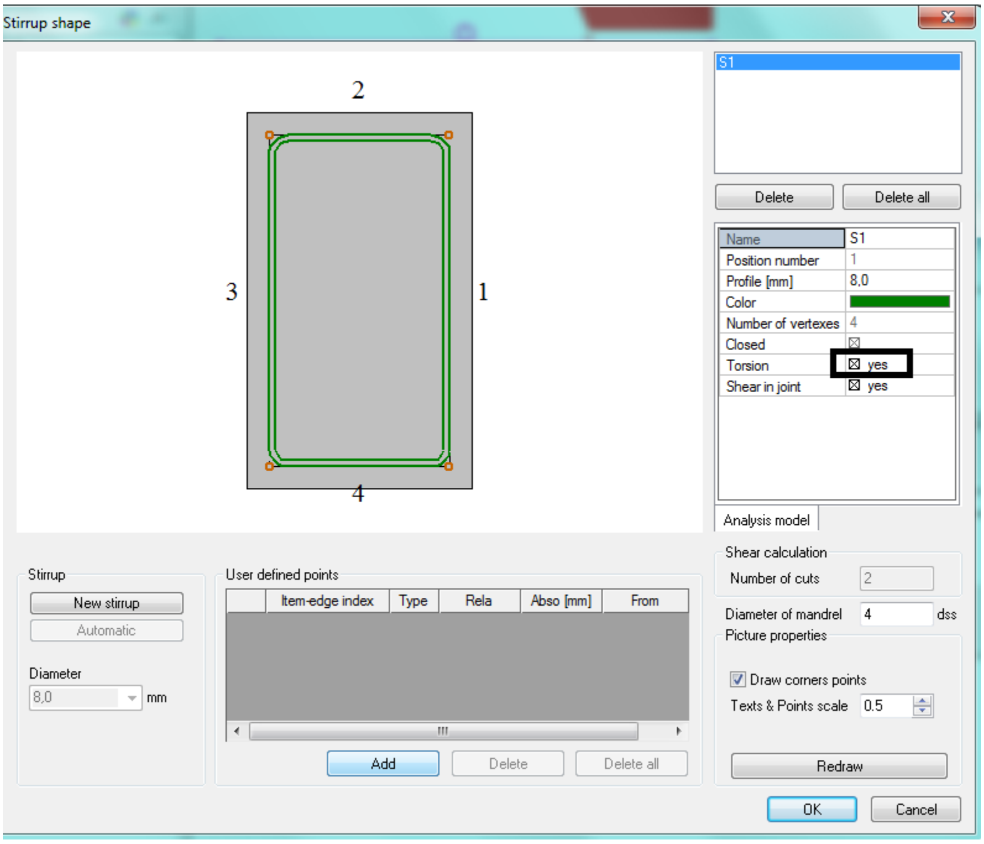
Pics.110 – Preview of check of shear

9.2.3. Torsion check

All cross-section types can be subjected to torsion check. A few steps need to be done before performing the check:

a) Tick the check in Setup/Concrete solver or in member data because it is deactivated as default because of long calculation time. **See pic. 90.**

b) Stirrups need to have the property that it is used for torsion check.



Name	S1
Position number	1
Profile [mm]	8,0
Color	🟩
Number of vertexes	4
Closed	☒
Torsion	☒ yes
Shear in joint	☒ yes

Stirrup

Diameter 8,0 mm

User defined points

	Item-edge index	Type	Rela	Abso [mm]	From

Shear calculation

Number of cuts 2

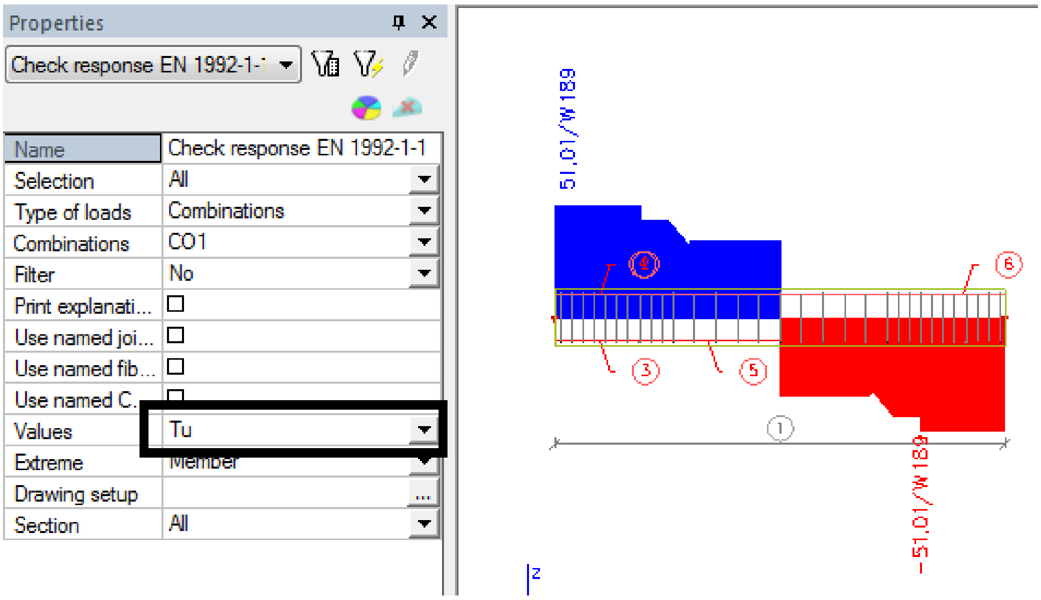
Diameter of mandrel 4 dss

Picture properties

☑ Draw corners points

Texts & Points scale 0.5

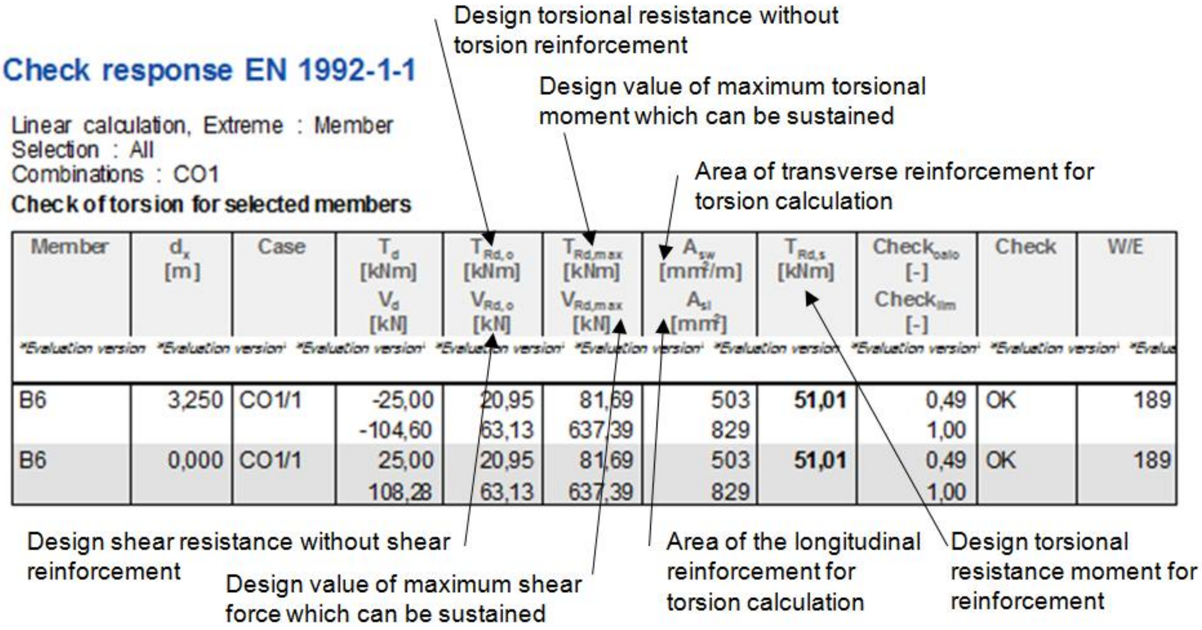
Pics.111 – Setting of stirrup for torsion calculation



Check response EN 1992-1-1

Name	Check response EN 1992-1-1
Selection	All
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named fib...	☐
Use named C...	☐
Values	Tu
Extreme	Member
Drawing setup	...
Section	All

Pics.112 – Check of torsion for whole beam, output display



Check response EN 1992-1-1

Linear calculation, Extreme : Member
Selection : All
Combinations : CO1

Check of torsion for selected members

Member	d_x [m]	Case	T_d [kNm] V_d [kN]	$T_{Rd,o}$ [kNm] $V_{Rd,o}$ [kN]	$T_{Rd,max}$ [kNm] $V_{Rd,max}$ [kN]	A_{sw} [mm²/m] A_{sl} [mm²]	$T_{Rd,s}$ [kNm]	$Check_{calc}$ [-] $Check_{lim}$ [-]	Check	W/E
B6	3,250	CO1/1	-25,00 -104,60	20,95 63,13	81,69 637,39	503 829	**51,01**	0,49 1,00	OK	189
B6	0,000	CO1/1	25,00 108,28	20,95 63,13	81,69 637,39	503 829	**51,01**	0,49 1,00	OK	189

$$\frac{\sum A_{sl,req} \cdot f_{yd}}{u_k} = \frac{T_{Ed}}{2 \cdot A_k} \cdot \cot\theta$$

$$A_{sw,req} = \left(\frac{T_{Ed}}{2 \cdot A_k} + \frac{V_{Ed}}{n_s \cdot z} \right) \cdot \frac{1}{f_{ywd} \cdot \cot\theta}$$

Pics.113 – Preview of check of torsion and used formulas

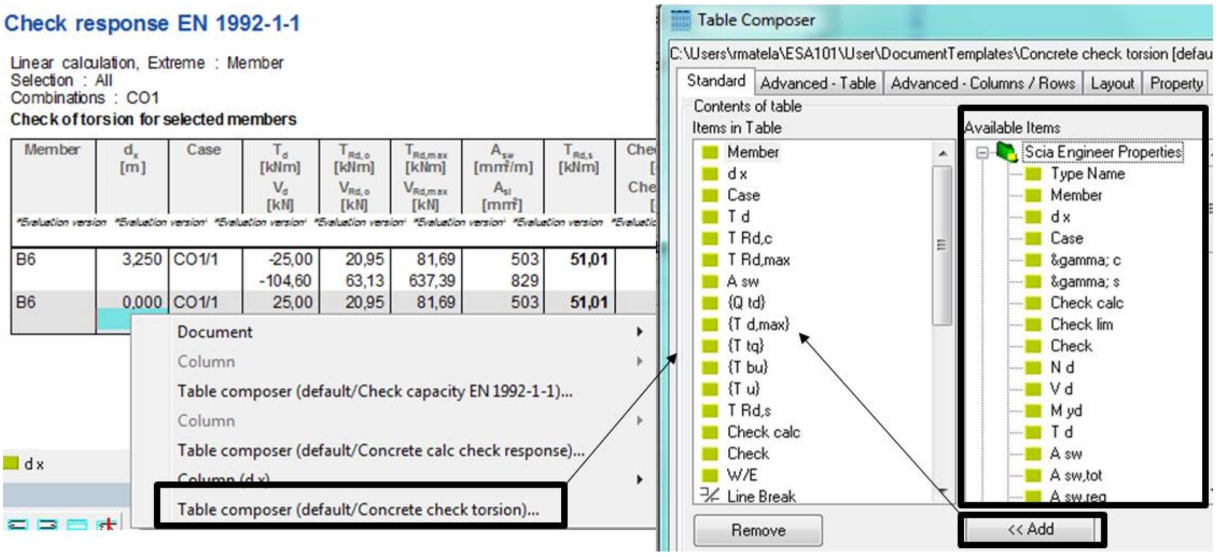
The check proceeds in compliance with method:

If $\mathbf{T_{Ed}/T_{Rd,max} + V_{Ed}/V_{Rd,max}} \geq \mathbf{1}$ => error “not ok“
If $\mathbf{T_{Ed}/T_{Rd,max} + V_{Ed}/V_{Rd,max}} \leq \mathbf{1}$, then

- If $\mathbf{T_{Ed}/T_{Rd,c} + V_{Ed}/V_{R,dc}} \leq \mathbf{1}$ => warning “Stirrups for torsion are not required“
- If $\mathbf{T_{Ed}/T_{Rd,c} + V_{Ed}/V_{R,dc}} \geq \mathbf{1}$ => design of longitudinal and shear reinrofcement is made
  - Longitudinal reinforcement design **Asl ≥ As,req**
  - Shear reinforcememtndesign **Asw ≥ Asw,req**

Trick:

Only the essential values are displayed in tables and previews of checks. When you want to know more output values click with right mouse button on the table and choose Table editor.



Check response EN 1992-1-1

Linear calculation, Extreme : Member
Selection : All
Combinations : CO1

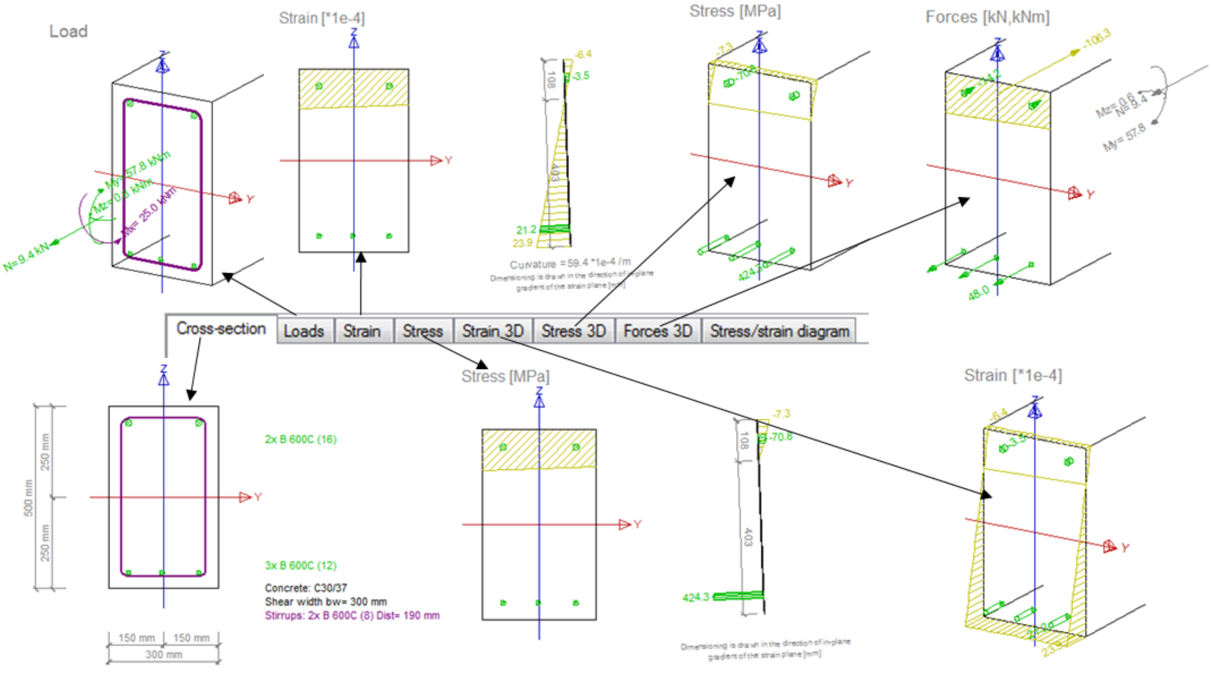
Check of torsion for selected members

Member	d_x [m]	Case	T_d [kNm] V_d [kN]	$T_{Rd,o}$ [kNm] $V_{Rd,o}$ [kN]	$T_{Rd,max}$ [kNm] $V_{Rd,max}$ [kN]	A_{sw} [mm²/m] A_{sl} [mm²]	$T_{Rd,s}$ [kNm]	Che [Che [
*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version		
B6	3,250	CO1/1	-25,00 -104,60	20,95 63,13	81,69 637,39	503 829	**51,01**	
B6	0,000	CO1/1	25,00	20,95	81,69	503	**51,01**	

Pics.114 – Inserting of calculations values into table

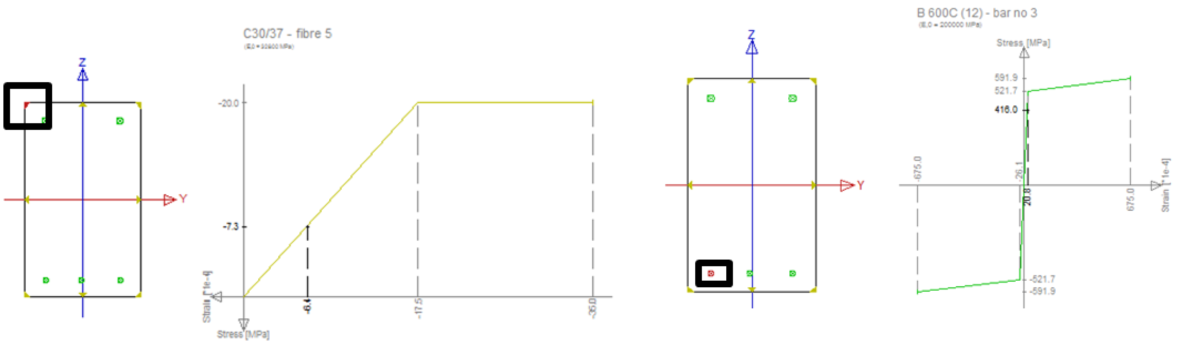
9.2.4. Detailed check

Detailed check can be done using Single check action button in the properties window. Following quantities may be displayed. The handling is similar to capacity check.



Pics.115 – Single check for check response

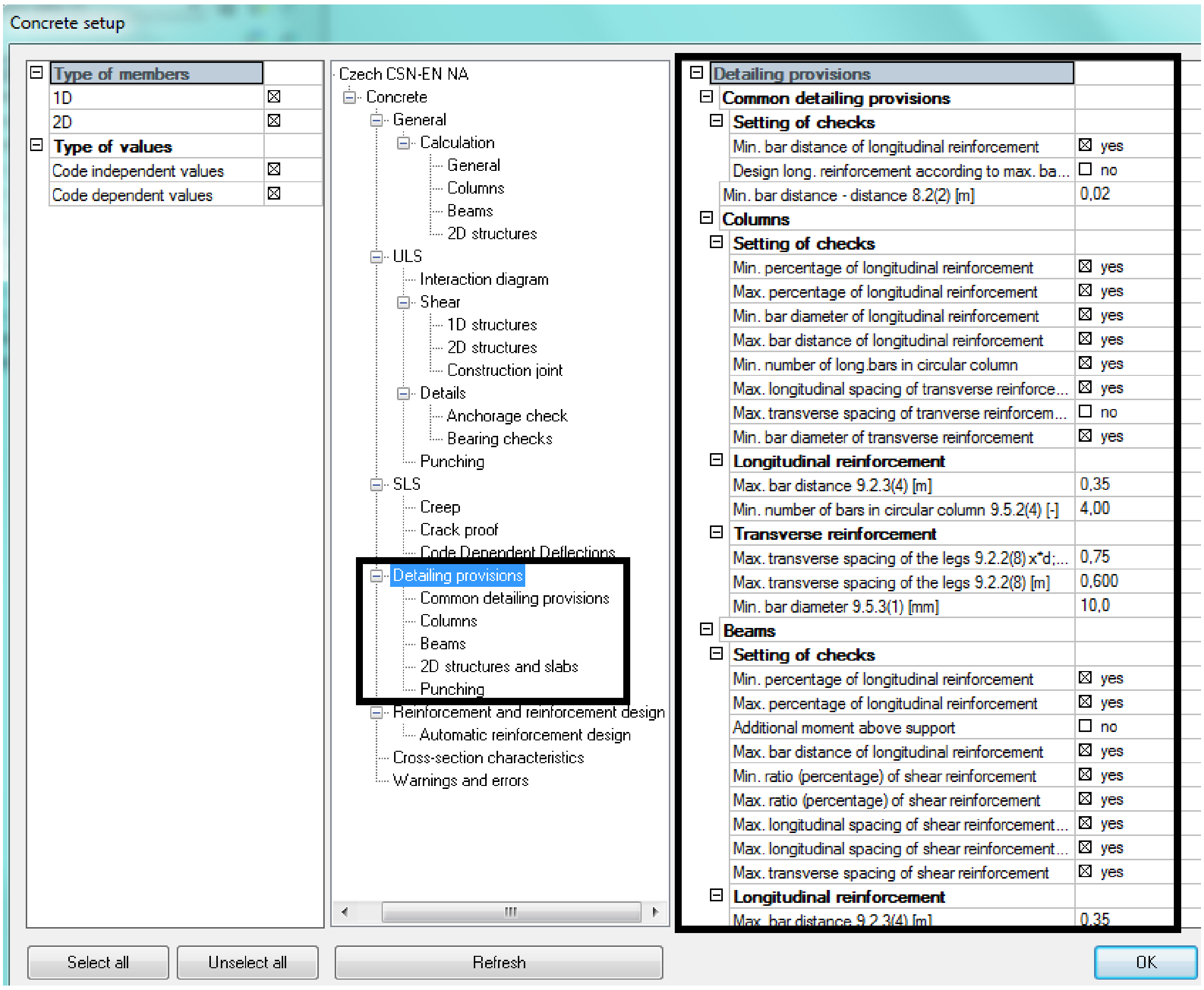
Stress-strain diagram for arbitrary fibre and for arbitrary steel bar can be seen.



Pics.116 – Stress/strain diagrams

9.3. Detailing provisions

Real reinforcement is needed for this type of check. Setting can be found in Setup/**Concrete solver**.


Concrete setup

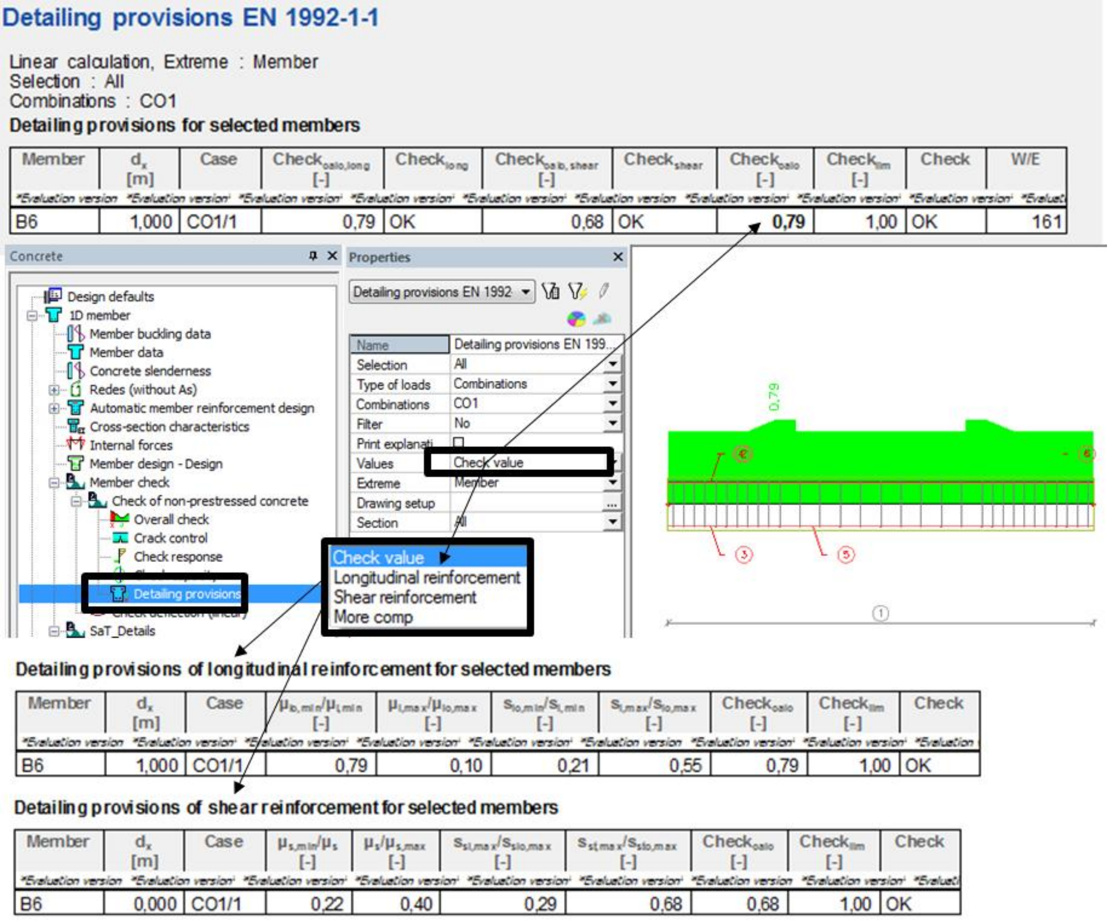
⊟ **Type of members**	
1D	☒
2D	☒
⊟ **Type of values**	
Code independent values	☒
Code dependent values	☒

- Czech CSN-EN NA
  - Concrete
    - General
      - Calculation
        - General
        - Columns
        - Beams
        - 2D structures
    - ULS
      - Interaction diagram
      - Shear
        - 1D structures
        - 2D structures
        - Construction joint
      - Details
        - Anchorage check
        - Bearing checks
      - Punching
    - SLS
      - Creep
      - Crack proof
      - Code Dependent Deflections
    - Detailing provisions
      - Common detailing provisions
      - Columns
      - Beams
      - 2D structures and slabs
      - Punching
    - Reinforcement and reinforcement design
      - Automatic reinforcement design
    - Cross-section characteristics
    - Warnings and errors

⊟ Detailing provisions	
⊟ **Common detailing provisions**	
⊟ **Setting of checks**	
Min. bar distance of longitudinal reinforcement	☒ yes
Design long. reinforcement according to max. ba...	☐ no
Min. bar distance - distance 8.2(2) [m]	0,02
⊟ **Columns**	
⊟ **Setting of checks**	
Min. percentage of longitudinal reinforcement	☒ yes
Max. percentage of longitudinal reinforcement	☒ yes
Min. bar diameter of longitudinal reinforcement	☒ yes
Max. bar distance of longitudinal reinforcement	☒ yes
Min. number of long.bars in circular column	☒ yes
Max. longitudinal spacing of transverse reinforce...	☒ yes
Max. transverse spacing of tranverse reinforcem...	☐ no
Min. bar diameter of transverse reinforcement	☒ yes
⊟ **Longitudinal reinforcement**	
Max. bar distance 9.2.3(4) [m]	0,35
Min. number of bars in circular column 9.5.2(4) [-]	4,00
⊟ **Transverse reinforcement**	
Max. transverse spacing of the legs 9.2.2(8) x*d;...	0,75
Max. transverse spacing of the legs 9.2.2(8) [m]	0,600
Min. bar diameter 9.5.3(1) [mm]	10,0
⊟ **Beams**	
⊟ **Setting of checks**	
Min. percentage of longitudinal reinforcement	☒ yes
Max. percentage of longitudinal reinforcement	☒ yes
Additional moment above support	☐ no
Max. bar distance of longitudinal reinforcement	☒ yes
Min. ratio (percentage) of shear reinforcement	☒ yes
Max. ratio (percentage) of shear reinforcement	☒ yes
Max. longitudinal spacing of shear reinforcement...	☒ yes
Max. longitudinal spacing of shear reinforcement...	☒ yes
Max. transverse spacing of shear reinforcement	☒ yes
⊟ **Longitudinal reinforcement**	
Max. bar distance 9.2.3(4) [m]	0,35

Pics.117 – Setting of detailing provisions

The check consists of overall check and of detailed checks of longitudinal ans shear reinforcement.



Detailing provisions EN 1992-1-1

Linear calculation, Extreme : Member
Selection : All
Combinations : CO1

Detailing provisions for selected members

Member	d_x [m]	Case	$Check_{oalo,long}$ [-]	$Check_{long}$	$Check_{oalo,shear}$ [-]	$Check_{shear}$	$Check_{oalo}$ [-]	$Check_{lim}$ [-]	Check	W/E
*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluat
B6	1,000	CO1/1	0,79	OK	0,68	OK	**0,79**	1,00	OK	161

Properties

Detailing provisions EN 1992

Name	Detailing provisions EN 199...
Selection	All
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati	☐
Values	Check value
Extreme	Member
Drawing setup	...
Section	All

Check value
Longitudinal reinforcement
Shear reinforcement
More comp

Detailing provisions of longitudinal reinforcement for selected members

Member	d_x [m]	Case	$\mu_{lo,min}/\mu_{l,min}$ [-]	$\mu_{l,max}/\mu_{lo,max}$ [-]	$s_{lo,min}/s_{l,min}$ [-]	$s_{l,max}/s_{lo,max}$ [-]	$Check_{oalo}$ [-]	$Check_{lim}$ [-]	Check
*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation
B6	1,000	CO1/1	0,79	0,10	0,21	0,55	0,79	1,00	OK

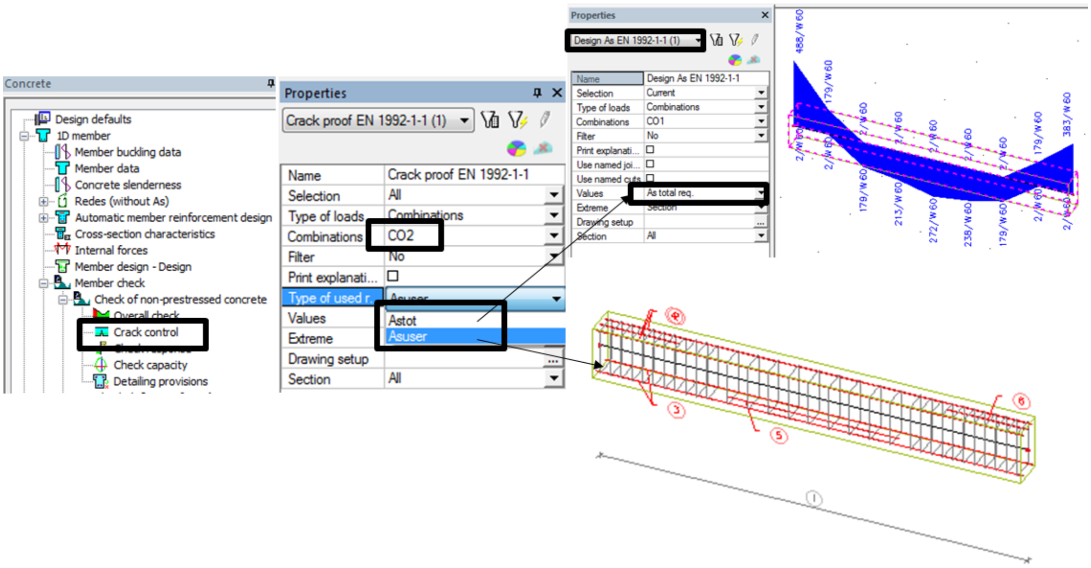
Detailing provisions of shear reinforcement for selected members

Member	d_x [m]	Case	$\mu_{s,min}/\mu_s$ [-]	$\mu_s/\mu_{s,max}$ [-]	$s_{sl,max}/s_{slo,max}$ [-]	$s_{st,max}/s_{sto,max}$ [-]	$Check_{oalo}$ [-]	$Check_{lim}$ [-]	Check
*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluati
B6	0,000	CO1/1	0,22	0,40	0,29	0,68	0,68	1,00	OK

Pics.118 – Check of detailing provisions

9.4. Crack control

This check can be made for both types of reinforcement. If you set **As tot**, program uses always areas reinforcement, which is displayed at member design as **As total required reinforcement**. If you set **As user**, program uses always inputting reinforcement into member.



Properties

Crack proof EN 1992-1-1 (1)

Name	Crack proof EN 1992-1-1
Selection	All
Type of loads	Combinations
Combinations	CO2
Filter	No
Print explanati...	☐
Type of used r...	Asuser
Values	Astot Asuser
Extreme	
Drawing setup	...
Section	All

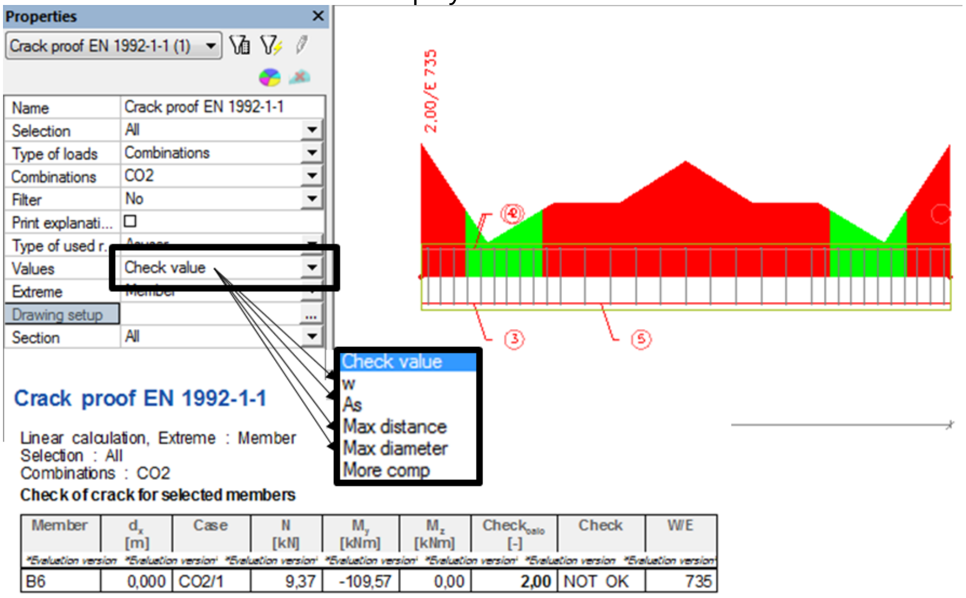
Properties

Design As EN 1992-1-1 (1)

Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanati...	☐
Use named joi...	☐
Use named cuts	☐
Values	As total req.
Extreme	Section
Drawing setup	...
Section	All

Pics.119 – Options of reinforcement use

If you choose the value for crack control as “Check value” all of checks hidden under this possibility are made and the worst case is displayed..



Name	Crack proof EN 1992-1-1
Selection	All
Type of loads	Combinations
Combinations	CO2
Filter	No
Print explanati...	☐
Type of used r...	Average
Values	Check value
Extreme	Member
Drawing setup	...
Section	All

Check value
w
As
Max distance
Max diameter
More comp

Crack proof EN 1992-1-1

Linear calculation, Extreme : Member
Selection : All
Combinations : CO2
Check of crack for selected members

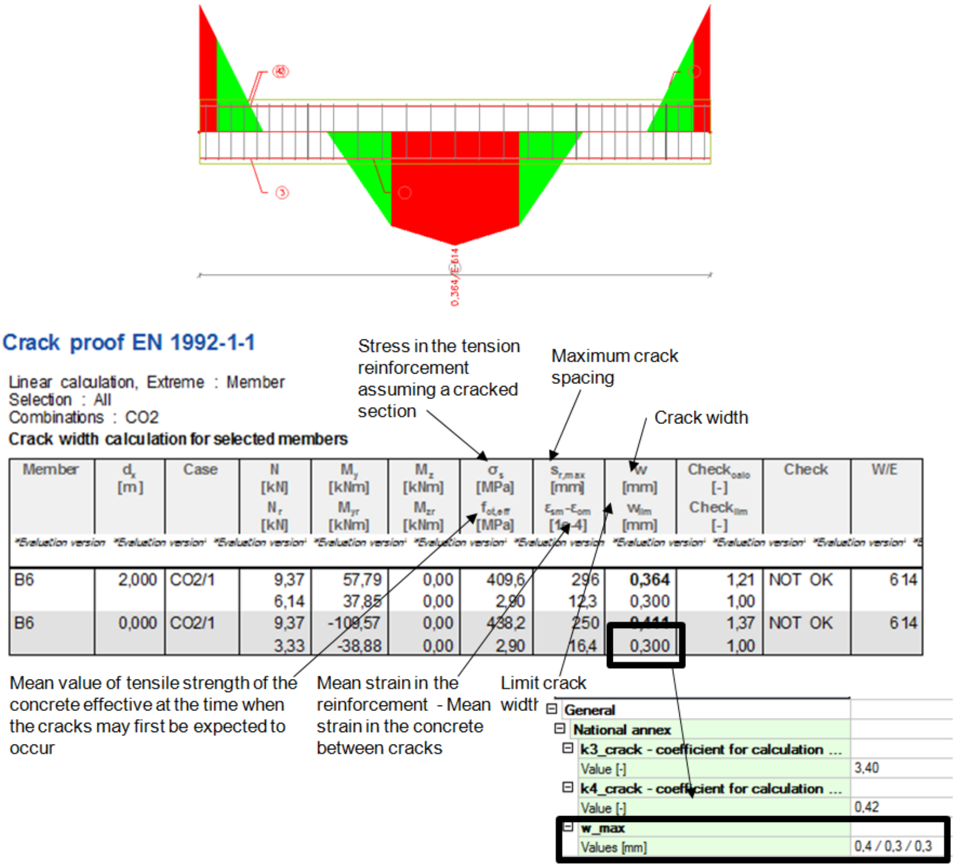
Member	d_x [m]	Case	N [kN]	M_y [kNm]	M_z [kNm]	$Check_{calc}$ [-]	Check	W/E
*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version		
B6	0,000	CO2/1	9,37	-109,57	0,00	**2,00**	NOT OK	735

Pics.120 – Crack control

9.4.1. Crack control (w) check

All types of cross-section are supported. At least one serviceability combination have to be created. Cracks are calculated from the combination of bending moments and normal forces according to paragraph 7.3.4.

The stress after first crack formation is calculated. Limit values for crack width is included in the national annex.



Crack proof EN 1992-1-1

Linear calculation, Extreme : Member
Selection : All
Combinations : CO2
Crack width calculation for selected members

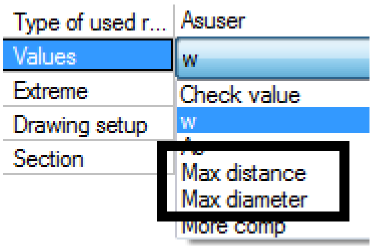
Member	d_x [m]	Case	N [kN] N_r [kN]	M_y [kNm] M_{yr} [kNm]	M_z [kNm] M_{zr} [kNm]	σ_s [MPa] $f_{ct,eff}$ [MPa]	$s_{r,max}$ [mm] $\varepsilon_{sm}-\varepsilon_{cm}$ [1e-4]	w [mm] w_{lim} [mm]	$Check_{calc}$ [-] $Check_{lim}$ [-]	Check	W/E
*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version	*Evaluation version		
B6	2,000	CO2/1	9,37 6,14	57,79 37,85	0,00 0,00	409,6 2,90	296 12,3	**0,364** 0,300	1,21 1,00	NOT OK	614
B6	0,000	CO2/1	9,37 3,33	-109,57 -38,88	0,00 0,00	438,2 2,90	250 16,4	**0,411** 0,300	1,37 1,00	NOT OK	614

⊟ **General**	
⊟ **National annex**	
⊟ **k3_crack - coefficient for calculation ...**	
Value [-]	3,40
⊟ **k4_crack - coefficient for calculation ...**	
Value [-]	0,42
⊟ **w_max**	
Values [mm]	0,4 / 0,3 / 0,3

Pics.121 – Crack control check

9.4.2. Maximal distance and maximal diameter check

Eurocode says that if the test of maximal steel bars distance and maximal bar diameter is passed no crack control is necessary. One of the values is enough. The condition of minimal reinforcement amount in the tensile area should be satisfied then.



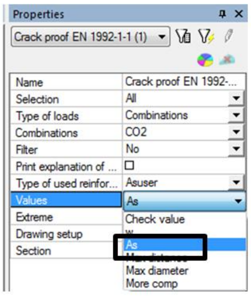
Type of used r...	Asuser
Values	w
Extreme	Check value
Drawing setup	w
Section	As Max distance Max diameter More comp

Pics.122 – Maximum distance and diameter

Check maximum distance between bars of reinforcement according to 7.3.3. tab. 7.3N
Check maximum daimeter bars of reinforcement according to 7.3.3. tab. 7.2N.

9.4.3. As check

These values are compared:
As, min – minimal reinforcement area (for crack control) in the tensile area.
As, prov (P) - reinforcement area in the tensile area (real reinforcement)



Name	Crack proof EN 1992-...
Selection	All
Type of loads	Combinations
Combinations	CO2
Filter	No
Print explanation of ...	☐
Type of used reinfor...	Asuser
Values	As
Extreme	Check value
Drawing setup	w
Section	As Max distance Max diameter More comp

Crack proof EN 1992-1-1

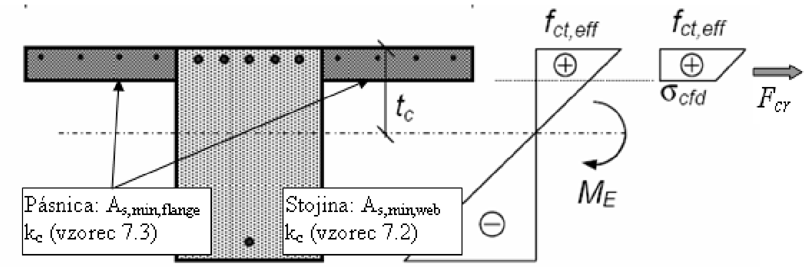
Linear calculation, Extreme : Member
Selection : All
Combinations : CO2

Minimum reinforcement for selected members

Member	d_x [m]	Case	k_c [-] k [-]	h [mm] h' [mm]	σ [MPa] $f_{ct,eff}$ [MPa]	$A_{s,min}$ [mm²] $A_{s,prov}$(P) [mm²]	$Check_{calc}$ [-] $Check_{lim}$ [-]	Check
Evaluation version	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*		*Evaluation version*	*Evaluation
B5	0,500	CO2/1	0,41 0,86	500 500	260,7 2,90	303 603	0,50 1,00	OK

Pics.123 – As

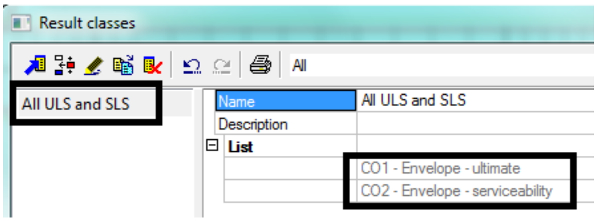
Minimal reinforcement area As,min is calculated separately for web and flange for T, I and L cross-sections (according to 7.3.2(2)).



Pics.124 – Calculation of As, min

9.5. Overall check

Over check serves for performing all possible checks with sigle mouse-click. A comprehensive table of all checks is displayed and graphically only the worst case is illustrated. If you want to do this check you should prepare the result class with ULS and SLS combinations included. Program chooses itself necessary combination for each unity check.



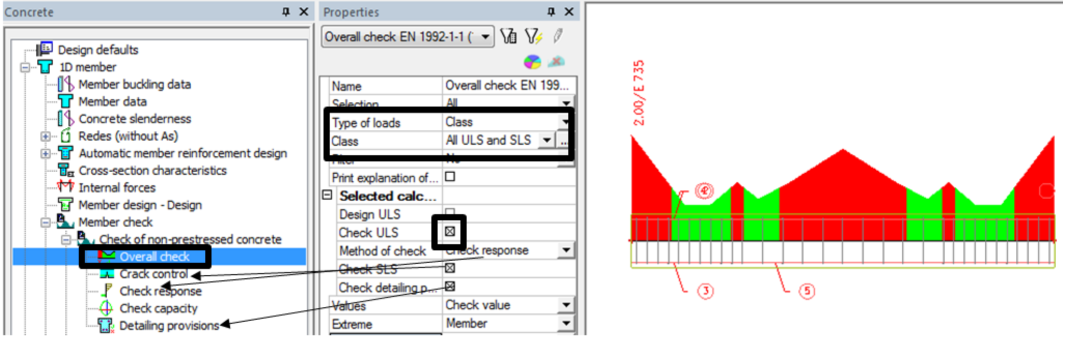
All ULS and SLS

Name	All ULS and SLS
Description	
List	CO1 - Envelope - ultimate CO2 - Envelope - serviceability

Pics.125 – Result classes

Different types of check combinations can be set, you may want to:

a) Check response



Name	Overall check EN 199...
Selection	All
Type of loads	Class
Class	All ULS and SLS
Filter	No
Print explanation of...	☐
Selected calc...	
Design ULS	☐
Check ULS	☒
Method of check	Check response
Check SLS	☒
Check detailing p...	☒
Values	Check value
Extreme	Member

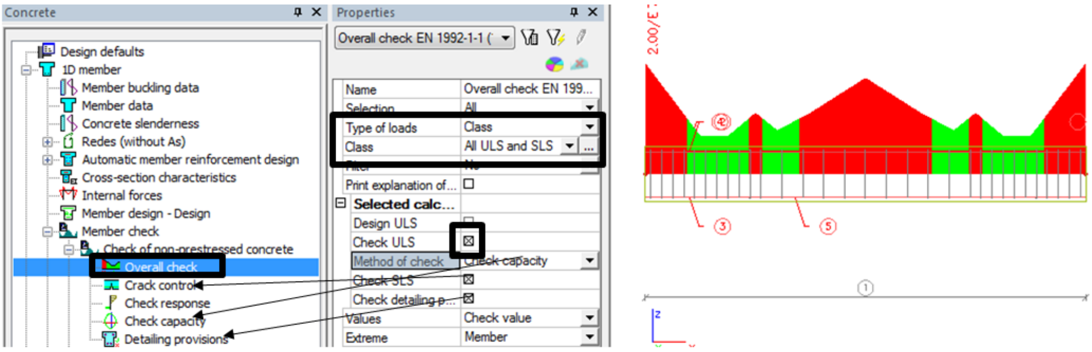
Overall check EN 1992-1-1

Overall check EN 1992-1-1
Linear calculation, Extreme : Member
Selection : All
Class : All ULS and SLS
Overall check for selected members

Member	d_x [m]	Case	Type of reinforcement	Design$_{ULS}$	Check$_{ULS}$ Check$_{oalo,ULS}$ [-]	Check$_{orack}$ Check$_{oalo,orack}$ [-]	Check$_{det}$ Check$_{oalo,det}$ [-]	Check$_{oalo}$ [-] Check$_{lim}$ [-]	Check W/E
Evaluation version	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version* *Evaluat
B6	0,000	All ULS and SLS	User real	OFF	OK 0,66	NOT OK 2,00	OK 0,68	**2,00** 1,00	NOT OK 668

Pics.126 – Overall check and setting for check response

b) Check capacity



Concrete

- Design defaults
- 1D member
  - Member buckling data
  - Member data
  - Concrete slenderness
  - Redes (without As)
  - Automatic member reinforcement design
  - Cross-section characteristics
  - Internal forces
  - Member design - Design
  - Member check
    - Check of non-prestressed concrete
      - Overall check
      - Crack control
      - Check response
      - Check capacity
      - Detailing provisions

Properties

Overall check EN 1992-1-1 (

Name	Overall check EN 199...
Selection	All
Type of loads	Class
Class	All ULS and SLS
Filter	No
Print explanation of...	☐
Selected calc...	
Design ULS	☐
Check ULS	☒
Method of check	Check capacity
Check SLS	☒
Check detailing p...	☒
Values	Check value
Extreme	Member

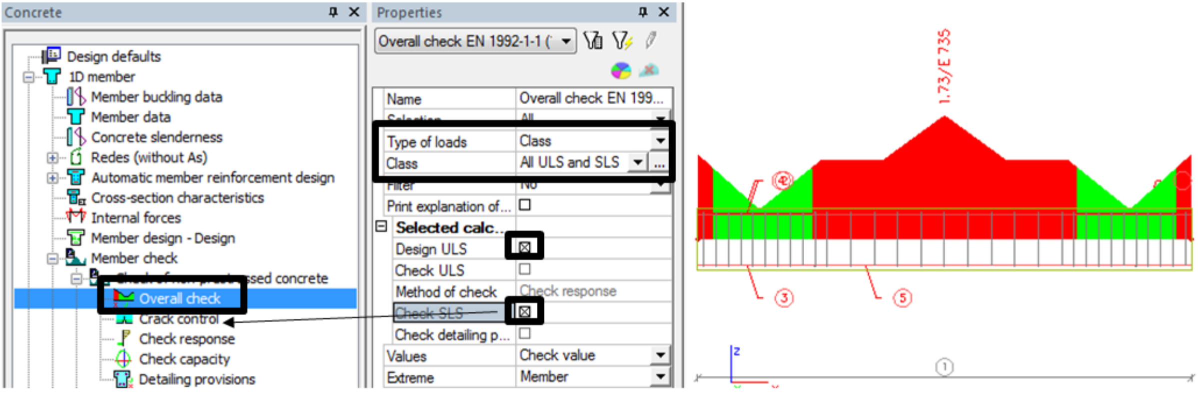
Overall check EN 1992-1-1

Overall check EN 1992-1-1
Linear calculation, Extreme : Member
Selection : All
Class : All ULS and SLS
Overall check for selected members

Member	d_x [m]	Case	Type of reinforcement	$Design_{ULS}$	$Check_{ULS}$ $Check_{oalo,ULS}$ [-]	$Check_{orsok}$ $Check_{oalo,orsok}$ [-]	$Check_{det}$ $Check_{oalo,det}$ [-]	$Check_{oalo}$ [-] $Check_{lim}$ [-]	Check W/E
B6	0,000	All ULS and SLS	User real	OFF	OK 0,79	NOT OK 2,00	OK 0,68	**2,00** 1,00	NOT OK 668

Pics.127 – Overall check and setting for check capacity

c) It is possible to quickly set crack control check for designed reinforcement



Concrete

- Design defaults
- 1D member
  - Member buckling data
  - Member data
  - Concrete slenderness
  - Redes (without As)
  - Automatic member reinforcement design
  - Cross-section characteristics
  - Internal forces
  - Member design - Design
  - Member check
    - Check of non-prestressed concrete
      - Overall check
      - Crack control
      - Check response
      - Check capacity
      - Detailing provisions

Properties

Overall check EN 1992-1-1 (

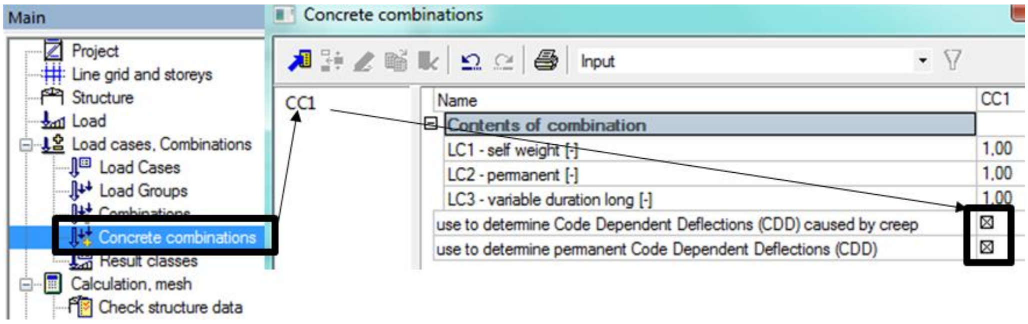
Name	Overall check EN 199...
Selection	All
Type of loads	Class
Class	All ULS and SLS
Filter	No
Print explanation of...	☐
Selected calc...	
Design ULS	☒
Check ULS	☐
Method of check	Check response
Check SLS	☒
Check detailing p...	☐
Values	Check value
Extreme	Member

Pics.128 – Overall check, setting for reinforcement design and check crack control

10. Code dependant deflection (CDD) calculation

Calculation process:

1) Concrete combinations have to be created



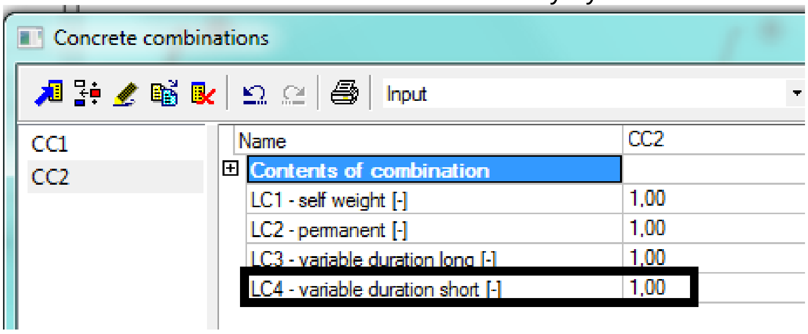
Name	CC1
Contents of combination	
LC1 - self weight [-]	1,00
LC2 - permanent [-]	1,00
LC3 - variable duration long [-]	1,00
use to determine Code Dependent Deflections (CDD) caused by creep	☒
use to determine permanent Code Dependent Deflections (CDD)	☒

Pics.129 – Concrete combinations

Because it is nonlinear analysis which takes much calculation time and which would run for each combination again, following check boxes were introduced to eliminate duration of the analysis:

- Use to determine CDD caused by creep
- Use to determine permanent CDD

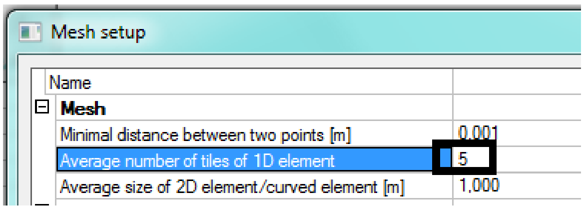
Combination with ticked check boxes becames “leading” for the others. It should involve all permanent and long-term vaiable loads because deflections from such a combination remain the same all the time and are not calculated in the rest of combinations. Only load cases with short-term variable loads should be added to other concrete combinations and deflection only from these added load cases are calculated. Calculation time is reduced noticeably by this.



Name	CC2
Contents of combination	
LC1 - self weight [-]	1,00
LC2 - permanent [-]	1,00
LC3 - variable duration long [-]	1,00
LC4 - variable duration short [-]	1,00

Pics.130 – Concrete combinations

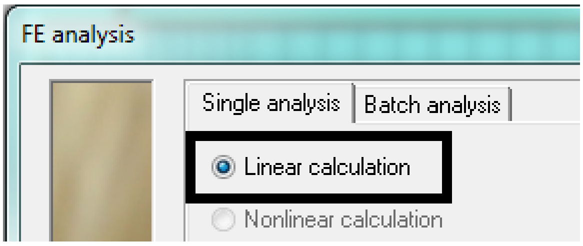
2) Before the analysis mesh refinement is requested because nonlinear calculation is to be performed. Minimal average number of tiles of 1D member is 5.



Name	
Mesh	
Minimal distance between two points [m]	0,001
Average number of tiles of 1D element	5
Average size of 2D element/curved element [m]	1,000

Pics.131 – Setting of mesh setup

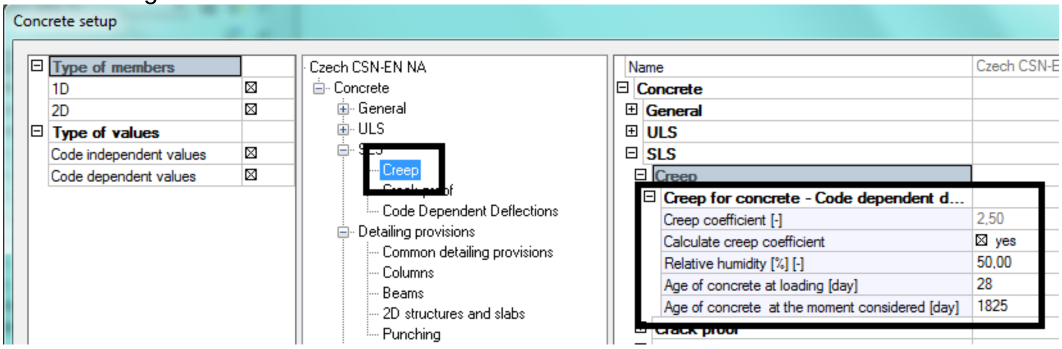
3) Run linear analysis



● Linear calculation
○ Nonlinear calculation

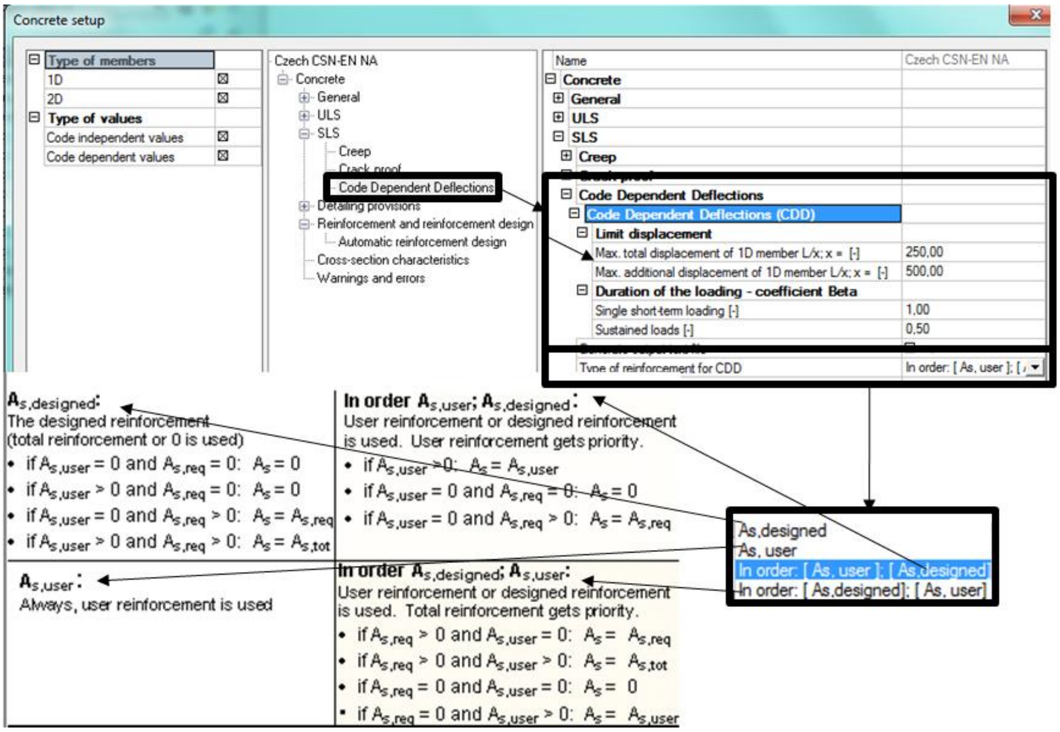
Pics.132 – Linear calculation

4) Set the creep coefficient. Select which reinforcement is to be considered in the calculation. This setting is accessible via Concrete solver.



Name	Czech CSN-E
Concrete	
General	
ULS	
SLS	
Creep	
Creep for concrete - Code dependent d...	
Creep coefficient [-]	2,50
Calculate creep coefficient	☒ yes
Relative humidity [%] [-]	50,00
Age of concrete at loading [day]	28
Age of concrete at the moment considered [day]	1825
Crack proof	

Pics.133 – Setting of calculation creep



Name	Czech CSN-EN NA
Concrete	
General	
ULS	
SLS	
Creep	
Crack proof	
Code Dependent Deflections	
Code Dependent Deflections (CDD)	
Limit displacement	
Max. total displacement of 1D member L/x; x = [-]	250,00
Max. additional displacement of 1D member L/x; x = [-]	500,00
Duration of the loading - coefficient Beta	
Single short-term loading [-]	1,00
Sustained loads [-]	0,50
Type of reinforcement for CDD	In order: [As, user]; [/

As,designed
As, user
In order: [As, user]; [As,designed]
In order: [As,designed]; [As, user]

$A_{s,designed}$:
The designed reinforcement
(total reinforcement or 0 is used)
- if $A_{s,user} = 0$ and $A_{s,req} = 0$: $A_s = 0$
- if $A_{s,user} > 0$ and $A_{s,req} = 0$: $A_s = 0$
- if $A_{s,user} = 0$ and $A_{s,req} > 0$: $A_s = A_{s,req}$
- if $A_{s,user} > 0$ and $A_{s,req} > 0$: $A_s = A_{s,tot}$

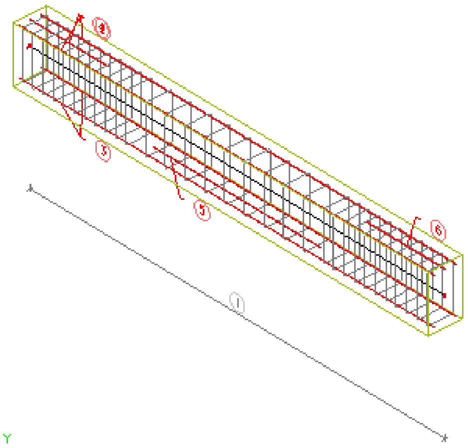
In order $A_{s,user}$; $A_{s,designed}$:
User reinforcement or designed reinforcement is used. User reinforcement gets priority.
- if $A_{s,user} > 0$: $A_s = A_{s,user}$
- if $A_{s,user} = 0$ and $A_{s,req} = 0$: $A_s = 0$
- if $A_{s,user} = 0$ and $A_{s,req} > 0$: $A_s = A_{s,req}$

$A_{s,user}$:
Always, user reinforcement is used

In order $A_{s,designed}$; $A_{s,user}$:
User reinforcement or designed reinforcement is used. Total reinforcement gets priority.
- if $A_{s,req} > 0$ and $A_{s,user} = 0$: $A_s = A_{s,req}$
- if $A_{s,req} > 0$ and $A_{s,user} > 0$: $A_s = A_{s,tot}$
- if $A_{s,req} = 0$ and $A_{s,user} = 0$: $A_s = 0$
- if $A_{s,req} = 0$ and $A_{s,user} > 0$: $A_s = A_{s,user}$

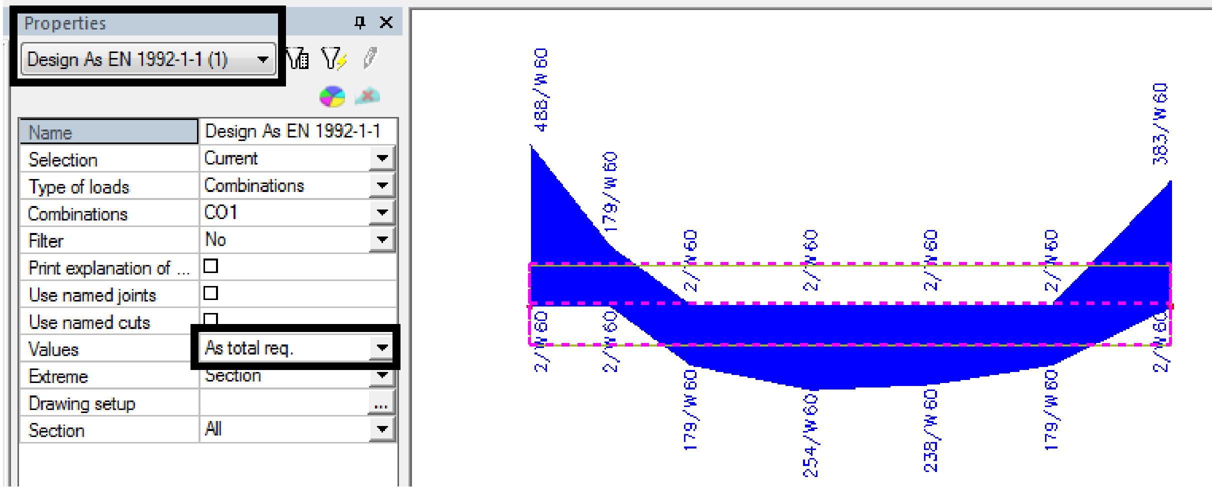
Pics.134 – Setting of reinforcement types for calculation of code dependent deflections

As, user – means that program consideres only real reinforcement.



Pics.135 – As, user

As, designed – is always the reinforcement that is displayed when design of total requested reinforcement is made.



Properties

Design As EN 1992-1-1 (1)

Name	Design As EN 1992-1-1
Selection	Current
Type of loads	Combinations
Combinations	CO1
Filter	No
Print explanation of ...	☐
Use named joints	☐
Use named cuts	☐
Values	As total req.
Extreme	Section
Drawing setup	...
Section	All

Pics.136 – As designed

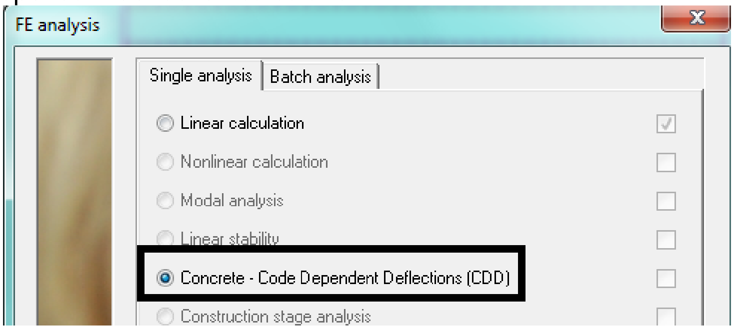
In order: As, user; As sedigned – if user reinforcemet is present it takes this reinforcement, if user reinf. is not present designed (total requested) is considered, if no reinforcement is designed nothing is considered

In order: As designed; As user– if designed reinforcement is present it takes this one, if As designed is not applied As user is considered, if there is no reinforcement found no reinforcement is considered.

Note:

setting:**In order: As user; As designed and In order: As designed; As user** – can be used when only part of the structure is intended for CDD analysis and you know the real reinforcement of this part only.

5) Model or design reinforcement for the structure
6) Run Code dependant deflection calculation



FE analysis

Single analysis | Batch analysis

○ Linear calculation ☑
○ Nonlinear calculation ☐
○ Modal analysis ☐
○ Linear stability ☐
● Concrete - Code Dependent Deflections (CDD) ☐
○ Construction stage analysis ☐

Pics.137 – Calculation – Code dependent deflections (CDD)

Brief description of the calculation:

Program calculates two types of stiffness:

$$\boxed{(EI)_r = \frac{1}{\frac{\zeta}{(EI)_{II}} + \frac{1-\zeta}{(EI)_I}}}$$

- short-term (EI)r,short with elastic modulus Ec = Ecm,
- Long-term (EI)r,long with elastic modulus Ec = Ec,eff (formula 7.20),

Steps for stiffnesses calculation:

- Transformation of cross-section properties Ai, Ii, xi and calculation of forces at crack formation Nr and Mr
- Calculation of corss-section stiffnesses of a solid beam (EI)I =EcIi

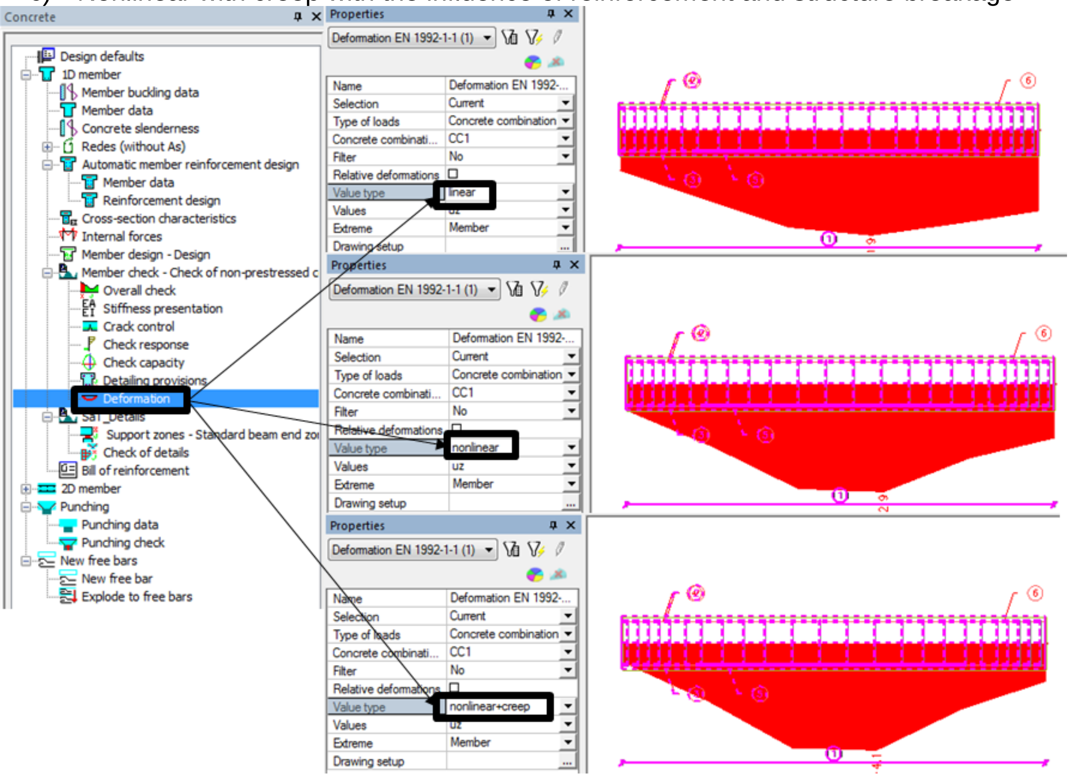
- Calculation of xr , Iir and max. Stress in the reinforcement σsr in fully teared cross-section (eliminating concrete stress) for forces at crack formation Nr a Mr
- calculation of xr , Iir and max. Stress in the reinforcement σs in fully teared cross-section (eliminating concrete stress)for the inut of N and M
- Calculation of stifnesses at fully teared coros-section (EI)II =EcIir
- Calculation of redistribution coefficien ζ according to (formula 7.19)...
- Then stiffnesses (EI)r are calculated according to formula 7.18

$$\boxed{\zeta = 1 - \beta \cdot \left(\frac{\sigma_{sr}}{\sigma_s} \right)^2}$$

9.6. Deformation

After CDD calculation a new type of check appears in the concrete service. Following items can be diplayed:

a) Linear deformation without the influence of reinforcement, identical to results service
b) Nonlinear with the influence of reinforcement and beam tearing
c) Nonlinear with creep with the influence of reinforcement and structure breakage



Name	Deformation EN 1992-...
Selection	Current
Type of loads	Concrete combination
Concrete combinati...	CC1
Filter	No
Relative deformations	☐
Value type	linear
Values	uz
Extreme	Member
Drawing setup	...

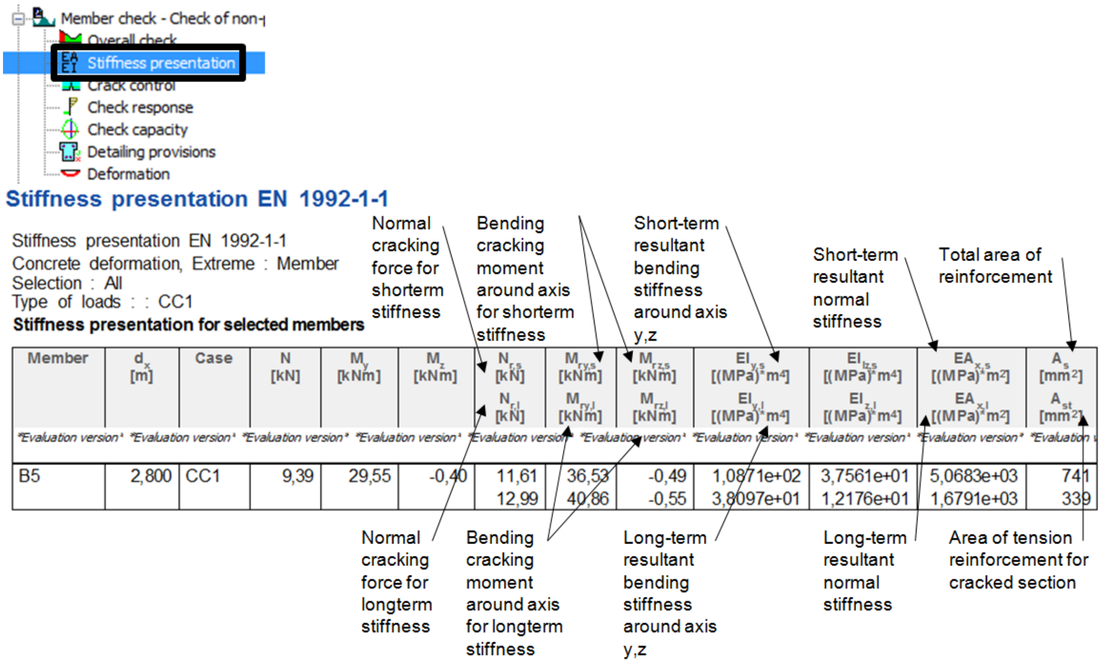
Name	Deformation EN 1992-...
Selection	Current
Type of loads	Concrete combination
Concrete combinati...	CC1
Filter	No
Relative deformations	☐
Value type	nonlinear
Values	uz
Extreme	Member
Drawing setup	...

Name	Deformation EN 1992-...
Selection	Current
Type of loads	Concrete combination
Concrete combinati...	CC1
Filter	No
Relative deformations	☐
Value type	nonlinear+creep
Values	uz
Extreme	Member
Drawing setup	...

Pics.138 – Code dependent deflections and displaying of deformation

9.7. Stiffness presentation

New icon is available after CDD analysis where you can view individual stiffnesses during CDD calculation, for manual control.



Stiffness presentation EN 1992-1-1

Stiffness presentation EN 1992-1-1
Concrete deformation, Extreme : Member
Selection : All
Type of loads : : CC1

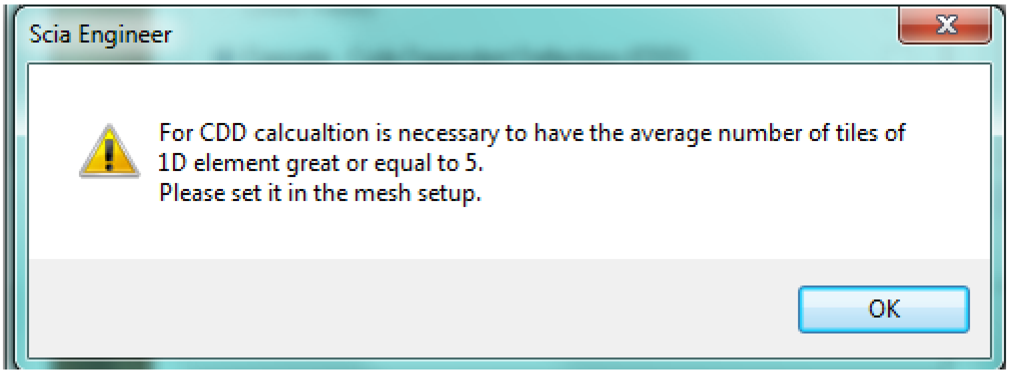
Stiffness presentation for selected members

Member	d_x [m]	Case	N [kN]	M_y [kNm]	M_z [kNm]	$N_{r,s}$ [kN] $N_{r,l}$ [kN]	$M_{ry,s}$ [kNm] $M_{ry,l}$ [kNm]	$M_{rz,s}$ [kNm] $M_{rz,l}$ [kNm]	$EI_{y,s}$ [(MPa)*m4] $EI_{y,l}$ [(MPa)*m4]	$EI_{lz,s}$ [(MPa)*m4] $EI_{z,l}$ [(MPa)*m4]	$EA_{x,s}$ [(MPa)*m2] $EA_{x,l}$ [(MPa)*m2]	A_s [mm2] A_{st} [mm2]
Evaluation version	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation version*	*Evaluation	
B5	2,800	CC1	9,39	29,55	-0,40	11,61 12,99	36,53 40,86	-0,49 -0,55	1,0871e+02 3,8097e+01	3,7561e+01 1,2176e+01	5,0683e+03 1,6791e+03	741 339

Pics.139 – Stiffness presentation – Code dependet deflections

Trick:

If you forget to change the value of average number of tiles per 1D member to 5 before CDD calculation you will get error message. When mesh modification is done results are cleaned. Thus you should adust the FEM mesh prior to linear calculation.



For CDD calcualtion is necessary to have the average number of tiles of 1D element great or equal to 5.
Please set it in the mesh setup.

Pics.140 – Warning – Code dependent deflections

Literature

[1] Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings
[2] Ing. Pavol Valach, PhD., 1D concrete member, SCIA CZ