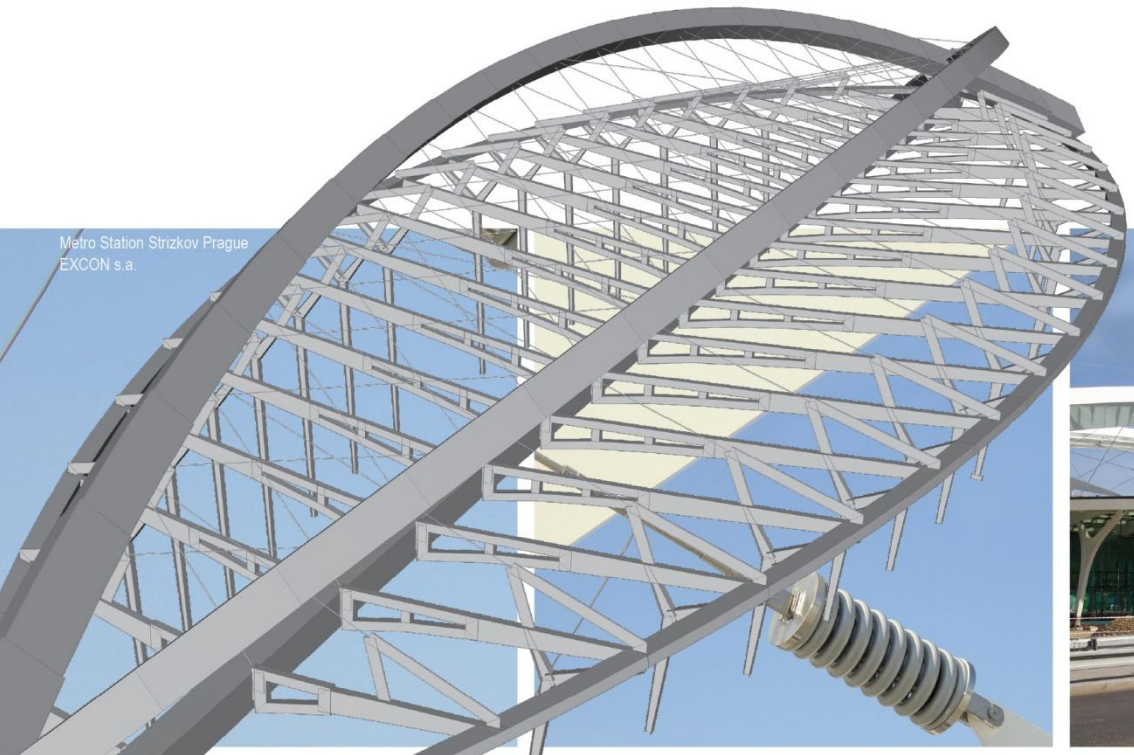
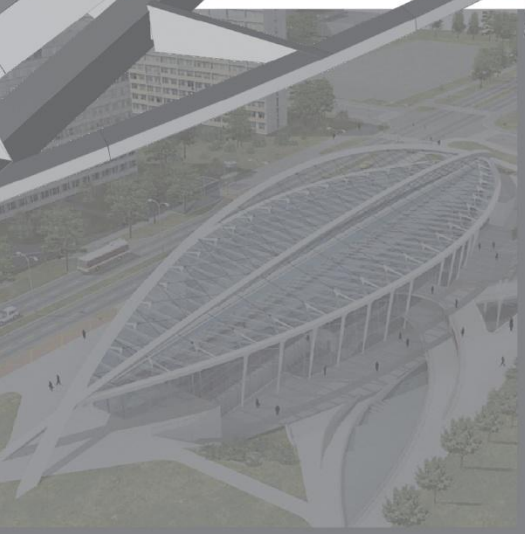
NEMETSCHEK Scia





Training

Prestressed concrete, construction stages, concrete checks

Scia Engineer

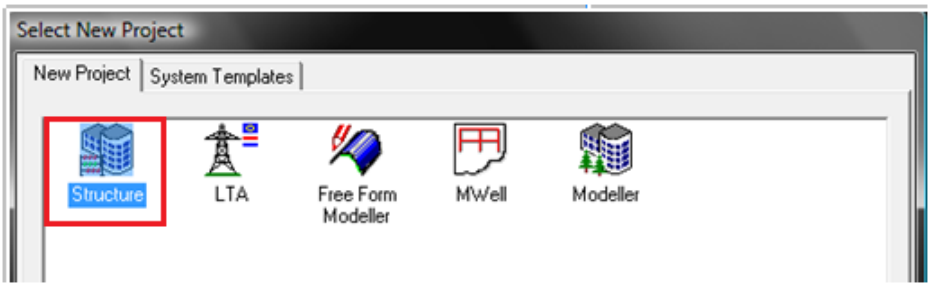
Table of contents

1 The post-tensioned bridge – tutorial from training

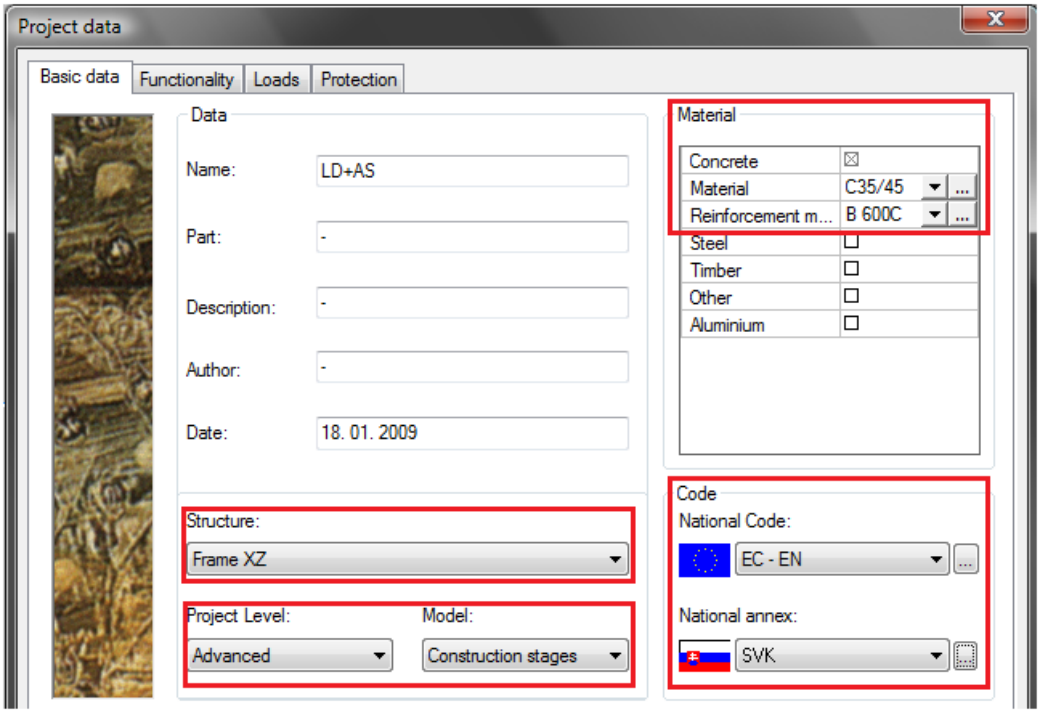
This paper describes one typical postensioned prestressed concrete bridge built in construction stages. The traffic load is taken from EN1991-2 with respect of EN1990/A1. The code for check is according to EN1992-1-1.

1.1 Project setup

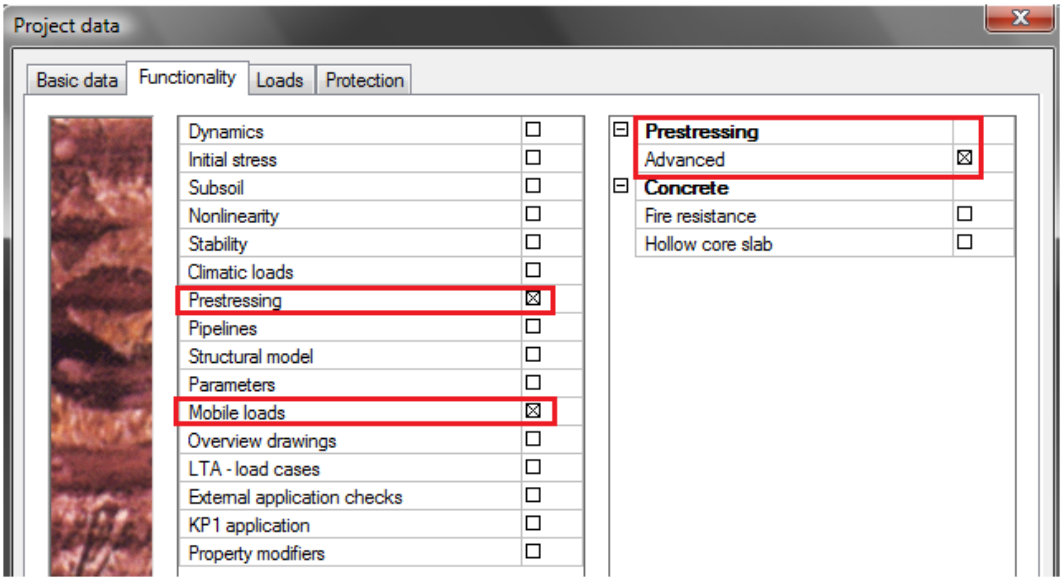
The new project is created using button ***New*** and ***Structure*** is selected.



The settings of the project are necessary to set in ***Project data***. The structure type ***Frame XZ*** should be selected for the TDA analysis of the structure (only frame XZ should be analyzed using TDA). At least one material should be selected in the project - ***Concrete***. When concrete material is selected then automatically ***Reinforcement material*** (nonprestressed) is offered to user. The ***Project level - Advanced*** is recommended. The ***Construction stages*** model should be selected for modelling of structure using construction stages. National code for analysis and check is necessary to select ***EC-EN***. Each country has its own ***National annexes*** for Eurocodes.



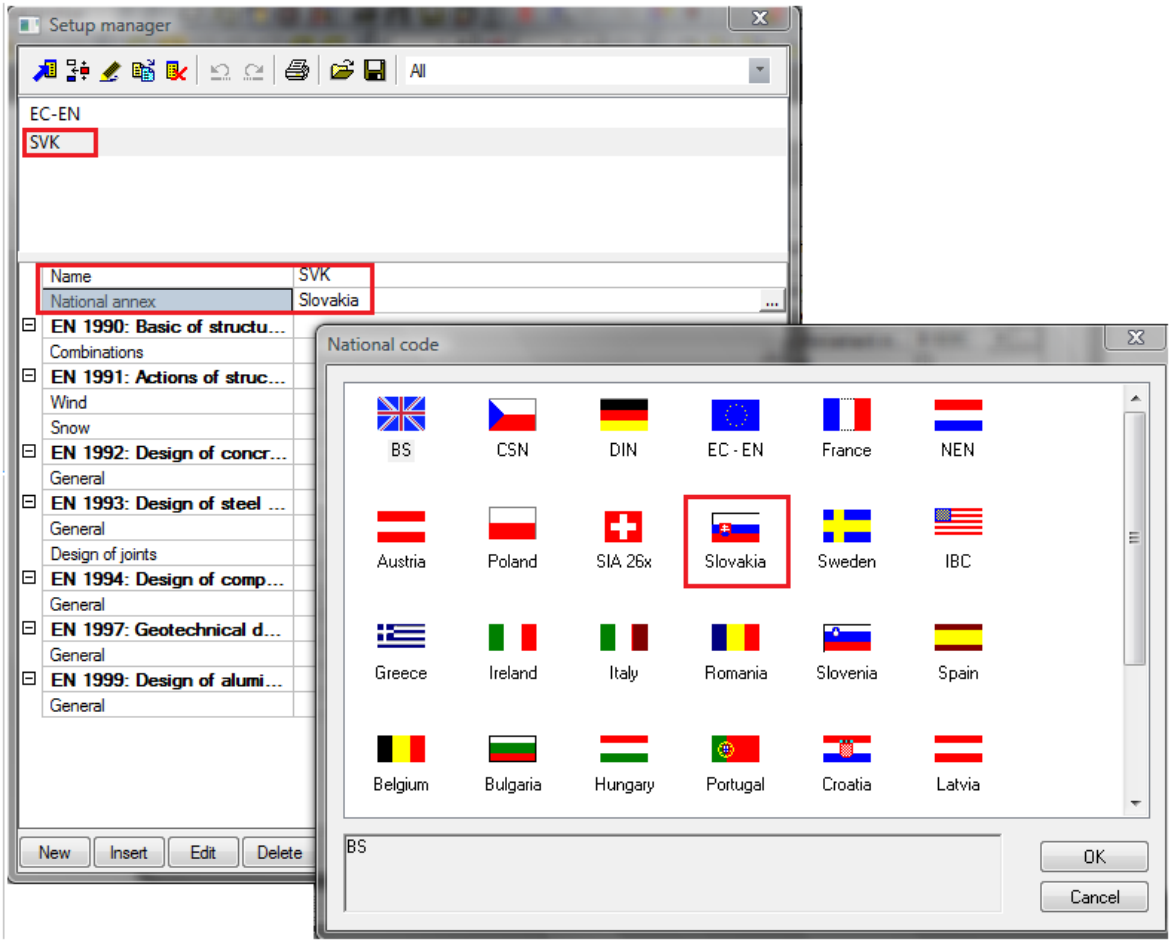
The checkbox ***Prestressing*** should be turns on for modelling and calculation with prestressing in project. The Level of prestressing - ***Advanced*** is recommended. The checkbox ***Mobile loads*** should be turns on for mobile load analysis.



1.2 National annexes

National code for analysis and check is necessary to select ***EC-EN***. Each country has its own ***National annexes*** for Eurocodes. This annex is possible to define by ***National annex***. In current version user has to fill in all national annexes himself. From the version 2010.1 all necessary national annexes will be prepared and stored in program. User will be able to select appropriate national annexes according to country.

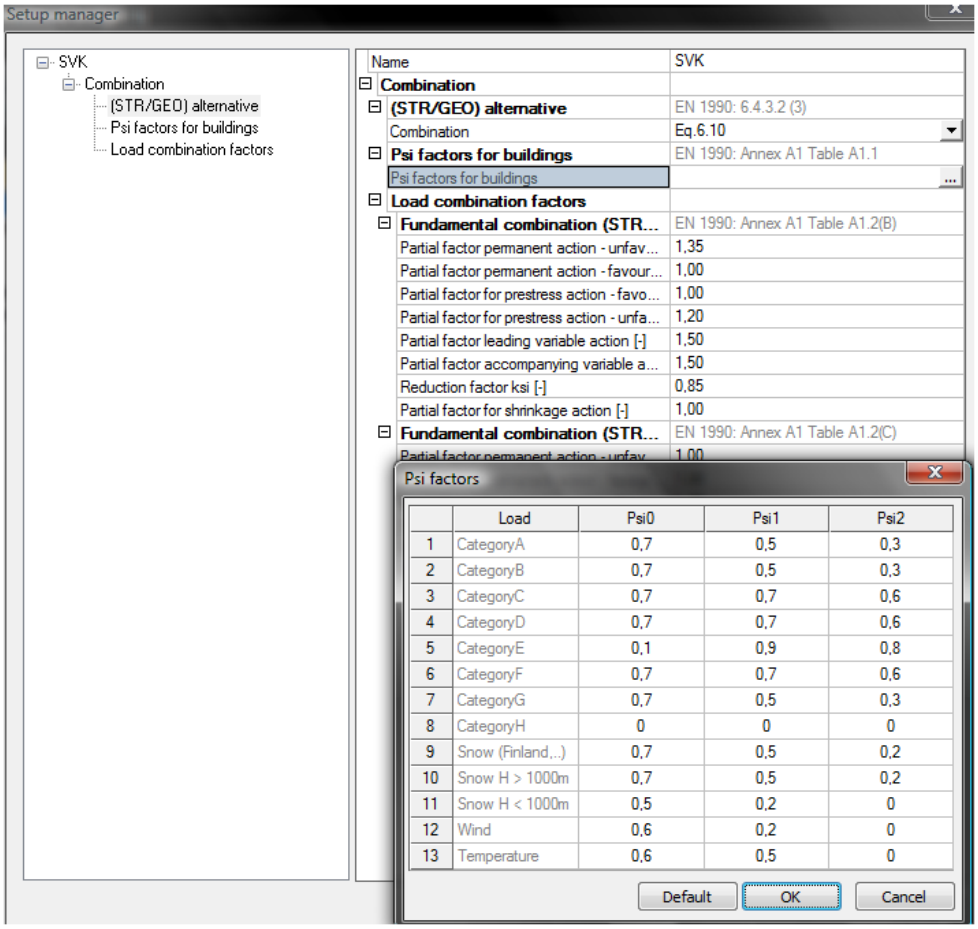
When user opens setup manager he can define several national annexes which he needs. There is possible to assign appropriate flag for selected country.



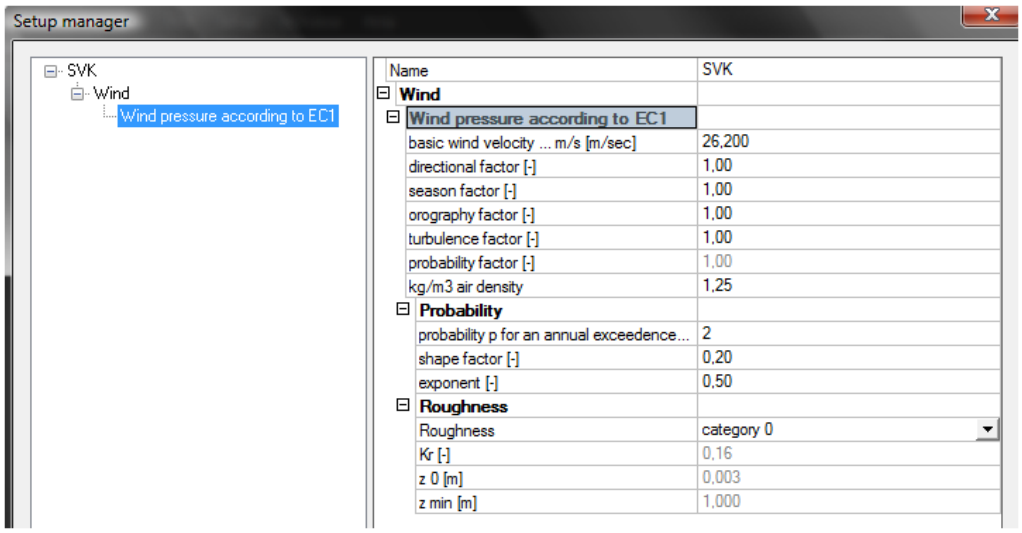
Each national annex has its own values of national annexes. Now user defines national annexes himself in that place in the program. These values are possible to edit for each design code. EN1990,

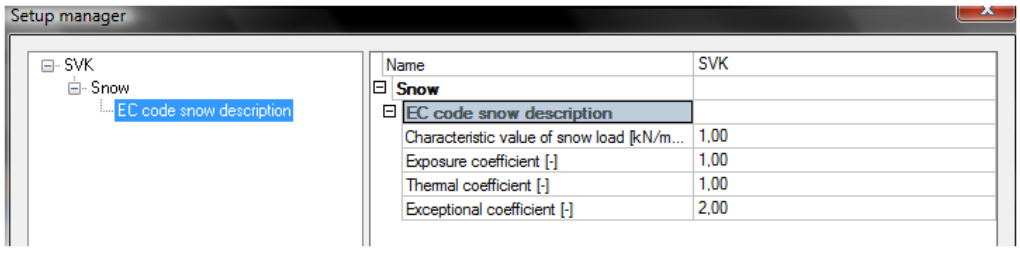
EN1991 and En1992 are important codes for us. National annexes for mentioned codes are shown in the following figures.

- National annexes for EN1990 – basic of structural design

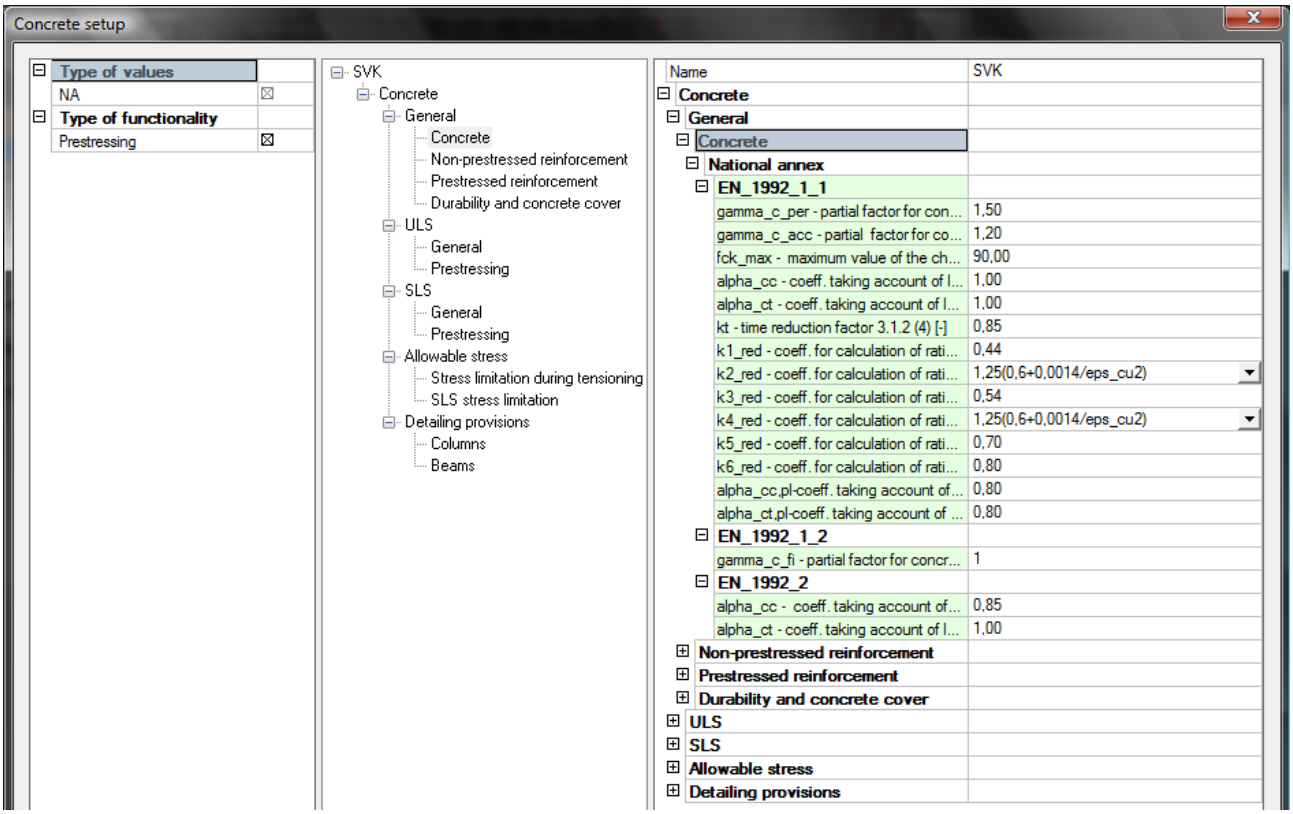


- National annexes for EN1991 – wind + snow





- National annexes for EN1992 – concrete checks

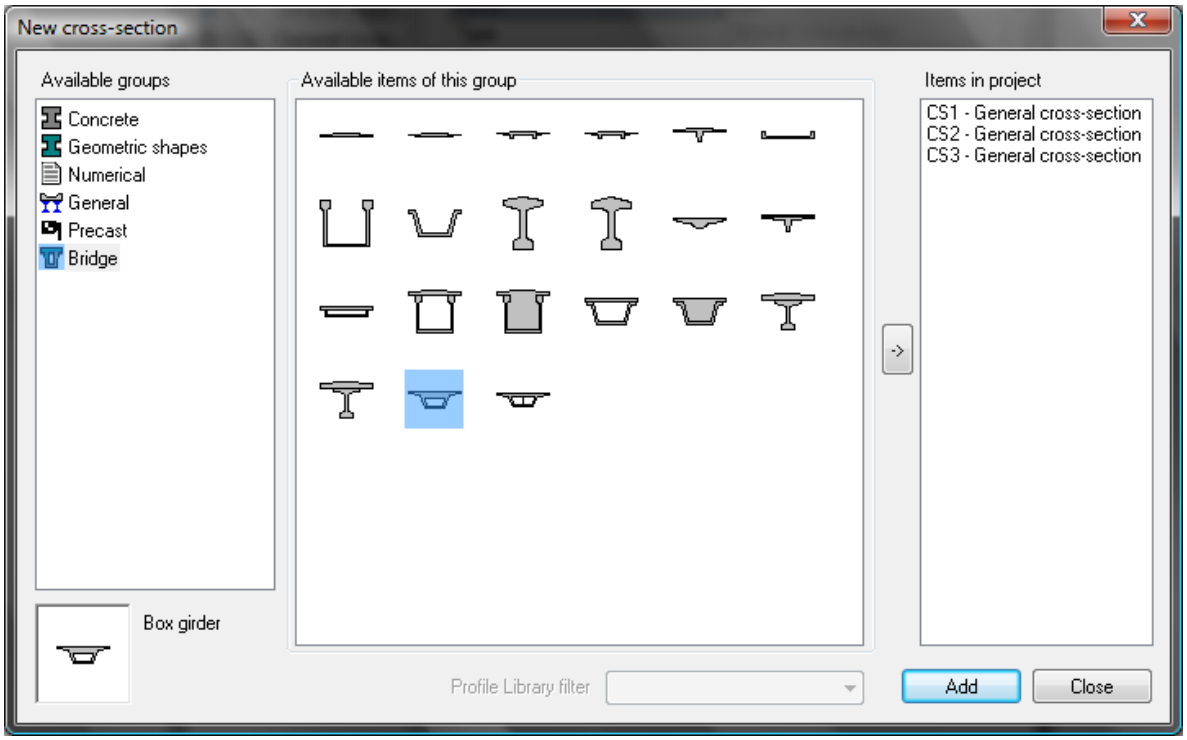


2 Model

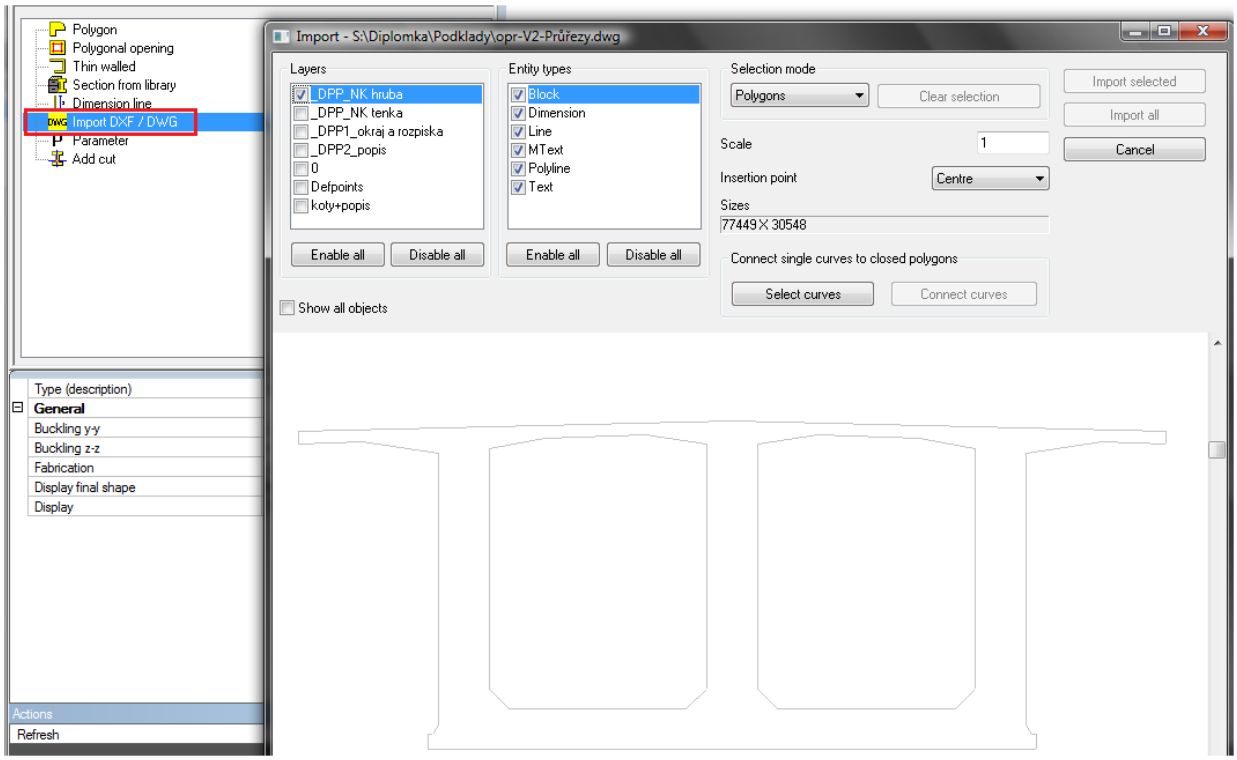
2.1 Structure

2.1.1 Cross-sections

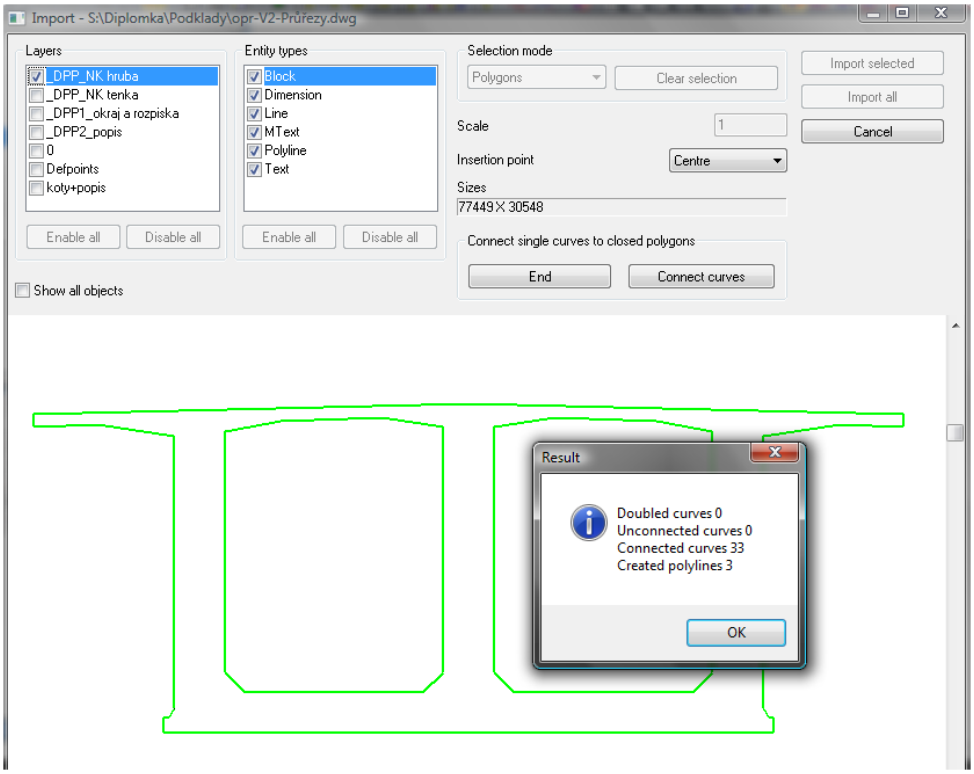
The structure is defined by standard modelling using in ***Scia Engineer (SEN)***. The cross-sections are defined in CSS library using button ***New***. There are several predefined ***Precast*** and ***Bridge CSS***.



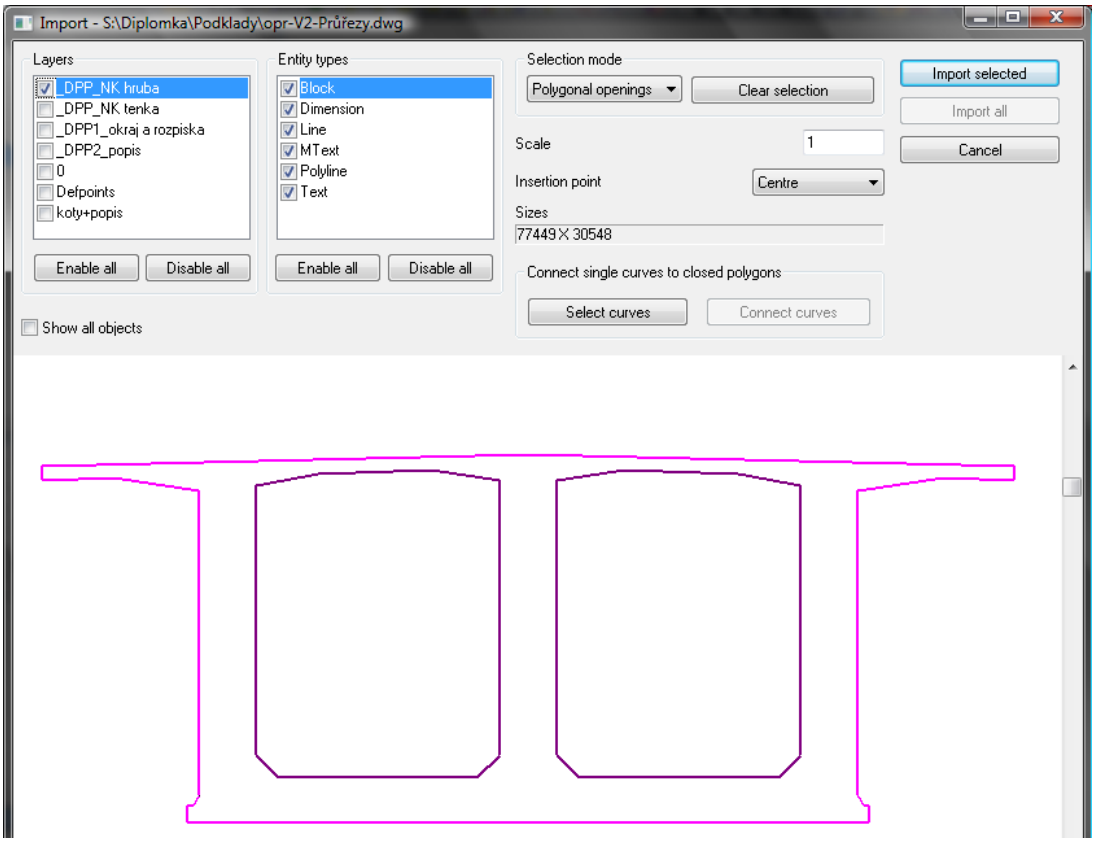
The General CSS enables to user prepares completely different CSS himself. It is possible to define it using definition of polygons directly in SEN or import CSS from dwg or dxf format.

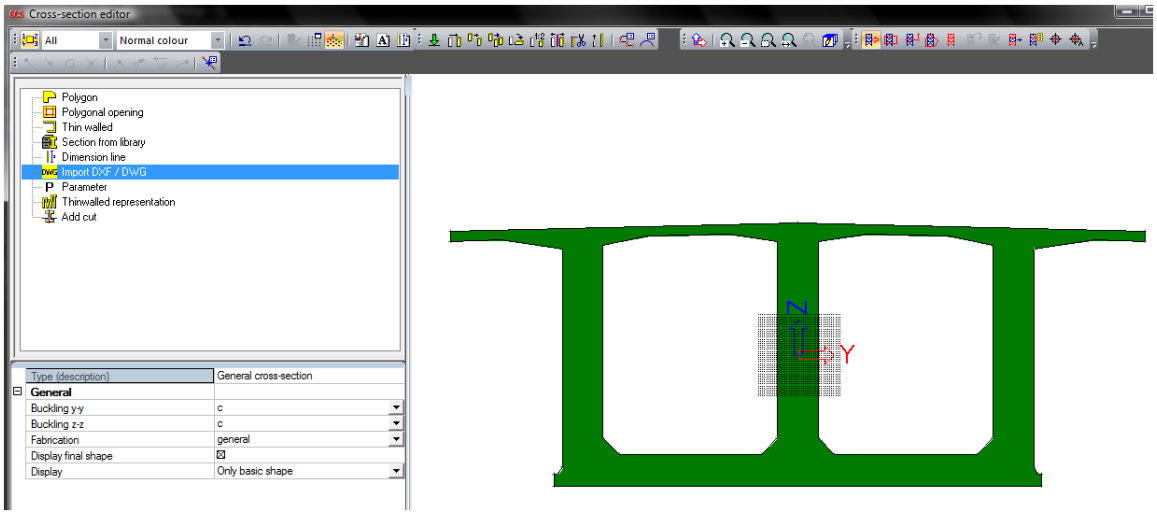


The CSS in the drawing format has to be prepared by Lines and Polylines. Connect all polylines is necessary to do as first (***Select curves>Connect curves***). Then polylines are created.

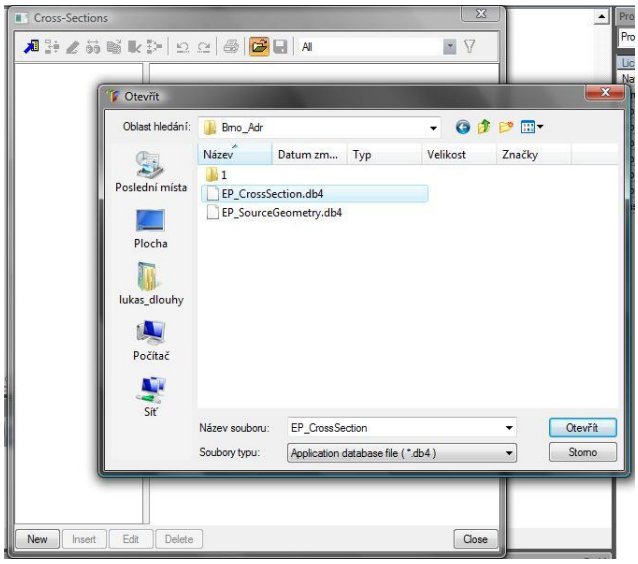


The selection of polygons and polygons openings is necessary for proper import from drawing format. User selects ***Selection mode>Polygons*** and selects outer polyline. Then he switches to ***Polygons openings*** and selects the polylines representing the openings. Afterthat the CSS can be imported from drawing format to SEN as general CSS

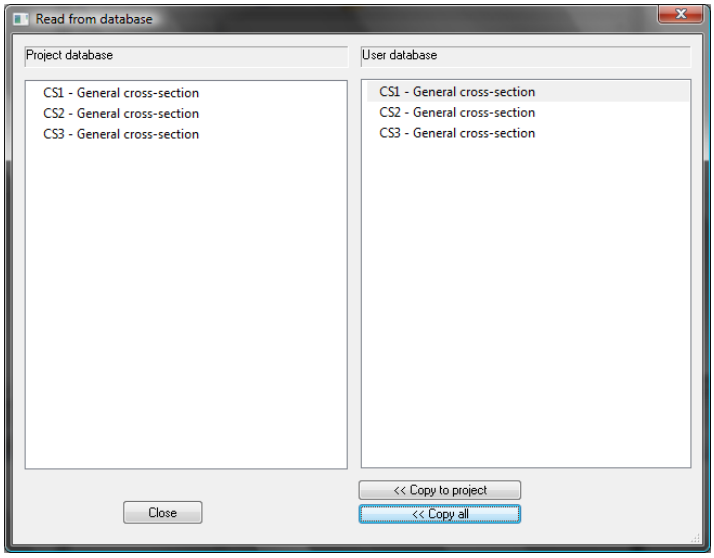




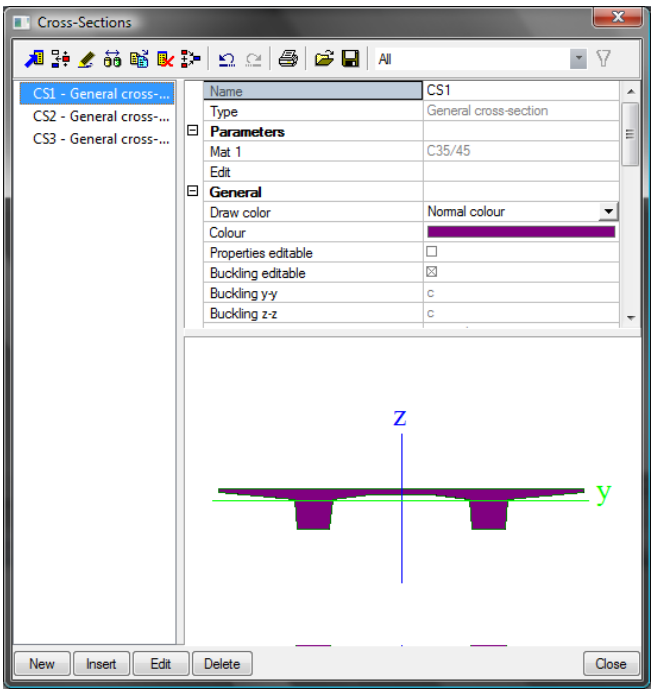
The cross-sections (CSS) should be also ***imported*** from previous similar SEN project.



The user can select which CSS will be import from user database file.

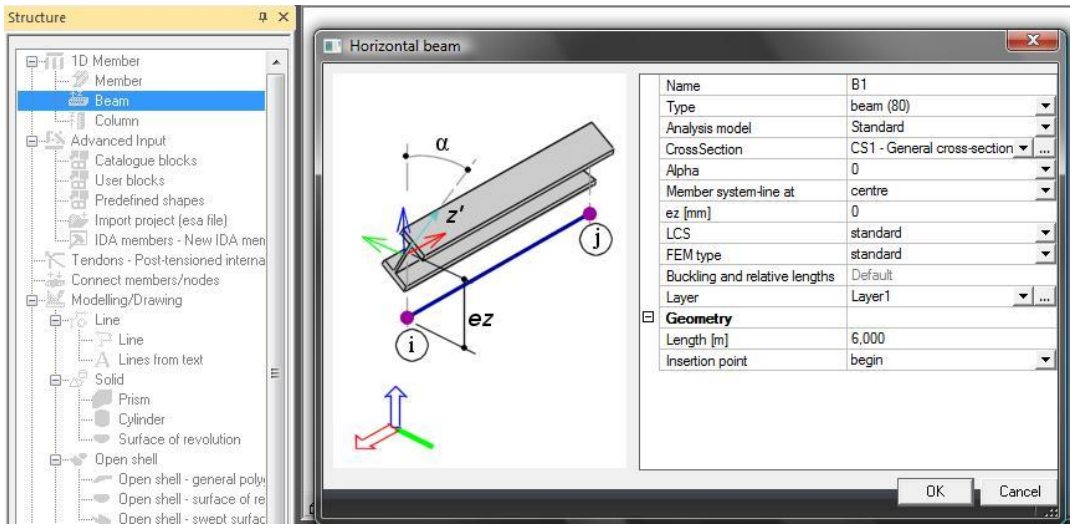


The dialog of CSS looks like following



2.1.2 Beams

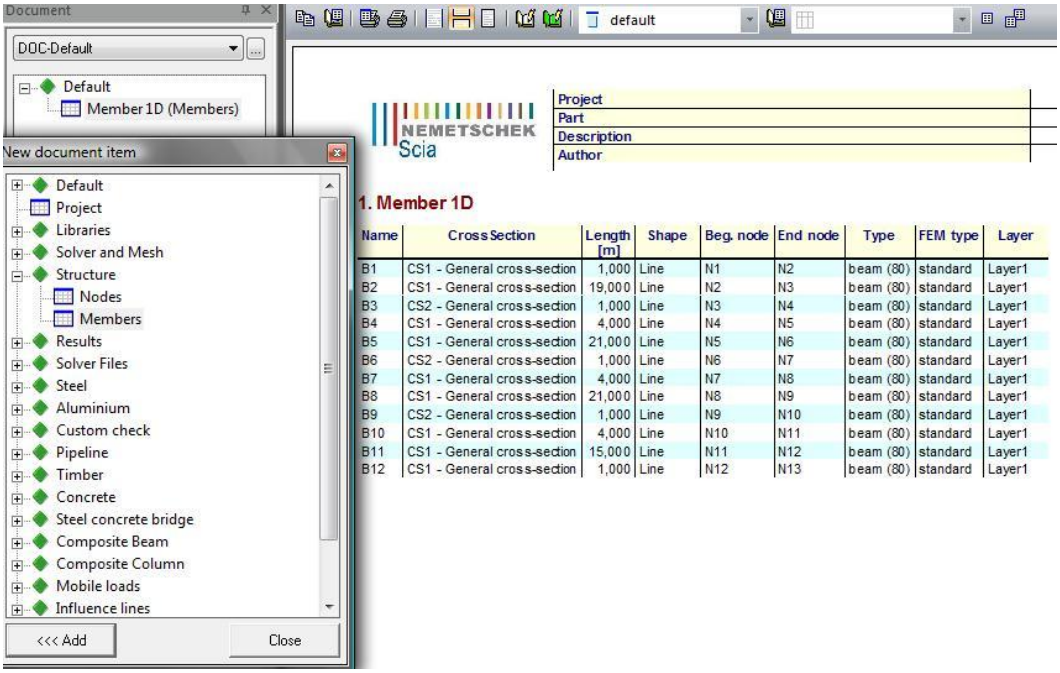
The beams are defined using item ***Structure>1D Member>Beam*** with following properties.



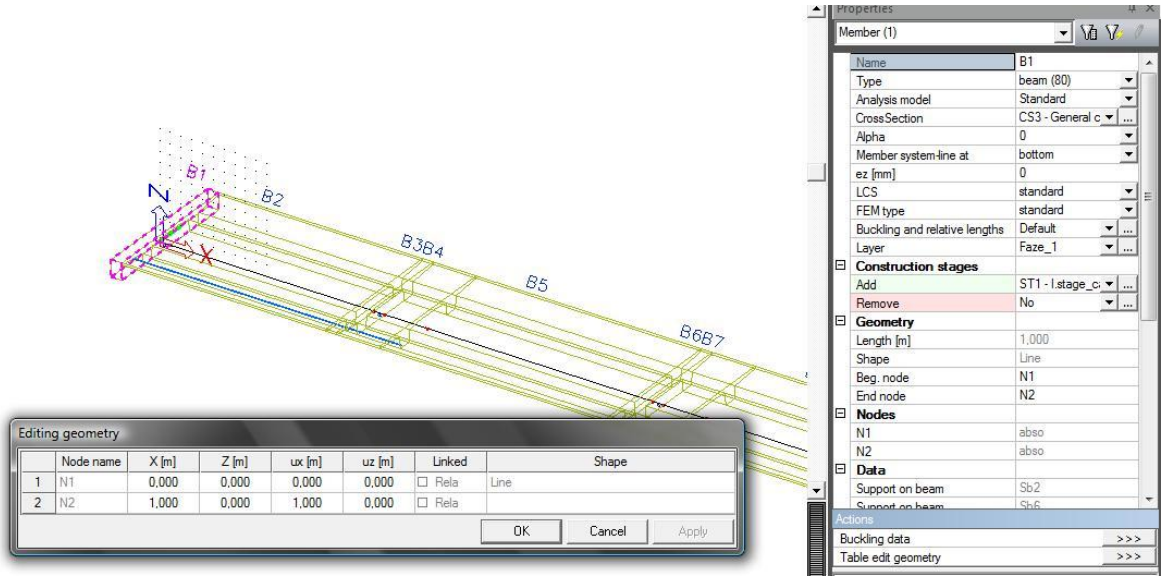
The following lengths of the beams will be defined in meters and appropriate CSS will be selected.

B1	1,0
B2	19,0
B3	1,0
B4	4,0
B5	21,0
B6	1,0
B7	4,0
B8	21,0
B9	1,0
B10	4,0
B11	15,0
B12	1,0

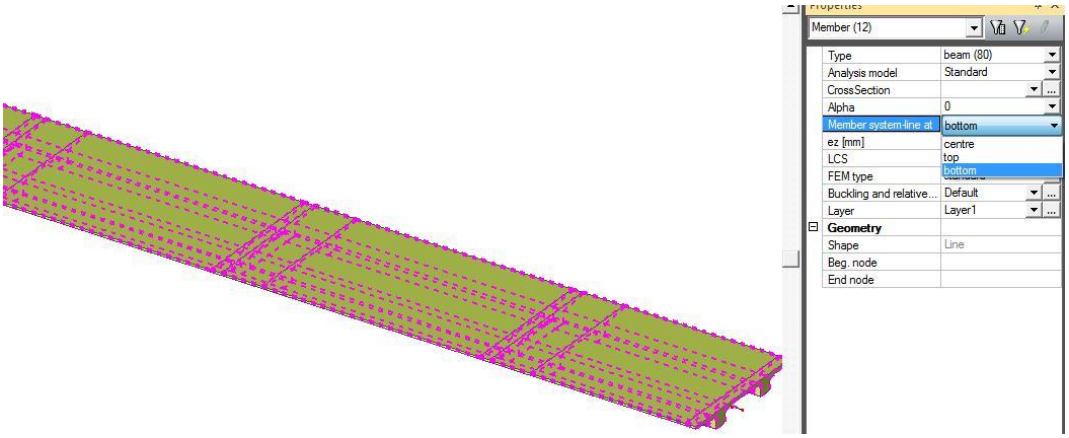
The user can see table of the beams in ***Document>Structure>Members***



The coordinates of the beam´s nodes are possible to modify by ***Table edit geometry***.

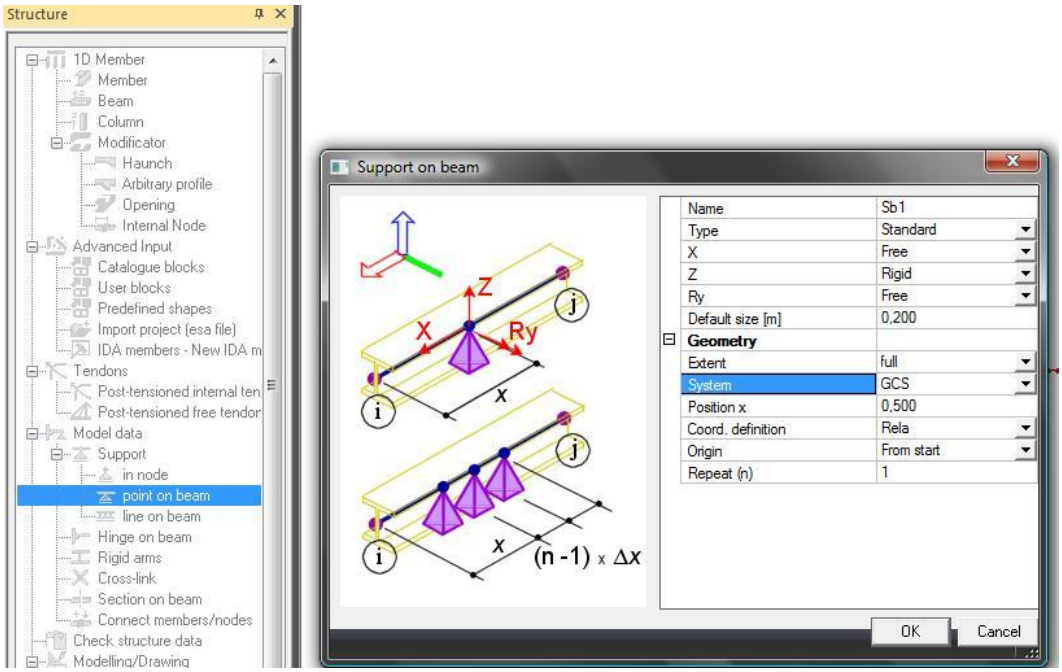


The ***alignment*** of the CSS should be changed to the ***bottom*** using filter of the beam in ones step because of different CSS in the structure.

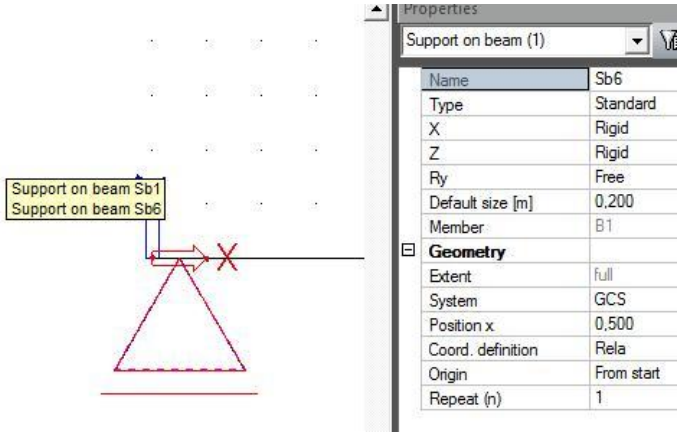


2.1.3 Supports

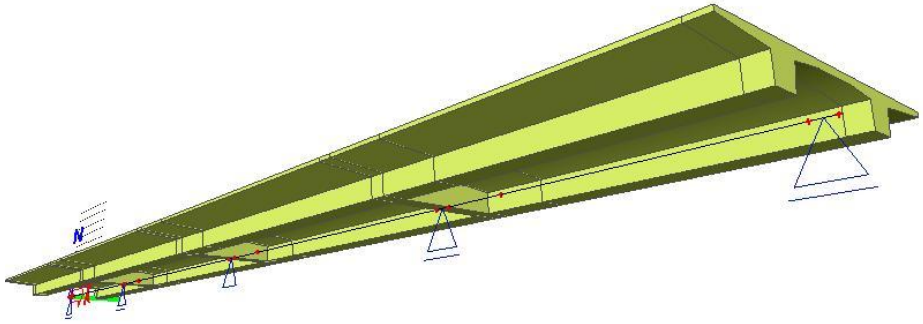
The supports should be defined using ***Structure > Model data>Support>Point on beam.*** The Z support is defined on support in the middle of the beam B1, B3, B9 and B12. The X, Z support is defined in the middle of the beam B6.



The additional support in the first beam has to be defined twice, because it is different during the construction stages.

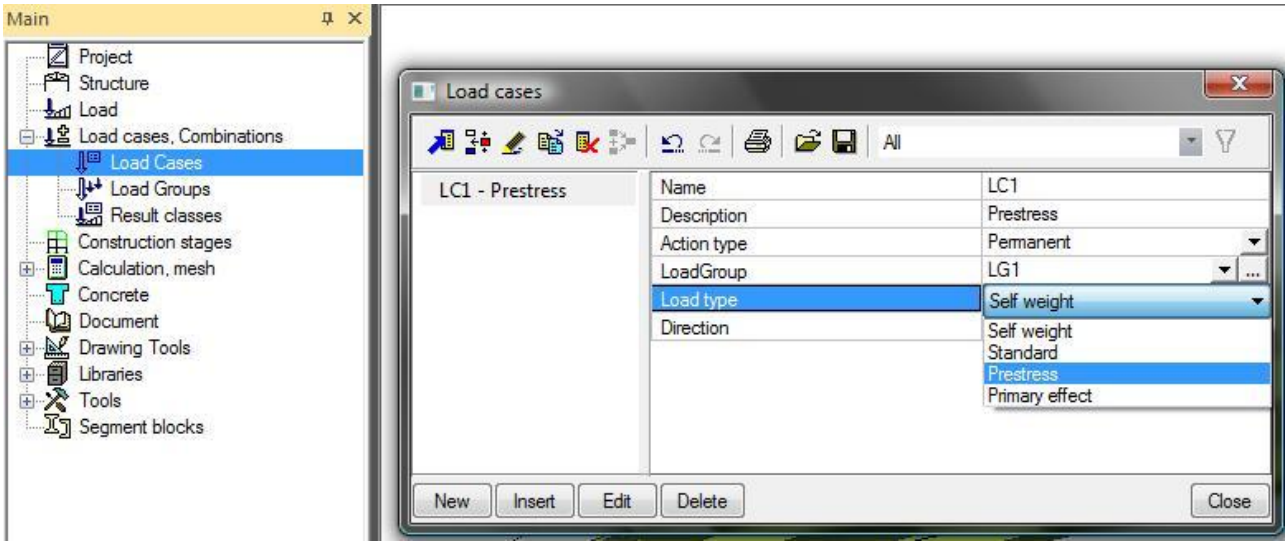


The 3D perspective model of the structure looks like following.

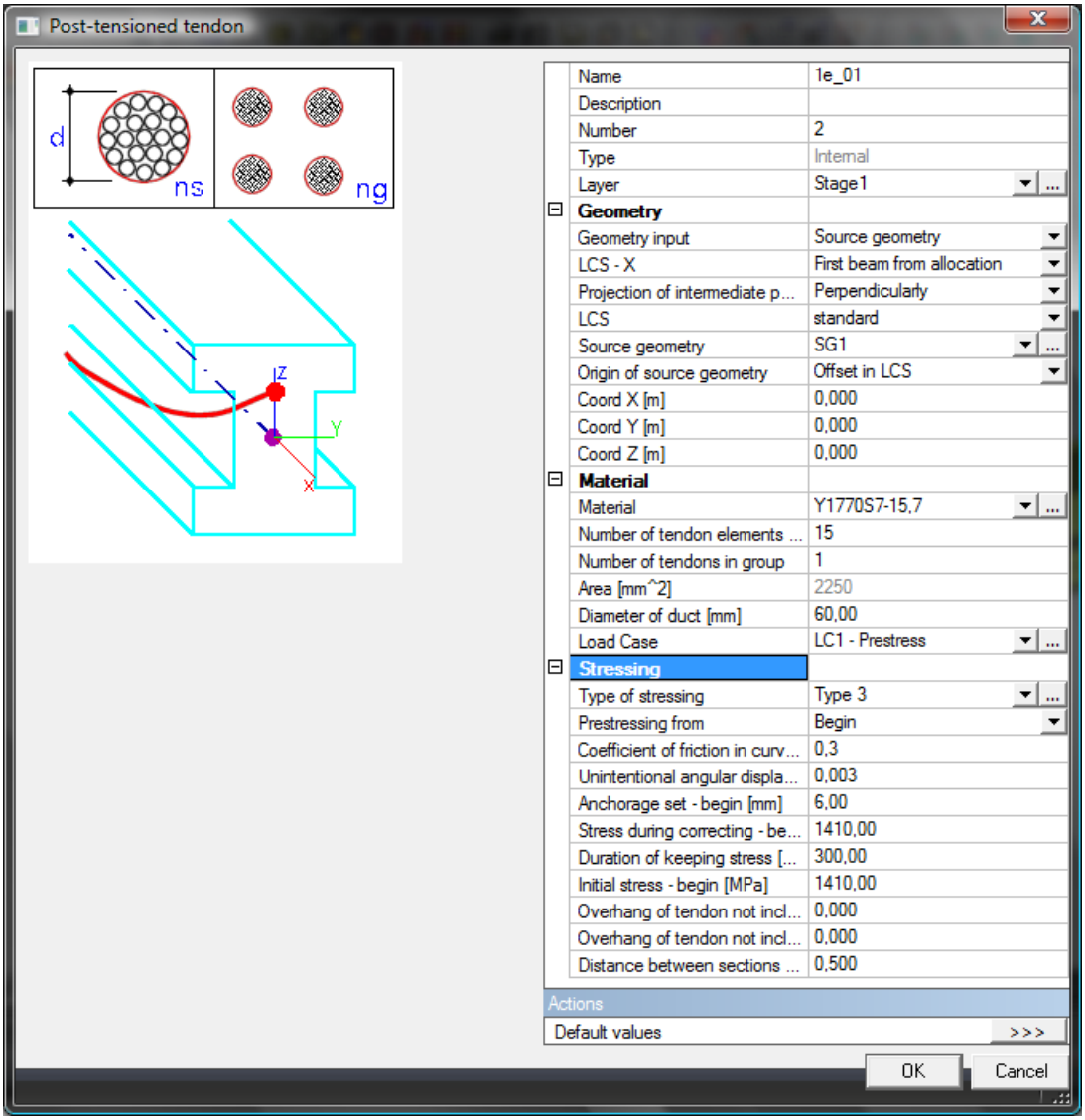


2.1.4 Prestressing

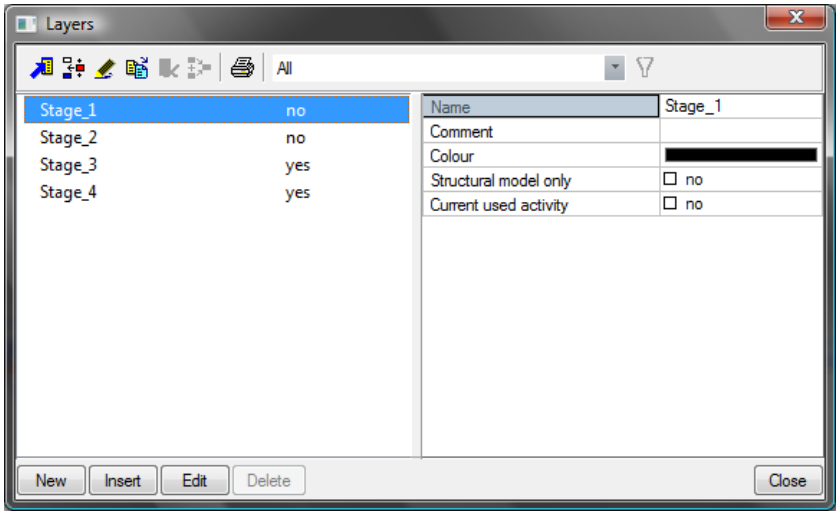
The loadcase type Prestress has to be defined for definition of the postensioned tendons. The loadcase is defined using ***Load cases, Combinations > Load cases.***



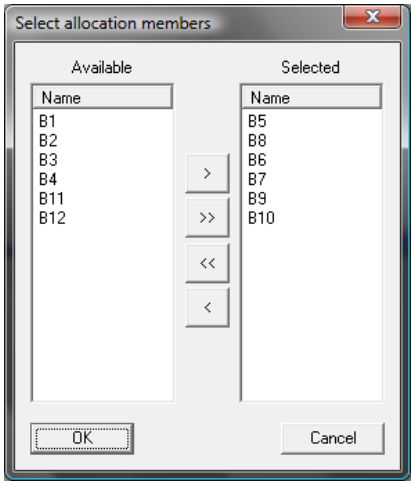
The postensioned tendons are possible to defined now in ***Structure>Tendons>Internal postensioned tendons***. There are many input values and the most important is explained. The following items will be defined in this example.



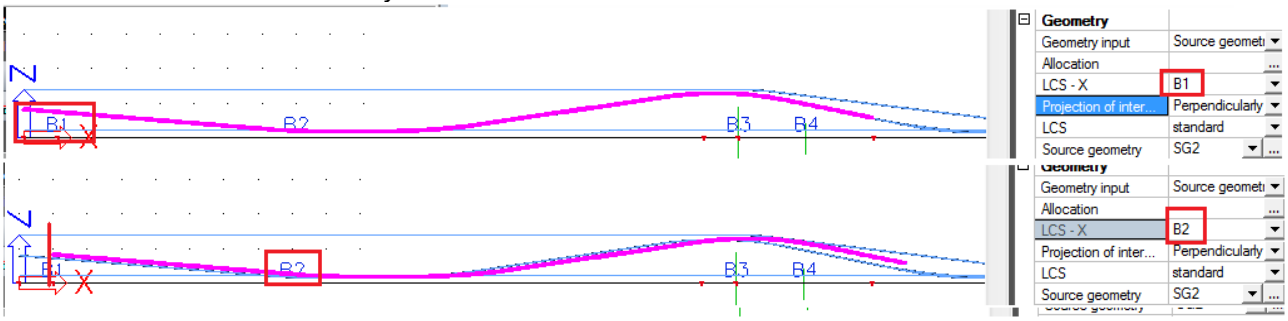
- ***Name*** – from ***1e_01*** up to ***4e_16*** – 30 tendons
- ***Layer*** – the four different layers were defined according to construction stages which will be defined later - ***Stage1, 2, 3 and 4***. The name of tendon beginning on number ***1*** belongs to layer ***Stage 1*** and other...



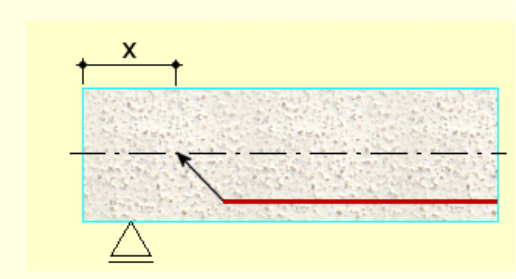
- ***Geometry input*** – type ***Source geometry*** is used; there are three possibilities of definition of tendon geometry
  - **Source geometry** – user defines geometry in library of SG
  - **Direct input** – user defines geometry of tendon in 3D window directly; the imported geometry from CAD program should be used by this option
  - **Reference line with source geometry** – the source geometry is winded on user defined reference line
- ***Allocation*** – the beams (slabs) where tendons are allocated on should be selected



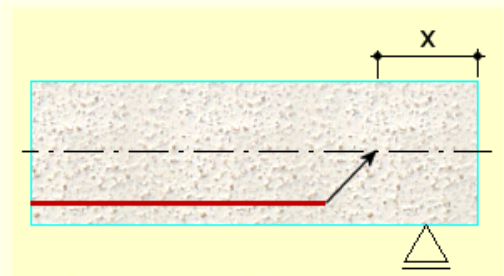
- ***LCS–X –*** the beam where start the local system of tendons; it could be a first beam from allocation or directly selected beam



- ***Projection of intermediate points –*** this option is relevant only in case of ***Hanging nodes***
  - ***Proportionally*** – user defines the length where the tendon effects are projected on
    - ***Way of location – begin***
      - ***First node –*** the beginning of projected tendon effects to the beam is from the first node of the allocated beam
      - ***Location*** – distance from the beginning of the beam



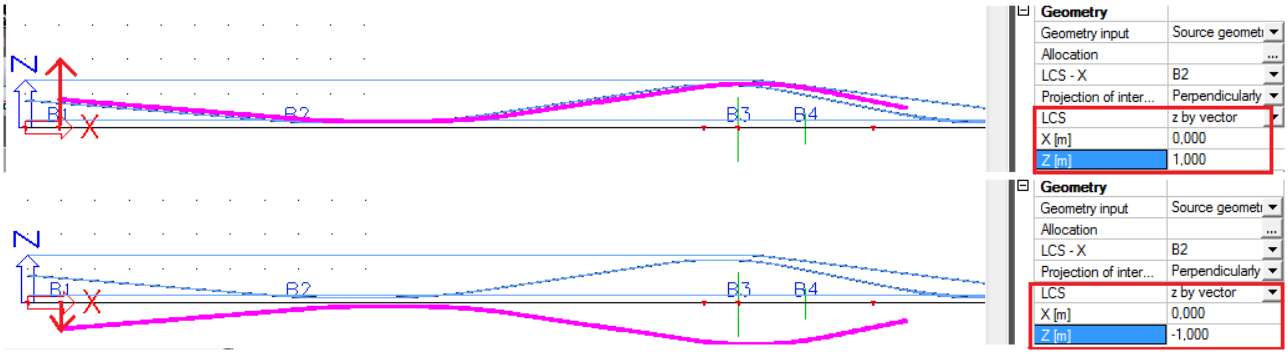
    - ***Way of location – end***
      - ***Last node –*** the beginning of projected tendon effects to the beam is to the last node of the allocated beam
      - ***Location*** – distance from the end of the beam



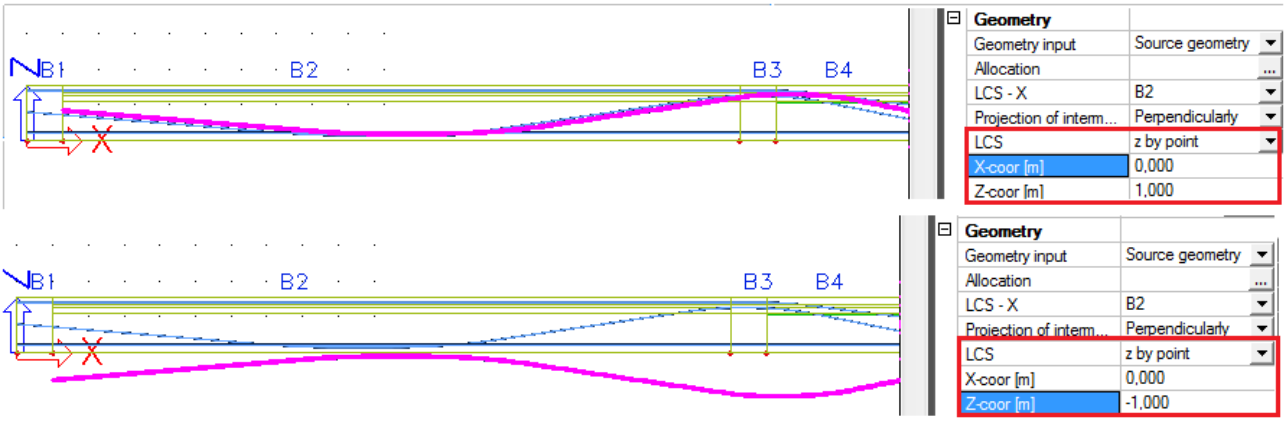
  - ***Perpendicularly*** – tendon is projected directly in perpendiculars to the beams

The hanging nodes are not available for TDA calculation

- ***LCS*** – type of local axis of tendon
  - ***Standard*** – local axis of tendon is the same as local axis of the allocated element
  - ***Z by vector*** – user sets the vector by points X and Z and the direction of z is according to these values

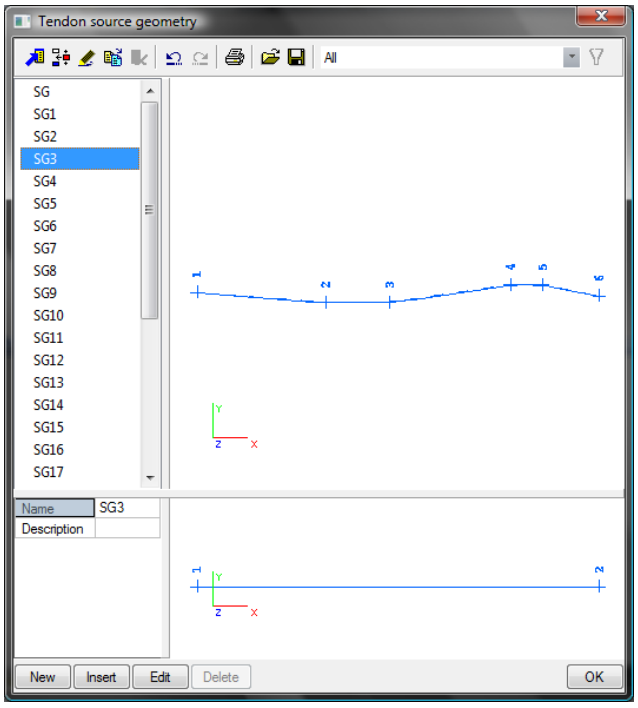


  - ***Z by point*** – user sets the point which shows direction of local coordinate system

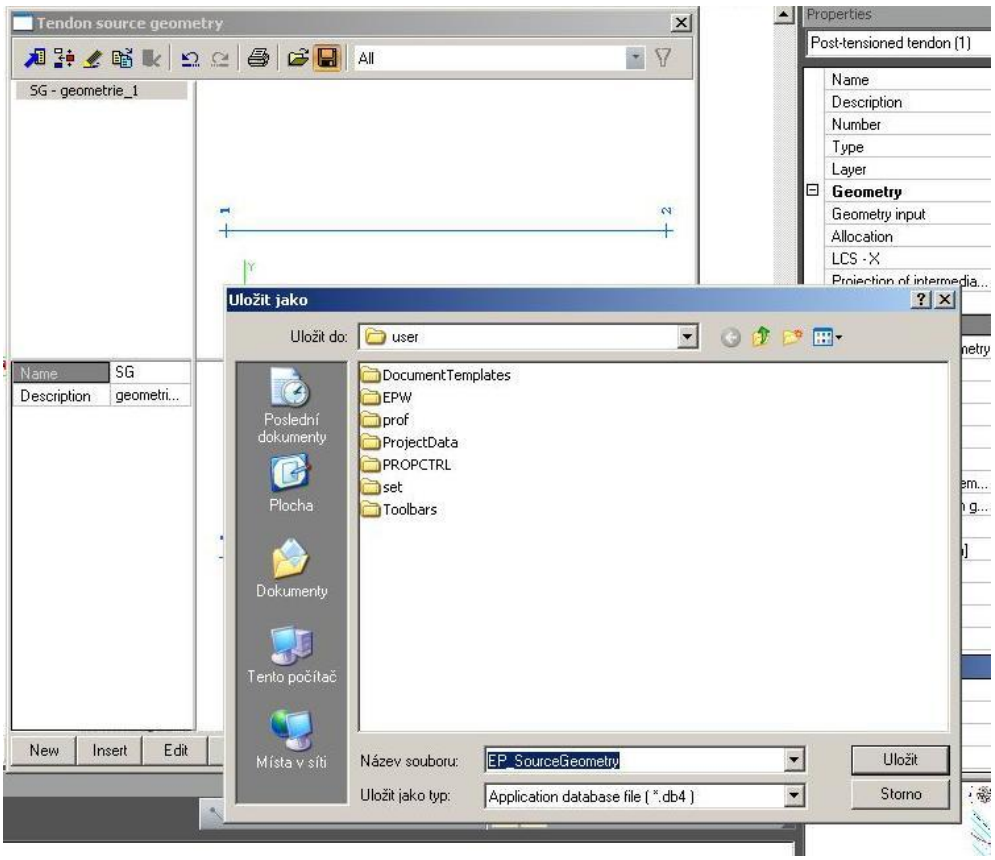


- ***Z from UCS*** – XXX

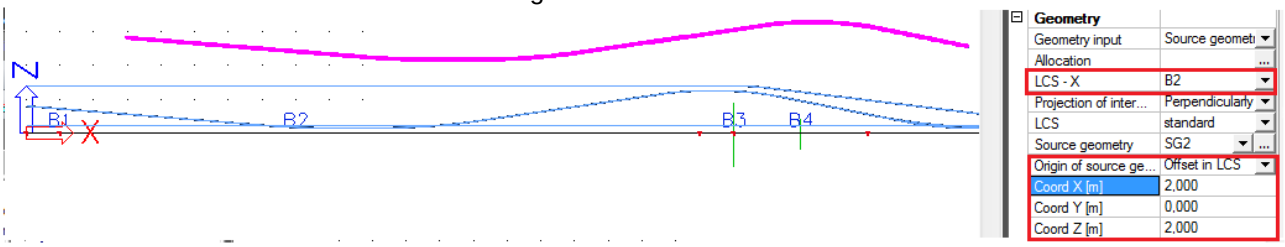
- ***Source geometry*** – 30 types of SG will be defined by user



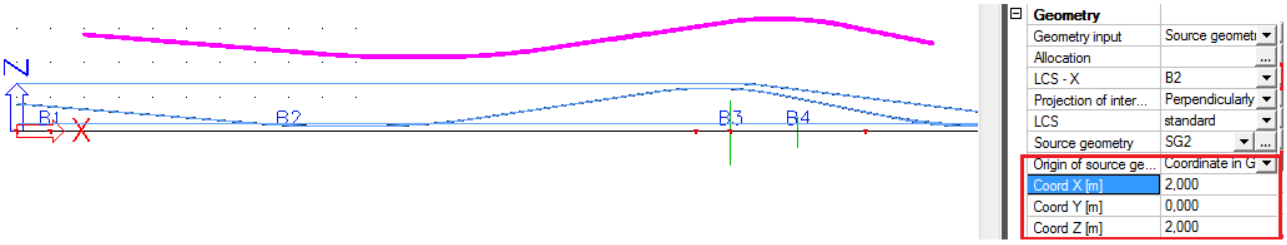
The source geometry should be also imported from user database file.



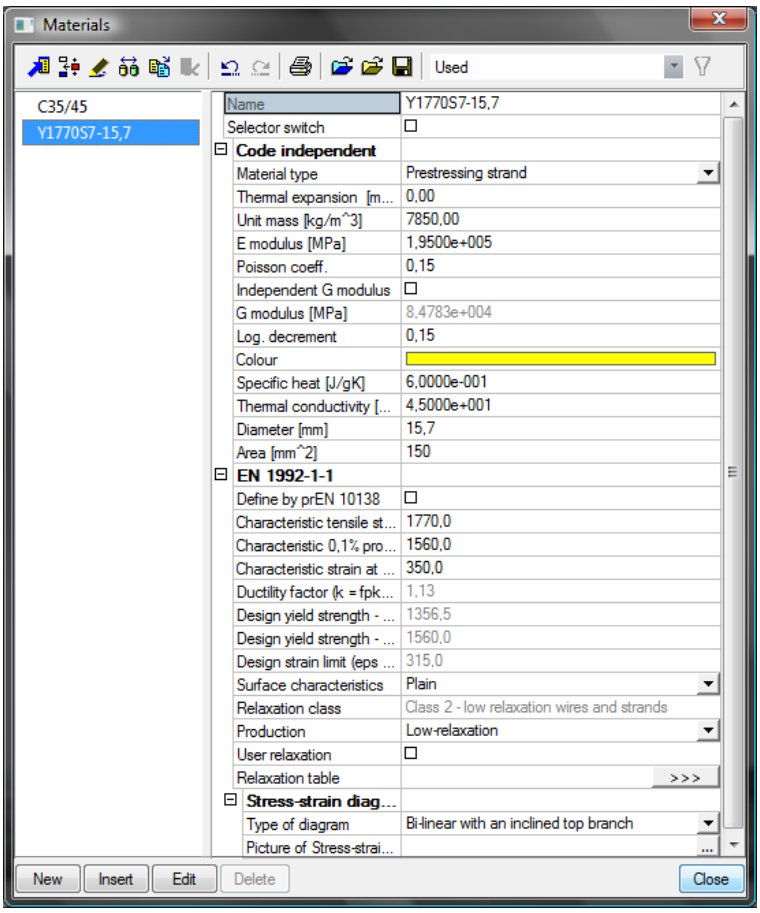
- ***Origin of SG*** – type of origin of SG
  - ***Offset in LCS*** – the origin can be set related to local coordinates of the beam



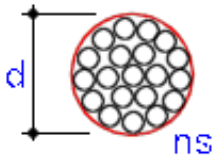
  - ***Coordinate in GCS*** – the origin is set related to global coordinates of the file



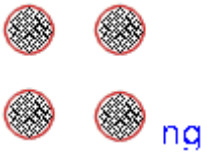
- ***Material*** – material Y1770S7-15,7 is used;



- ***Number of elements in tendon***– 15 ➔ tendon has 15 strands

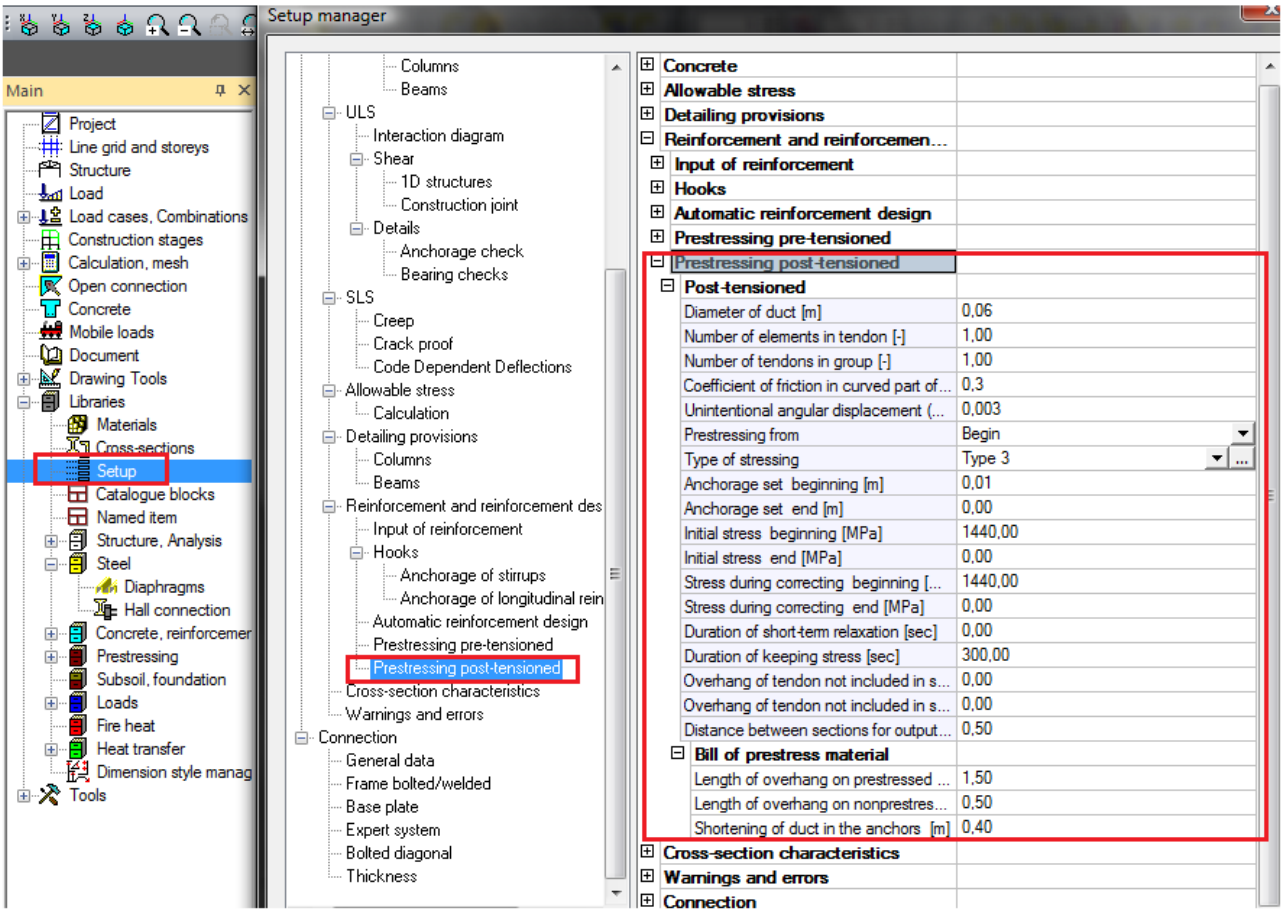


- ***Number of tendons in group*** – 1 ➔ only 1 tendon exists with the same properties and geometry

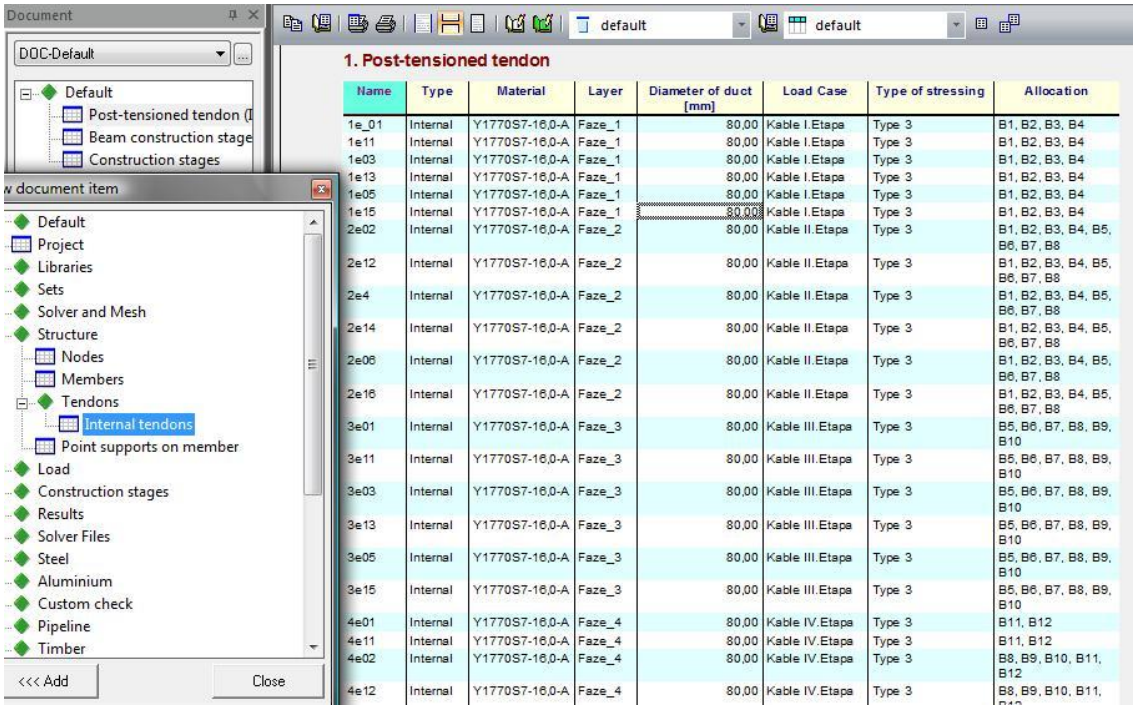


- ***Diameter of the duct*** – 80mm
- ***Stressing***
  - ***Type of stressing*** – type 3
  - ***Prestressing from*** – End
  - ***Stress during correcting*** – 1410MPa
  - ***Initial stress*** – 1410MPa

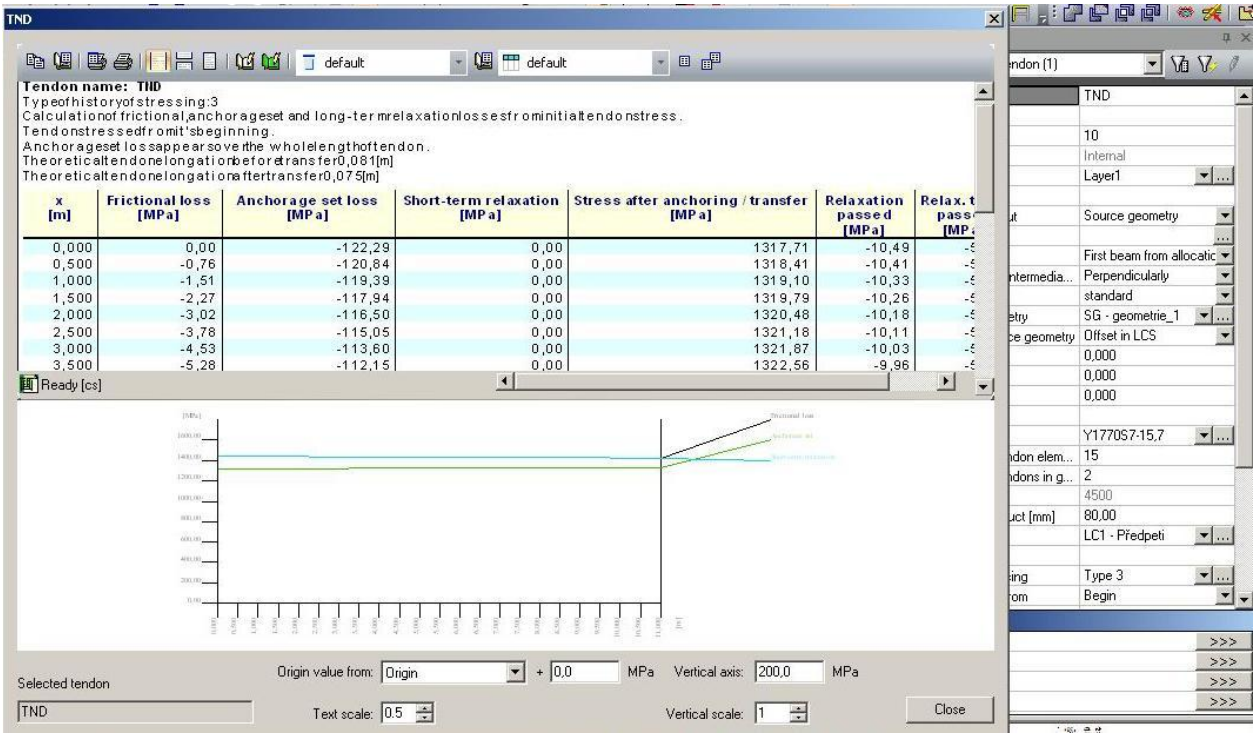
Another value are taken from default settings ***Libraries>Setup > Prestressing-Postensioned***



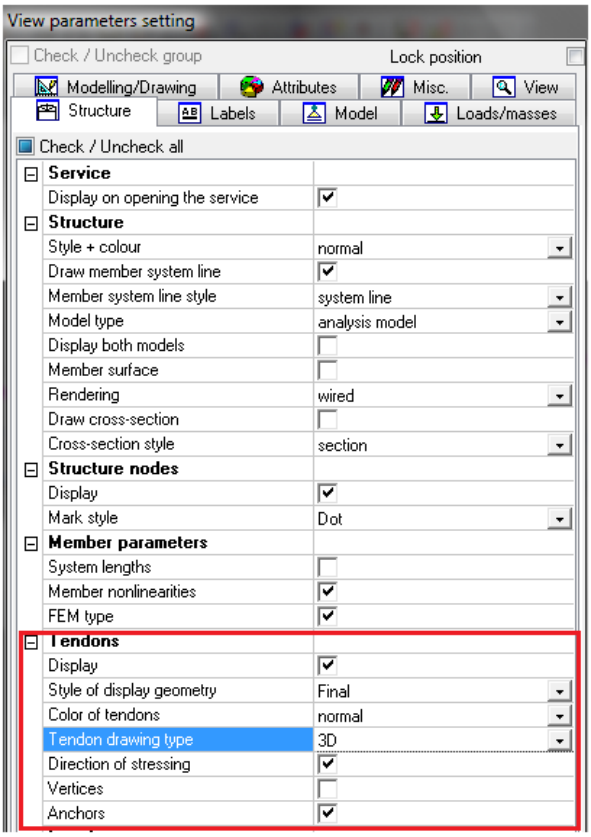
The parameters brief table of tendon is possible to view in document ***Structure>Tendons>Internal tendons.***

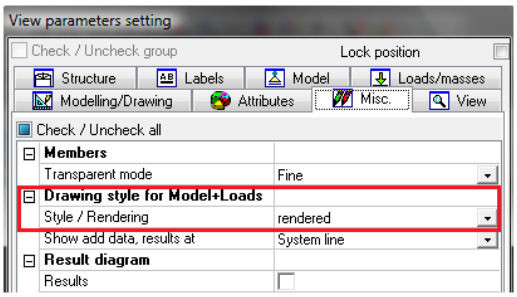


The tendon shorterm losses should be dispalyed for each selected tendons

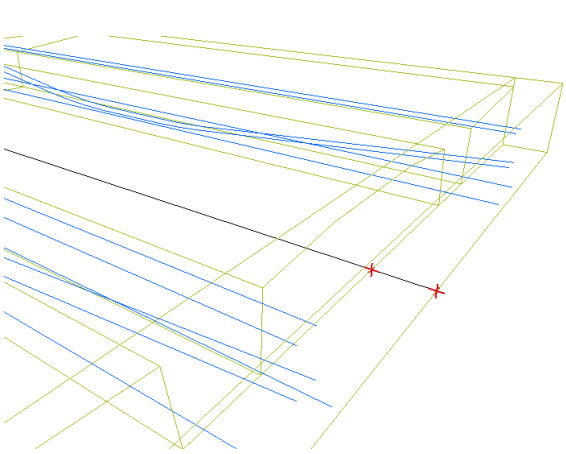


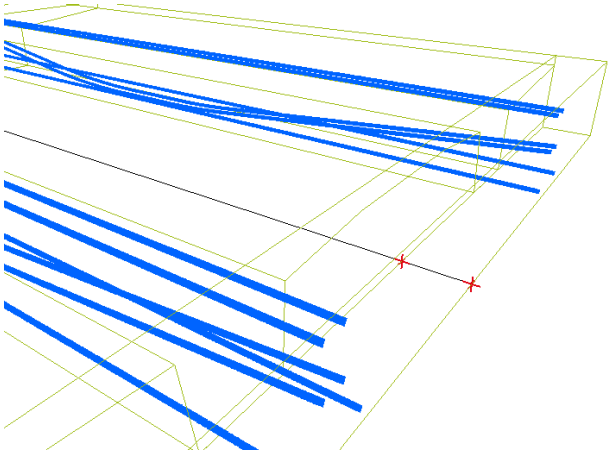
The tendons are drawing in 3D window depending on ***View parameters settings***.

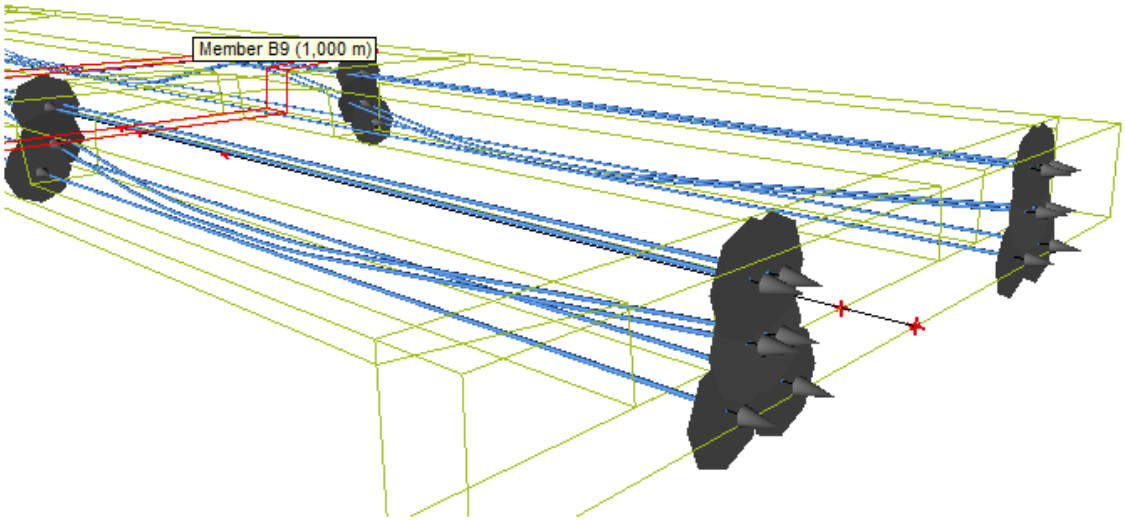




There are three possibilities of displaying of tendons in 3D window – thin line, diameter, 3D. Anchors and directions of stressing are also possible to display. 3D drawing with rendered model can give very nice pictures.






Member B9 (1,000 m)

2.2 Load

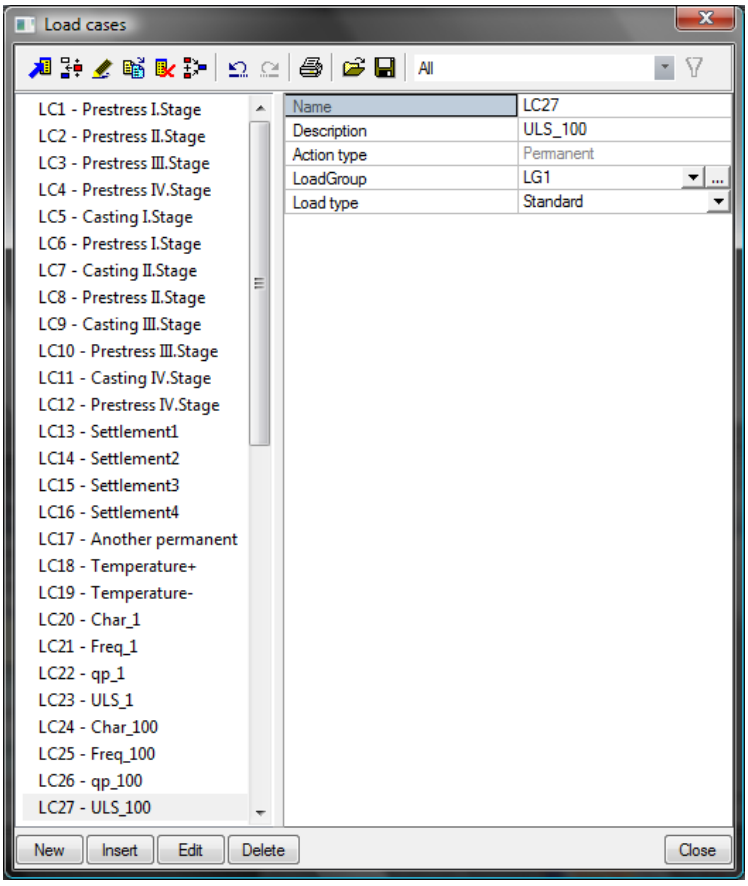
2.2.1 Loadcases

The loadcases have to be defined before construction stages are defined. The following list of load cases will be defined. There are several possibilities of load definition.

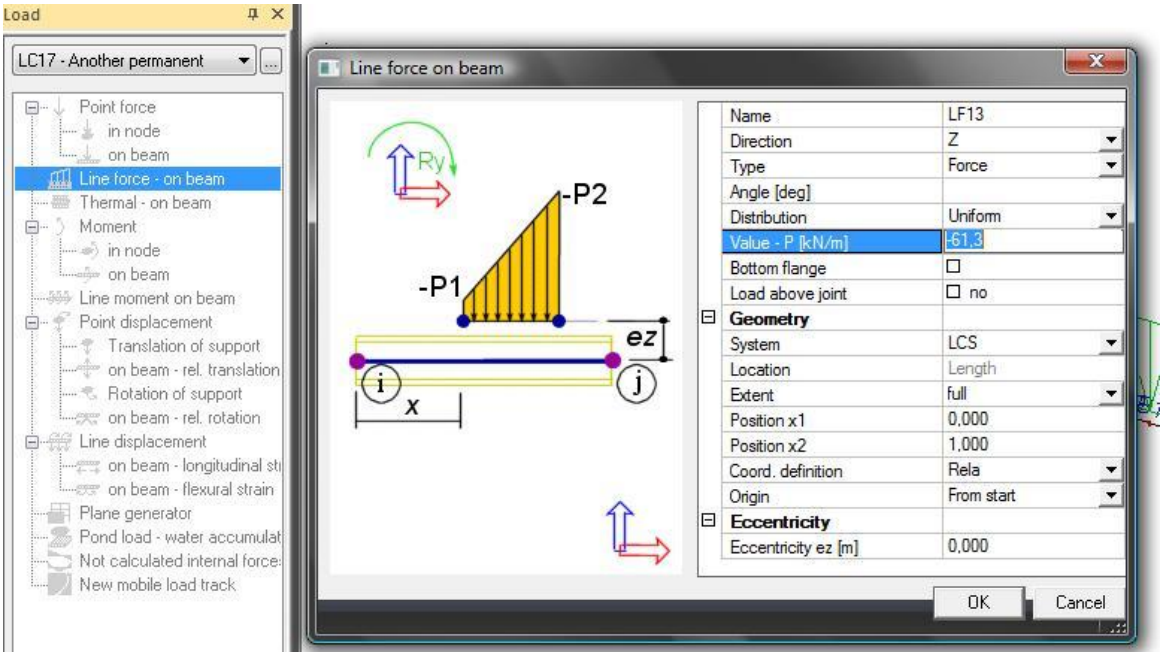
- Permanent
  - Type
    - Standard – necessary for definition of stages in construction stages library, could be empty loadcase used only for definition of stages
    - Selfweight – loadcase from load of selweight
    - Prestress – necessary for definition of prestressing
  - Loadgroup
    - Link to library of Load group – see (4.1)
- Variable
  - Specification
    - Standard
    - Temperature – only thermal load should be defined in this LC
  - Loadgroup
    - Link to library of Load group – see (4.1)

2.2.2 Loads

Load is defined according to type of load using Loads. For example - permanent load (road, safety fence and other bridge accessories) is defined in loadcase ***LC17-Another permanent – type permanent***

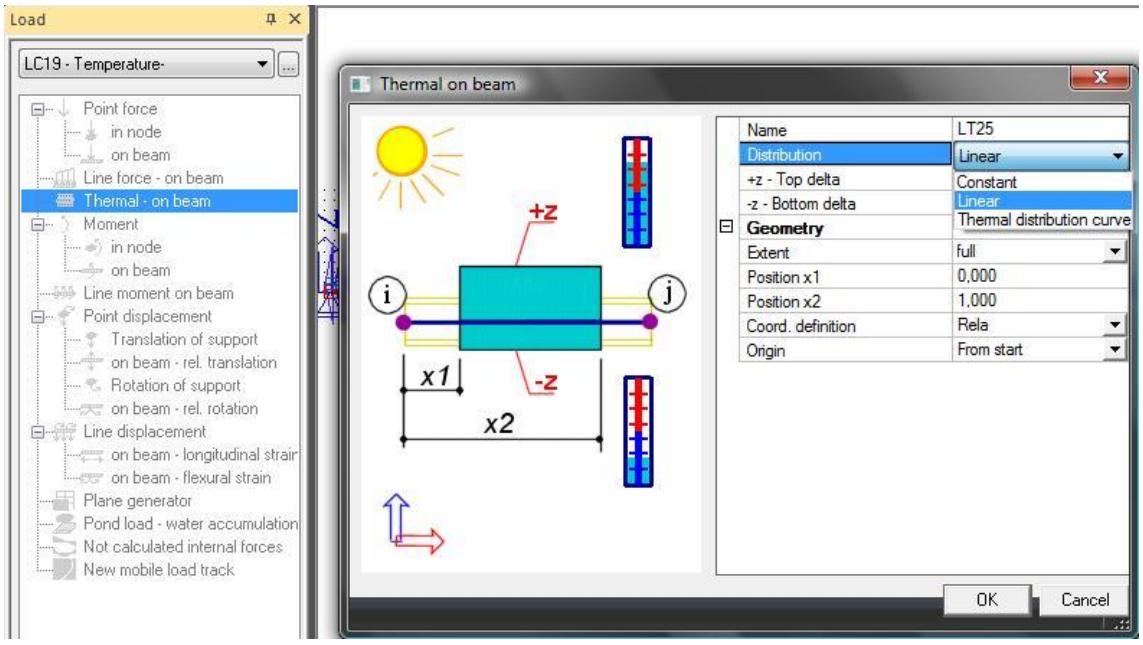


The definition of the load value is available in ***Loads>Line*** force on beam and user defined value **-*61,3kN/m***.



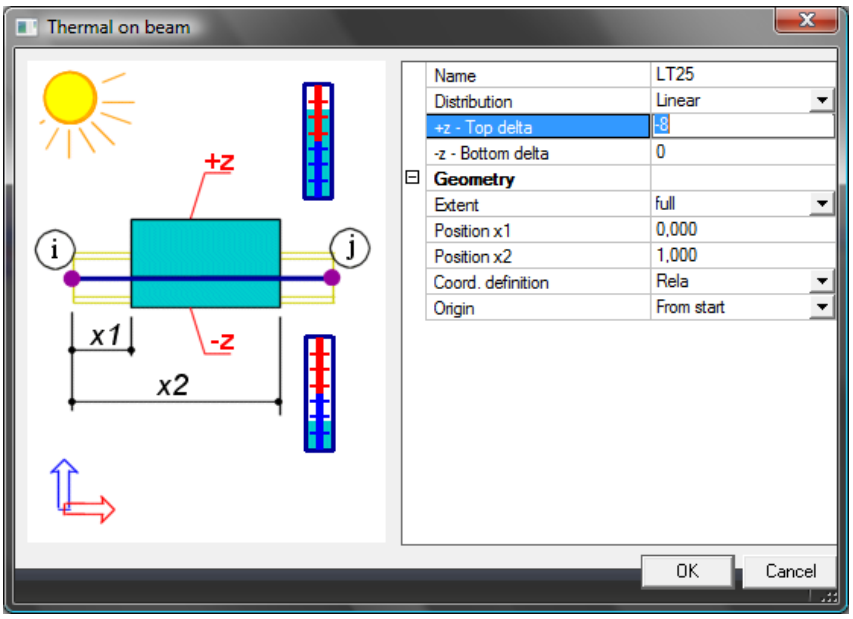
2.2.2.1 Temperature load

The variable loadcase with specification temperature has to be defined. The temperature load is defined in ***Load>Thermal on beam***.

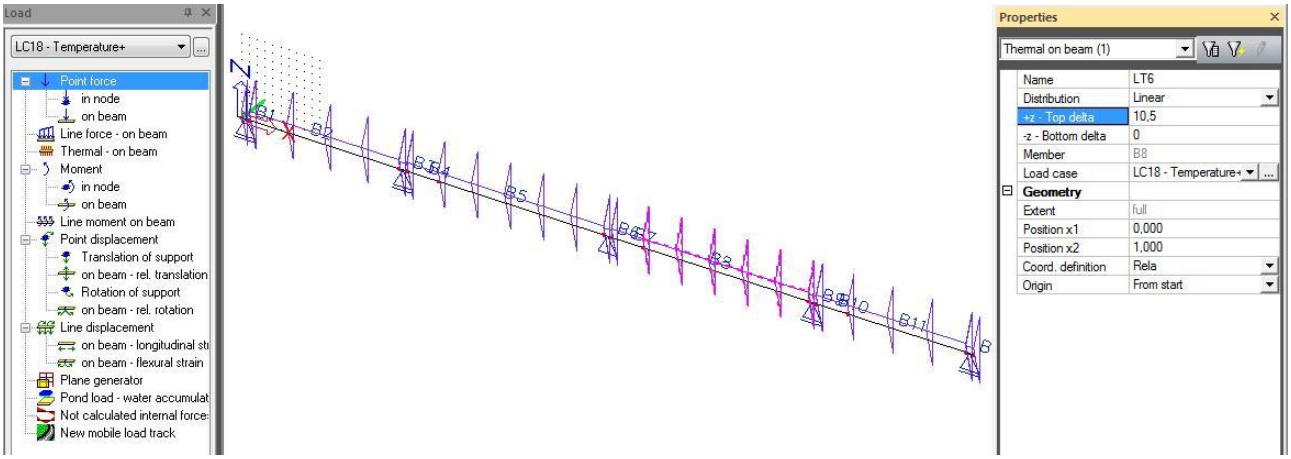


The ***linear*** thermal load will be defined.

- LC – Temperature–
  - Top delta **- 8°C**
  - Bottom delta **0°C**
- LC – Temperature+
  - Top delta **+10,5°C**
  - Bottom delta **0°C**

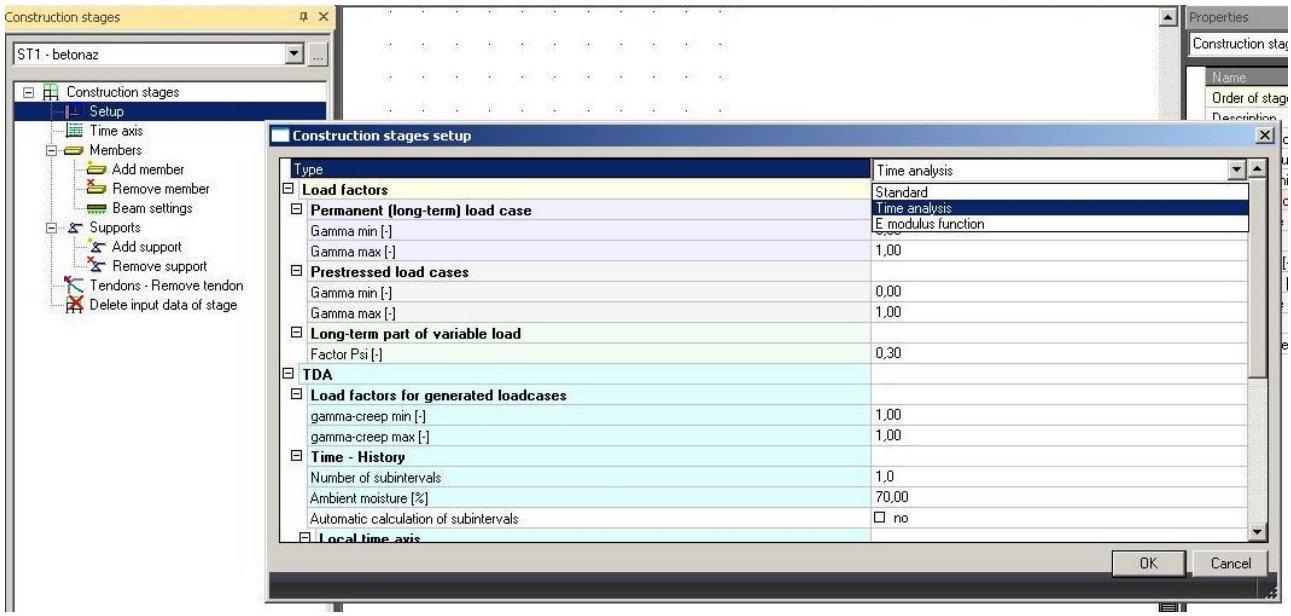


The temperature load is drawn in 3D window following (using triangles).



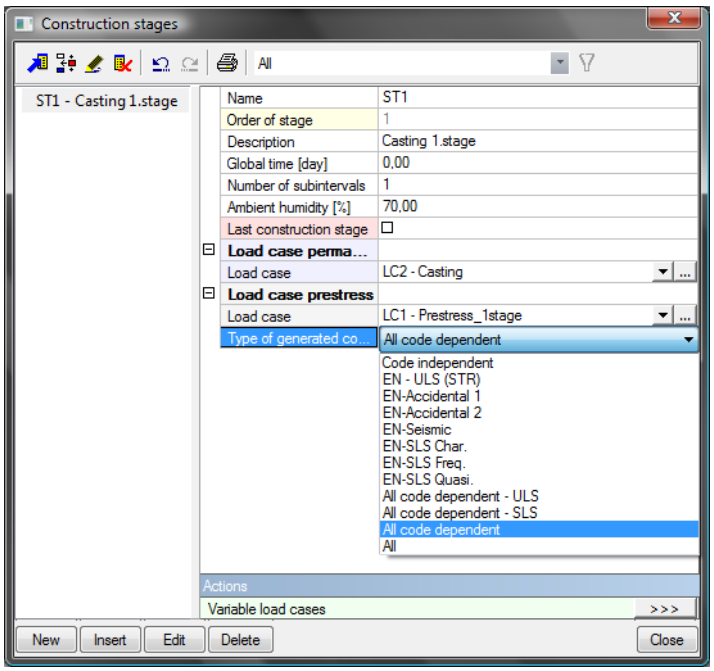
3 Construction stages

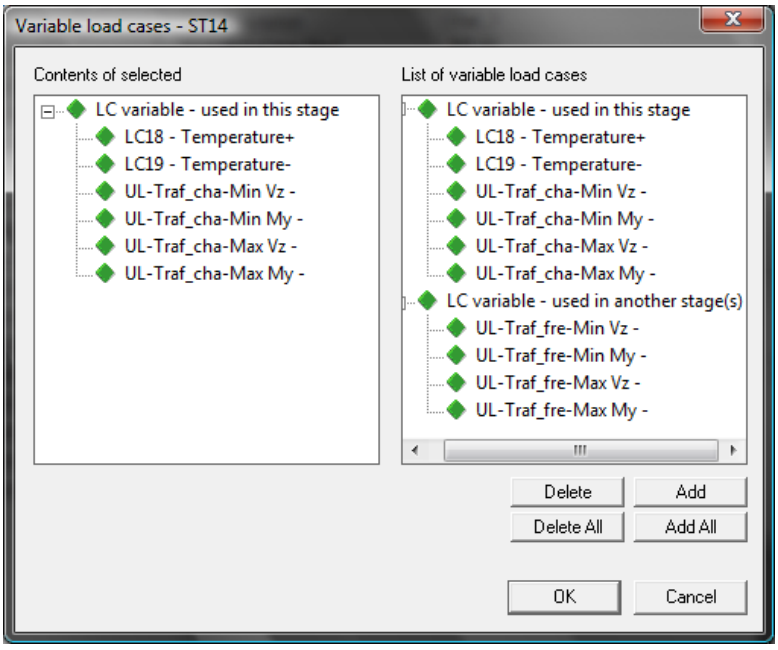
The construction stages are necessary to define for time dependant analysis (TDA). The User has to define ***Type - Time analysis*** in ***Setup of construction stages***.



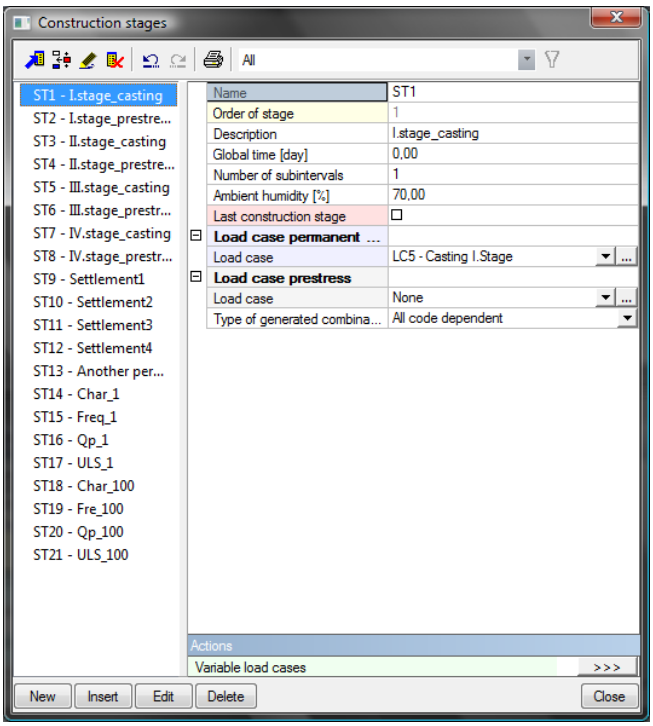
Then it is necessary to define each construction stage using three dot buttons. There are several important values

- ***Name*** – ST1 – ST19
- ***Description*** – description of appropriate stage
- ***Global time*** – global time of time axis in days
- ***Number of subintervals*** – number of subintervals in appropriate stage, the creep and shrinkage increment are calculated in this subintervals
- ***Ambient humidity*** – in percentage, needed for calculation of shrinkage
- ***Last construction stage*** – checkbox which signed last construction stages, the stages after that are service stages, variable load applied before ***Last construction stage*** cannot be used in another stage.
- ***Permanent load case*** – load case type permanent – each stage has to have only one loadcase type permanent (longterm variable), this loadcase could be also empty only (for measurement-without load), but it is necessary for creation of stages
- ***Prestress type loadcase*** – optional loadcase, by this loadcase are determined prestressing tendons in appropriate stage
- ***Type of generated combination*** – user has several opportunity which type of combination will be automatically generated according to selected code in project data
- ***Variable action button*** – the variable loadcase is possible to add into selected stage by this button (see chapter 4.3)

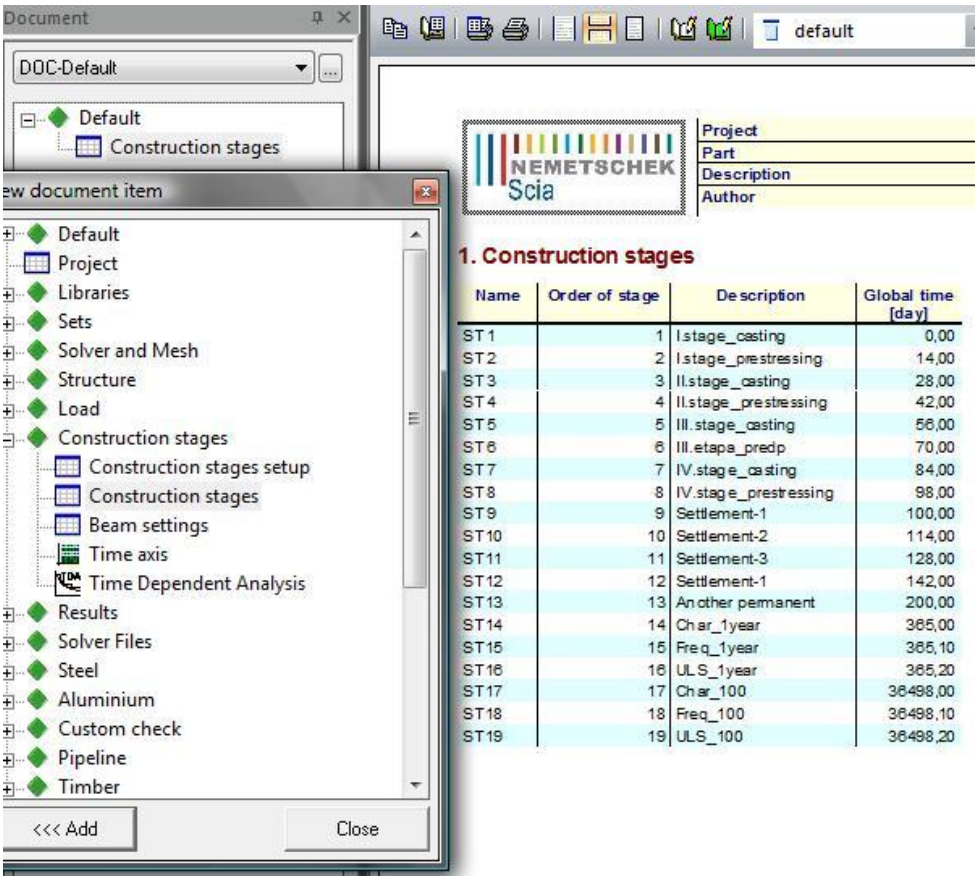




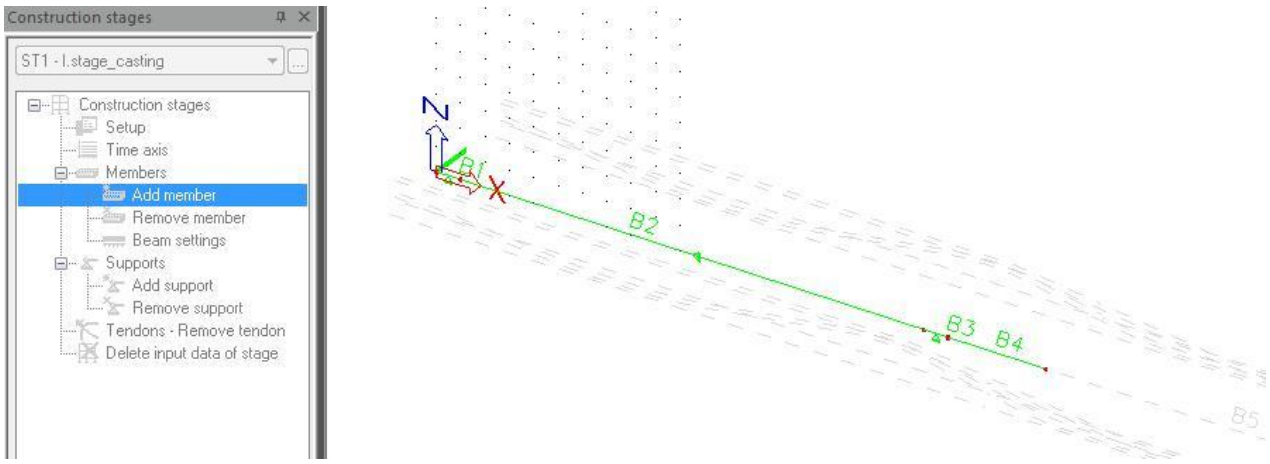
The all stages will be defined by this way. The total content of the stages is following.



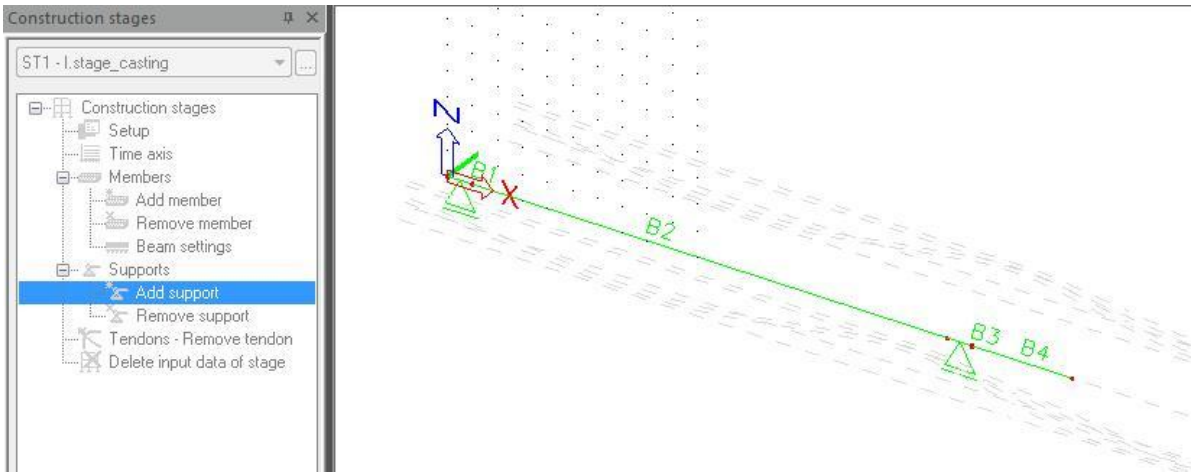
The very user friendly list of construction stages is possible to add into document.



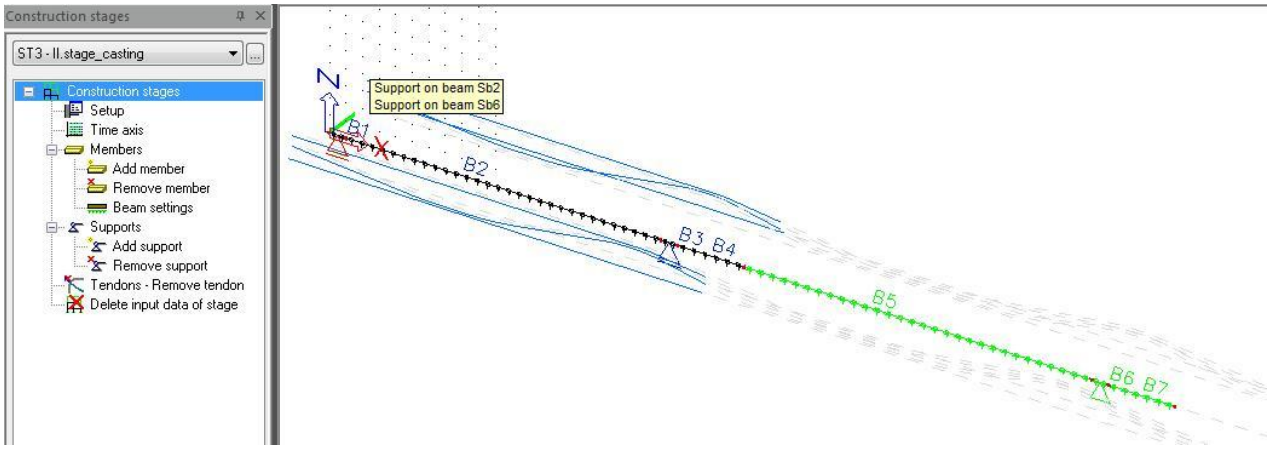
The construction stages are defined now is necessary to assign which members and supports belong to which construction stages. The members are defined by button ***Members>Add members*** and selected appropriate member in selected stage.



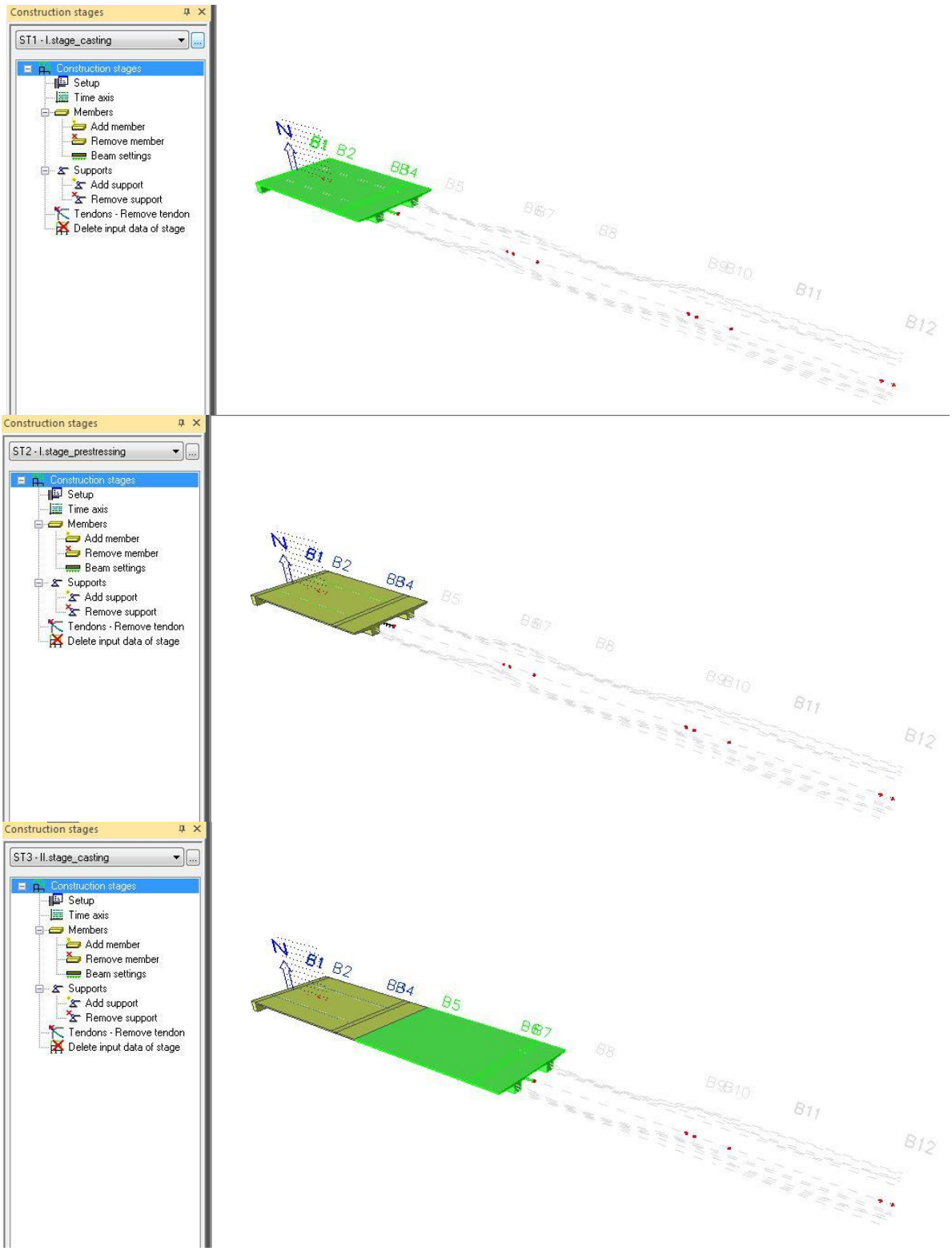
The supports are defined in similar way ***Supports> Add supports***.

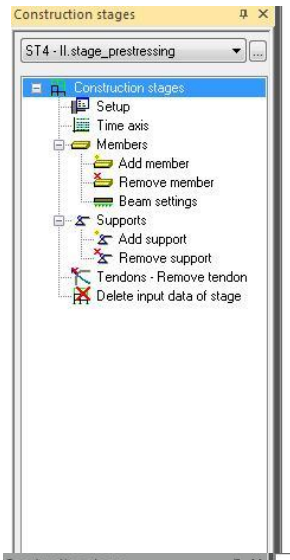


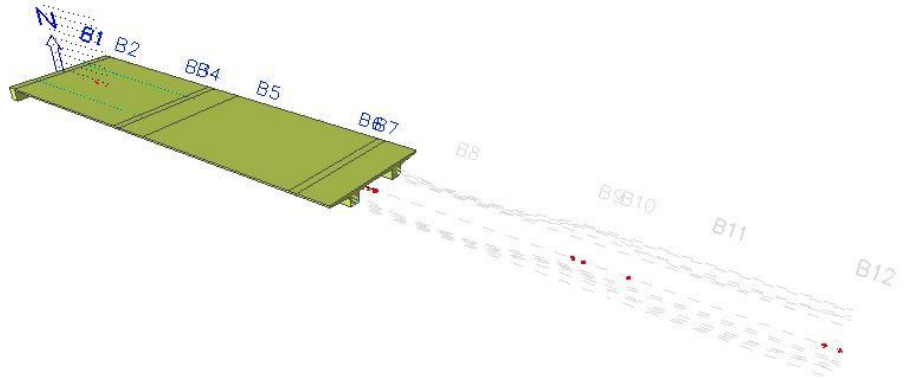
The support on beam B1 is defined in the ST1 (X,Z support) and removed in ST3. The support (Z only) is added in ST3.

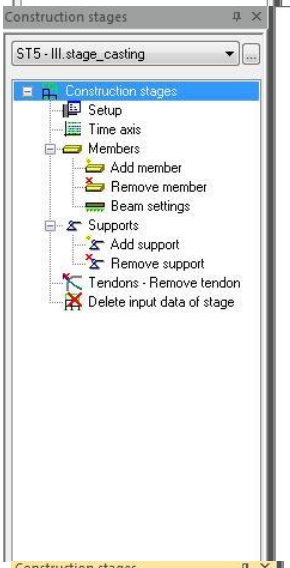


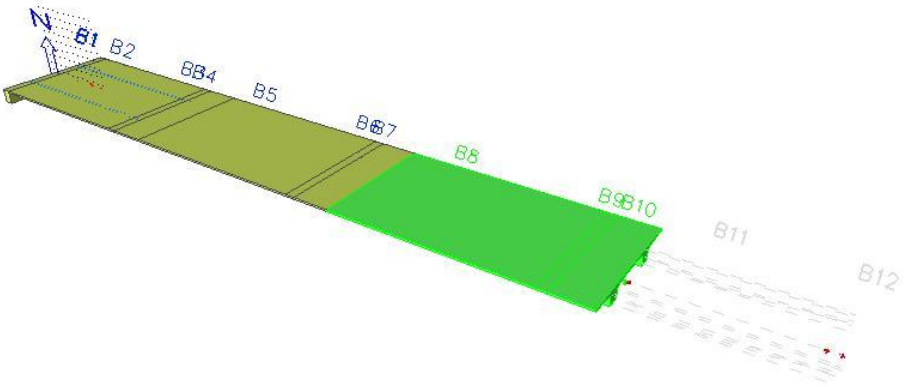
The whole structure will be defined by this way described in upper figures. The graphical presentation in 3D window is following during of construction.

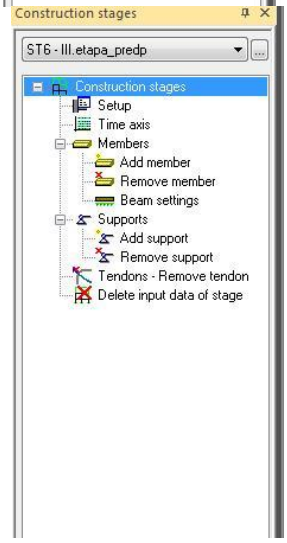

Construction stages
ST1 - I.stage_casting
Construction stages
Setup
Time axis
Members
Add member
Remove member
Beam settings
Supports
Add support
Remove support
Tendons - Remove tendon
Delete input data of stage
Construction stages
ST2 - I.stage_prestressing
Construction stages
Setup
Time axis
Members
Add member
Remove member
Beam settings
Supports
Add support
Remove support
Tendons - Remove tendon
Delete input data of stage
Construction stages
ST3 - II.stage_casting
Construction stages
Setup
Time axis
Members
Add member
Remove member
Beam settings
Supports
Add support
Remove support
Tendons - Remove tendon
Delete input data of stage
B1
B2
B4
B5
B7
B8
B10
B11
B12

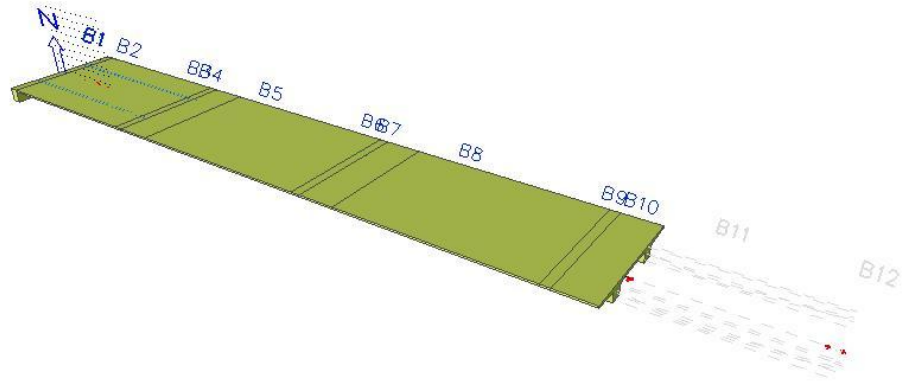

Construction stages
ST4 - II.stage_prestressing
Construction stages
Setup
Time axis
Members
Add member
Remove member
Beam settings
Supports
Add support
Remove support
Tendons - Remove tendon
Delete input data of stage

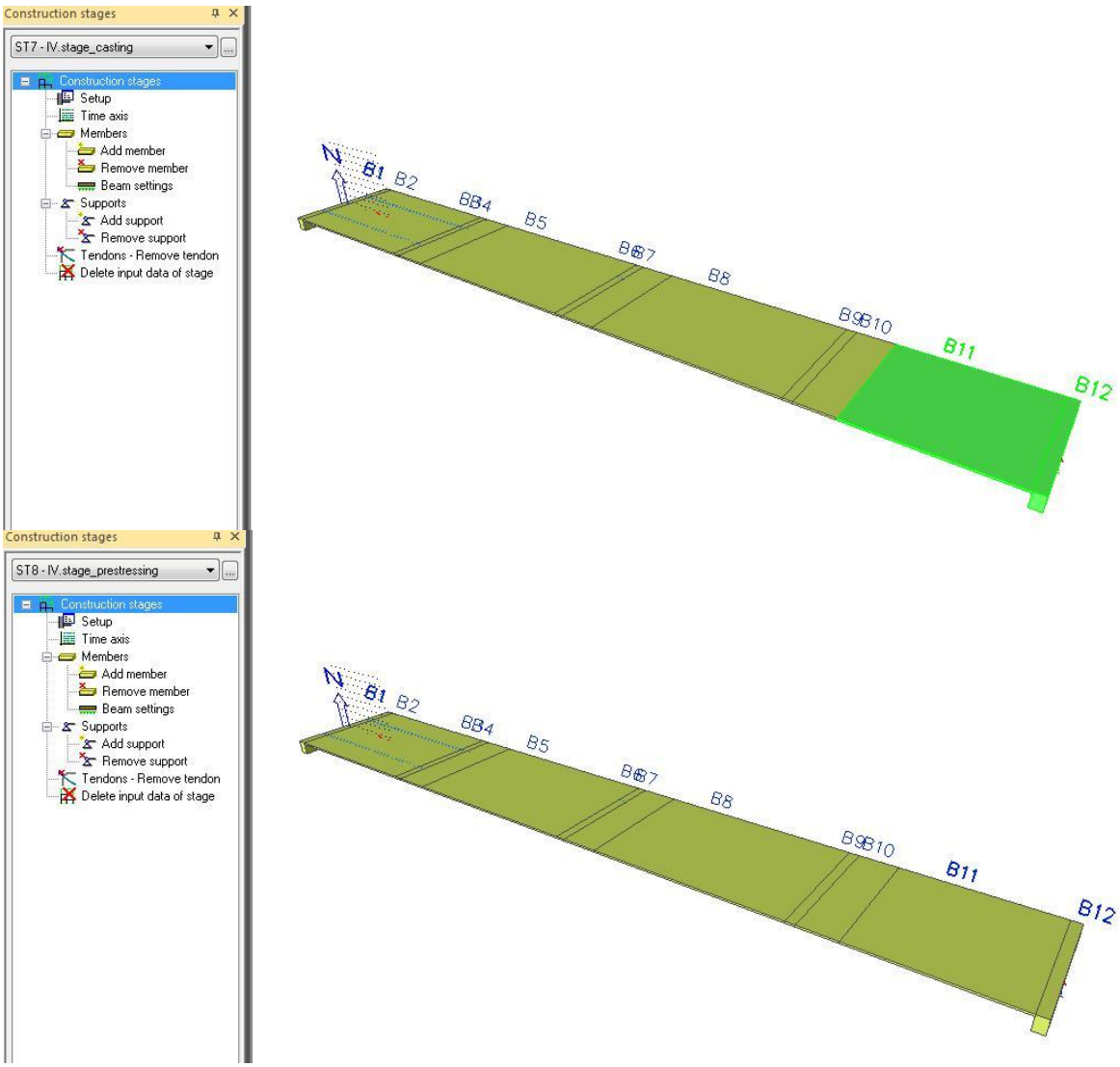

N
B1
B2
B4
B5
B7
B8
B10
B11
B12


Construction stages
ST5 - III.stage_casting
Construction stages
Setup
Time axis
Members
Add member
Remove member
Beam settings
Supports
Add support
Remove support
Tendons - Remove tendon
Delete input data of stage


N
B1
B2
B4
B5
B7
B8
B10
B11
B12

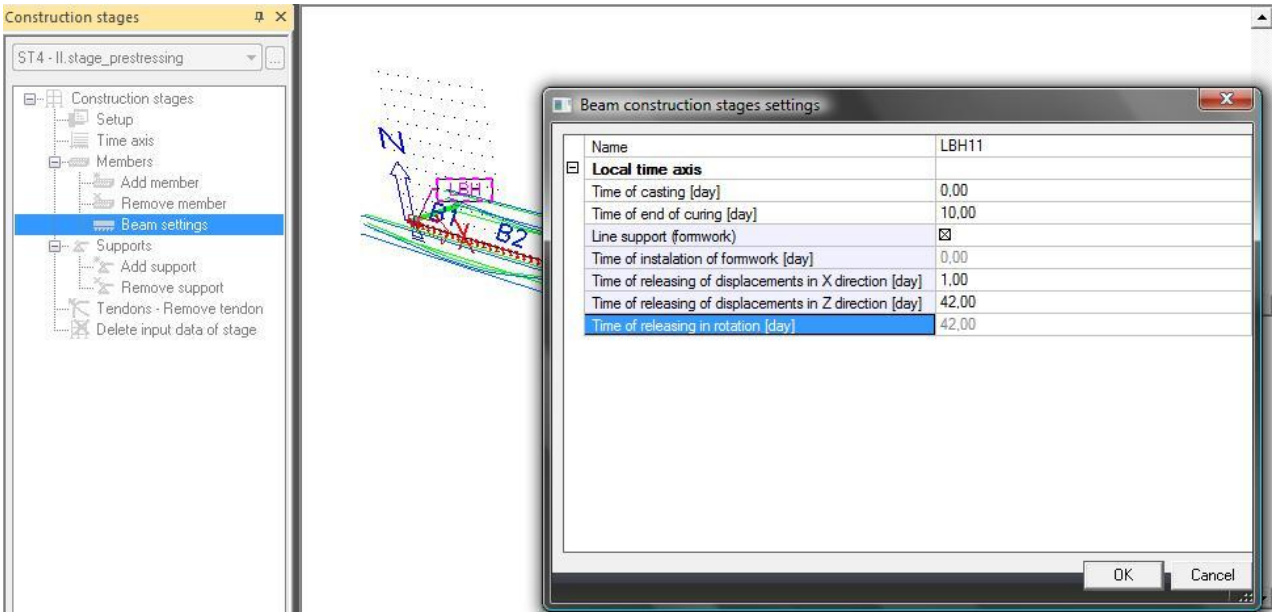

Construction stages
ST6 - III.etapa_predp
Construction stages
Setup
Time axis
Members
Add member
Remove member
Beam settings
Supports
Add support
Remove support
Tendons - Remove tendon
Delete input data of stage


N
B1
B2
B4
B5
B7
B8
B10
B11
B12



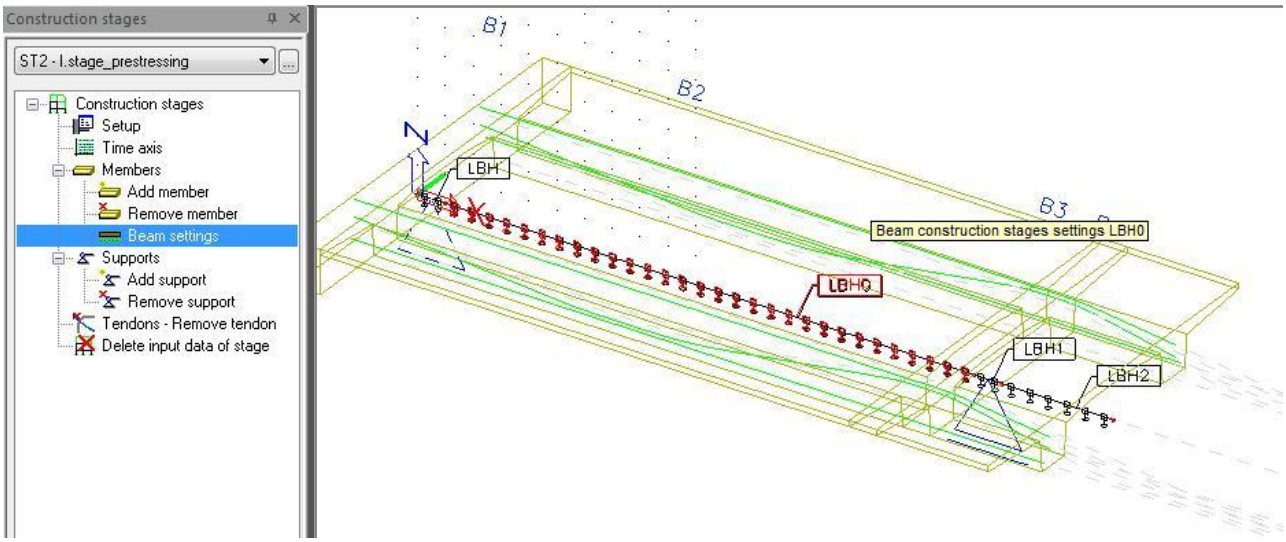
3.1 Local beam history

One from the most important setting for time dependant analysis is ***Local Beam settings (LBH)***. This LBH will be assigned to each member.

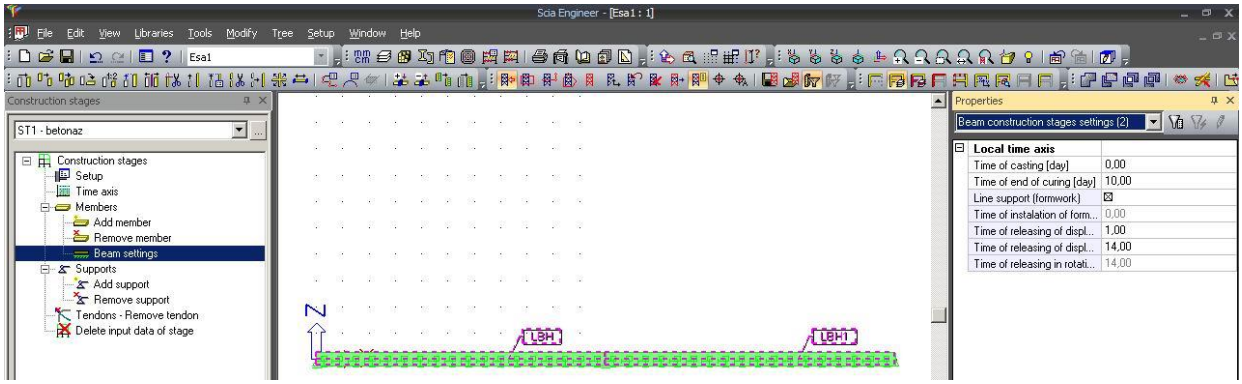


- ***Time of casting*** - it is time of casting of concrete in days in local time axis related to the global time axis. It is possible to input negative value. The linear support hasn't to be used in this case. The ageing of the concrete starts in this time. It is significant for age of concrete for creep calculation. An example - construction stage 1 - global time 5 days; time of casting -3 days. It means that global time of casting is 2 days. The user doesn't have to input linear support - formwork
- ***Time of end of curing*** - it is time of end of curing of concrete. If phased CSS is used, then it is time of end of cuing of the first phase of CSS. It is significant time for calculation of shrinkage.
- ***Time of end of curing of composite phases*** - it is significant only for phased CSS, this time is end of curing of the second, third...phase of CSS if exists. It is significant time for calculation of shrinkage of second, third phase of CSS again.
- ***Time of releasing of displacement in X(Z) direction*** – time when formwork in X(Z) direction is replaced.

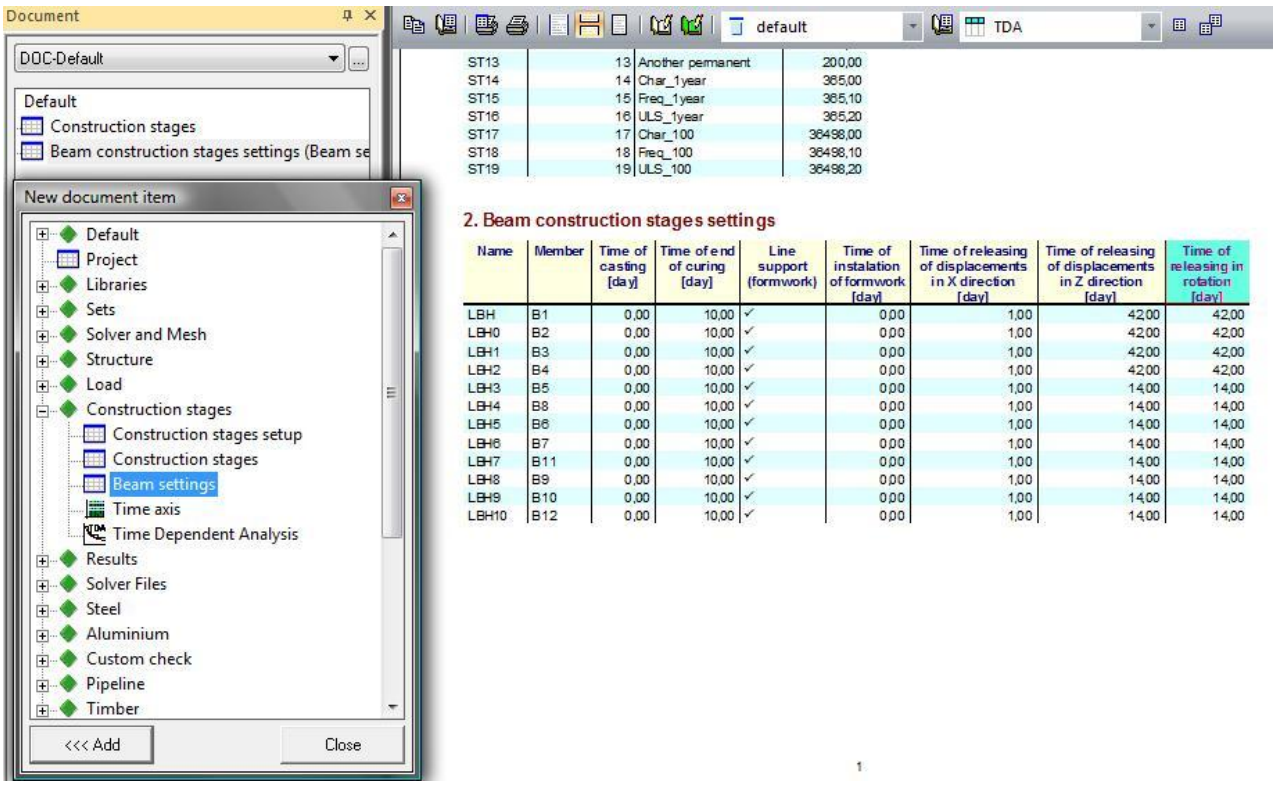
The displaying of LBH in 3D window is as linear support (formwork).



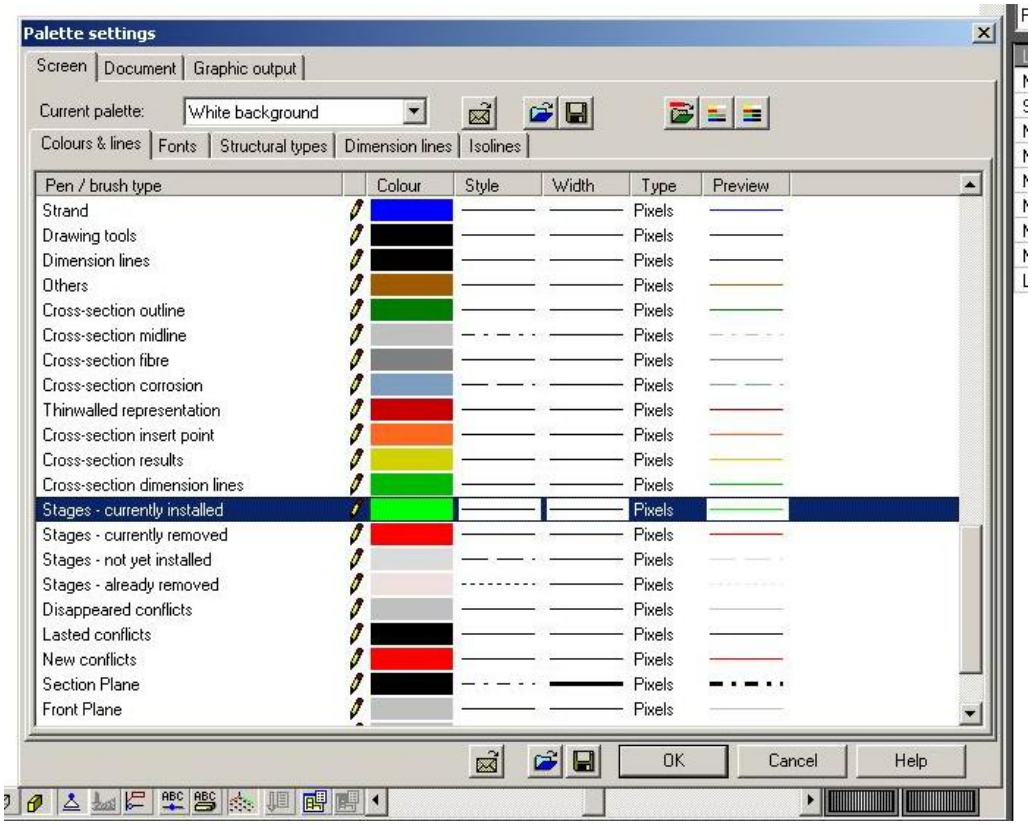
More LBH is possible to edit in one step



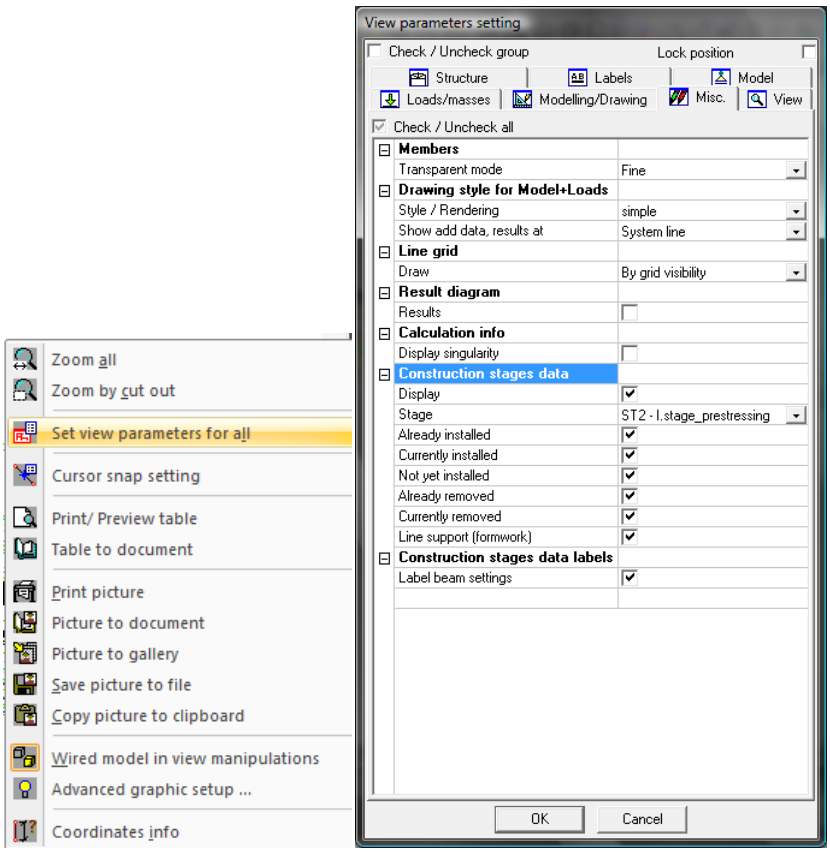
The LBHs are possible to view in document.



The colour drawing in 3D windows depends on settings in ***Setup> Colour/lines > Palette settings***.

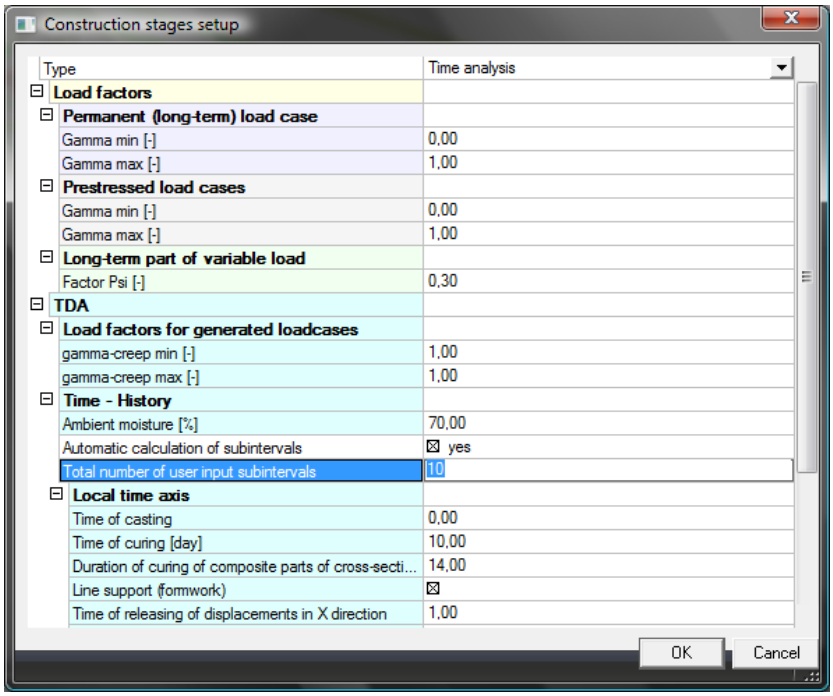


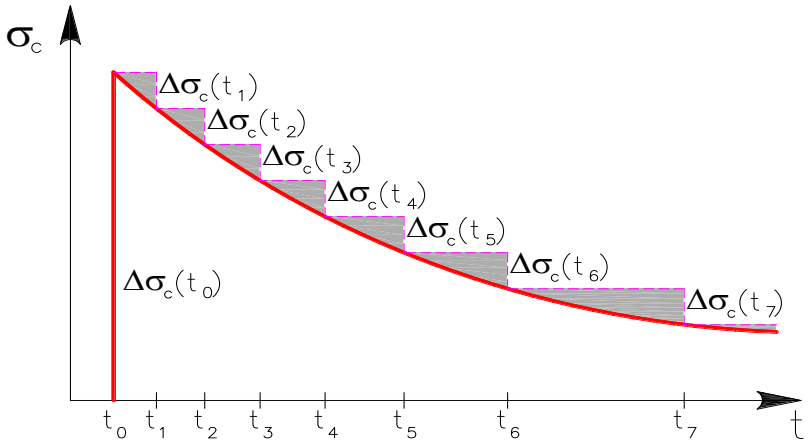
The drawing according to stages is possible to set by right click in 3D window ***Set view parameters for all*** and set which components of stages will be drawn.



3.2 Automatic calculation of subintervals

The user has to define in each stage number of subintervals. There is also possibility to defined total number of subintervals in whole construction in ***Setup of stages> Total number of subintervals***. The time axis will be divided according to the same logarithm increment into whole construction.

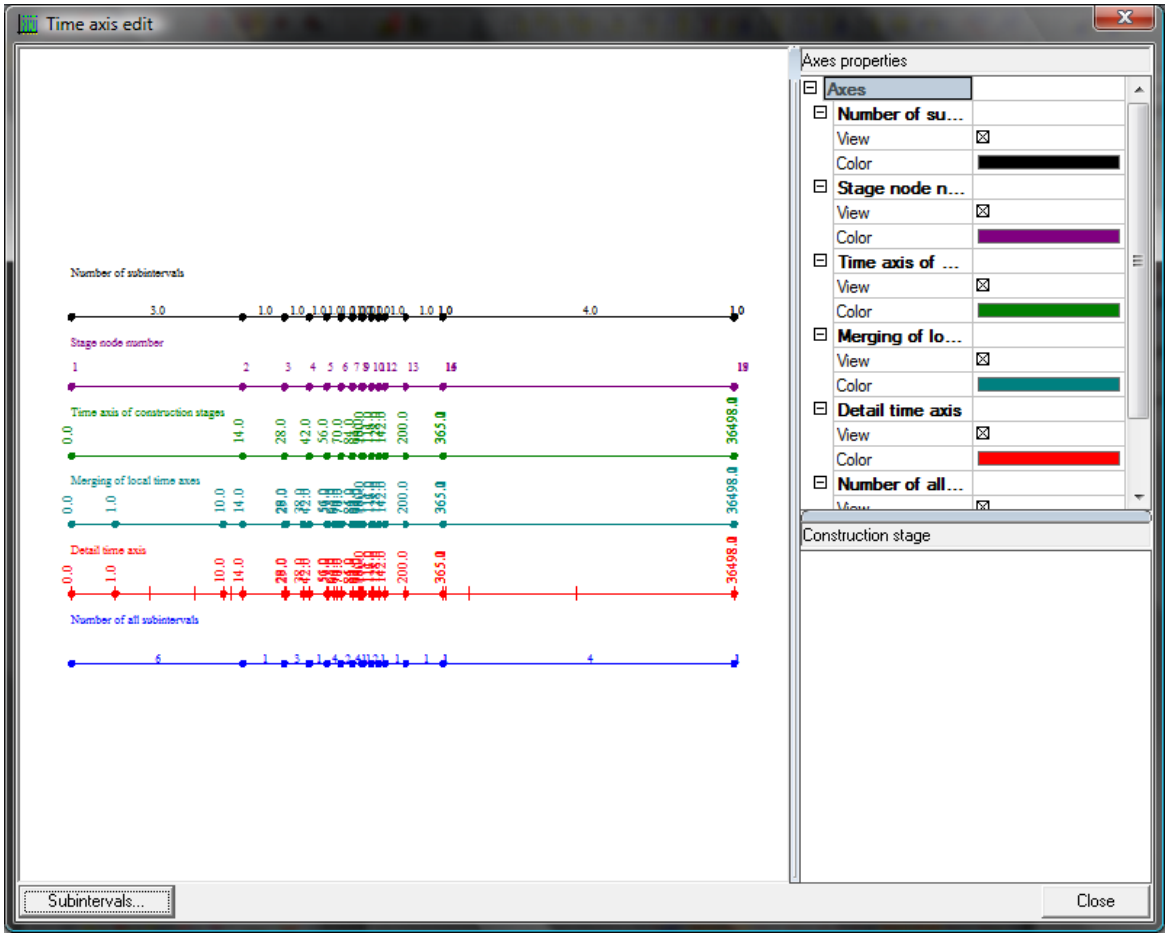


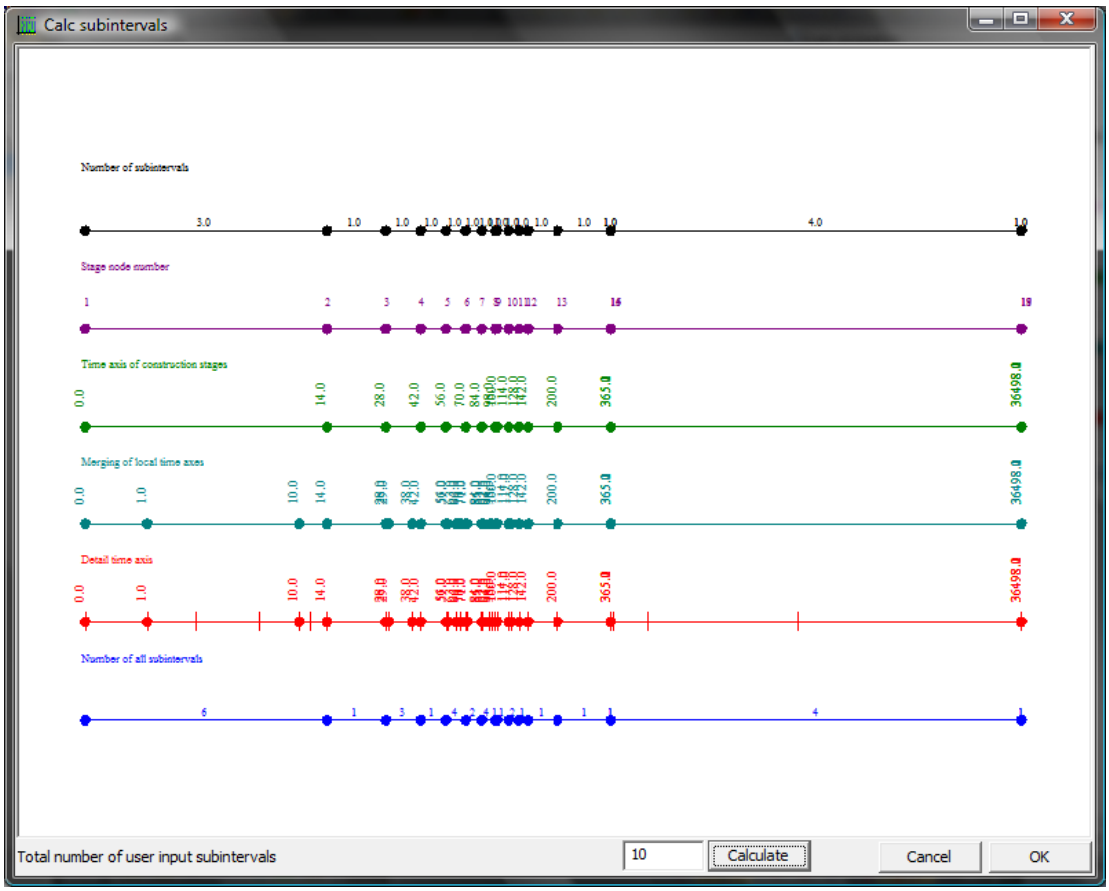


Total number of subinterval can be bigger then user defined because of following:

- **At least one subinterval has to be in each stage**
- **Keeping stress (duration of shorterm relaxation) is also considered as time point**

This option is possible also in ***Time axis> subintervals***. The user set total number of subintervals and could admit or refuse this offered solution of subintervals.




Calc subintervals
Number of subintervals
Stage node number
Time axis of construction stages
Merging of local time axes
Detail time axis
Number of all subintervals
Total number of user input subintervals
10
Calculate
Cancel
OK

4 Mobile loads

The load system gr1a (according to table 4.4 EN1991-2) is the most efficient load system for design and check of bridges. This system consists from

- Load model – LM1
  - Tandem system – TS
  - Uniformly distribute load – UDL
- Pedestrian or cyclist load

The combinations coefficients (ψ_0, ψ_1 a ψ_2) are different for the separate loads in this load system according to table A2.1 from the EN 1990/A1. The procedure of modelling and check using characteristic, frequent and quasi-permanent combination including load system gr1a is different from the using of standard procedure with loadcases which belongs to appropriate loadgroup with defined combination coefficient in menu ***Project***.

Zatížení	Značka		ψ_0	ψ_1	ψ_2
Zatížení dopravou (viz EN 1991-2, Tabulka 4.4)	gr1a (LM1+ zatížení chodci nebo cyklisty)[1)]	TS (dvojnápravy)	0,75	0,75	0
		UDL (rovnoměrné zatížení)	0,40	0,40	0
		Zatížení chodci + zatížení cyklisty[2)]	0,40	0,40	0
	gr1b (jednotlivá náprava)		0	0,75	0
	gr2 (vodorovné síly)		0	0	0
	gr3 (zatížení chodci)		0	0	0
	gr4 (LM4 (zatížení davem lidí))		0	0,75	0
	gr5 (LM3 (zvláštní vozidla))		0	0	0
Zatížení větrem	F_{wk}				
	- Trvalé návrhové situace		0,6	0,2	0
	- Provádění		0,8	-	0
	F_w*		1,0	-	-
Zatížení teplotou	T_k		0,6[3)]	0,6	0,5

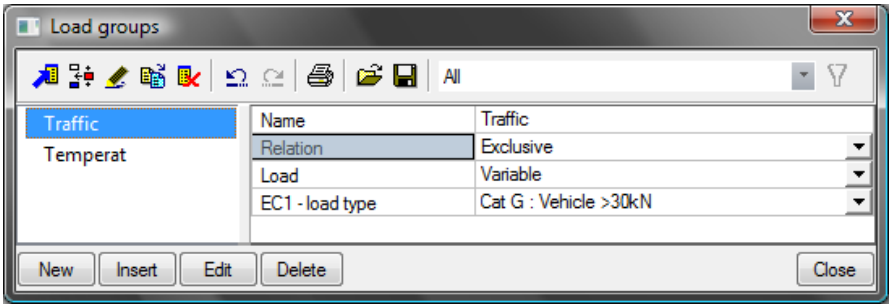
The rules for SLS combination according to tab. A2.6 from EN1990/A1

	Permanent	Prestress	The dominant variable (traffic)	The subordinate variable (temperature)
Characteristic	Gi	P	1,0*Qk1	ψ_0* Qki
Frequent	Gi	P	ψ_1*Qk1	ψ_2* Qki
Quasi-permanent	Gi	P	ψ_2* Qki	ψ_2* Qki

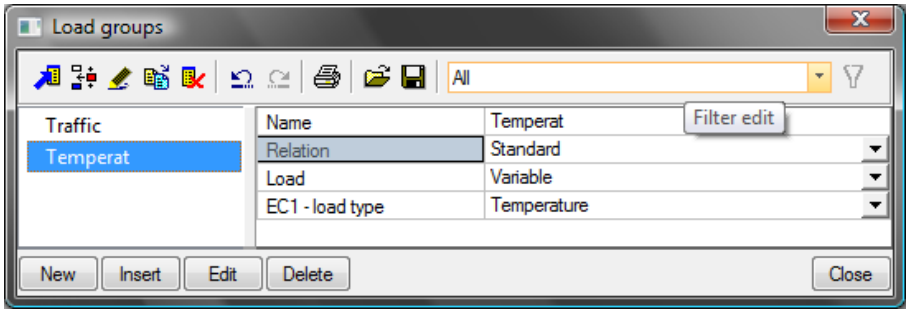
4.1 Preparation of mobile load in SEN

4.1.1 The load group

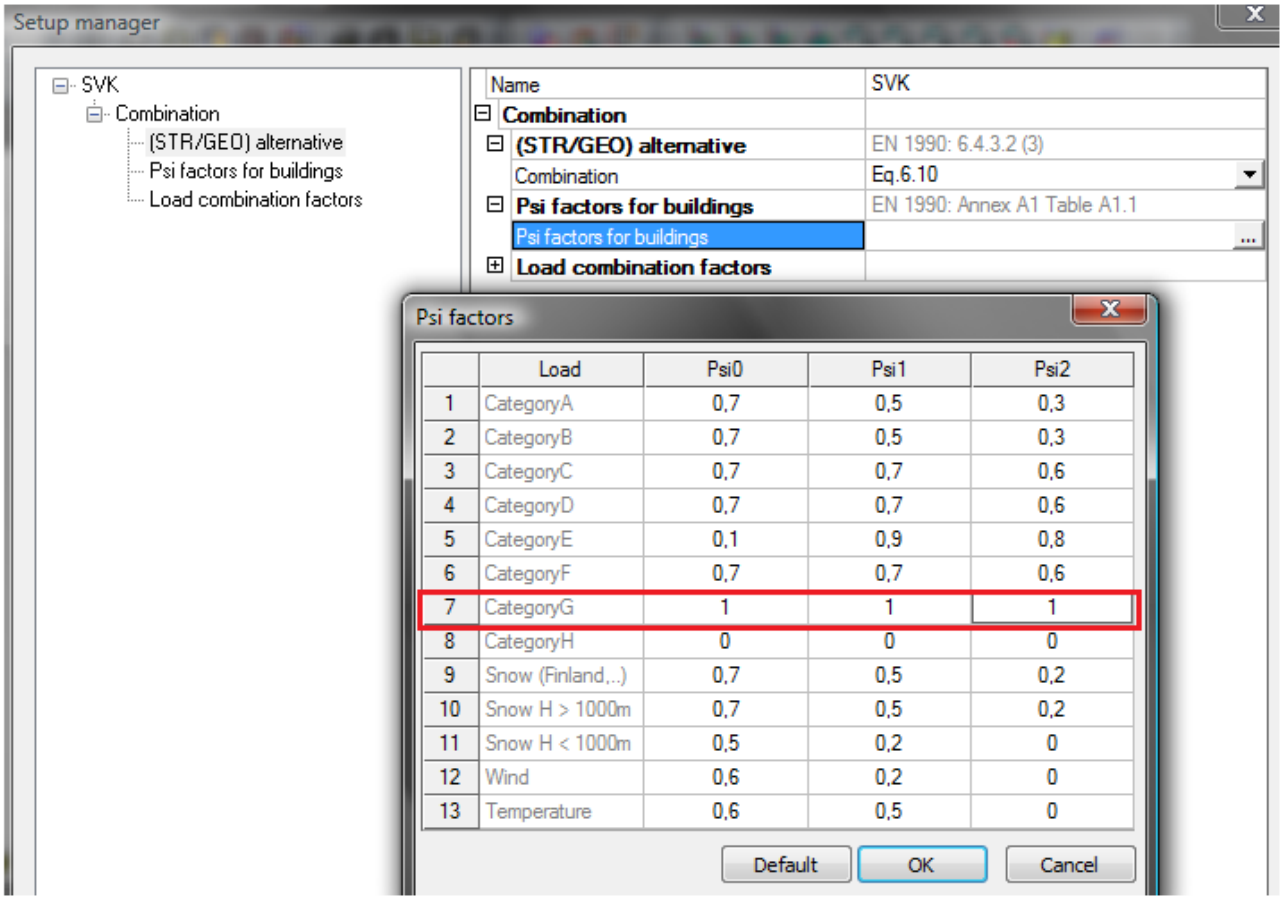
The new Load group (LG) with name ***Traffic*** is created, type is ***Variable exclusive***. This LG will be registered to category of load G – traffic >30kN



The temperature load is possible to insert to different LG (temperature) with predefined combination coefficient (the coefficient cannot be set to 1,0)

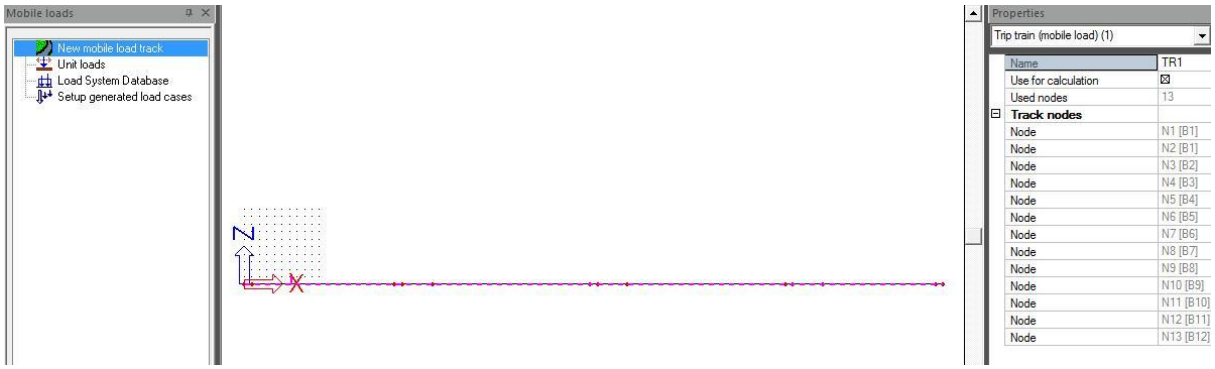


The default combination factors should be set to ***1,0*** for selected LG.



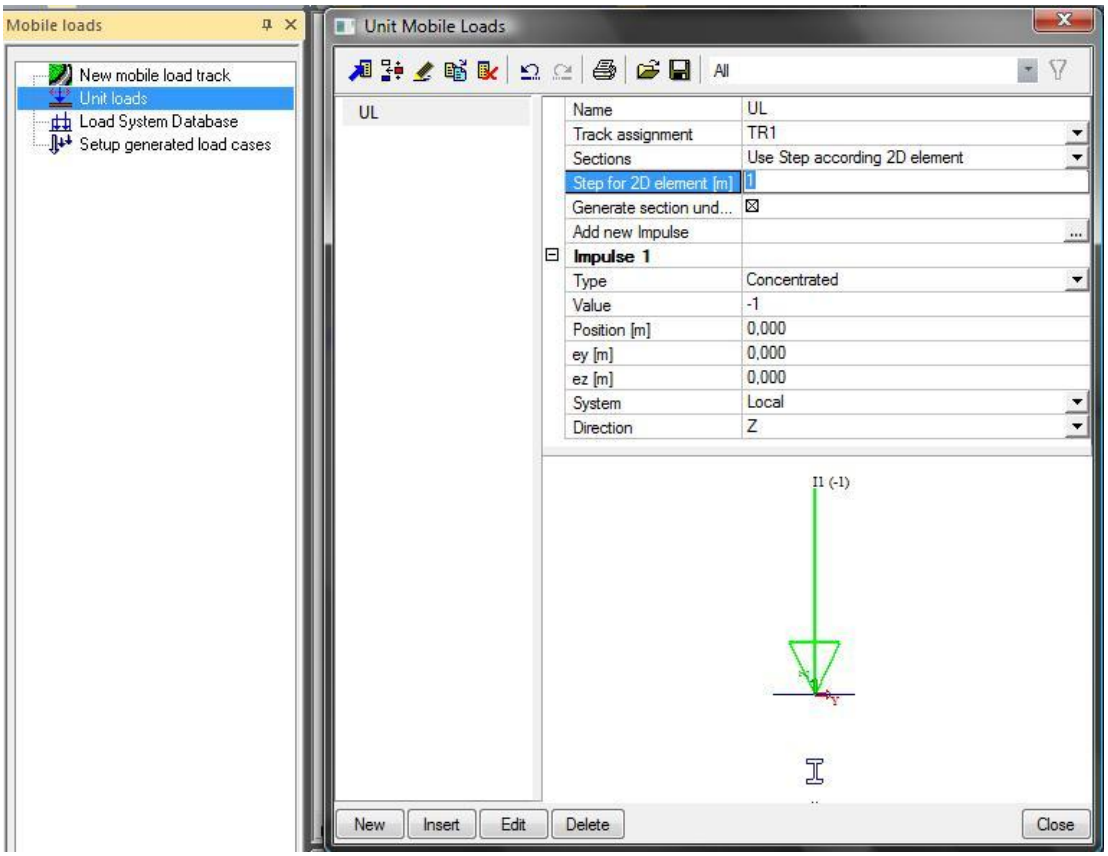
4.1.2 Mobile load track

New mobile load track (TR1) has to be defined by user ***Mobile loads > New mobile load track.*** The first and last node will be selected and track will be automatically defined on whole structure



4.1.3 Unit load

New Unit load (UL) will be defined by user ***Mobile loads > Unit loads.***

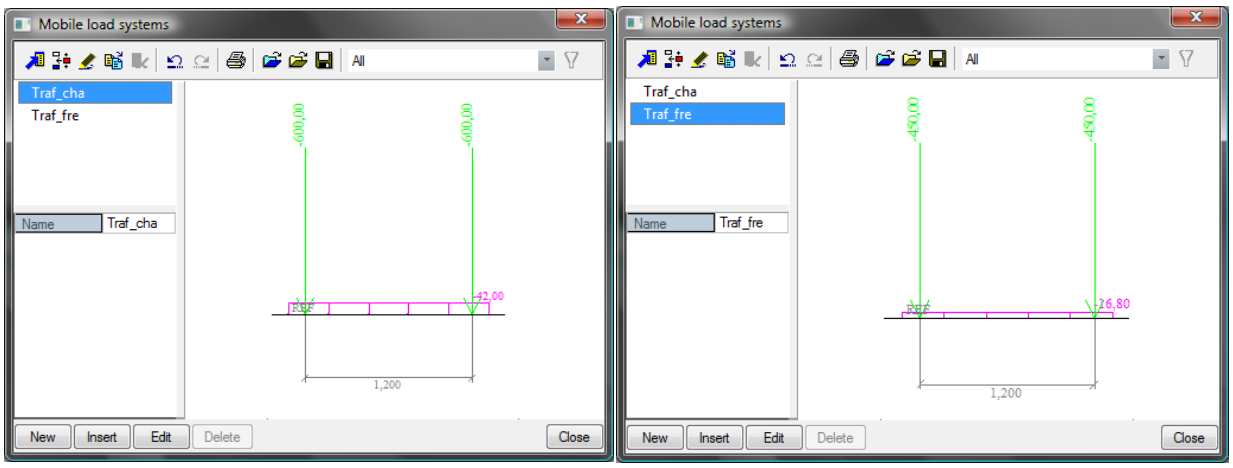


4.1.4 Load system database

The new Load system databases will be defined for each type of combination including combination coefficients for characteristic and frequent combination. ***Mobile loads > Load system database***

Traf_char – Load system for characteristic combination ***1,0*TS+1,0*UDL***

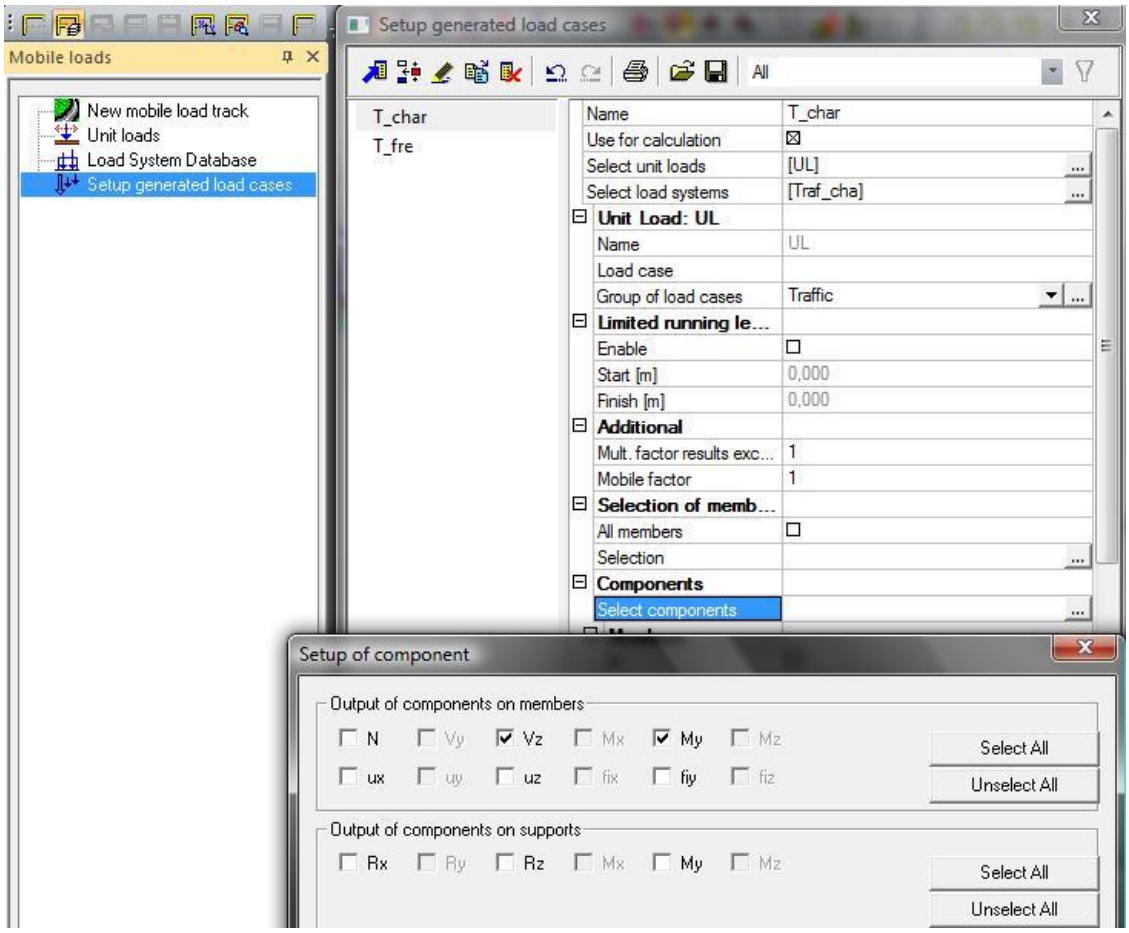
Traf_fre – Load system for frequent combination ***0,75*TS+0,4*UDL***

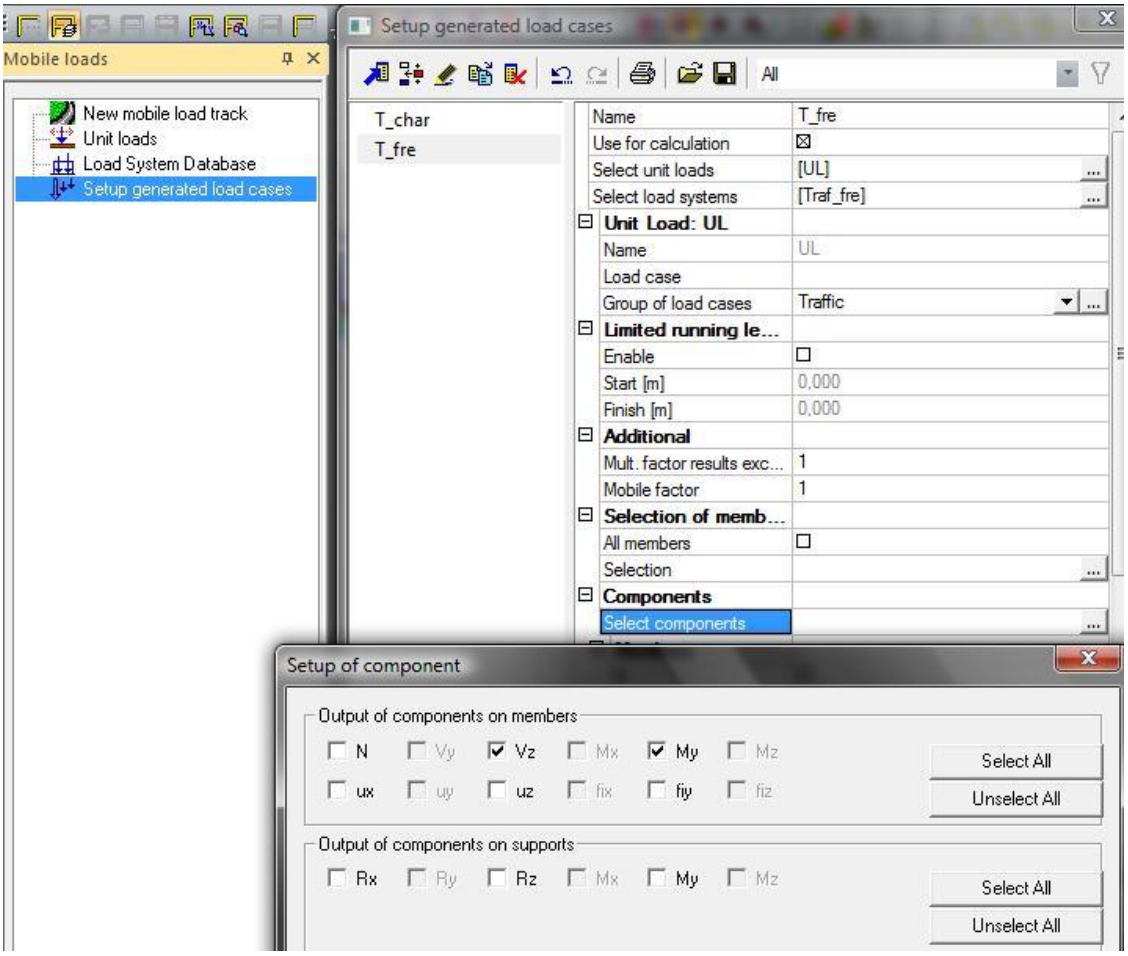


4.2 Setup of generated loadcase

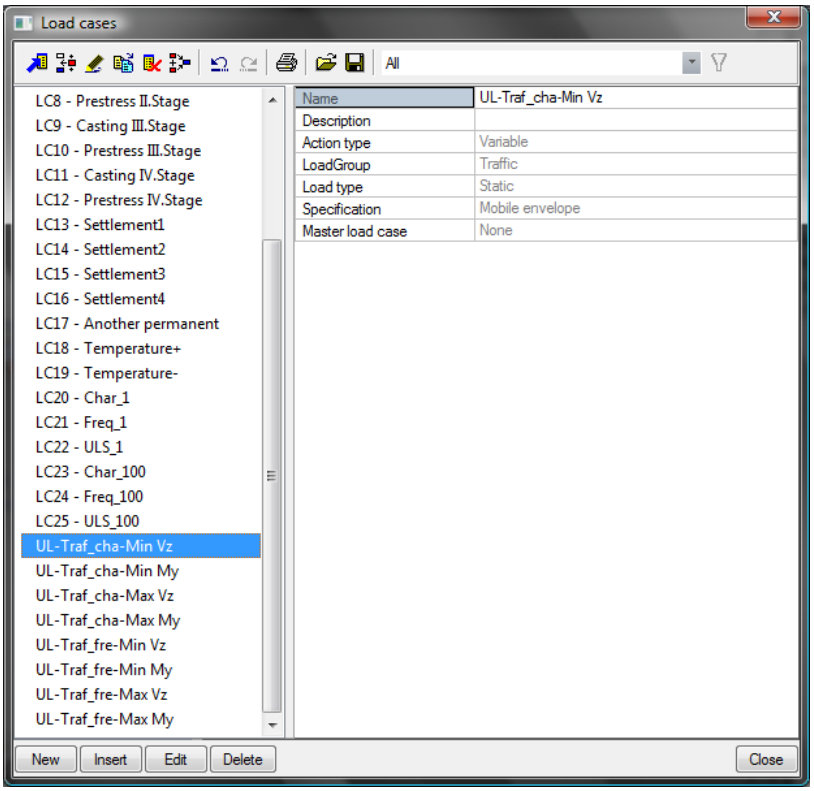
Two groups of generated loadcase should be set in ***Setup of generated loadcase***. The same LG - ***Traffic*** should be assign to each group of generated LC. The components ***Vz*** and ***My*** will be evaluated.

- ***T_char*** – Unit loads (***UL***) + load system database (***Traf_char***)
- ***T_fre*** – Unit loads (***UL***) + load system database (***Traf_fre***)





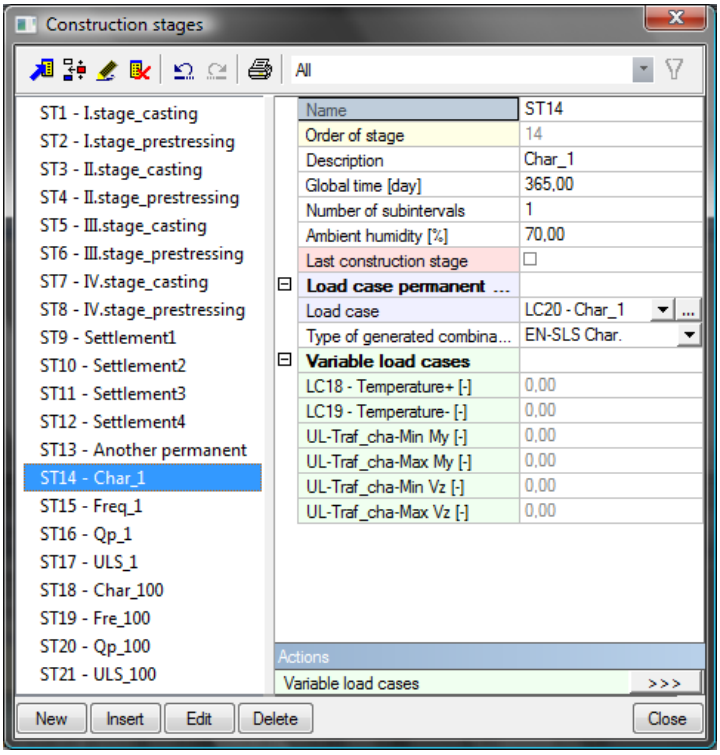
The envelopes of LC will be automatically generated after linear calculation finish. These generated LC will be added into appropriate stages.



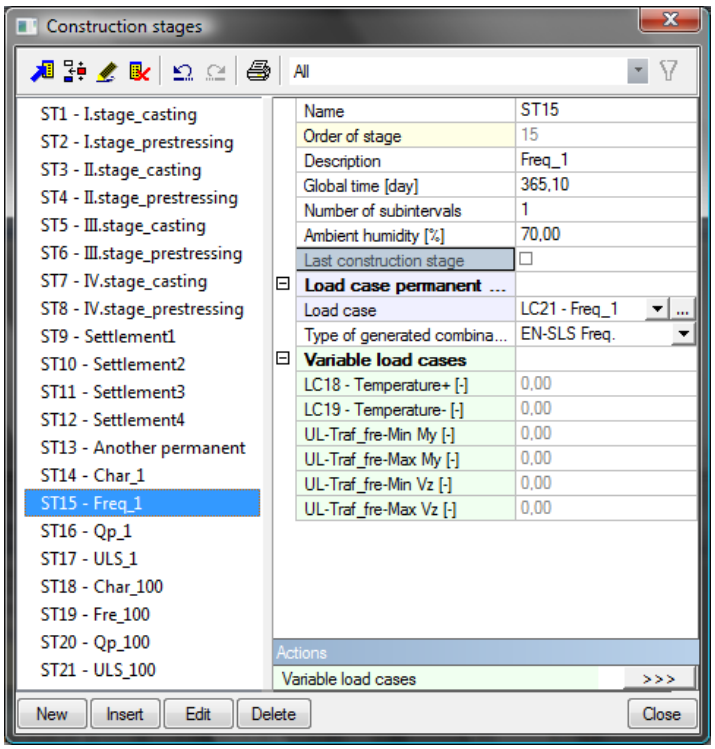
4.3 Definition of construction stages

The separated construction stages were created in construction stages library (see). The appropriate envelopes of variable LC will be add to each construction stage according to type of generated combination

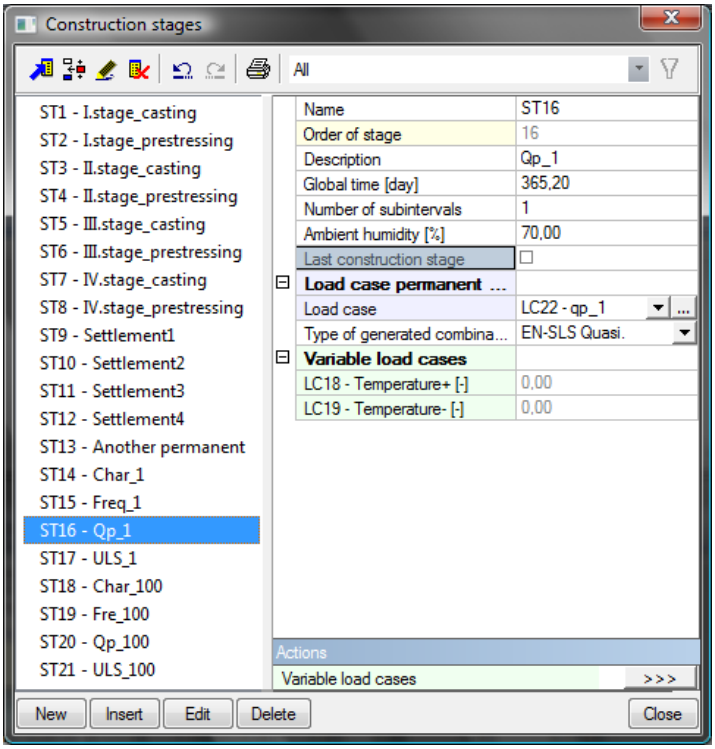
- **Char_1** – characteristic combination
  - time 365 days
  - MSP-characteristic
  - UL-Traf_char-Min My
  - UL-Traf_char-Max My
  - UL-Traf_char-Min Vz
  - UL-Traf_char-Max Vz
  - Temperature+
  - Temperature-



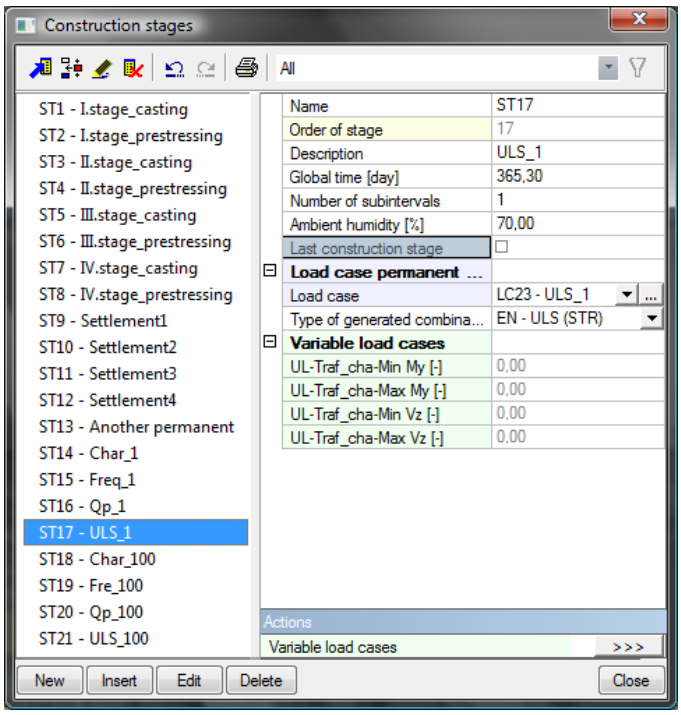
- **Fre_1**– frequent combination
  - time 365,1days
  - MSP-frequent
  - UL-Traf_fre-Min My
  - UL-Traf_fre-Max My
  - UL-Traf_fre-Min Vz
  - UL-Traf_fre-Max Vz
  - Temperature+
  - Temperature-



- **QP_1**– quasi-permanent combination
  - time 365,2days
  - MSP-quasi-permanent
  - Temperature+
  - Temperature-



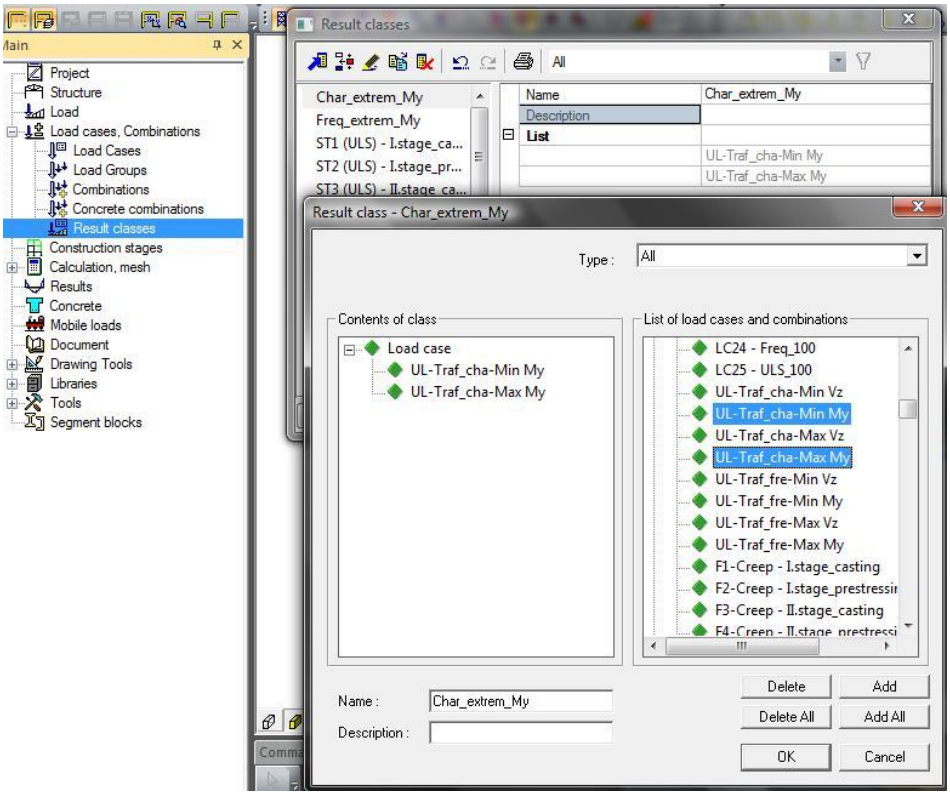
- **ULS_1** – ULS(STR) combination
  - time 365,3 days
  - ULS(STR)-combination
  - UL-Traf_char-Min My
  - UL-Traf_char-Max My
  - UL-Traf_char-Min Vz
  - UL-Traf_char-Max Vz



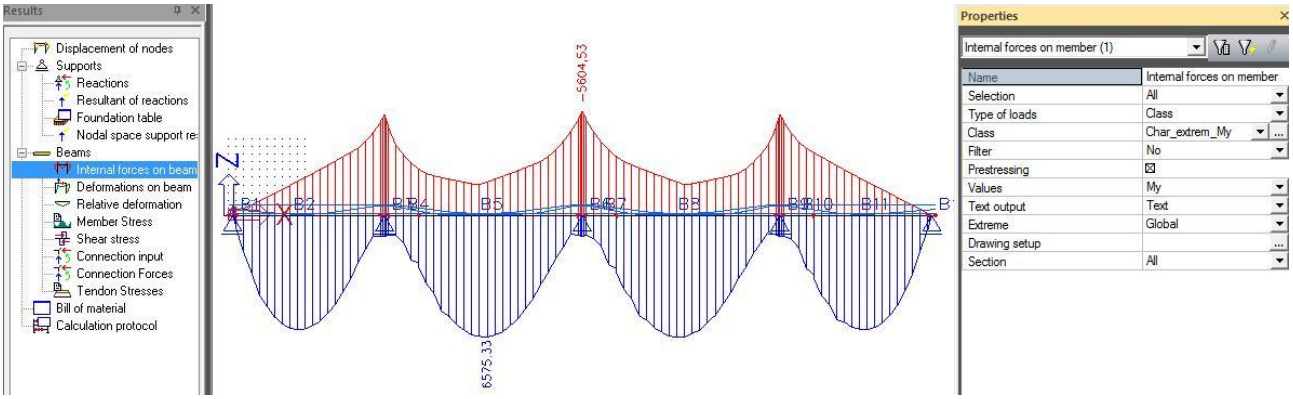
4.4 Evaluation of mobile loads - envelopes

The evaluation of maximum and minimum envelopes in one presentation in results is possible using ***Loadcases, Combination>Results classes***.

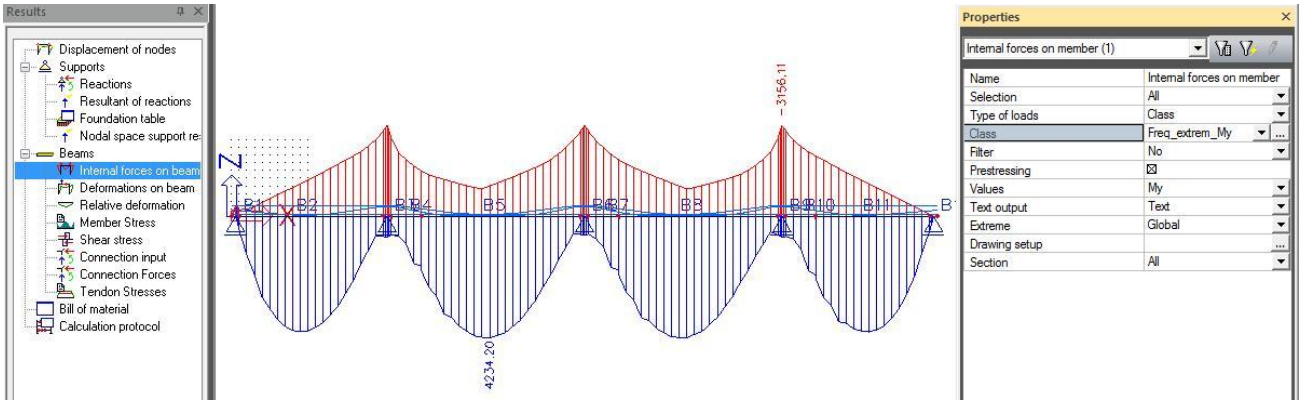
- ***Char_extrem_My*** – extreme of envelopes of mobile loads for ***characteristic*** combination
  - UL_Traf_char_maxMy
  - UL_Traf_char_minMy
- ***Fre_extrem_My*** – extreme of envelopes of mobile loads for ***frequent*** combination
  - UL_Traf_fre_maxMy
  - UL_Traf_fre_minMy



The internal force are possible to see in ***Results> Internal forces***. The user can select in ***Type of loads – Class*** and form the list of classes selects ***Char_extrem_My***. The extreme moment is drawn from minimum and maximum envelopes of mobile load for characteristic combination***.***

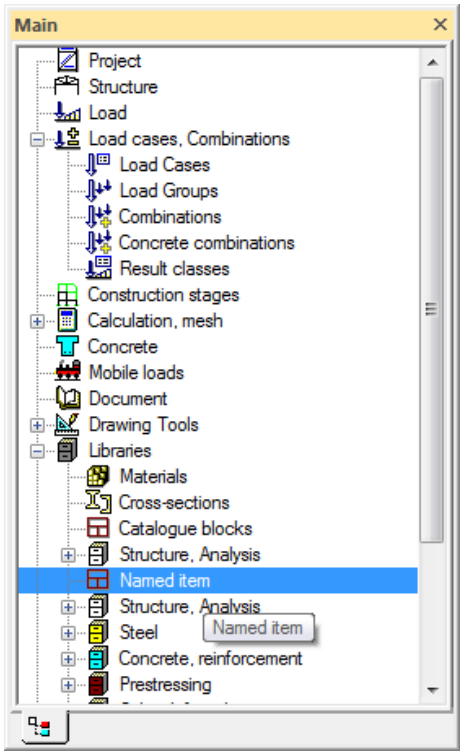


And for ***frequent*** combination.



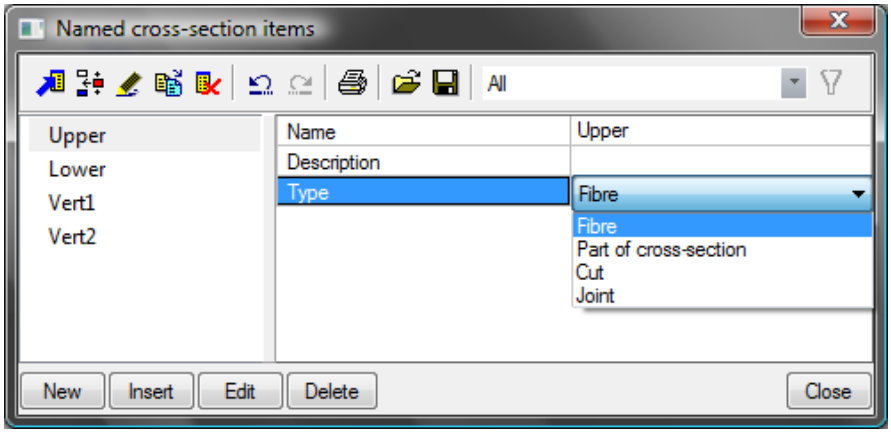
5 Library of Named items

The library of Named items is possible to view in ***Library>Named item***.



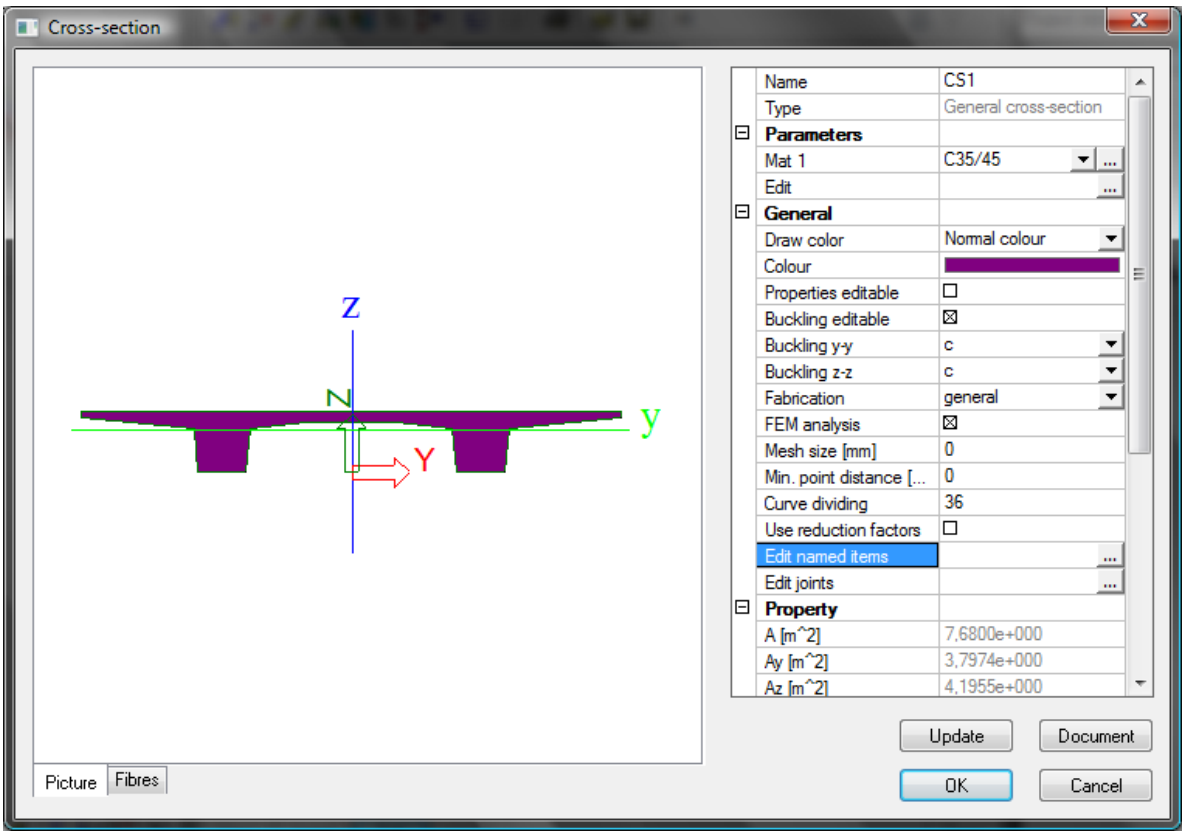
The user has possibility to defined following named items in this library

- ***Fibre*** – for evaluation of results of allowable concrete stresses in predefined named fibres only
- ***Part of cross-section*** - for evaluation of results of allowable principal stresses in predefined named part of cross-section if phased CSS exists
- ***Cut*** - for evaluation of results of allowable principal stresses in predefined named cuts of cross-section
- ***Joint*** – for evaluation of results of shear stress in construction joint in predefined named joint if phased CSS exists

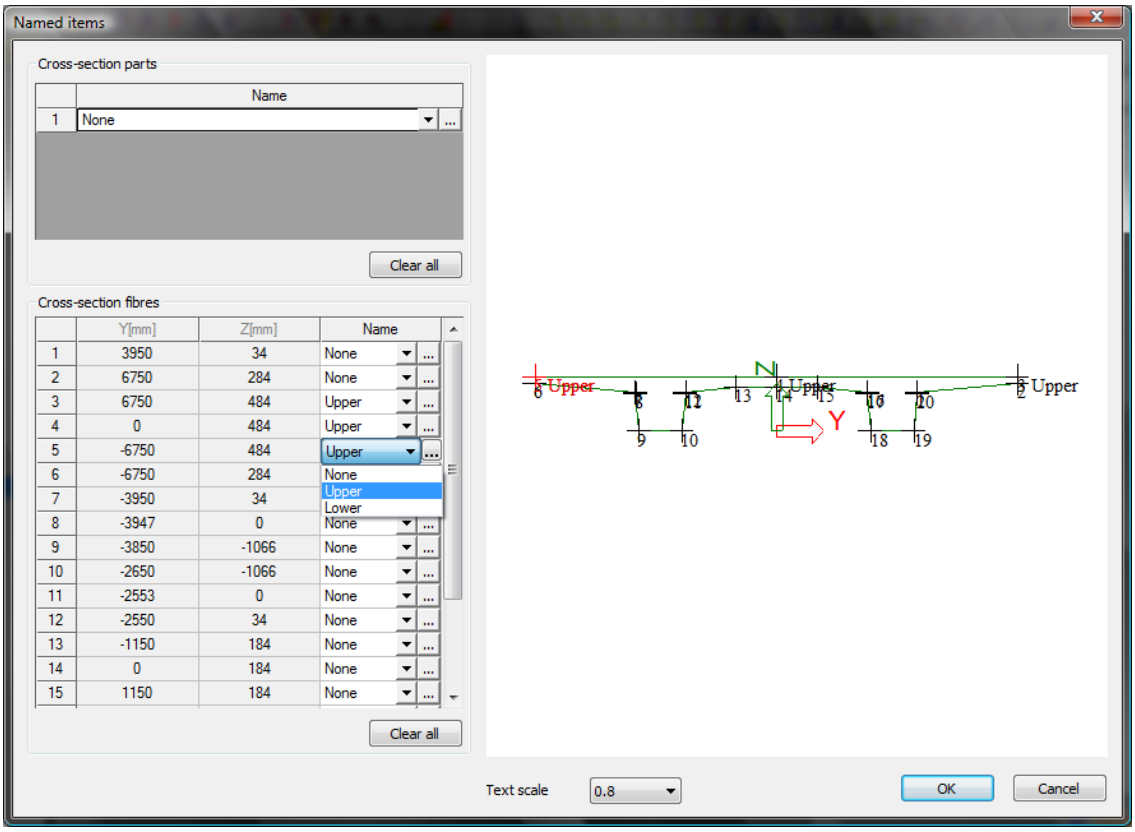


5.1 Named fibres

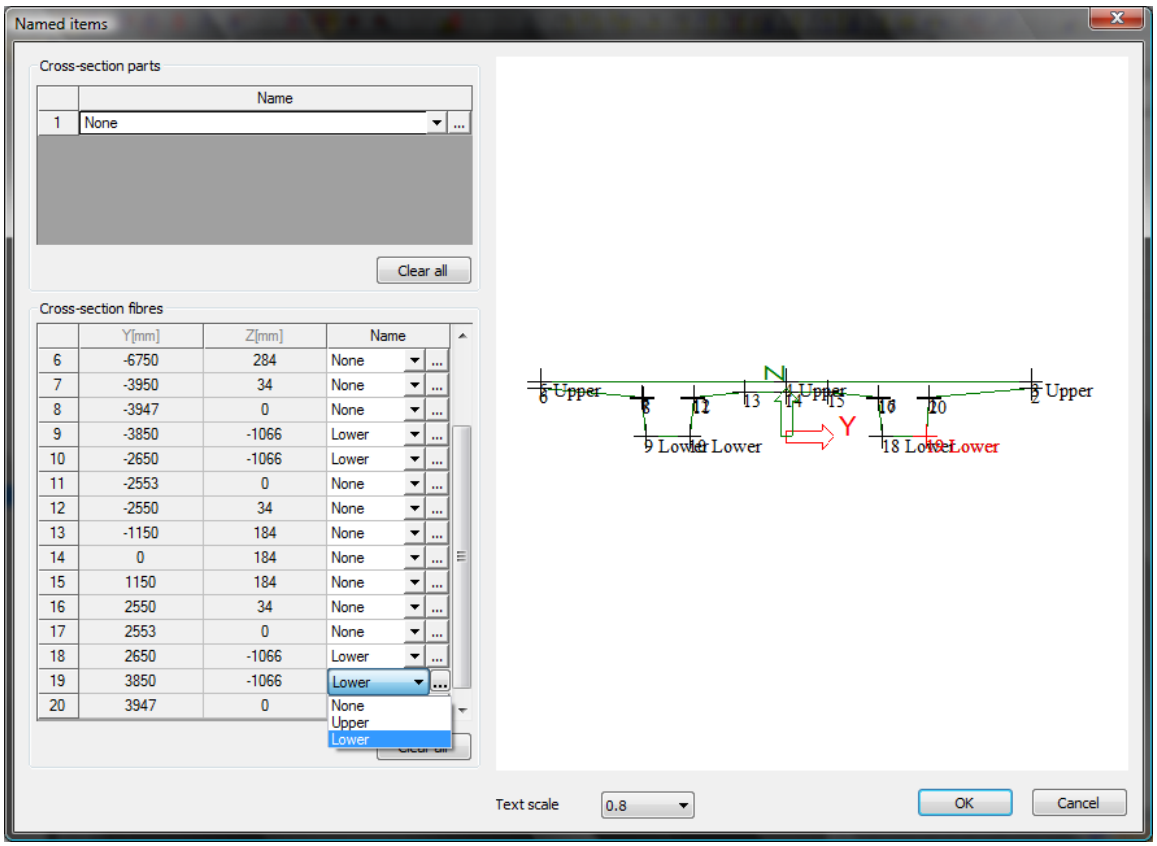
When user defined named items in library, then is necessary to linked named items to appropriate fibres, cuts, part of CSS and joints in selected CSS. The fibres and part of CSS are possible to define in selected CSS by button ***Edit named items***.



To the upper fibres with number 4, 5, 6 will be assigned named fibre ***Upper*** from named fibre library.

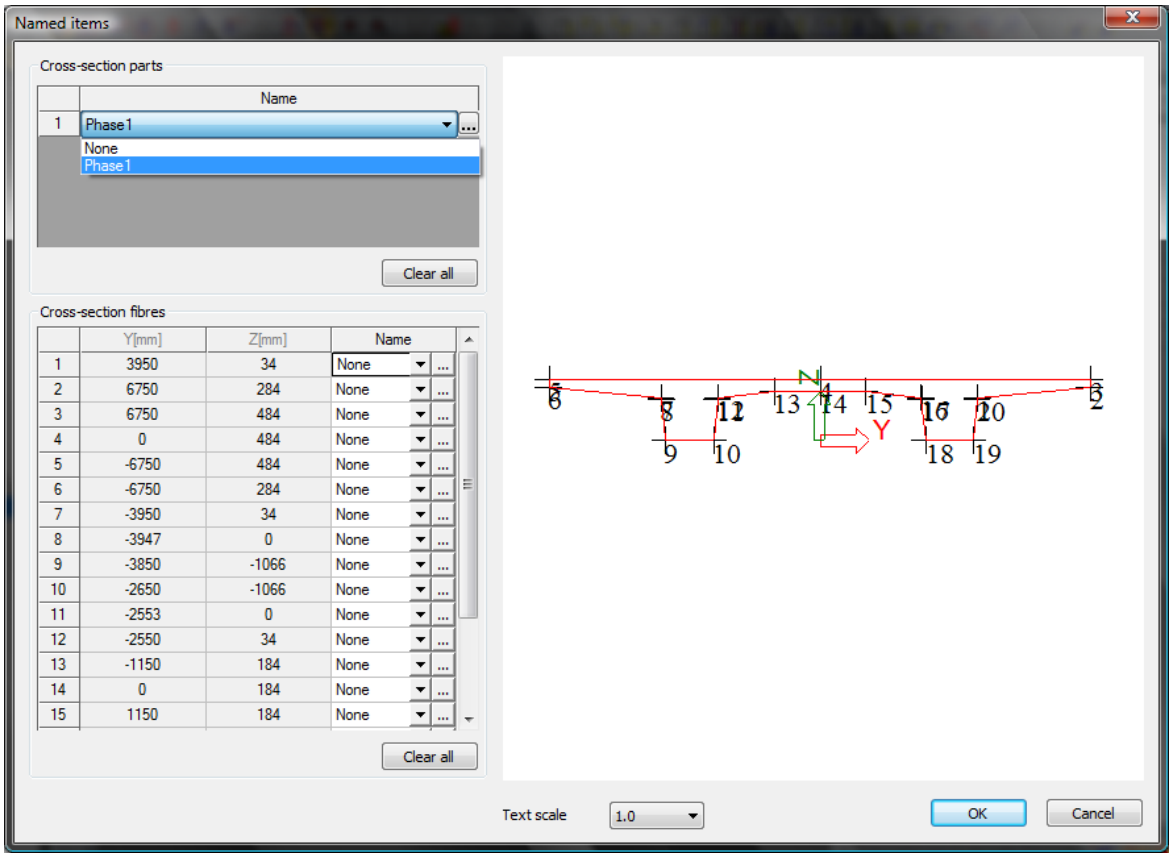


To the lower fibres with number 9 10, 18, 19 will be assigned named fibre ***Lower*** from named fibre library.



5.2 The named part of CSS

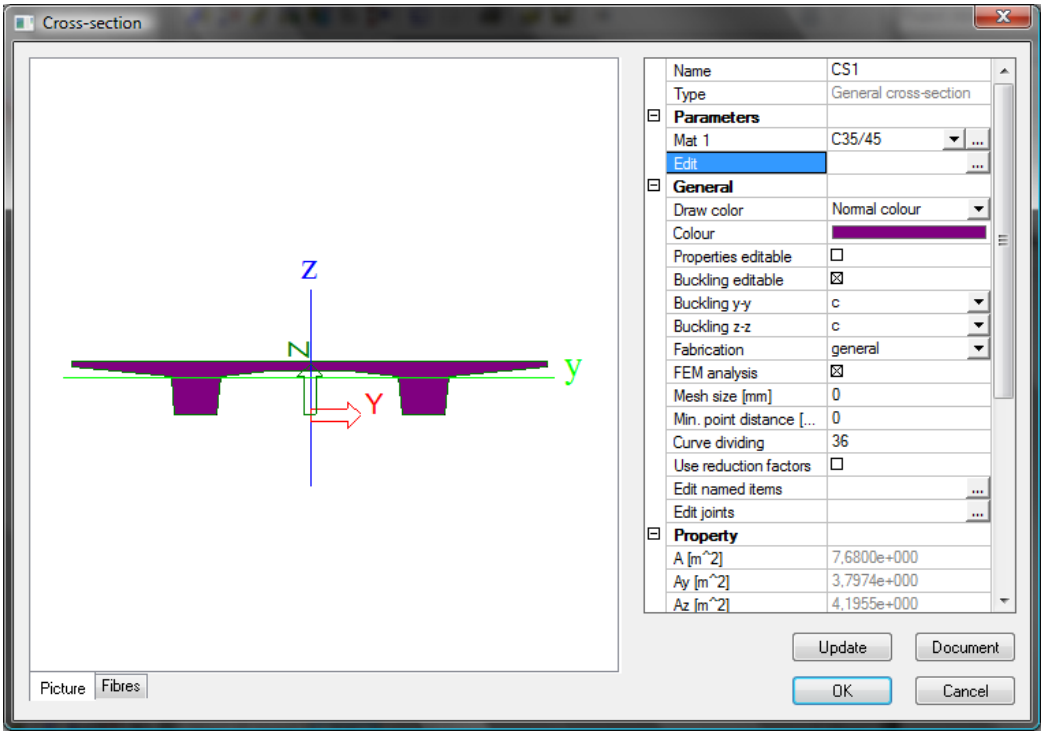
The named part of CSS could be defined in case of phased CSS in upper left part of dialog.



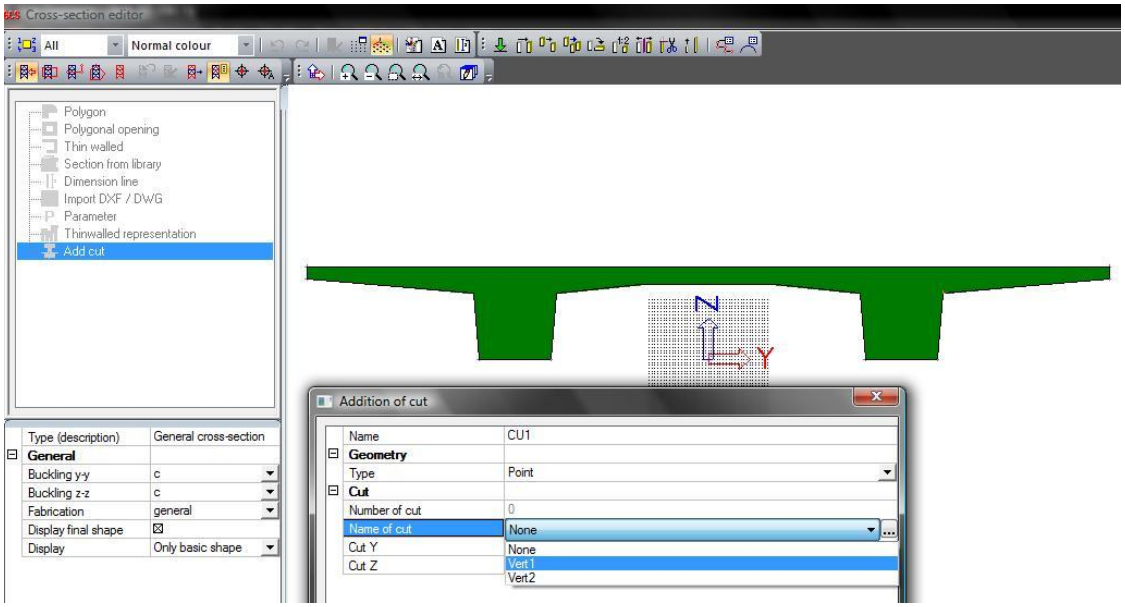
5.3 Named cuts

5.3.1 For general CSS

The named cuts are possible to add to the cut in ***Editor of general CSS***.



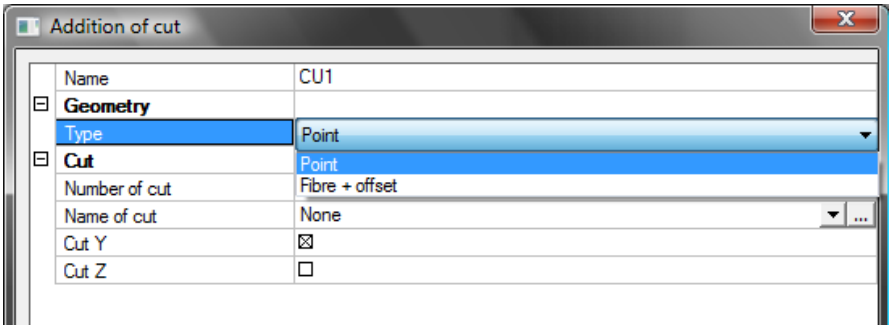
The definition of new cut is possible by button ***Add cut*** in ***editor of general CSS***.



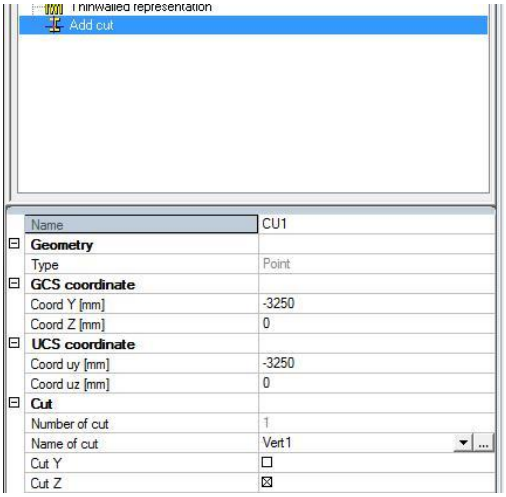
There are two possibilities how to defined a cut

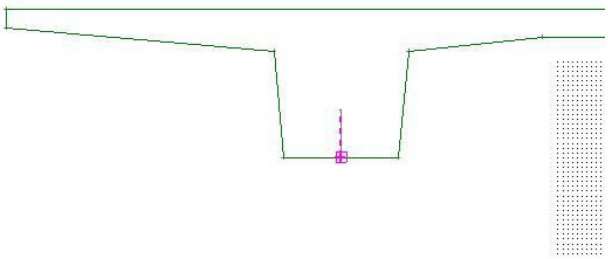
- ***Point*** – cut is defined in selected point
- ***Fibre + offset*** – cut is defined in offset from selected fibre

There is also possibility to set only cut in direction Y or Z.



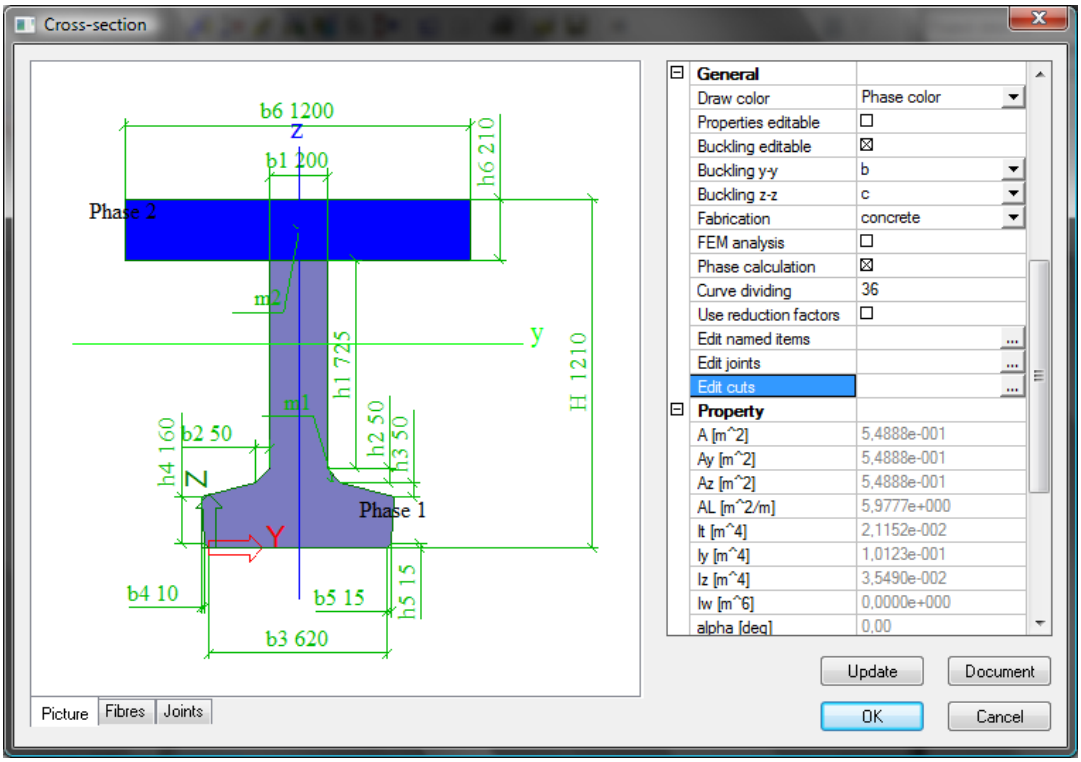
The vertical cut in the left beam of CSS was defined.



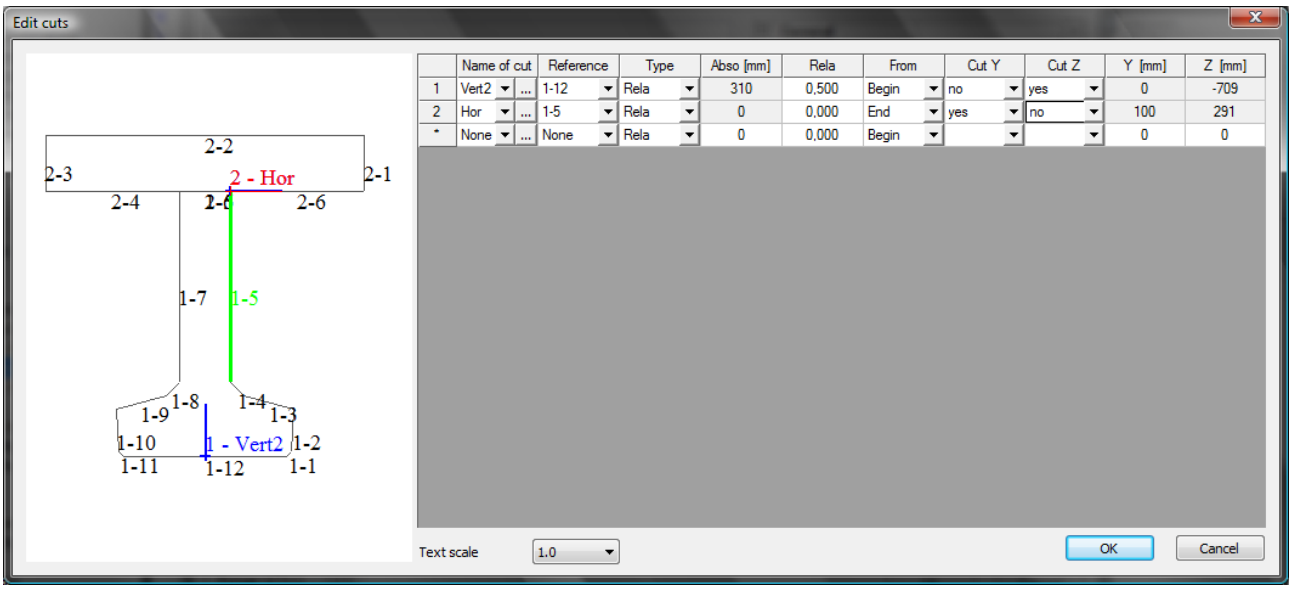


5.3.2 For database CSS

The definition of new cut is possible by button ***Edit cuts*** for database CSS.

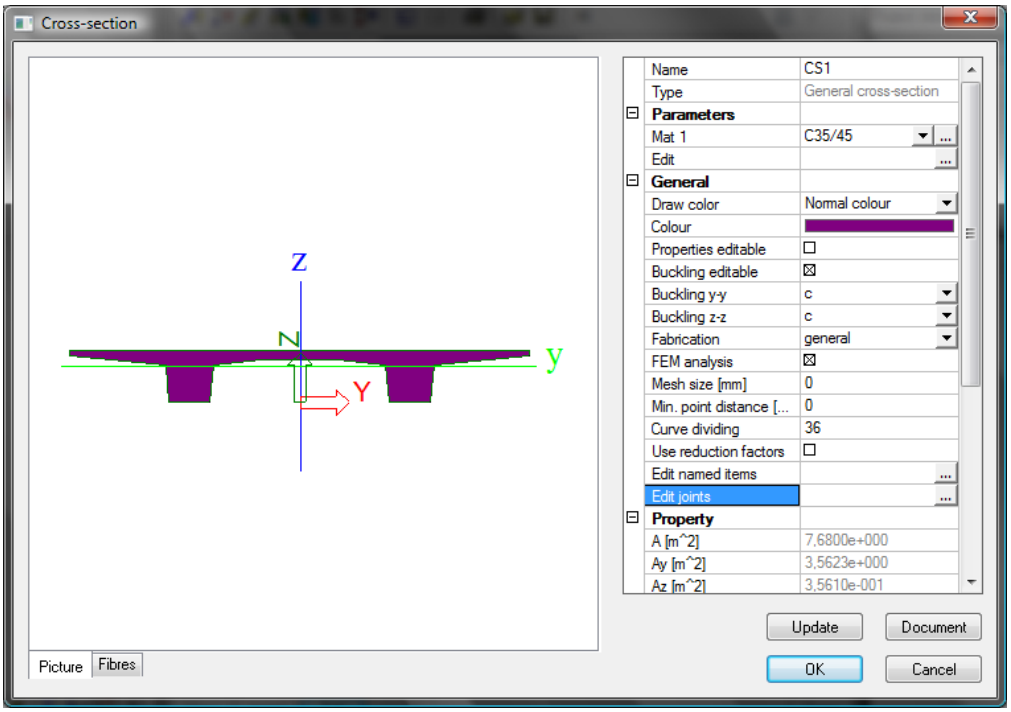


The property of ***Edit cuts dialog*** for database CSS is following.



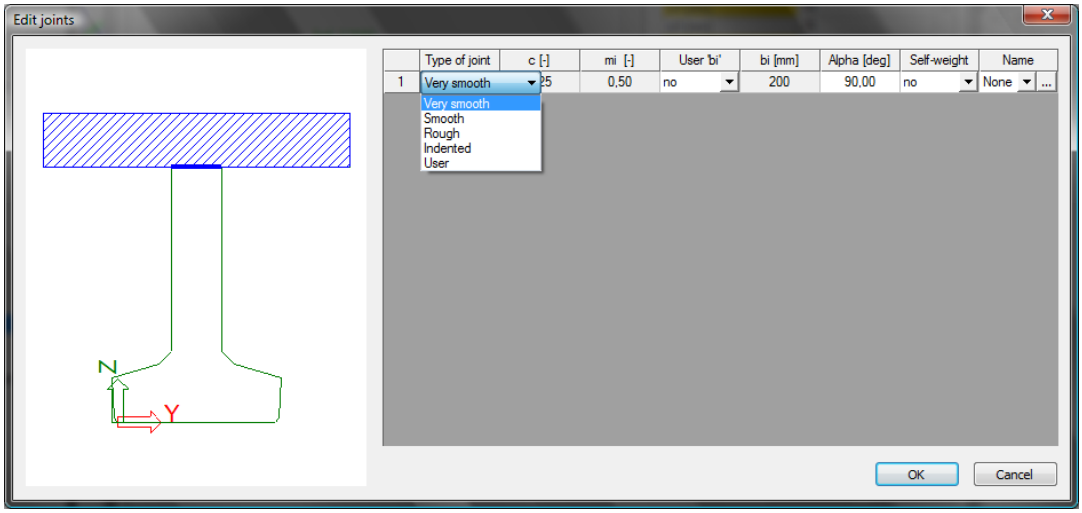
5.4 Named joints

The named joint could be defined in case of phased CSS using button ***Edit named joint*** in General CSS dialog.



The CSS is solid, that's why no joints are displayed in Joint dialog.

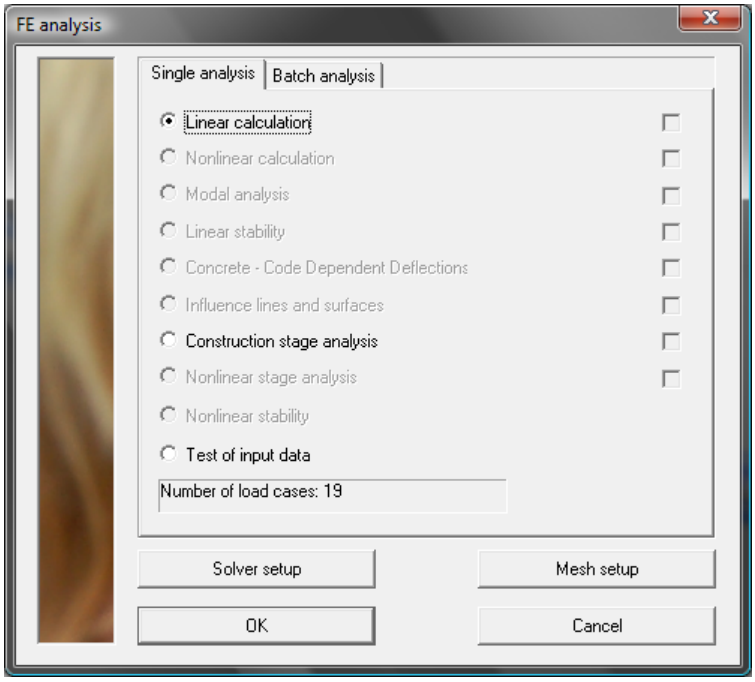
The following properties will be displayed in case of phased CSS.



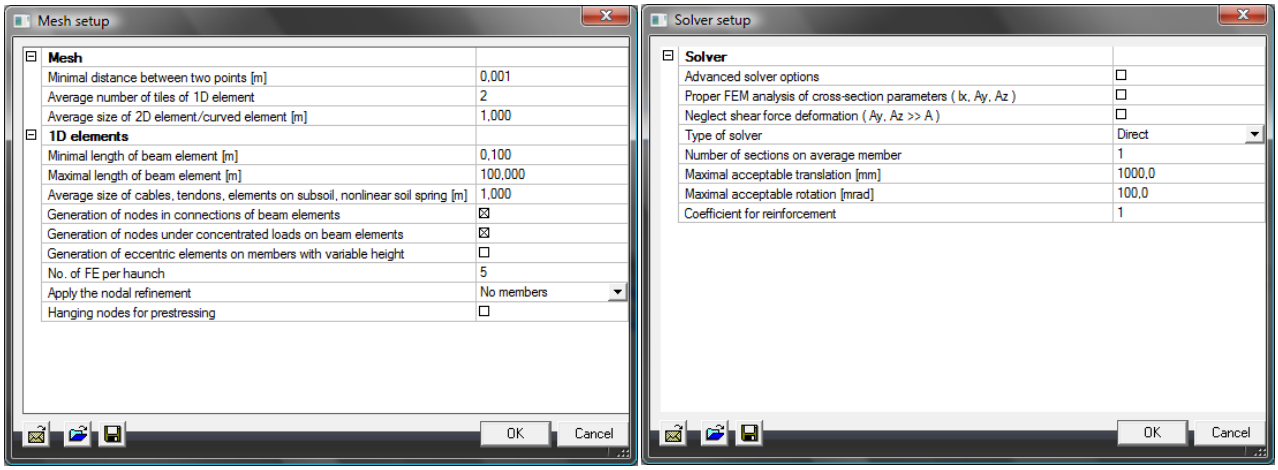
6 Analysis

6.1 Linear analysis

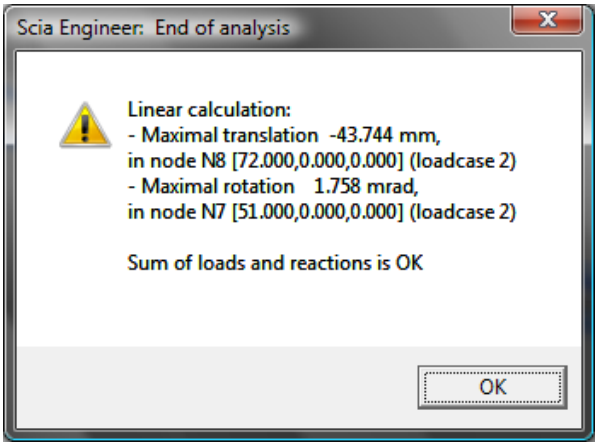
The linear analysis has to be done for generation of envelopes from mobile loads (see 4.2).



Mesh and Solver setup values used in analysis is possible to modify in ***Setup> Mesh, Solver***.

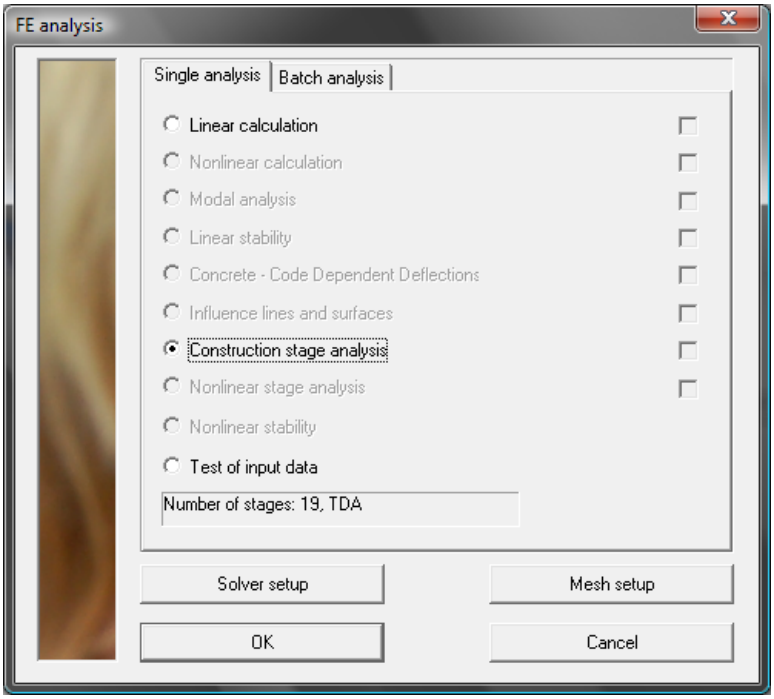


After successful calculation appear following message.



6.2 Construction stage analysis (TDA EN1992-1-1)

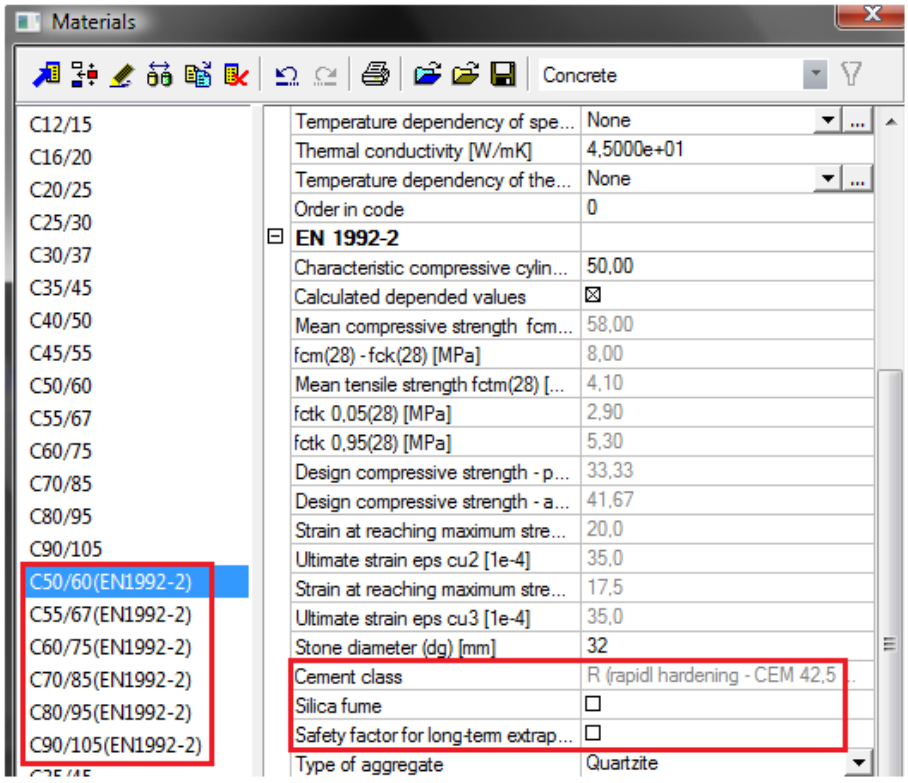
The construction stage analysis is performed for calculation of effects of stages with influence of effects creep and shrinkage (TDA). Effects of creep and shrinkage are performed according to EN1992-1-1 annex B.



6.3 Construction stage analysis (TDA EN1992-2)

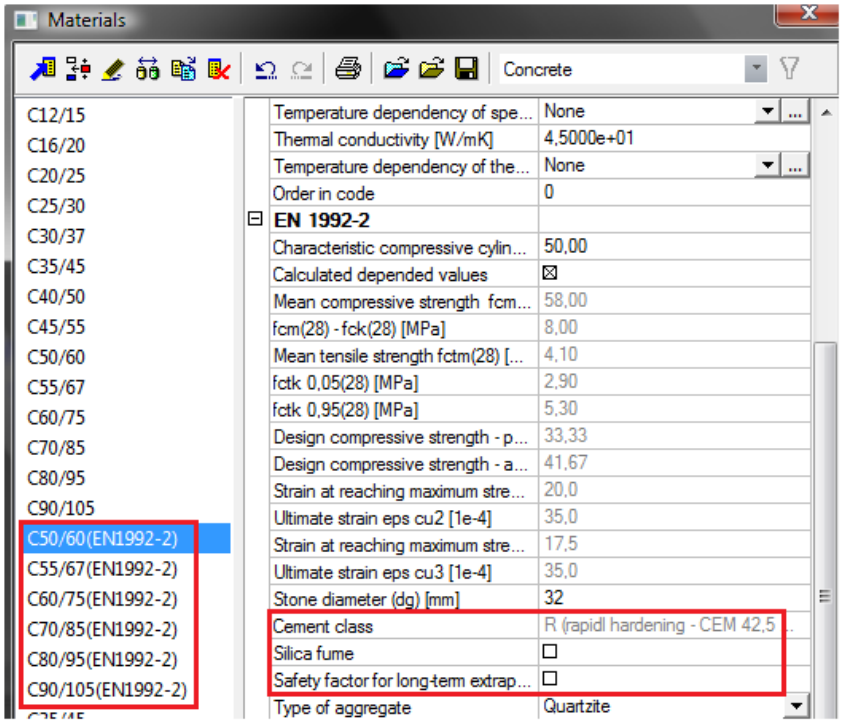
There is also possibility to run calculation of TDA (creep and shrinkage calculation) according to code EN 1992-2 annex B, but some necessary steps have to be done.

The main idea is to include another type (EN 1992-2) of material into one code EN 1992. There are two groups of materials (EN1992-1-1 and EN1992-2). Due to implementation of calculation creep and shrinkage of concrete according to EN 1992-2 is suitable to present new type of concrete material. These materials are signed similar as standard EN material with suffix EN1992-2. New materials are following:



- **Materials with f_{ck} < 50 MPa is not available.**
- **Cement class** – only type R (read only)
- **Silica fume** – checkbox YES/NO – influence on calculation of creep and shrinkage acc. to EN 1992-2 annex B
- **Relative humidity** - The code EN 1992-2 is not allowed calculation creep and shrinkage for relative ambient humidity bigger then 80%. When user uses concrete material according to EN1992-2 and sets RH>80% then during start TDA calculation appears warning about relative humidity.

- **Long term delayed strain estimation**
- Long term delayed strain estimation is used acc. to chapter B.105, implementation of formula B.128. The coefficient calculated with that formula is applied on formulas for concrete aged 1 year or more:
  - φ(t;t0) (B.1) and εcd,0 (B.11) for concrete EN1992-1-1
  - εcd(t) (B.116) and φb(t;t0) (B.118) for concrete EN1992-2
- User can set this option in material database in property of concrete for both EN concrete (see following)



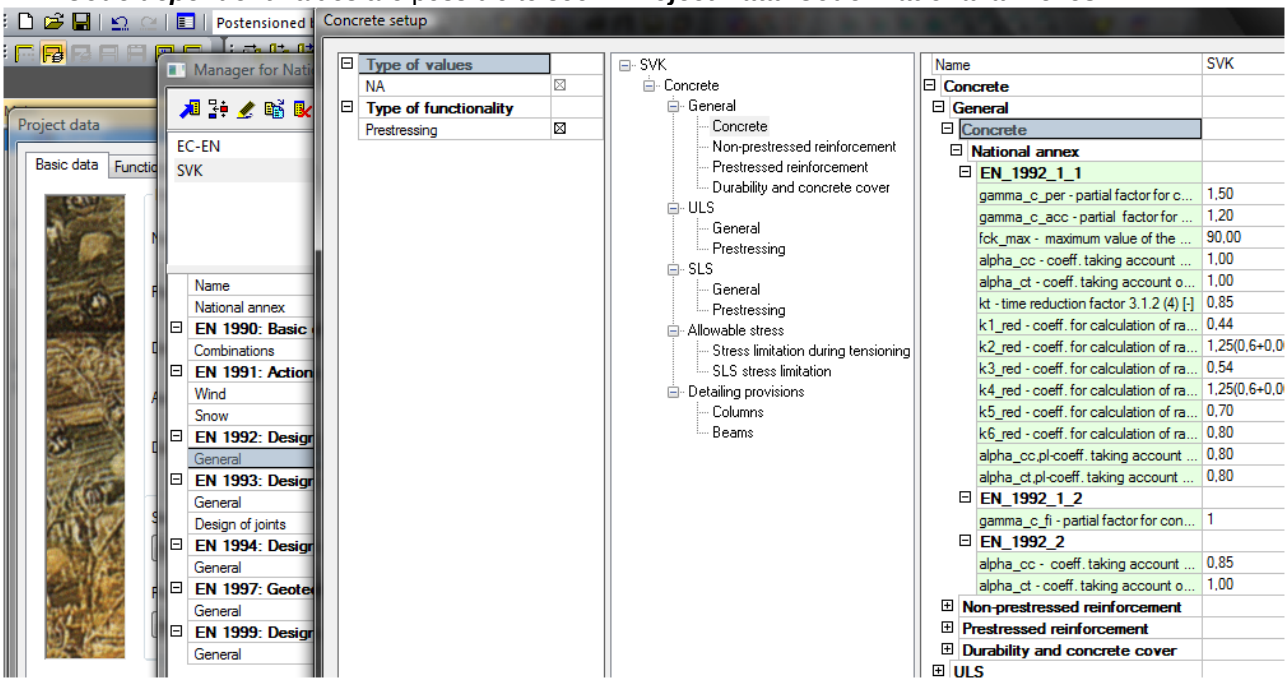
7 Check of prestressed concrete according to EN1992-1-1

The check of prestressed concrete is performed only according to EN1992-1-1. There are not any implementation of special check according to EN1992-2 which is code for design of bridges. There is only possible to used special TDA calculation according that code (see 6.3).

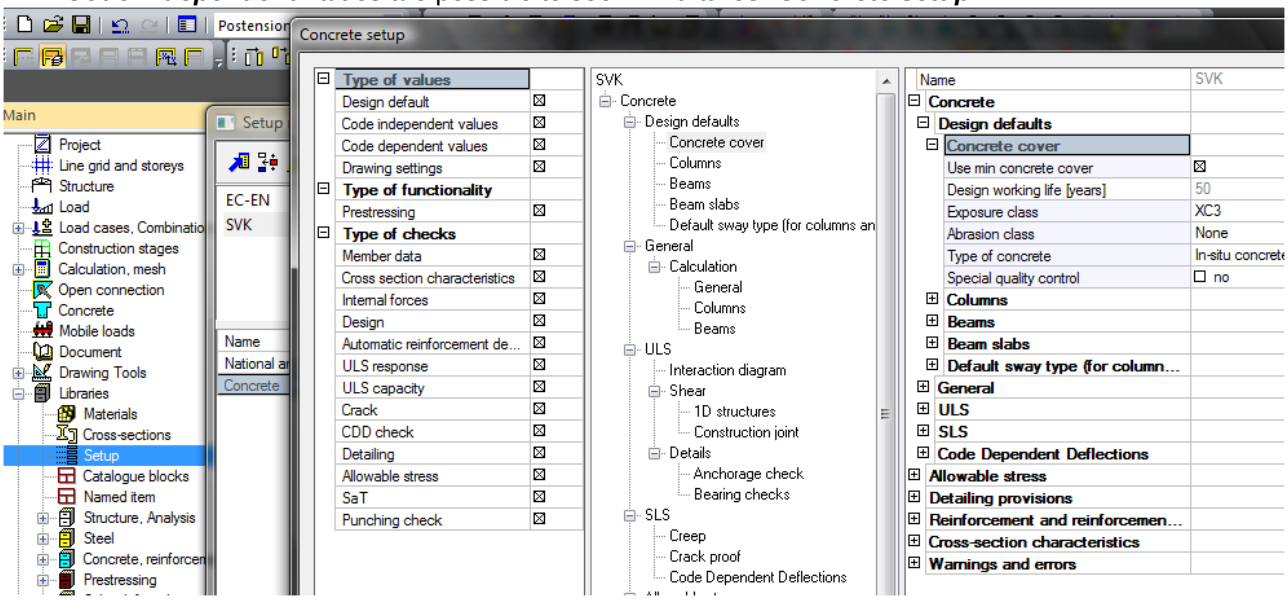
7.1 Concrete setup

The final concrete setup is synthesis of national dependent values and standard setup independent values.

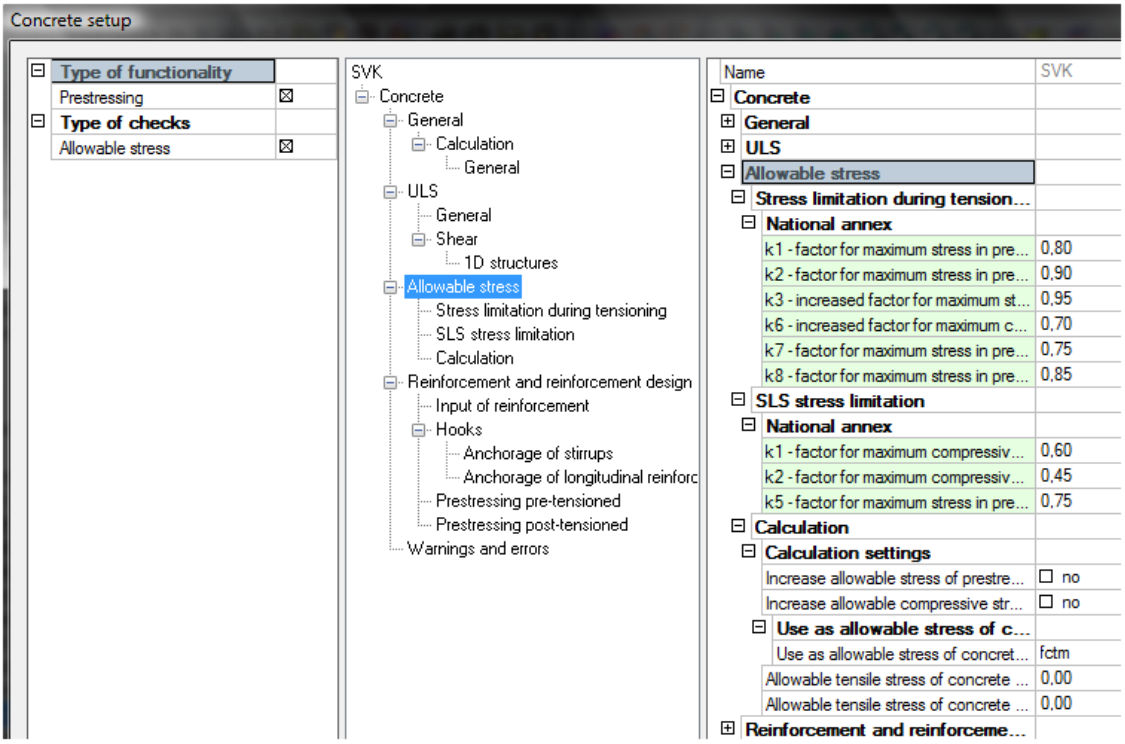
Code dependent values are possible to see in ***Project Data>Code>National annexes***.



Code independent values are possible to see in ***Libraries>Concrete setup***.



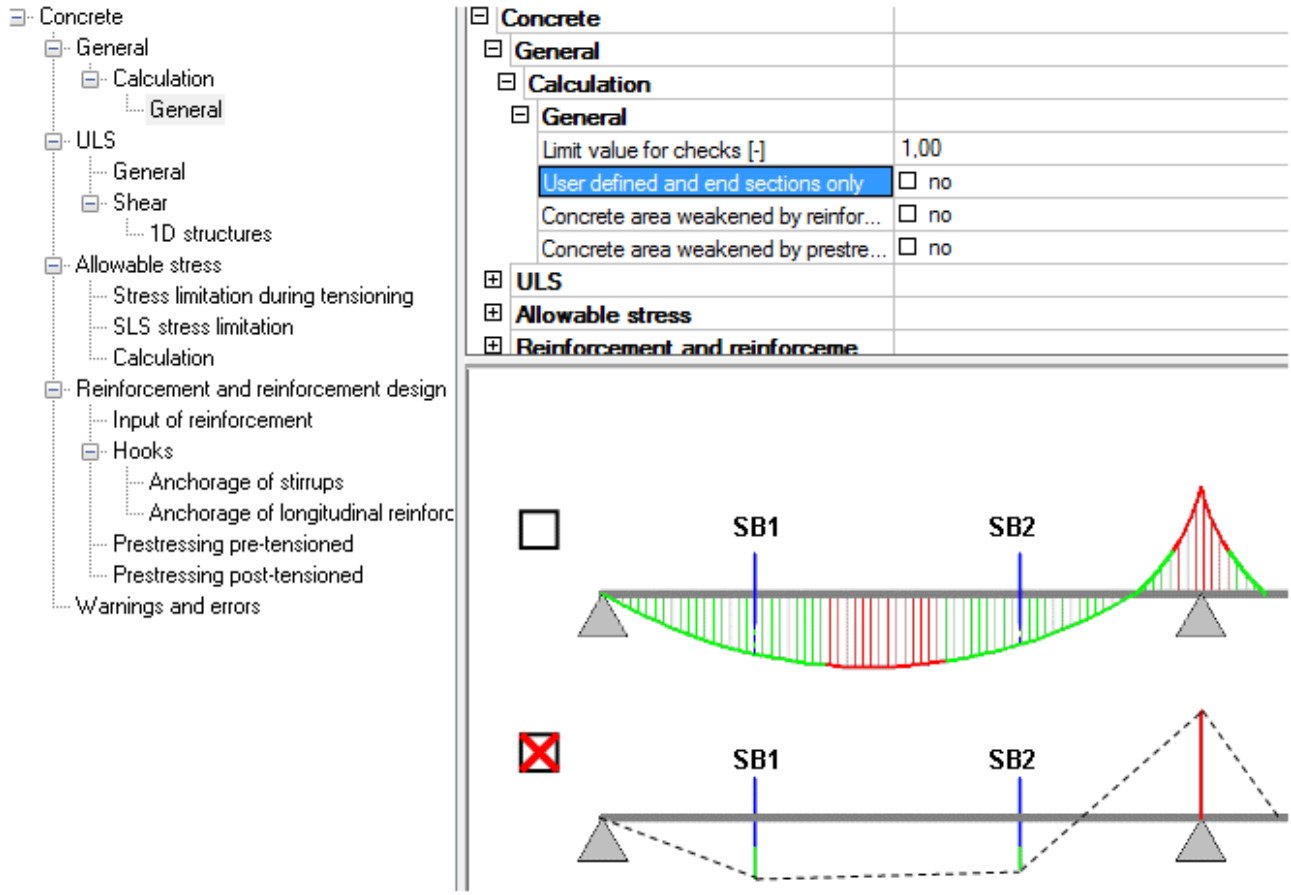
Complete setup is visible in appropriate concrete check filtered according to check. For instance see concrete setup for ***Allowable stresses of concrete***.



Some important settings from concrete setup will be explained in the following chapters

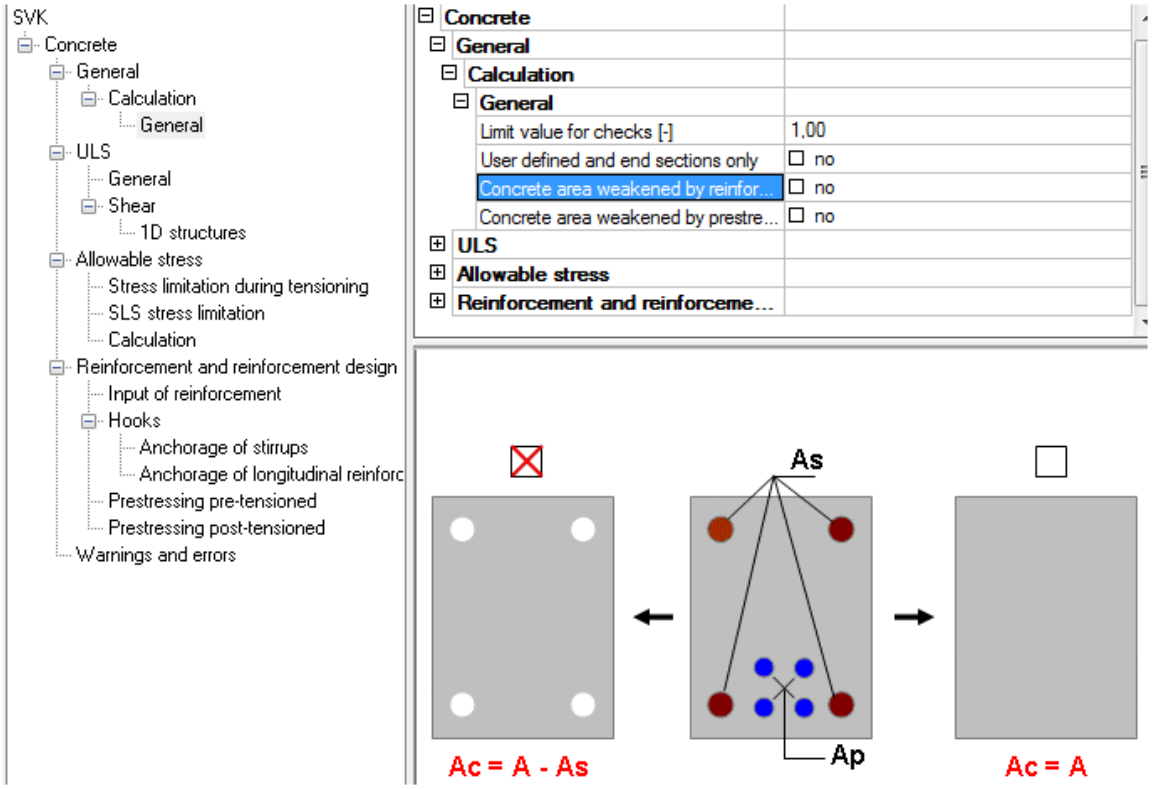
7.1.1 User defined section only

This functionality is suitable for fast performing of concrete checks only in user defined section, where is supposed the most loaded structure and extreme results. Check is performed only in those user defined d section and duration of check is shorter. It is available for all concrete checks and design.



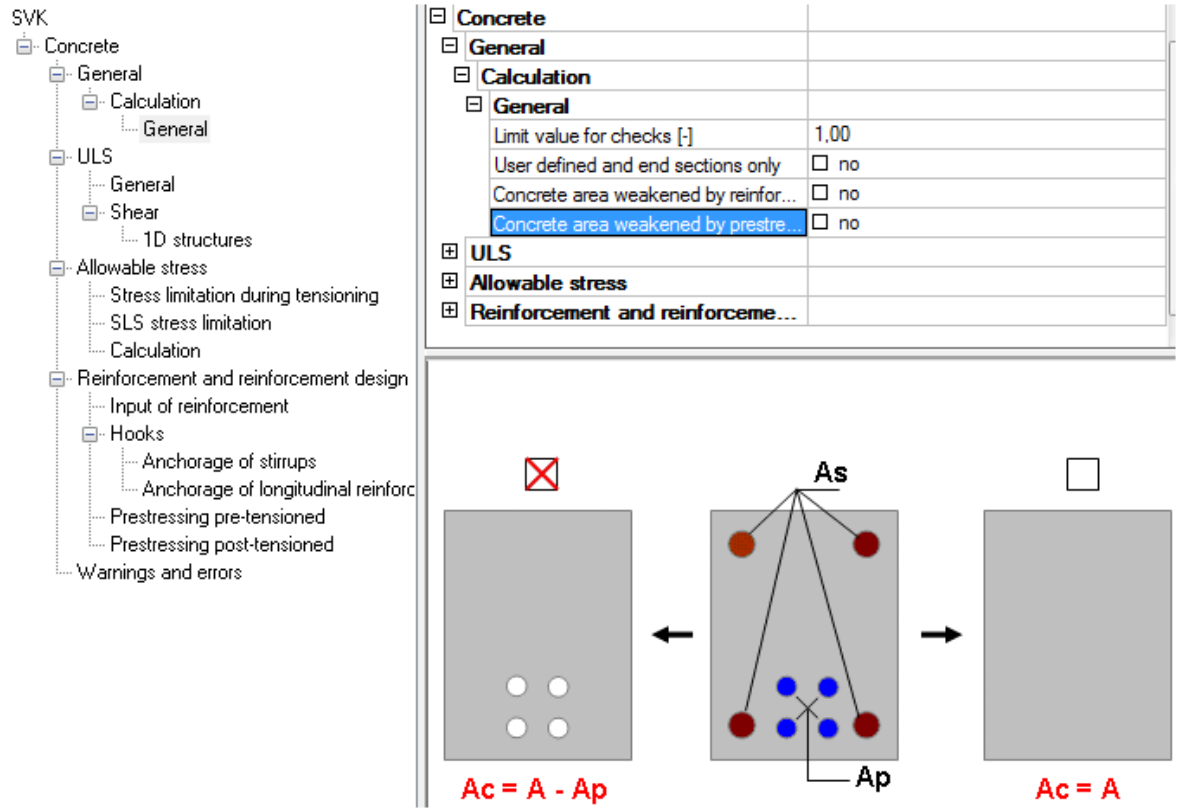
7.1.2 Concrete area weakened by reinforcement bars

When this checkbox is switch ON, then area of concrete CSS is reduced by bars. It has effects on all concrete 1D checks.



7.1.3 Concrete area weakened by prestressed bars

When this checkbox is switch ON, then area of concrete CSS is reduced by bars. It has effects on all concrete 1D checks.



7.1.4 Warning and errors

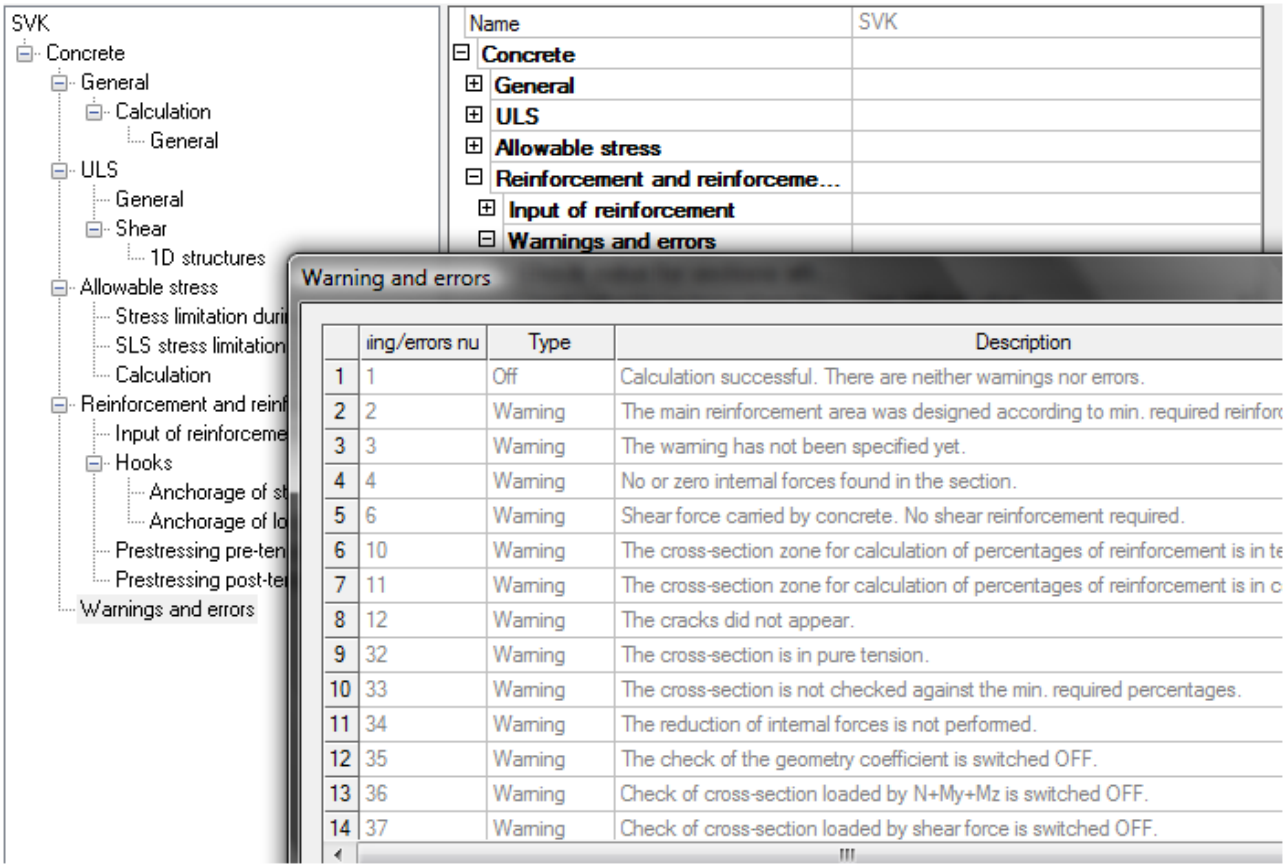
When some check is performed then warning or error can be printed in the table.

Allowable stress concrete EN 1992-1-1

Linear calculation, Extreme : Member
Selection : All
Combinations : F20-EN-SLS Quasi
Evaluated for selected group of fibres : Upper
Prestress check of allowable stress concrete for selected members

Member	d_x [m]	Case	Fibre	N [kN]	M_y [kNm] / M_z [kNm]	$\sigma_{o,ss}$ [MPa] / $\sigma_{oo,max}$ [MPa]	$\sigma_{oq,min}$ [MPa] / $\sigma_{oo,oh}$ [MPa]	$\sigma_{oq,max}$ [MPa] / $f_{ot,eff}$ [MPa]	$\sigma_{oit,min}$ [MPa] / $\sigma_{oo,qp}$ [MPa]	$\sigma_{oit,max}$ [MPa] / $f_{ot,eff,qp}$ [MPa]	$Check_{oalo}$ [-] / $Check_{lim}$ [-]	Check W/E
B1	0,000	F20-EN-SLS Quasi/1		0,00	0,00 0,00	0,00 0,00	0,00 0,00	0,00 0,00	**0,00** **0,00**	**0,00** **0,00**	0,00 1,00	NOT OK 858
B2	0,000	F20-EN-SLS Quasi/1	3	-30818,21	-7906,03 0,00	-1,39 0,00	-1,39 0,00	-1,39 0,00	**-1,66** **-15,75**	**-1,12** **0,00**	0,11 1,00	OK 224,198,197
B2	15,000	F20-EN-SLS Quasi/1	3	-32512,02	-373,99 0,00	-4,03 0,00	-4,03 0,00	-4,03 0,00	**-4,63** **-15,75**	-3,43 0,00	0,29 1,00	OK 224,198,197

All warnings and errors are stored in the concrete setup.



7.2 Member check, single check

The modelled structure can be checked by two ways:

- globally using ***Memebr check***
- detailed using ***Single check***

7.2.1 Member check

Member check is performed from the standard concrete check service. The results are displayed along the selected members. The output table has different output according to extreme:

- ***Global*** – one extreme result of all checked members

Allowable stress concrete EN 1992-1-1

Linear calculation Extreme : Global
Selection : All
Combinations : F20-EN-SLS Quasi.
Evaluated for selected group of fibres : Upper
Prestress check of allowable stress concrete for selected members

Member	d_y [m]	Case	Fibre	N [kN]	M_y [kNm] / M_z [kNm]	$\sigma_{c,ch}$ [MPa] / $\sigma_{cc,max}$ [MPa]	$\sigma_{cc,min}$ [MPa] / $\sigma_{cc,ch}$ [MPa]	$\sigma_{cc,max}$ [MPa] / f_{ctaff} [MPa]	$\sigma_{ct,min}$ [MPa] / $\sigma_{cc,sp}$ [MPa]	$\sigma_{ct,max}$ [MPa] / $f_{ctaffsp}$ [MPa]	$Check_{calc}$ [-] / $Check_{fm}$ [-]	Check / W/E
B2	0,000	F20-EN-SLS Quasi./1	3	-30818,21	-7906,03	-1,39	-1,39	-1,39	**-1,66**	**-1,12**	0,11	OK
					0,00	0,00	0,00	0,00	**-15,75**	**0,00**	1,00	224,198,197
B7	1,000	F20-EN-SLS Quasi./1	3	-32523,00	1343,12	-4,47	-4,47	-4,47	**-5,20**	-3,74	0,33	OK
					0,00	0,00	0,00	0,00	**-15,75**	0,00	1,00	224,198,197

- ***Member*** – one extreme results of each checked member

Allowable stress concrete EN 1992-1-1

Linear calculation Extreme : Member
Selection : All
Combinations : F20-EN-SLS Quasi.
Evaluated for selected group of fibres : Upper
Prestress check of allowable stress concrete for selected members

Member	d_y [m]	Case	Fibre	N [kN]	M_y [kNm] / M_z [kNm]	$\sigma_{c,ch}$ [MPa] / $\sigma_{cc,max}$ [MPa]	$\sigma_{cc,min}$ [MPa] / $\sigma_{cc,ch}$ [MPa]	$\sigma_{cc,max}$ [MPa] / f_{ctaff} [MPa]	$\sigma_{ct,min}$ [MPa] / $\sigma_{cc,sp}$ [MPa]	$\sigma_{ct,max}$ [MPa] / $f_{ctaffsp}$ [MPa]	$Check_{calc}$ [-] / $Check_{fm}$ [-]	Check / W/E
B1	0,000	F20-EN-SLS Quasi./1		0,00	0,00	0,00	0,00	0,00	**0,00**	**0,00**	0,00	NOT OK
					0,00	0,00	0,00	0,00	**0,00**	**0,00**	1,00	858
B2	0,000	F20-EN-SLS Quasi./1	3	-30818,21	-7906,03	-1,39	-1,39	-1,39	**-1,66**	**-1,12**	0,11	OK
					0,00	0,00	0,00	0,00	**-15,75**	**0,00**	1,00	224,198,197
B2	15,000	F20-EN-SLS Quasi./1	3	-32512,02	-373,99	-4,03	-4,03	-4,03	**-4,63**	-3,43	0,29	OK
					0,00	0,00	0,00	0,00	**-15,75**	0,00	1,00	224,198,197
B3	0,000	F20-EN-SLS Quasi./1		0,00	0,00	0,00	0,00	0,00	**0,00**	**0,00**	0,00	NOT OK
					0,00	0,00	0,00	0,00	**0,00**	**0,00**	1,00	858
B4	0,000	F20-EN-SLS Quasi./1	3	-32301,44	-2157,54	-3,28	-3,28	-3,28	**-4,05**	**-2,51**	0,26	OK
					0,00	0,00	0,00	0,00	**-15,75**	**0,00**	1,00	224,198,197
B4	1,000	F20-EN-SLS Quasi./1	3	-32573,55	-913,65	-3,79	-3,79	-3,79	**-4,54**	-3,04	0,29	OK
					0,00	0,00	0,00	0,00	**-15,75**	0,00	1,00	224,198,197

- ***Section*** – extreme results in each section along all checked members

Allowable stress concrete EN 1992-1-1

Linear calculation Extreme : Section
Selection : All
Combinations : F20-EN-SLS Quasi.
Evaluated for selected group of fibres : Upper
Prestress check of allowable stress concrete for selected members

Member	d_y [m]	Case	Fibre	N [kN]	M_y [kNm] / M_z [kNm]	$\sigma_{c,ch}$ [MPa] / $\sigma_{cc,max}$ [MPa]	$\sigma_{cc,min}$ [MPa] / $\sigma_{cc,ch}$ [MPa]	$\sigma_{cc,max}$ [MPa] / f_{ctaff} [MPa]	$\sigma_{ct,min}$ [MPa] / $\sigma_{cc,sp}$ [MPa]	$\sigma_{ct,max}$ [MPa] / $f_{ctaffsp}$ [MPa]	$Check_{calc}$ [-] / $Check_{fm}$ [-]	Check / W/E
B1	0,000	F20-EN-SLS Quasi./1		0,00	0,00	0,00	0,00	0,00	**0,00**	**0,00**	0,00	NOT OK
					0,00	0,00	0,00	0,00	**0,00**	**0,00**	1,00	858
B1	0,250	F20-EN-SLS Quasi./1		0,00	0,00	0,00	0,00	0,00	**0,00**	**0,00**	0,00	NOT OK
					0,00	0,00	0,00	0,00	**0,00**	**0,00**	1,00	858
B1	0,250	F20-EN-SLS Quasi./1		0,00	0,00	0,00	0,00	0,00	**0,00**	**0,00**	0,00	NOT OK
					0,00	0,00	0,00	0,00	**0,00**	**0,00**	1,00	858
B1	0,500	F20-EN-SLS Quasi./1		0,00	0,00	0,00	0,00	0,00	**0,00**	**0,00**	0,00	NOT OK
					0,00	0,00	0,00	0,00	**0,00**	**0,00**	1,00	858
B1	0,500	F20-EN-SLS Quasi./1		0,00	0,00	0,00	0,00	0,00	**0,00**	**0,00**	0,00	NOT OK
					0,00	0,00	0,00	0,00	**0,00**	**0,00**	1,00	858
B1	0,750	F20-EN-SLS Quasi./1		0,00	0,00	0,00	0,00	0,00	**0,00**	**0,00**	0,00	NOT OK
					0,00	0,00	0,00	0,00	**0,00**	**0,00**	1,00	858

- ***Cross-section*** – one extreme results of all checked cross-section

Allowable stress concrete EN 1992-1-1

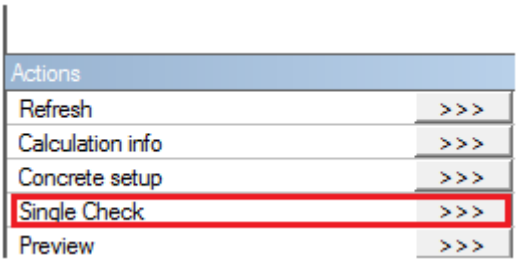
Linear calculation Extreme : Cross-section
Selection : All
Combinations : F20-EN-SLS Quasi.
Evaluated for selected group of fibres : Upper

Prestress check of allowable stress concrete for selected members

Member	d_x [m]	Case	Fibre	N [kN]	M_y [kNm] / M_z [kNm]	$\sigma_{c,sls}$ [MPa] / $\sigma_{cc,max}$ [MPa]	$\sigma_{cc,min}$ [MPa] / $\sigma_{cc,ch}$ [MPa]	$\sigma_{cc,max}$ [MPa] / f_{ctkeff} [MPa]	$\sigma_{ct,min}$ [MPa] / $\sigma_{ct,cp}$ [MPa]	$\sigma_{ct,max}$ [MPa] / $f_{ctkeffcp}$ [MPa]	Check$_{calc}$ [-] / Check$_{lim}$ [-]	Check W/E
B1	0,000	F20-EN-SLS Quasi /1		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	NOT OK
					0,00	0,00	0,00	0,00	0,00	0,00	1,00	858
B2	0,000	F20-EN-SLS Quasi /1	3	-30818,21	-7906,03	-1,39	-1,39	-1,39	-1,66	-1,12	0,11	OK
					0,00	0,00	0,00	0,00	-15,75	0,00	1,00	224,198,197
B7	1,000	F20-EN-SLS Quasi /1	3	-32523,00	1343,12	-4,47	-4,47	-4,47	-5,20	-3,74	0,33	OK
					0,00	0,00	0,00	0,00	-15,75	0,00	1,00	224,198,197

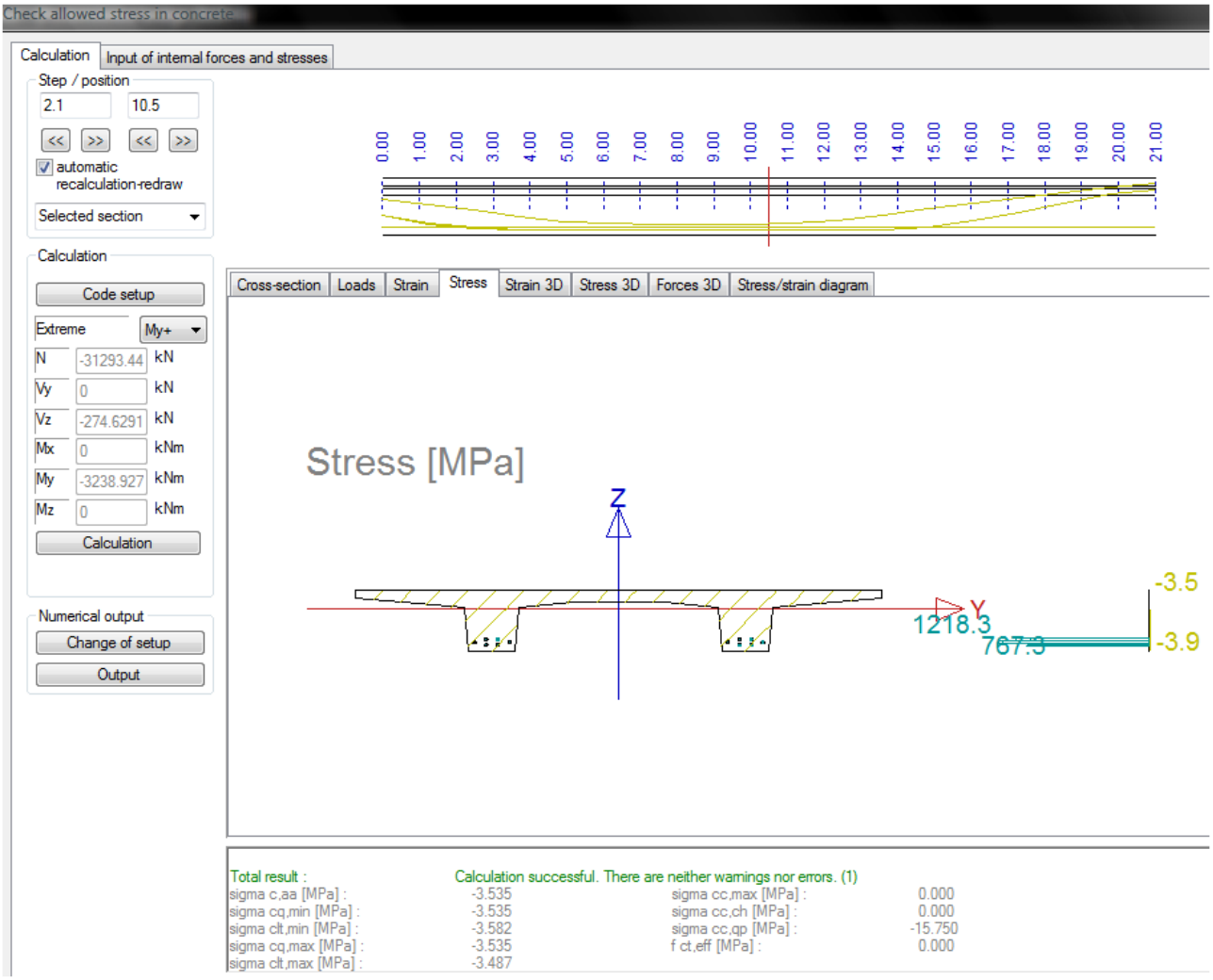
7.2.2 Single check

Almost all concrete checks has single check. It is detailed analysis of one cross-section. Action button to go there is following in the bottom of service.



Dialogue of single check provided to user selects:

- Extreme of normal forces (N+; N-; Vz+; Vz-...)
- Section along the selected member
- Appropriate tabsheet with detailed results. Tabsheets are dependent on type of concrete service, but mainly there are following:
  - Cross-section
  - Loads
  - Strain
  - Stress
  - Stress/strain diagram



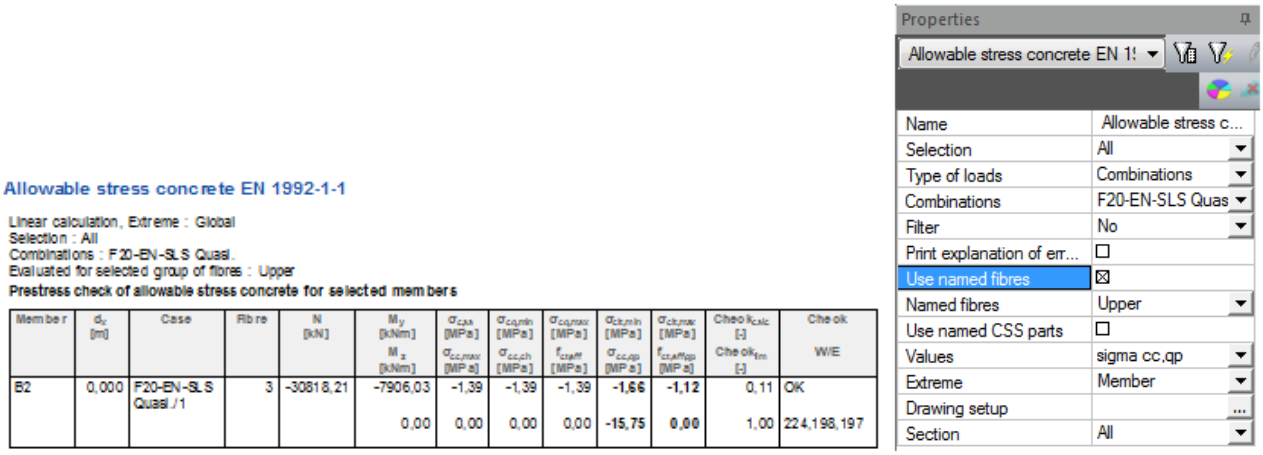
7.2.3 Check in named items – fibres, cuts, joints, parts of CSS

Definition of named items was described in chapter 5. Here the using in concrete checks will be explained. The idea of using named part is to get user friendly results and to increase speed of check. SEN supports following named items in the following services.

- Named fibres
  - Check response
  - Allowable stresses of concrete
- Named cuts
  - Allowable principal stresses
- Named joints
  - Check response – check of shear in construction joint
  - Design As
- Named parts of CSS
  - Check response
  - Allowable stresses of concrete
  - Allowable principal stresses

For instance you can see results of allowable concrete stress for upper fibres

- ***for member check***

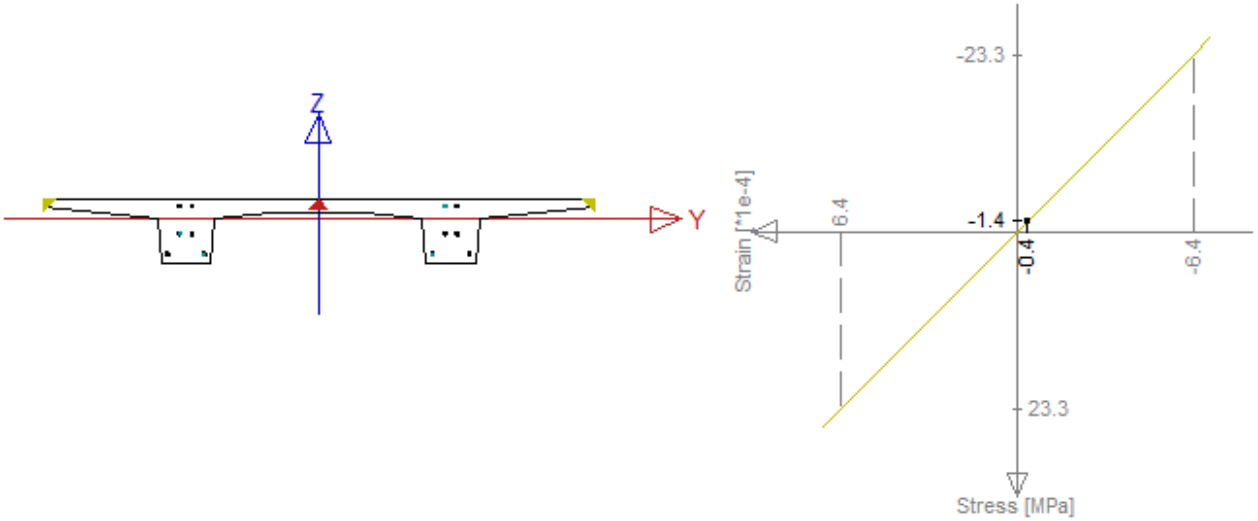


Allowable stress concrete EN 1992-1-1

Linear calculation, Extreme : Global
Selection : All
Combinations : F20-EN-SLS Quasi
Evaluated for selected group of fibres : Upper
Prestress check of allowable stress concrete for selected members

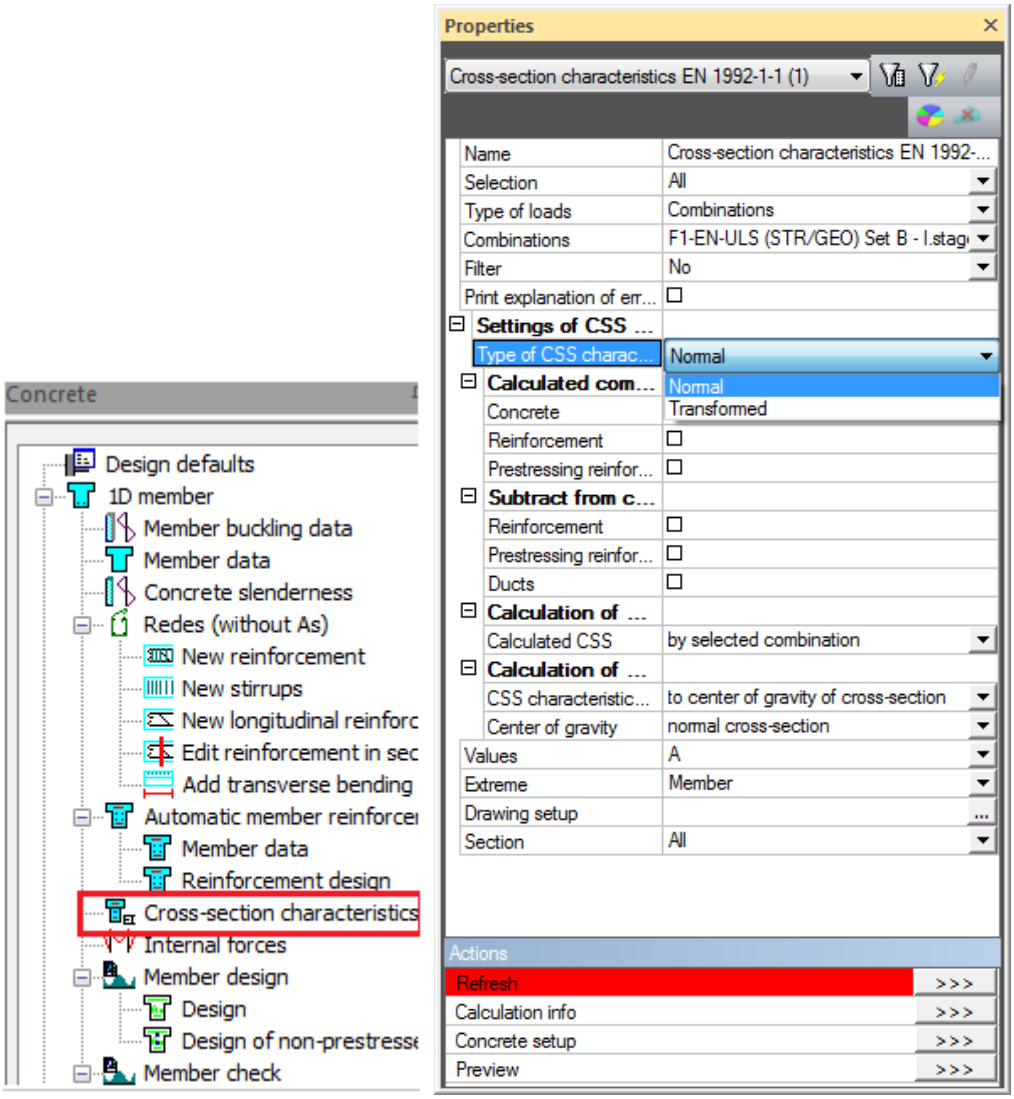
Member	d_x [m]	Case	Fibre	N [kN]	M_y [kNm] / M_z [kNm]	$\sigma_{c,ch}$ [MPa] / $\sigma_{cc,max}$ [MPa]	$\sigma_{cc,min}$ [MPa] / $\sigma_{cc,ch}$ [MPa]	$\sigma_{cc,max}$ [MPa] / f_{ctkeff} [MPa]	$\sigma_{ct,min}$ [MPa] / $\sigma_{cc,qp}$ [MPa]	$\sigma_{ct,max}$ [MPa] / $f_{ctkeff,qp}$ [MPa]	Check$_{calc}$ [-] / Check$_{lim}$ [-]	Check W/E
B2	0,000	F20-EN-SLS Quasi./1	3	-30818,21	-7906,03 / 0,00	-1,39 / 0,00	-1,39 / 0,00	-1,39 / 0,00	-1,66 / -15,75	-1,12 / 0,00	0,11 / 1,00	OK / 224,198,197

- ***for single check*** – only named fibres are available in single check



7.2.4 CSS characteristic, transformed

The service of CSS characteristic is service which can provide to user all necessary information about the CSS. This service is situated in ***Concrete > 1D member.***



This service performs calculation of geometrical properties of cross-section with including the following:

- the prestressed reinforcement
- the non-prestressed reinforcement
- ducts of tendons
- time

- ***Type of characteristic*** with two items
  - normal (only one check box from concrete, reinforcement and tendons can be switched on)
  - transformed
- ***Calculated components*** - three check boxes
  - concrete (for transformed characteristic, this check box will be always switched on)
  - reinforcement
  - tendons
- ***Subtracting from concrete*** will be active if the check box Concrete is switched on
  - reinforcement
  - tendon
  - ducts
- ***Characteristic related to*** with the following items
  - to centre of gravity of cross-section
  - to centre of gravity of cross-section phase (new combo Phase of cross-section with the following items:
    - all phases,
    - by selected combination,

        - defined by user
    - to selected named fibres (new combo with named fibres will be active)
    - to the point (new properties for definition y and z coordinates will be active)
- ***Values***
    - the values for normal characteristic
      A, Iy, Iz,ty,tz,Sy,Sz,bw, Wy+, Wy-, Wz+, Wz-, iy, iz
    - the values for transformed characteristic
      Ai, Iyi, Izi,tyi,tzi,Syi,Szi; Wyi+, Wyi-, Wzi+, Wzi-, iyi, izi

The results can be following:

Cross-section characteristics EN 1992-1-1

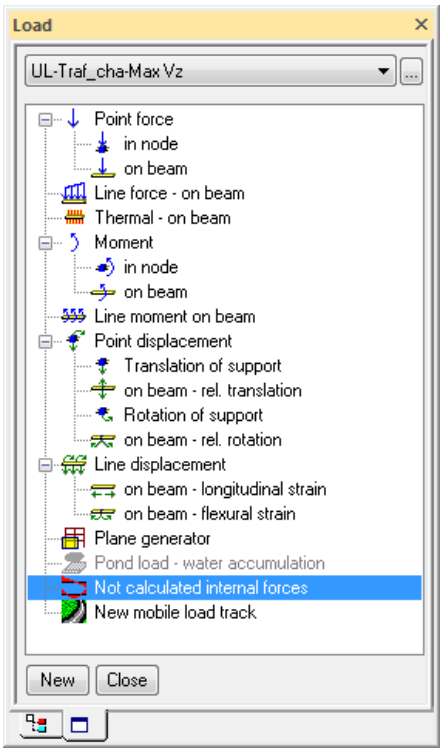
Linear calculation, Extreme : Member
Selection : B2
Combinations : F21-EN-ULS (STR/GEO) Set B
Cross section characteristics for selected members

Member	d_x [m]	Case	Y_c [mm] Z_c [mm]	t_y [mm] t_z [mm]	A [mm²] b_w [mm]	I_y [mm⁴] I_z [mm⁴]	S_y [mm³] S_z [mm³]	W_{y+} [mm³] W_{z+} [mm³]	W_{y-} [mm³] W_{z-} [mm³]
B2	0,000	F21-EN-ULS (STR/GEO) Set B/4	6750 1066	0 1	7652999 2788	1491194248199 97878318786621	7735502 0	3087944031 14500492096	1397438049 14500492096

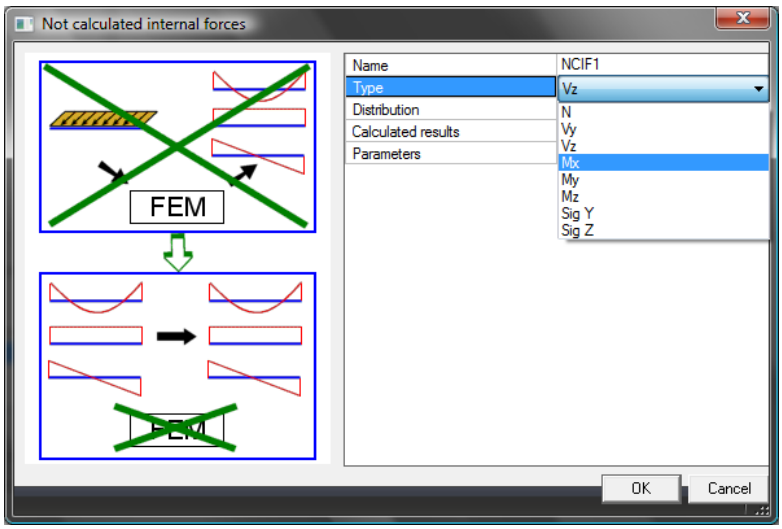
7.2.5 Not calculated internal forces

The ***frame XZ*** which is used for the time dependent analysis doesn't respect effects of torsion in this project. The envelopes of mobile loads for extreme ***Mx*** (torsion moment) should be analyzed on different project type ***frame XYZ***. The value of ***Mx*** should be defined in project Frame XZ as ***Not calculated internal force***.

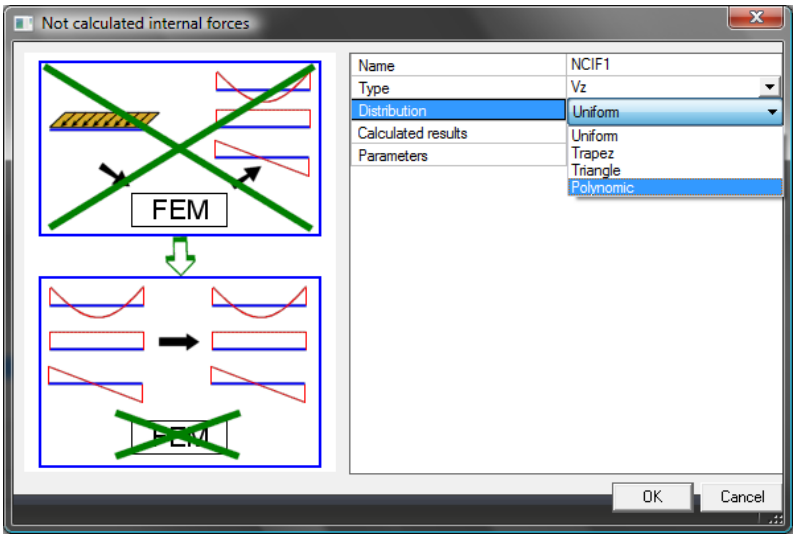
The user should defined not calculated internal forces in menu ***Loads>Not calculated internal forces*** for selected loadcase.



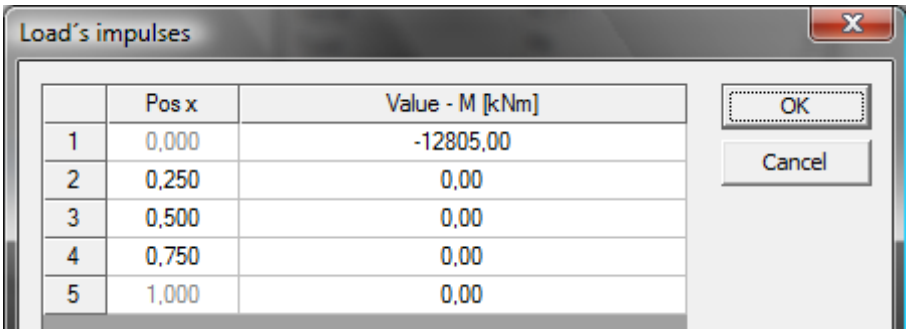
The dialog for definition of ***Not calculated internal forces*** is following. There are several types. We use type Mx.



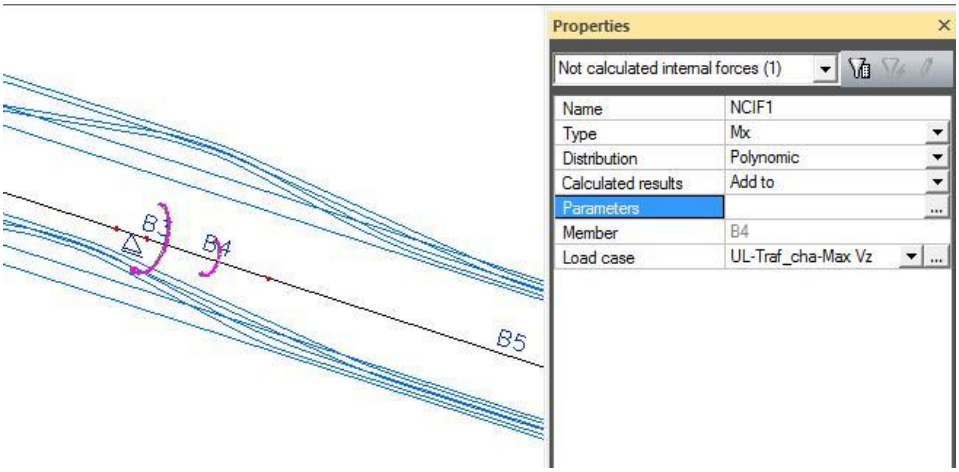
Distribution should be following; type ***Polynomic*** is used for definition only in one section near the second support.



The value of ***Mx*** is defined in this dialog.



The displaying of not calculated internal forces in 3D window is following



7.3 SLS – concrete checks

7.3.1 Prestress crack check

The cracks of the prestressed members are calculated according to chapter 7.3 from EN1992-1-1 and check is performed in service ***Concrete>Member check>check of prestressed concrete>Crack control.*** The prestressed structure is with bonded tendons and will be checked for frequent combination according to table 7.1N from EN1992-1-1. The exposure class is set in chapter 7.3.2.2 as XD3. The decompression has to be checked in this case.

7.3.2 Allowable concrete stresses

7.3.2.1 Domain knowledge of allowable concrete checks

The explanation of displayed values is following

- **The stress before and after anchoring**
  - In compression
    - $\sigma_{cc,max}$ – allowable stress in compression before and after anchoring, defined in chapter 5.42 in EN1992-1-1
      - $\sigma_{cc,\max} = k_6 f_{ck}(t)$ (5.42)
      - k_6 = 0,6 (for pretensioned concrete is possible to increase allowable stress on value 0,7 when it is verified that cracks don't appear)
    - $\sigma_{c,aa}$ – calculated stress in concrete,
  - In tension
    - $\sigma_{cc,max}$ – allowable concrete stress in tension before and after anchoring; defined in Concrete setup and default is 0MPa
    - $\sigma_{c,aa}$ – calculated stress in concrete,
- **Stress from SLS combination**
  - <u>Characteristic combination – longitudinal cracks</u>
    - In compression
      - $\sigma_{cc,ch}$ – allowable concrete stress in compression from SLS characteristic combination, only for exposure class XD, XF a XS.
        - $\sigma_{cc,ch} = k_1 \cdot f_{ck}(t)$ (7.2.(2))
        - k_1 = 0,6
      - $\sigma_{cq,min}$ – minimal stress in concrete after application selweight all permanent and variable loads
    - In tension
      - $f_{ct,eff}$ - allowable concrete stress in tension from SLS characteristic combination,
      - The value $f_{ct,eff}$ is possible to set in ***Concrete setup>Allowable stresses***:
        - f_{ctm} – the mean axial tensile strength
        - $f_{ctm,fl}$ – the mean flexural tensile strength
          - $f_{ctm,fl} = max\{(1,6-h/1000)*f_{ctm}; f_{ctm})\}$

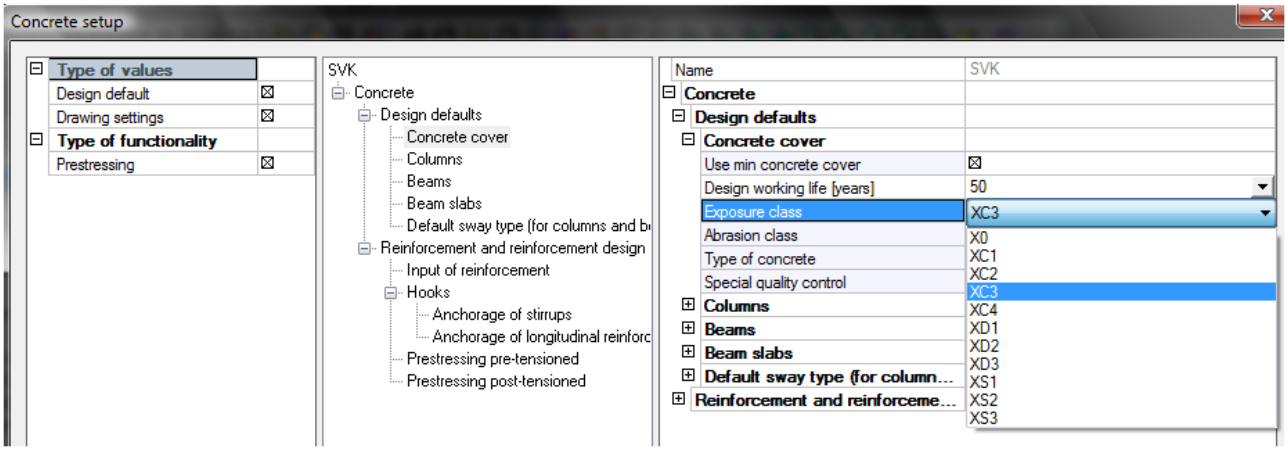
        - ***h*** total depth of CSS
      - $\sigma_{cq,max}$ – maximal stress in concrete after application selweight all permanent and variable loads
  - Quasi-permanent combination – great creep
    - In compression
      - $\sigma_{cc,qp}$ – allowable concrete stress in compression from SLS quasi-permanent combination, linear creep may be assumed
        - $\sigma_{cc,qp} = k_2 \cdot f_{ck}(t)$ (7.2.(3))
        - $k_2 = 0{,}45$
      - $\sigma_{clt,min}$ – minimal stress from longterm load
    - In tension
      - $f_{ct,eff,qp}$ – allowable concrete stress in tension from SLS quasi-permanent combination, The value $f_{ct,eff,qp}$ is possible to set in ***Concrete setup>Allowable stresses***; default 0MPa
      - $\sigma_{clt,max}$ – maximal stress from longterm load
- **Other not checked, only drawn**

$\sigma_{p,inc}$ – increment of stress from selected LC

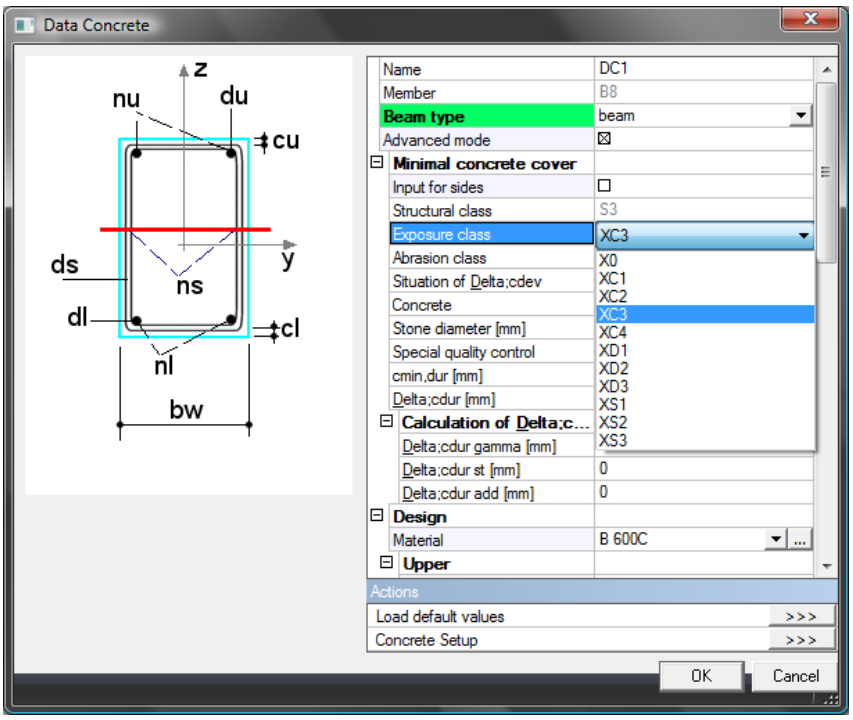
Some important values needed for calculation is recommended to set before check is performed.

7.3.2.2 Exposure class

The exposure class of concrete is possible to set in ***Concrete setup>Design defaults***. The check of allowable concrete stresses and crack width depends on this exposure class. The class XD3 is set in this example.

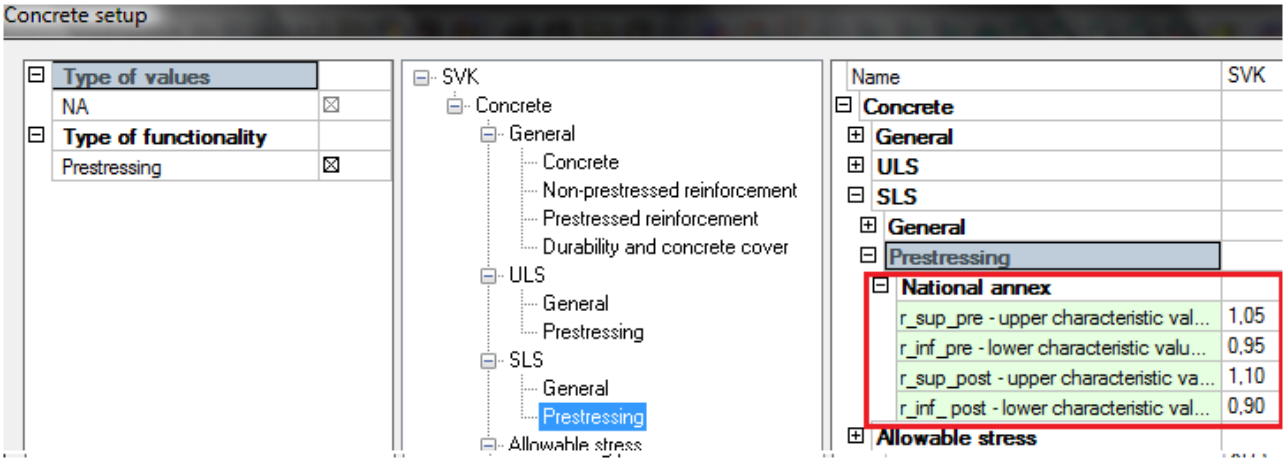


The exposure class for each member is also possible to set by ***Member data.***



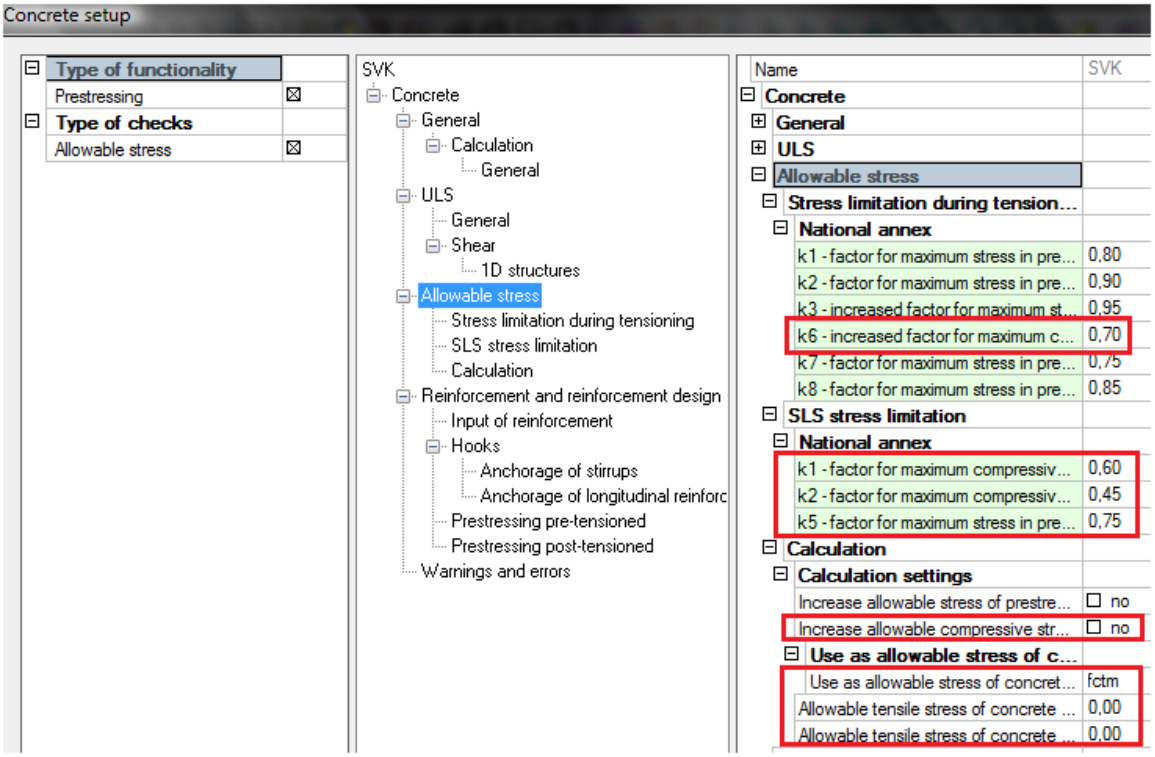
7.3.2.3 The factor for prestressing used in allowable concrete stresses

The upper and lower factors of prestressing force for check of allowable concrete stresses are possible to set in ***Concrete setup>SLS>Prestressing***.



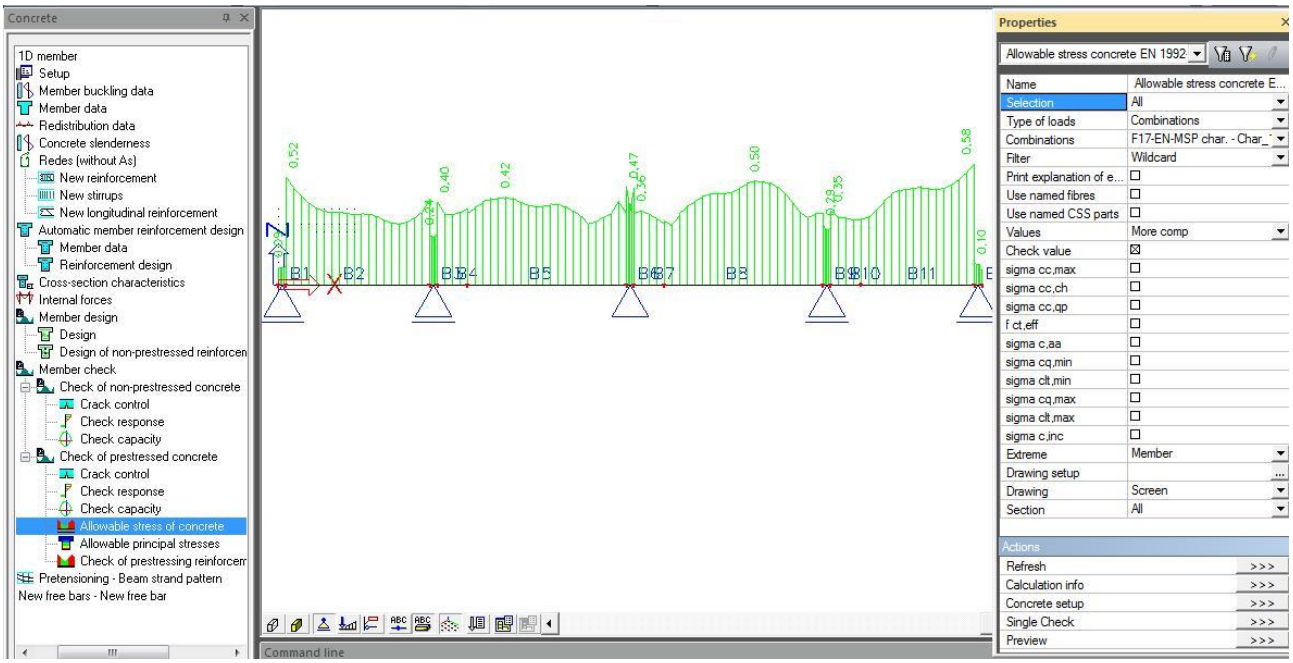
7.3.2.4 The factors for check of allowable concrete stresses

The factors for the calculation of limit values of concrete stresses from the code EN1992-1-1 is possible to set in ***Concrete setup>Allowable stresses***.



7.3.2.5 The check of Allowable concrete stresses

The user has possibility to perform this check in ***Concrete>Member check>Check of prestressed concrete>Allowable concrete stresses***. The results of the check will be calculated and drawn for selected combination and value. For instance Check value of the SLS characteristic combination in 100 years is following.



The output table with extreme ***Member*** is following.

Preview

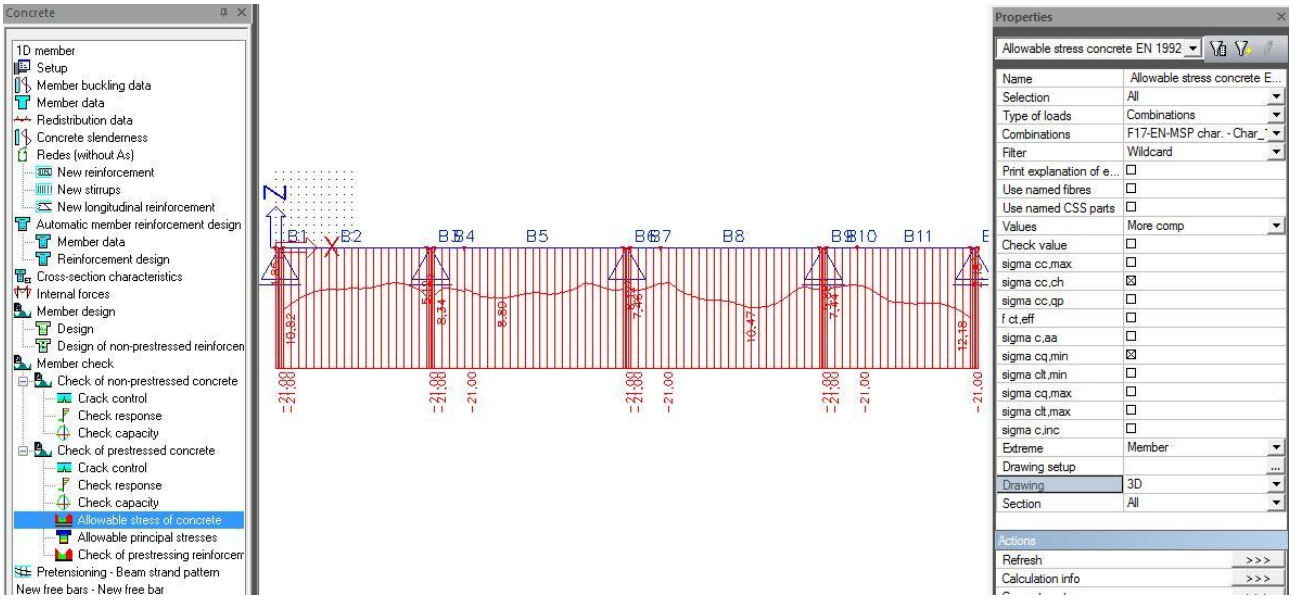
default default

Linear calculation, Extreme : Member
Selection : All
Combinations : F17-EN-MSP char.
Prestress check of allowable stress concrete for selected members

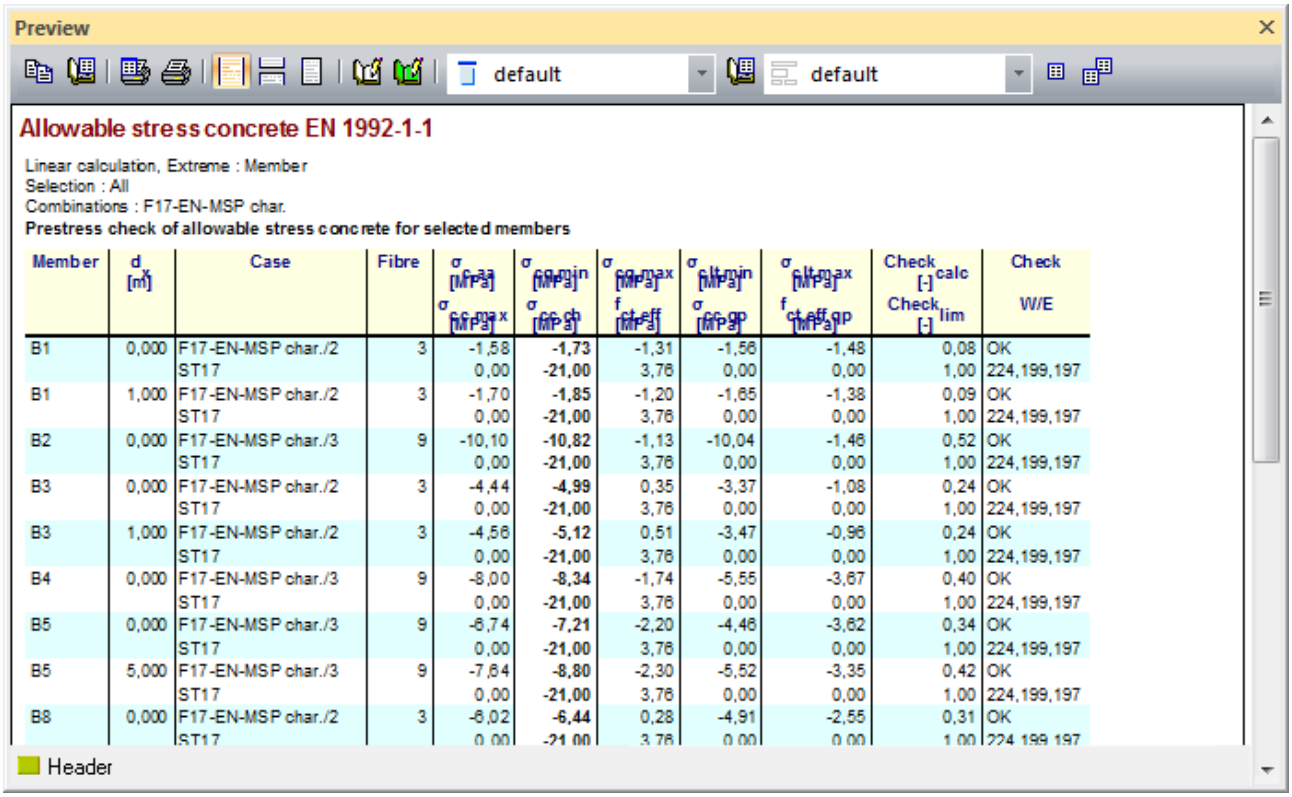
Member	d [m]	Case	Construction stage	Fibre	N [kN]	M_y [kNm]	M_z [kNm]	Check $_{calc}$ [-]	Check $_{lim}$ [-]	Check	W/E
B1	1,000	F17-EN-MSP char./1	ST17	3	-31721,98	851,48	0,00	**0,09**	1,00	OK	224,199,197
B2	0,000	F17-EN-MSP char./1	ST17	9	-31518,42	-8313,31	0,00	**0,52**	1,00	OK	224,199,197
B3	1,000	F17-EN-MSP char./1	ST17	3	-32718,74	9477,24	0,00	**0,24**	1,00	OK	224,199,197
B4	0,000	F17-EN-MSP char./1	ST17	9	-32491,44	-5245,18	0,00	**0,40**	1,00	OK	224,199,197
B5	5,000	F17-EN-MSP char./1	ST17	9	-30895,68	-5403,90	0,00	**0,42**	1,00	OK	224,199,197
B8	12,000	F17-EN-MSP char./1	ST17	9	-33777,20	-6847,59	0,00	**0,50**	1,00	OK	224,199,197
B6	0,000	F17-EN-MSP char./1	ST17	9	-32681,21	13448,56	0,00	**0,47**	1,00	OK	224,199,197
B7	1,000	F17-EN-MSP char./1	ST17	3	-32569,42	7628,46	0,00	**0,36**	1,00	OK	224,199,197
B11	15,000	F17-EN-MSP char./1	ST17	9	-35186,01	-8873,83	0,00	**0,58**	1,00	OK	224,199,197
B9	0,000	F17-EN-MSP char./1	ST17	9	-34702,71	11754,98	0,00	**0,29**	1,00	OK	224,199,197
B10	0,000	F17-EN-MSP char./1	ST17	9	-34487,38	-3812,17	0,00	**0,35**	1,00	OK	224,199,197
B12	0,000	F17-EN-MSP char./1	ST17	3	-35169,56	1554,66	0,00	**0,10**	1,00	OK	224,199,197

Ready [en]

For the selected values $\sigma_{cc,ch}$ and $\sigma_{cq,min}$ are results following

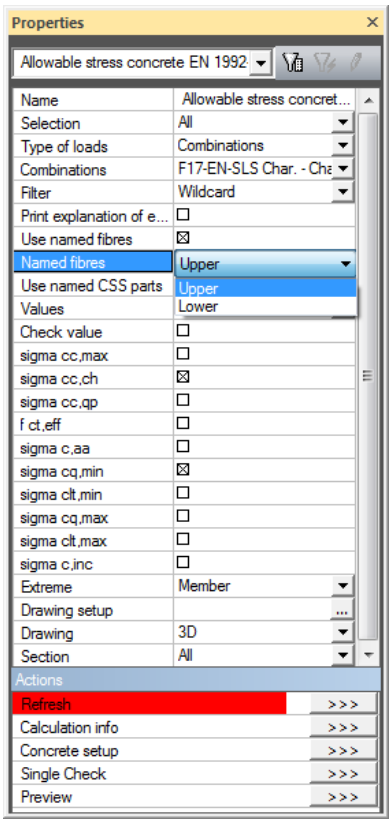


and output table is following

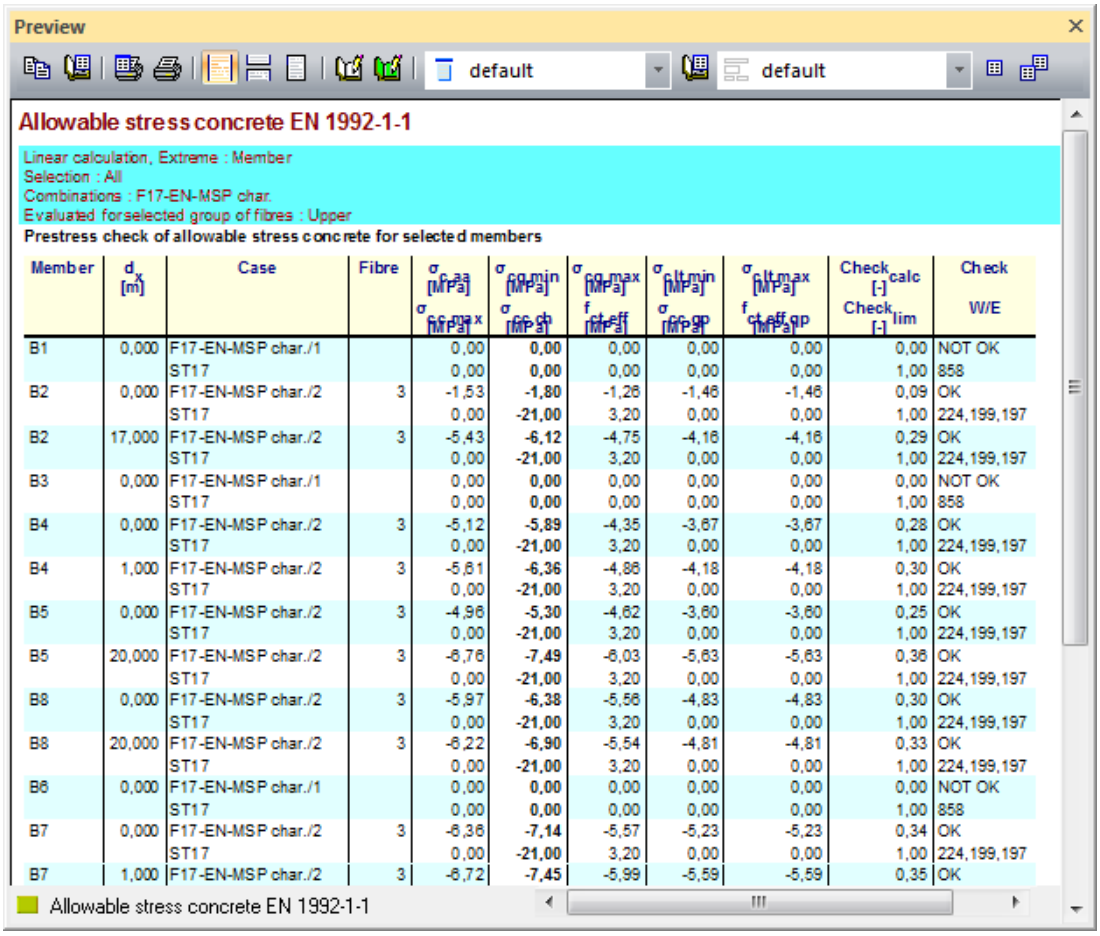


Member	d [m]	Case	Fibre	σc,aa [MPa] / σcc,max [MPa]	σcc,min [MPa] / σcc,ch [MPa]	σcc,max [MPa] / fct,eff [MPa]	σc,lt,min [MPa] / σcc,qp [MPa]	σc,lt,max [MPa] / fct,eff,qp [MPa]	Check calc [-] / Check lim [-]	Check W/E
B1	0,000	F17-EN-MSP char./2	3	-1,58	-1,73	-1,31	-1,56	-1,48	0,08	OK
		ST17		0,00	-21,00	3,76	0,00	0,00	1,00	224,199,197
B1	1,000	F17-EN-MSP char./2	3	-1,70	-1,85	-1,20	-1,65	-1,38	0,09	OK
		ST17		0,00	-21,00	3,76	0,00	0,00	1,00	224,199,197
B2	0,000	F17-EN-MSP char./3	9	-10,10	-10,82	-1,13	-10,04	-1,46	0,52	OK
		ST17		0,00	-21,00	3,76	0,00	0,00	1,00	224,199,197
B3	0,000	F17-EN-MSP char./2	3	-4,44	-4,99	0,35	-3,37	-1,08	0,24	OK
		ST17		0,00	-21,00	3,76	0,00	0,00	1,00	224,199,197
B3	1,000	F17-EN-MSP char./2	3	-4,56	-5,12	0,51	-3,47	-0,96	0,24	OK
		ST17		0,00	-21,00	3,76	0,00	0,00	1,00	224,199,197
B4	0,000	F17-EN-MSP char./3	9	-8,00	-8,34	-1,74	-5,55	-3,67	0,40	OK
		ST17		0,00	-21,00	3,76	0,00	0,00	1,00	224,199,197
B5	0,000	F17-EN-MSP char./3	9	-6,74	-7,21	-2,20	-4,46	-3,62	0,34	OK
		ST17		0,00	-21,00	3,76	0,00	0,00	1,00	224,199,197
B5	5,000	F17-EN-MSP char./3	9	-7,64	-8,80	-2,30	-5,52	-3,35	0,42	OK
		ST17		0,00	-21,00	3,76	0,00	0,00	1,00	224,199,197
B8	0,000	F17-EN-MSP char./2	3	-6,02	-6,44	0,28	-4,91	-2,55	0,31	OK
		ST17		0,00	-21,00	3,76	0,00	0,00	1,00	224,199,197

The concrete stress should be calculated for selected fibre only

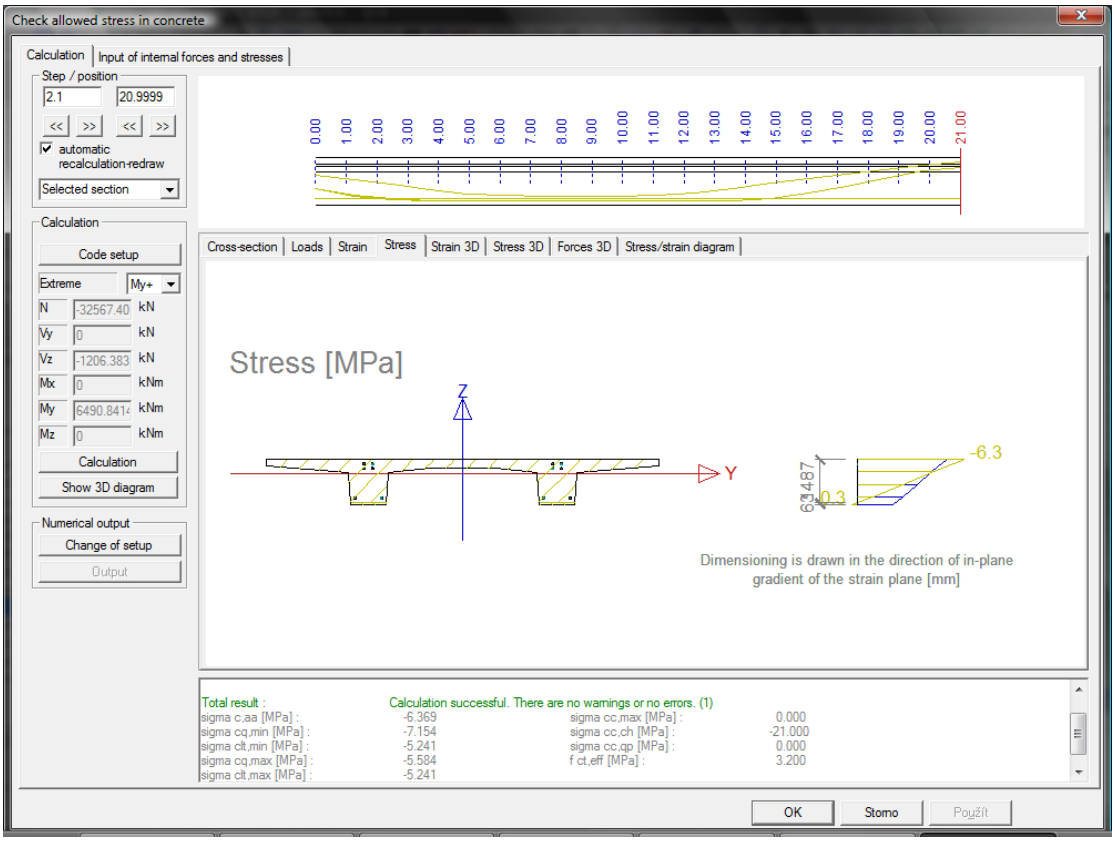


Then results for upper fibres are following



Member	d_x [m]	Case	Fibre	$\sigma_{c,aa}$ [MPa] / $\sigma_{cc,max}$ [MPa]	$\sigma_{cq,min}$ [MPa] / $\sigma_{cc,ch}$ [MPa]	$\sigma_{cq,max}$ [MPa] / $f_{ct,eff}$ [MPa]	$\sigma_{clt,min}$ [MPa] / $\sigma_{cc,qp}$ [MPa]	$\sigma_{clt,max}$ [MPa] / $f_{ct,eff,qp}$ [MPa]	$Check_{calc}$ [-] / $Check_{lim}$ [-]	Check W/E
B1	0,000	F17-EN-MSP char./1		0,00	0,00	0,00	0,00	0,00	0,00	NOT OK
		ST17		0,00	0,00	0,00	0,00	0,00	1,00	858
B2	0,000	F17-EN-MSP char./2	3	-1,53	-1,80	-1,26	-1,46	-1,46	0,09	OK
		ST17		0,00	-21,00	3,20	0,00	0,00	1,00	224,199,197
B2	17,000	F17-EN-MSP char./2	3	-5,43	-6,12	-4,75	-4,16	-4,16	0,29	OK
		ST17		0,00	-21,00	3,20	0,00	0,00	1,00	224,199,197
B3	0,000	F17-EN-MSP char./1		0,00	0,00	0,00	0,00	0,00	0,00	NOT OK
		ST17		0,00	0,00	0,00	0,00	0,00	1,00	858
B4	0,000	F17-EN-MSP char./2	3	-5,12	-5,89	-4,35	-3,67	-3,67	0,28	OK
		ST17		0,00	-21,00	3,20	0,00	0,00	1,00	224,199,197
B4	1,000	F17-EN-MSP char./2	3	-5,81	-6,36	-4,86	-4,18	-4,18	0,30	OK
		ST17		0,00	-21,00	3,20	0,00	0,00	1,00	224,199,197
B5	0,000	F17-EN-MSP char./2	3	-4,96	-5,30	-4,62	-3,60	-3,60	0,25	OK
		ST17		0,00	-21,00	3,20	0,00	0,00	1,00	224,199,197
B5	20,000	F17-EN-MSP char./2	3	-6,76	-7,49	-6,03	-5,63	-5,63	0,36	OK
		ST17		0,00	-21,00	3,20	0,00	0,00	1,00	224,199,197
B8	0,000	F17-EN-MSP char./2	3	-5,97	-6,38	-5,56	-4,83	-4,83	0,30	OK
		ST17		0,00	-21,00	3,20	0,00	0,00	1,00	224,199,197
B8	20,000	F17-EN-MSP char./2	3	-6,22	-6,90	-5,54	-4,81	-4,81	0,33	OK
		ST17		0,00	-21,00	3,20	0,00	0,00	1,00	224,199,197
B6	0,000	F17-EN-MSP char./1		0,00	0,00	0,00	0,00	0,00	0,00	NOT OK
		ST17		0,00	0,00	0,00	0,00	0,00	1,00	858
B7	0,000	F17-EN-MSP char./2	3	-6,36	-7,14	-5,57	-5,23	-5,23	0,34	OK
		ST17		0,00	-21,00	3,20	0,00	0,00	1,00	224,199,197
B7	1,000	F17-EN-MSP char./2	3	-6,72	-7,45	-5,99	-5,59	-5,59	0,35	OK

The detailed analysis only in one section is possible using button ***Single check***



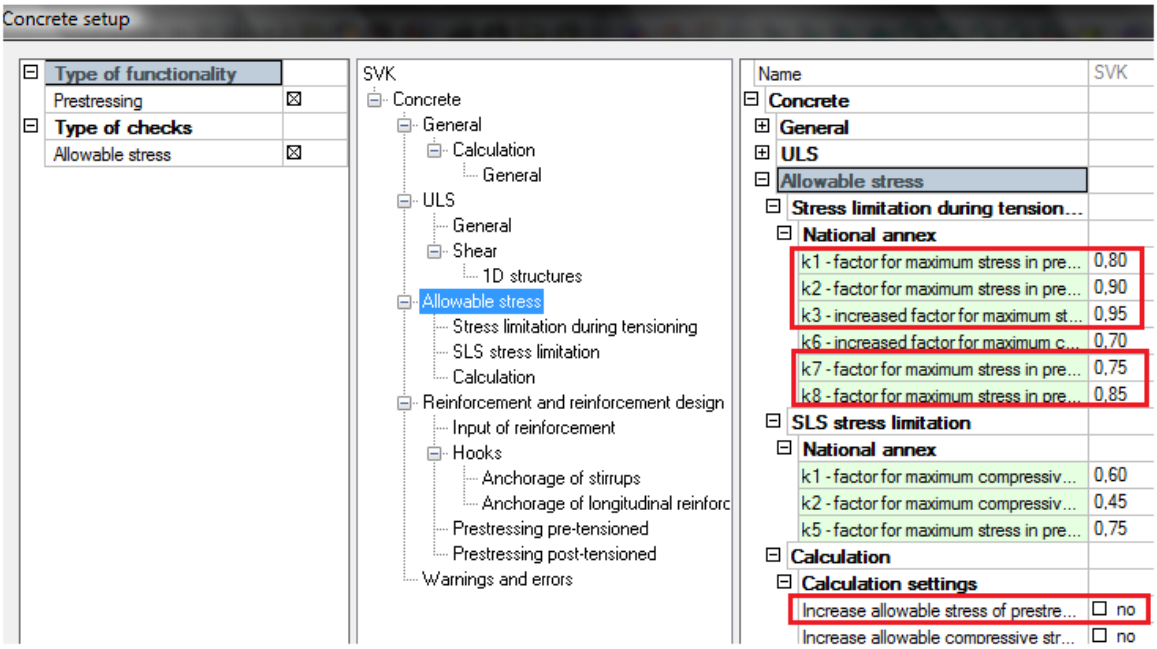
7.3.3 Check of prestressing reinforcement

7.3.3.1 Domain knowledge

The explanation of displayed values is following

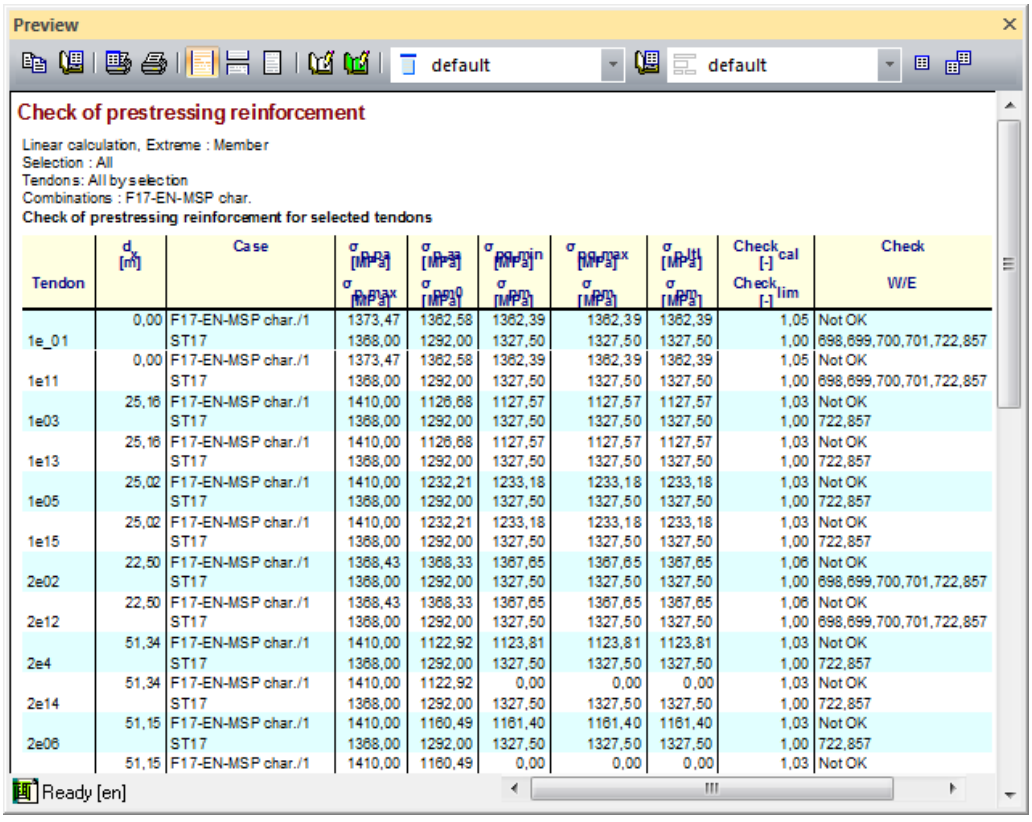
- **The stress before anchoring**
  - $\sigma_{p,max}$ – allowable stress in prestressing before anchoring
    - $\sigma_{p,\max} = \min\{k_1 f_{pk}; k_2 f_{p0.1k}\}$ (5.41)
    - $k_1 = 0{,}8$; $k_2 = 0{,}9$
    - $k_3 = 0{,}95$ ($\sigma_{p,max} = k_3 * f_{p01,k}$) if special measurement of prestress force is applied
  - $\sigma_{p,pa}$ – calculated stress before anchoring,
- **The stress after anchoring**
  - $\sigma_{p,m0}$ – allowable stress in prestressing after anchoring,
    - $\sigma_{pm0} = \min\{k_7 f_{pk}; k_8 f_{p0.1k}\}$ (5.43)
    - $k_1 = 0{,}75$; $k_2 = 0{,}85$
  - $\sigma_{p,aa}$ – calculated stress after anchoring
- **The crack limitation from SLS characteristic combination during service – cracks and deformation**
  - σ_{pm} – allowable stress in prestressing from SLS characteristic combination
    - $\sigma_{pm} = k_5 f_{pk}$ (7.2(5))
    - $k_5 = 0{,}75$
  - $\sigma_{p,LTL}$ – calculated stress after longterm losses
  - $\sigma_{pq,min}$ – minimal stress in concrete after application selweight all permanent and variable loads in prestressing
  - $\sigma_{pq,max}$ – maximal stress in concrete after application selweight all permanent and variable loads in prestressing
- **Others not checked stresses, only drawn**
  - $\sigma_{pq,max}$ – $\sigma_{pq,min}$ – the range of stresses in prestressing from maximal and minimal load in selected combination (envelopes of mobile loads)
  - $\sigma_{p,un}$ – unbalanced stresses, difference of stresses calculated from the strain determined from structural analysis once as elastic stress (Hook´s law) and the second stresses as nonlinear stress-strain relationship
  - $\sigma_{p,inc}$ – increment of stress from selected LC

The factors for the calculation of limit values of concrete stresses from the code EN1992-1-1 is possible to set in ***Concrete setup>Allowable stresses***.



The user has possibility to perform this check in ***Concrete>Member check>Check of prestressed concrete>Check of prestressing reinforcement***. The results of the check will be calculated and drawn for selected combination and value. For instance Check value of the SLS characteristic combination in 100 years is following.

The output table with extreme ***Member*** is following.



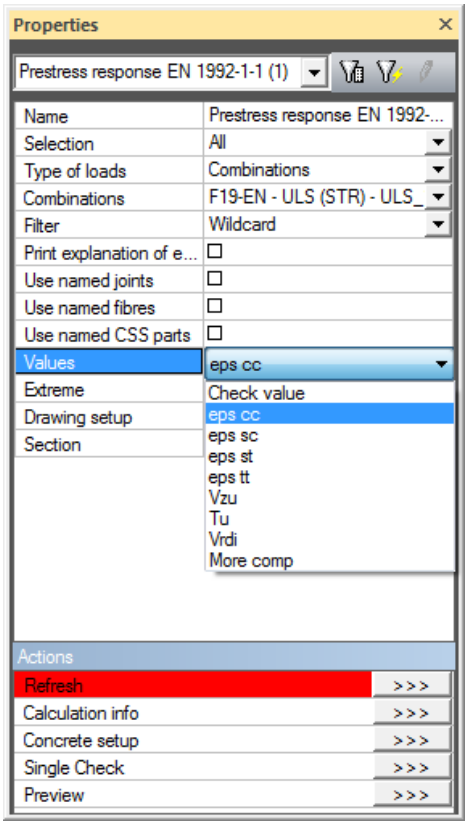
Tendon	d_x [m]	Case	$\sigma_{p,pa}$ [MPa]	$\sigma_{p,aa}$ [MPa]	$\sigma_{pq,min}$ [MPa]	$\sigma_{pq,max}$ [MPa]	$\sigma_{p,ltl}$ [MPa]	$Check_{cal}$ [-]	Check W/E
			$\sigma_{p,max}$ [MPa]	σ_{pm0} [MPa]	σ_{pm} [MPa]	σ_{pm} [MPa]	σ_{pm} [MPa]	$Check_{lim}$ [-]	
1e_01	0,00	F17-EN-MSP char./1	1373,47	1362,58	1362,39	1362,39	1362,39	1,05	Not OK
		ST17	1368,00	1292,00	1327,50	1327,50	1327,50	1,00	698,699,700,701,722,857
1e11	0,00	F17-EN-MSP char./1	1373,47	1362,58	1362,39	1362,39	1362,39	1,05	Not OK
		ST17	1368,00	1292,00	1327,50	1327,50	1327,50	1,00	698,699,700,701,722,857
1e03	25,16	F17-EN-MSP char./1	1410,00	1126,68	1127,57	1127,57	1127,57	1,03	Not OK
		ST17	1368,00	1292,00	1327,50	1327,50	1327,50	1,00	722,857
1e13	25,16	F17-EN-MSP char./1	1410,00	1126,68	1127,57	1127,57	1127,57	1,03	Not OK
		ST17	1368,00	1292,00	1327,50	1327,50	1327,50	1,00	722,857
1e05	25,02	F17-EN-MSP char./1	1410,00	1232,21	1233,18	1233,18	1233,18	1,03	Not OK
		ST17	1368,00	1292,00	1327,50	1327,50	1327,50	1,00	722,857
1e15	25,02	F17-EN-MSP char./1	1410,00	1232,21	1233,18	1233,18	1233,18	1,03	Not OK
		ST17	1368,00	1292,00	1327,50	1327,50	1327,50	1,00	722,857
2e02	22,50	F17-EN-MSP char./1	1368,43	1368,33	1367,65	1367,65	1367,65	1,06	Not OK
		ST17	1368,00	1292,00	1327,50	1327,50	1327,50	1,00	698,699,700,701,722,857
2e12	22,50	F17-EN-MSP char./1	1368,43	1368,33	1367,65	1367,65	1367,65	1,06	Not OK
		ST17	1368,00	1292,00	1327,50	1327,50	1327,50	1,00	698,699,700,701,722,857
2e4	51,34	F17-EN-MSP char./1	1410,00	1122,92	1123,81	1123,81	1123,81	1,03	Not OK
		ST17	1368,00	1292,00	1327,50	1327,50	1327,50	1,00	722,857
2e14	51,34	F17-EN-MSP char./1	1410,00	1122,92	0,00	0,00	0,00	1,03	Not OK
		ST17	1368,00	1292,00	1327,50	1327,50	1327,50	1,00	722,857
2e06	51,15	F17-EN-MSP char./1	1410,00	1160,49	1161,40	1161,40	1161,40	1,03	Not OK
		ST17	1368,00	1292,00	1327,50	1327,50	1327,50	1,00	722,857
	51,15	F17-EN-MSP char./1	1410,00	1160,49	0,00	0,00	0,00	1,03	Not OK

7.4 ULS – concrete checks

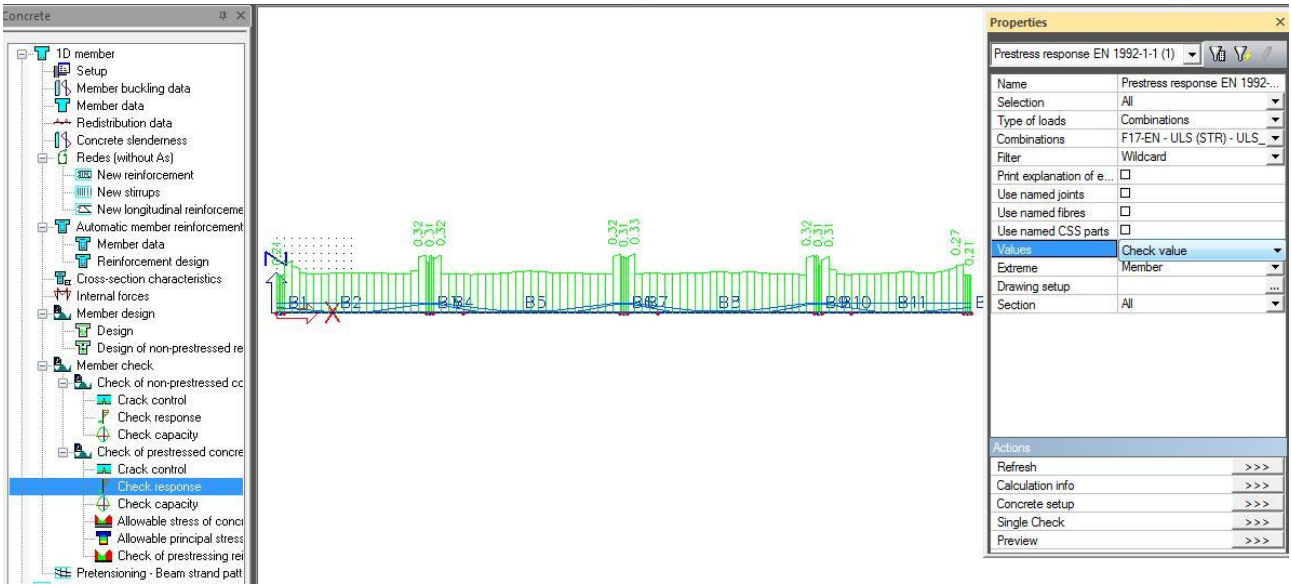
7.4.1 Prestress check response

The CSS response on acting combination is calculated in this check. The check is in ***Concrete>Member check>Check of prestressed concrete>Check response***. The results of the check will be calculated and drawn for selected combination and value. There are following values for selection

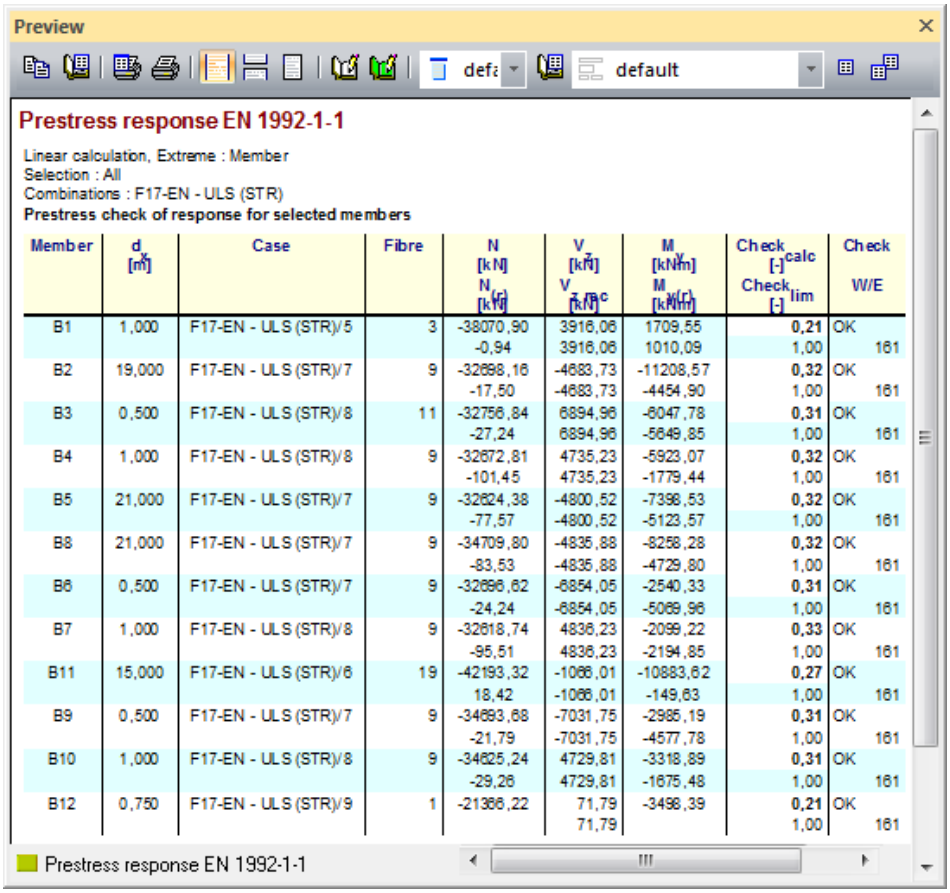
- ***eps_cc*** – the strain in concrete under compression
- ***eps_sc*** – the strain in nonprestressed reinforcement under compression
- ***eps_st***– the strain in nonprestressed reinforcement under tension
- ***eps_tt*** – the strain in prestressed reinforcement under tension
- ***Vzu*** – the shear resistance
- ***Tu*** – the torsional resistance
- ***Vrdi*** – the resistance of shear in construction joint



The results are calculated and drawn for F17-EN-ULS(STR) - check value.

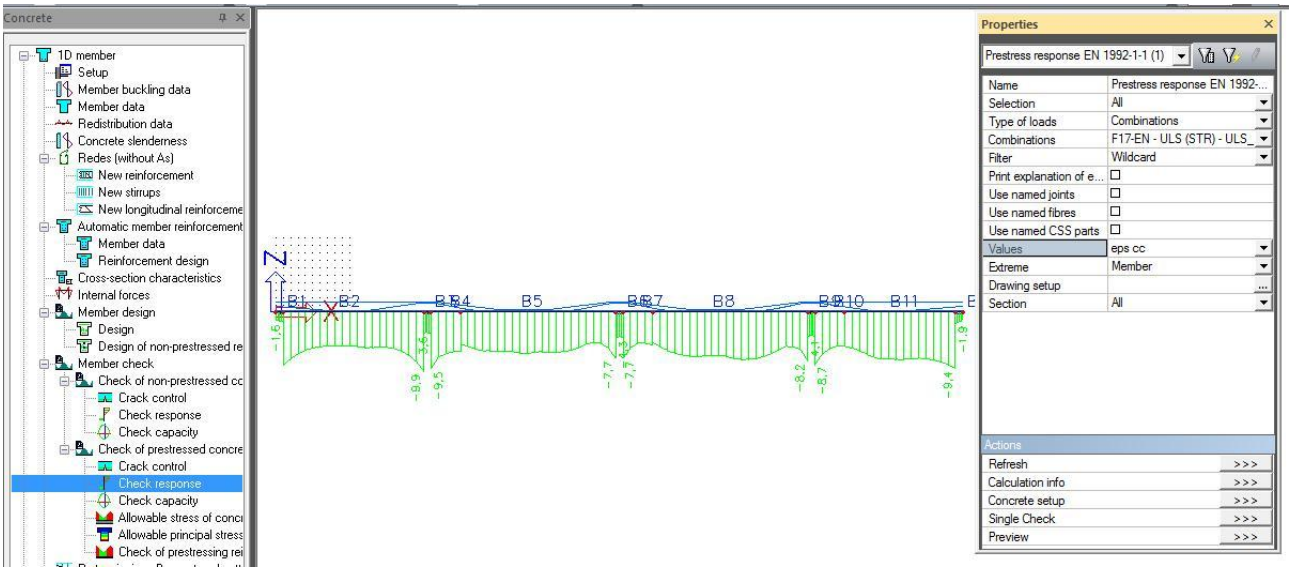


The output table with extreme ***Member*** is following.

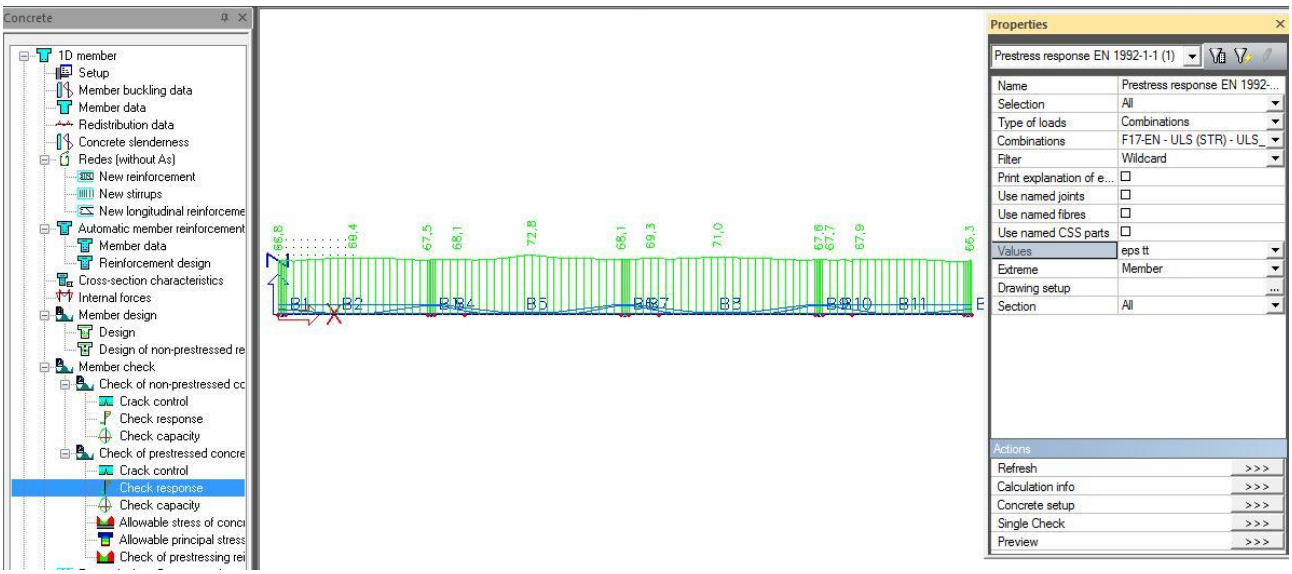


Member	d [m]	Case	Fibre	N [kN]	V [kN]	M [kNm]	Check [-]	Check
				N (r) [kN]	V (r) [kN]	M (r) [kNm]	Check lim [-]	W/E
B1	1,000	F17-EN - ULS (STR)/5	3	-38070,90	3916,06	1709,55	0,21	OK
				-0,94	3916,06	1010,09	1,00	161
B2	19,000	F17-EN - ULS (STR)/7	9	-32698,16	-4683,73	-11208,57	0,32	OK
				-17,50	-4683,73	-4454,90	1,00	161
B3	0,500	F17-EN - ULS (STR)/8	11	-32756,84	6894,96	-6047,78	0,31	OK
				-27,24	6894,96	-5649,85	1,00	161
B4	1,000	F17-EN - ULS (STR)/8	9	-32672,81	4735,23	-5923,07	0,32	OK
				-101,45	4735,23	-1779,44	1,00	161
B5	21,000	F17-EN - ULS (STR)/7	9	-32624,38	-4800,52	-7398,53	0,32	OK
				-77,57	-4800,52	-5123,57	1,00	161
B8	21,000	F17-EN - ULS (STR)/7	9	-34709,80	-4835,88	-8258,28	0,32	OK
				-83,53	-4835,88	-4729,80	1,00	161
B6	0,500	F17-EN - ULS (STR)/7	9	-32696,62	-6854,05	-2540,33	0,31	OK
				-24,24	-6854,05	-5069,96	1,00	161
B7	1,000	F17-EN - ULS (STR)/8	9	-32618,74	4836,23	-2099,22	0,33	OK
				-95,51	4836,23	-2194,85	1,00	161
B11	15,000	F17-EN - ULS (STR)/6	19	-42193,32	-1066,01	-10883,62	0,27	OK
				18,42	-1066,01	-149,63	1,00	161
B9	0,500	F17-EN - ULS (STR)/7	9	-34693,68	-7031,75	-2985,19	0,31	OK
				-21,79	-7031,75	-4577,78	1,00	161
B10	1,000	F17-EN - ULS (STR)/8	9	-34625,24	4729,81	-3318,89	0,31	OK
				-29,26	4729,81	-1675,48	1,00	161
B12	0,750	F17-EN - ULS (STR)/9	1	-21366,22	71,79	-3498,39	0,21	OK
					71,79		1,00	161

The strain in concrete under compression for F17-EN-ULS(STR) – ***eps_cc***.

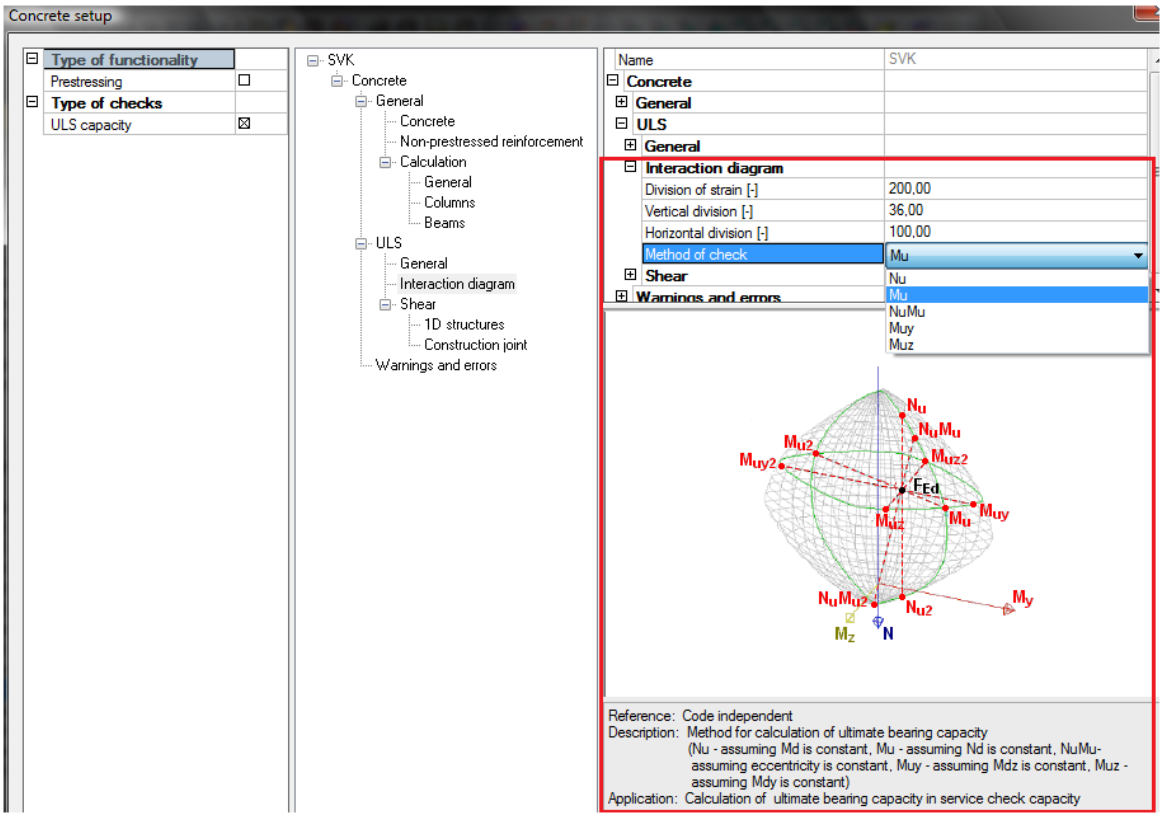


The strain in tendons under tension for F17-EN-ULS(STR) – ***eps_tt***.



7.4.2 Prestress check diagram

The resistance of CSS acting by combination of moment and normal force is calculated using interaction diagram in this check. The check is in ***Concrete>Member check>Check of prestressed concrete>Check capacity.*** The default setup options are following:

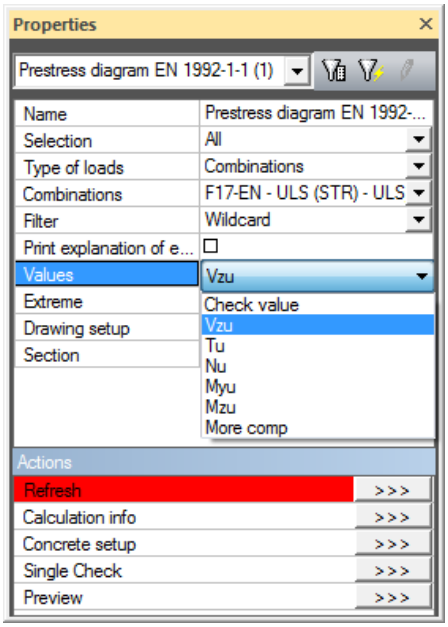


The recommended type of interaction diagram is following:

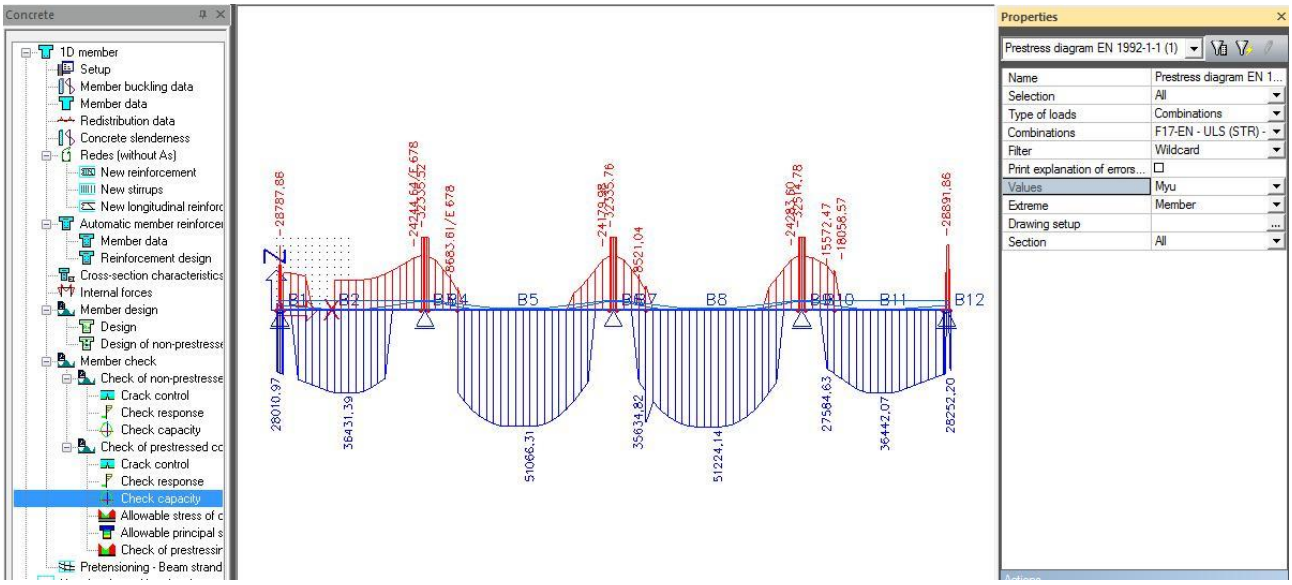
- When ***compression*** is dominant then ***NuMu*** is suitable because when structure is deformed by compression then moment is also increased
- When ***tension*** is dominant then ***Nu*** is suitable
- When pure ***bending*** is dominant then ***Mu*** is suitable

The results of the check will be calculated and drawn for selected combination and value. There are following values for selection

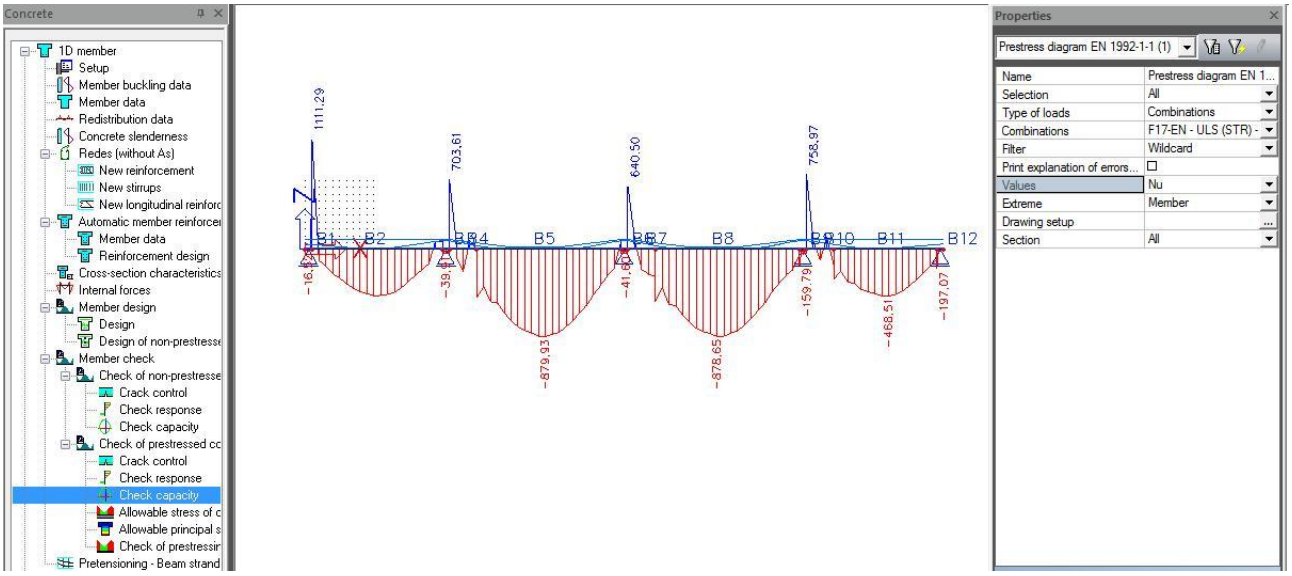
- ***Nu*** – capacity in axis x (axial capacity)
- ***Myu*** – moment capacity in direction y
- ***Mzu*** – moment capacity in direction z
- ***Vzu*** – shear capacity
- ***Tu*** – torsional capacity



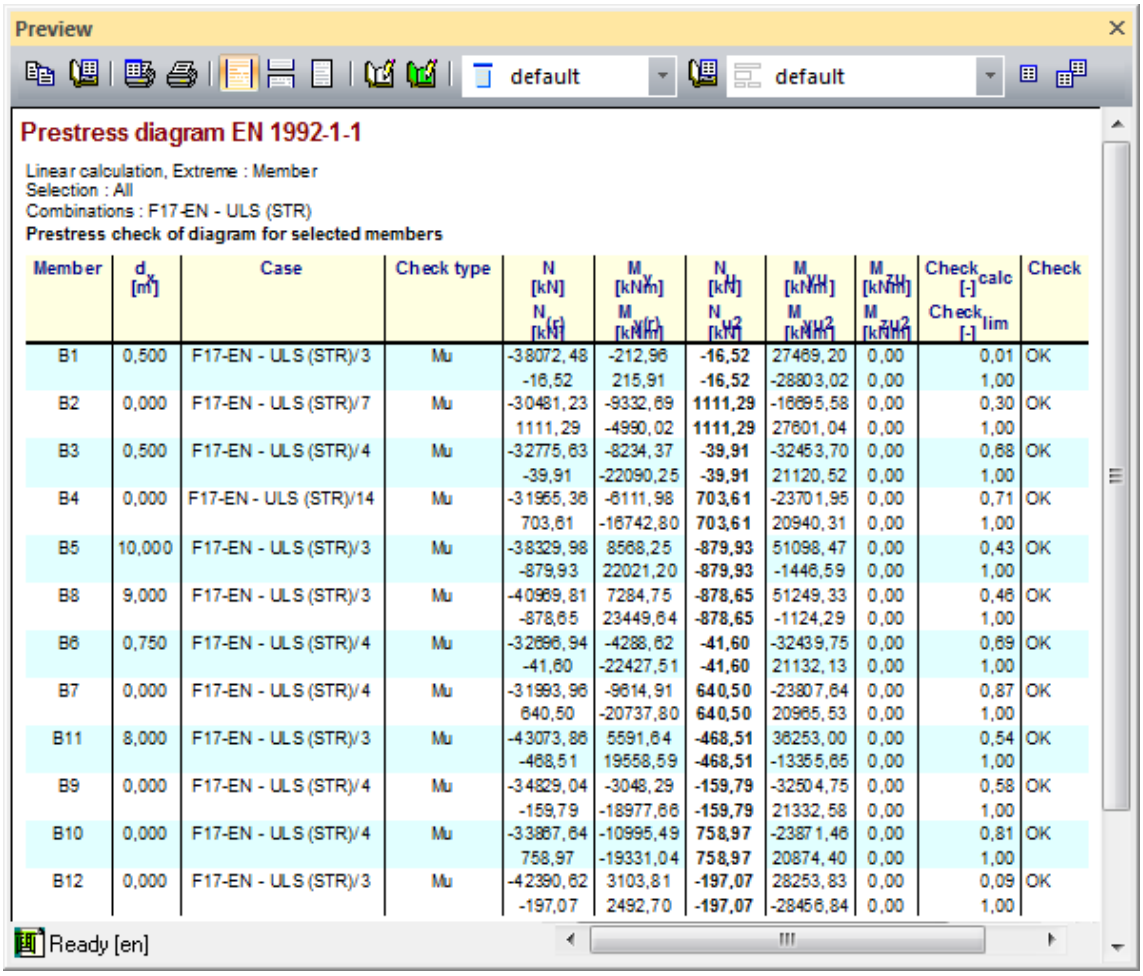
The moment capacity in direction y for F17-EN-ULS(STR) – ***Myu***



The axial capacity for F17-EN-ULS(STR) – ***Nu***



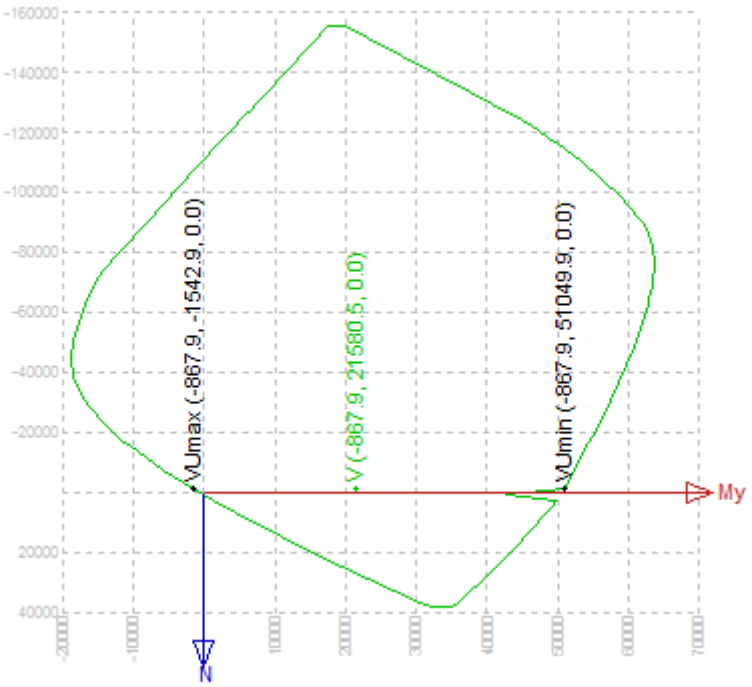
The output table for F17-EN-ULS(STR)



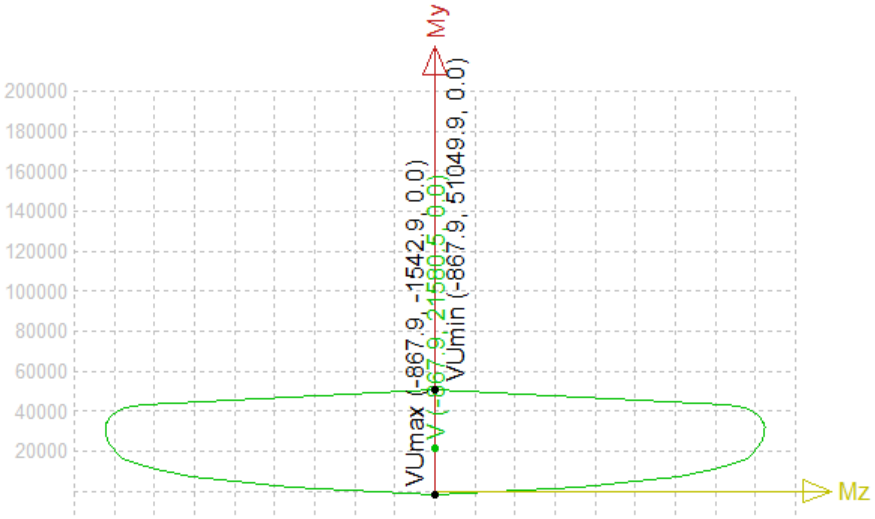
Member	d_x [m]	Case	Check type	N [kN] / $N_{(c)}$ [kN]	M_y [kNm] / $M_{y(c)}$ [kNm]	N_{Ed} [kN] / N_{Ed2} [kN]	M_{yEd} [kNm] / M_{yEd2} [kNm]	M_{zEd} [kNm] / M_{zEd2} [kNm]	$Check_{calc}$ [-] / $Check_{lim}$ [-]	Check
B1	0,500	F17-EN - ULS (STR)/3	Mu	-38072,48	-212,96	**-16,52**	27469,20	0,00	0,01	OK
				-16,52	215,91	**-16,52**	-28803,02	0,00	1,00	
B2	0,000	F17-EN - ULS (STR)/7	Mu	-30481,23	-9332,69	**1111,29**	-16695,58	0,00	0,30	OK
				1111,29	-4990,02	**1111,29**	27601,04	0,00	1,00	
B3	0,500	F17-EN - ULS (STR)/4	Mu	-32775,63	-8234,37	**-39,91**	-32453,70	0,00	0,68	OK
				-39,91	-22090,25	**-39,91**	21120,52	0,00	1,00	
B4	0,000	F17-EN - ULS (STR)/14	Mu	-31955,36	-6111,98	**703,61**	-23701,95	0,00	0,71	OK
				703,61	-16742,80	**703,61**	20940,31	0,00	1,00	
B5	10,000	F17-EN - ULS (STR)/3	Mu	-38329,98	8568,25	**-879,93**	51098,47	0,00	0,43	OK
				-879,93	22021,20	**-879,93**	-1446,59	0,00	1,00	
B8	9,000	F17-EN - ULS (STR)/3	Mu	-40969,81	7284,75	**-878,65**	51249,33	0,00	0,46	OK
				-878,65	23449,64	**-878,65**	-1124,29	0,00	1,00	
B6	0,750	F17-EN - ULS (STR)/4	Mu	-32696,94	-4288,62	**-41,60**	-32439,75	0,00	0,69	OK
				-41,60	-22427,51	**-41,60**	21132,13	0,00	1,00	
B7	0,000	F17-EN - ULS (STR)/4	Mu	-31993,96	-9614,91	**640,50**	-23807,64	0,00	0,87	OK
				640,50	-20737,80	**640,50**	20965,53	0,00	1,00	
B11	8,000	F17-EN - ULS (STR)/3	Mu	-43073,86	5591,64	**-468,51**	36253,00	0,00	0,54	OK
				-468,51	19558,59	**-468,51**	-13355,65	0,00	1,00	
B9	0,000	F17-EN - ULS (STR)/4	Mu	-34829,04	-3048,29	**-159,79**	-32504,75	0,00	0,58	OK
				-159,79	-18977,66	**-159,79**	21332,58	0,00	1,00	
B10	0,000	F17-EN - ULS (STR)/4	Mu	-33867,64	-10995,49	**758,97**	-23871,46	0,00	0,81	OK
				758,97	-19331,04	**758,97**	20874,40	0,00	1,00	
B12	0,000	F17-EN - ULS (STR)/3	Mu	-42390,62	3103,81	**-197,07**	28253,83	0,00	0,09	OK
				-197,07	2492,70	**-197,07**	-28456,84	0,00	1,00	

The results ain single checks are following:

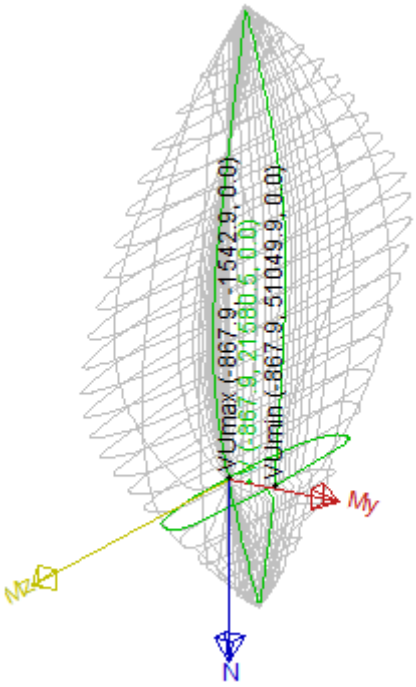
- Vertical section of interaction diagram



- Horizontal section of interaction diagram



- 3D interaction adiagram

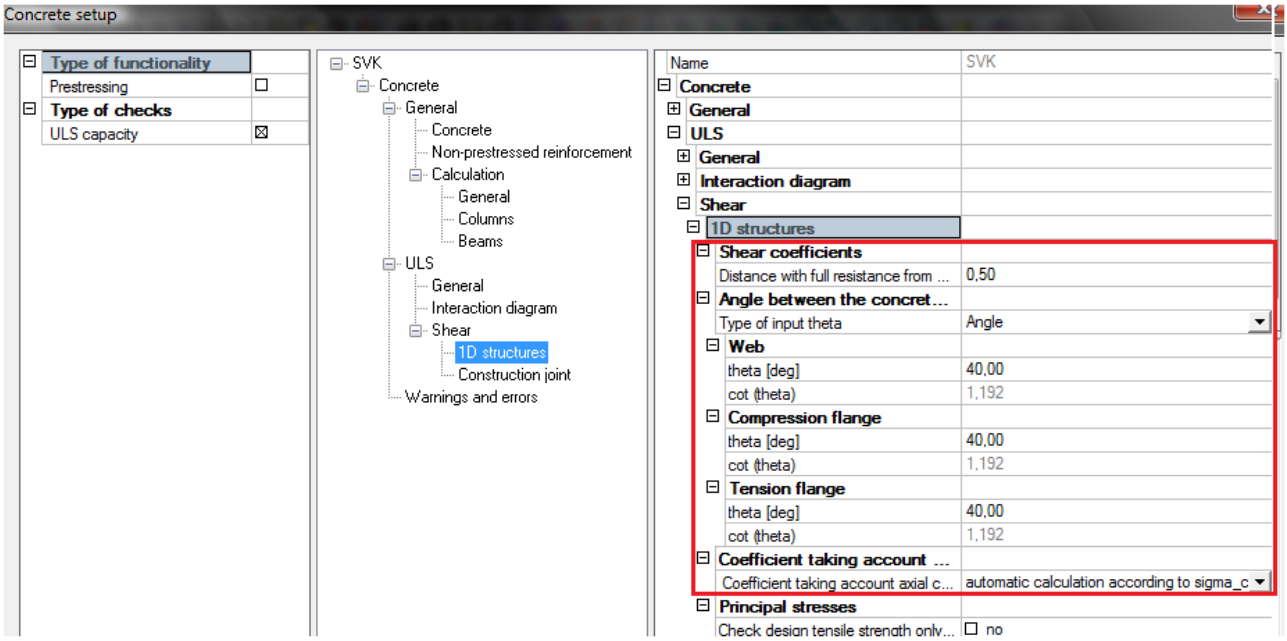


7.4.3 Shear check

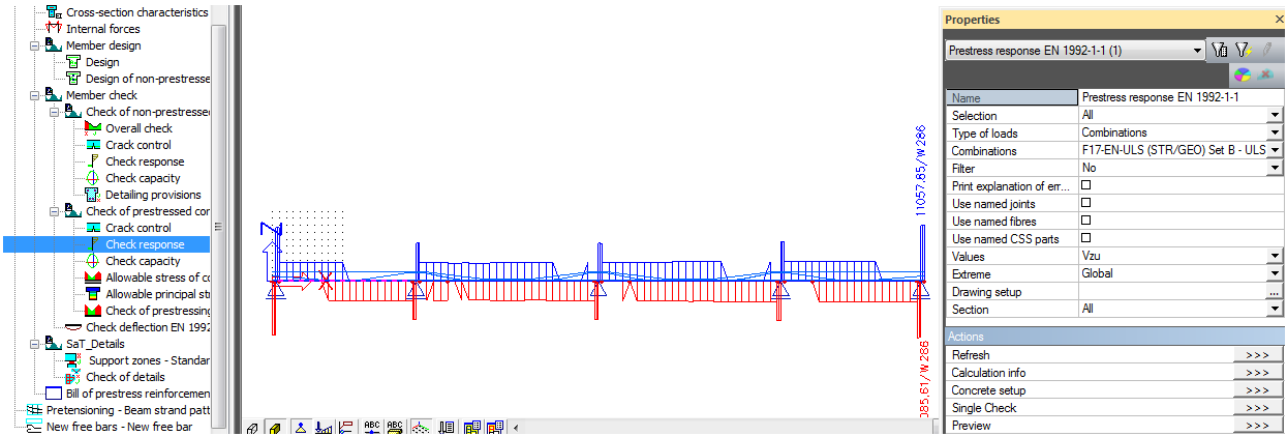
The shear check is performed in ***Check response*** and ***check capacity*** as value ***Vzu*** in property. At the beginning the existing of cracks in ULS is calculated:

- When the CSS is cracked then calculation is done according to chapter 12.6.3
- When the CSS is uncracked and without nonprestressed reinforcement then calculation is done according to chapter 12.6.3

The parameters for the calculation of shear check is possible to set in ***Concrete setup>ULS>Shear***.



The shear check for F17-EN-ULS(STR) – ***Vzu***.



The output table with extreme ***Member*** is following.

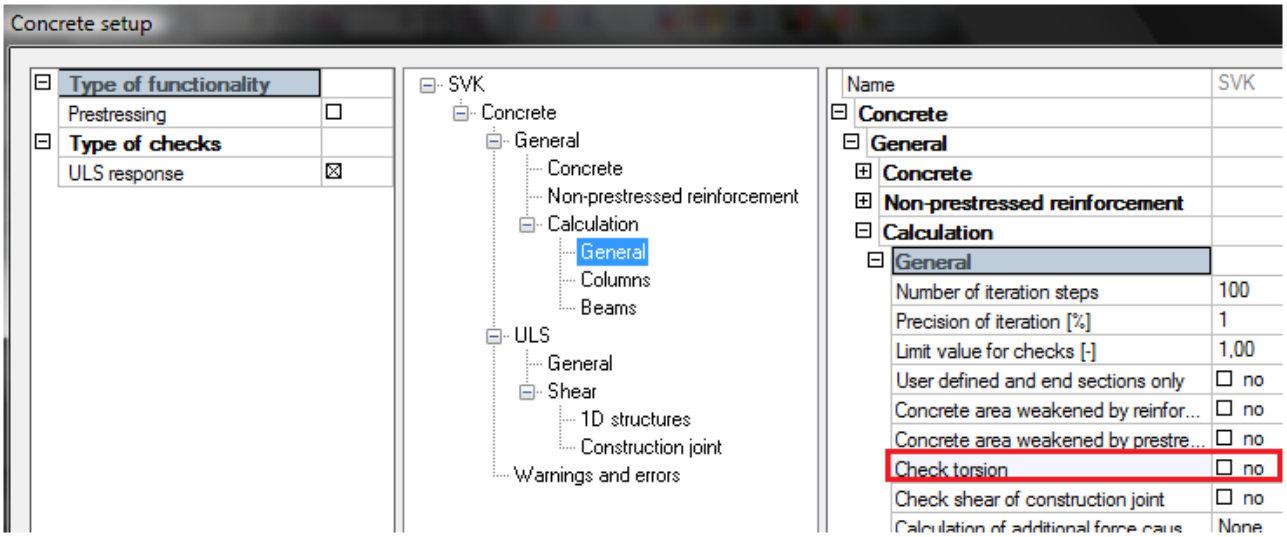
Prestress response EN 1992-1-1

Linear calculation, Extreme : Global
Selection : All
Combinations : F17-EN-ULS (STR/GEO) Set B
Check of shear for selected members

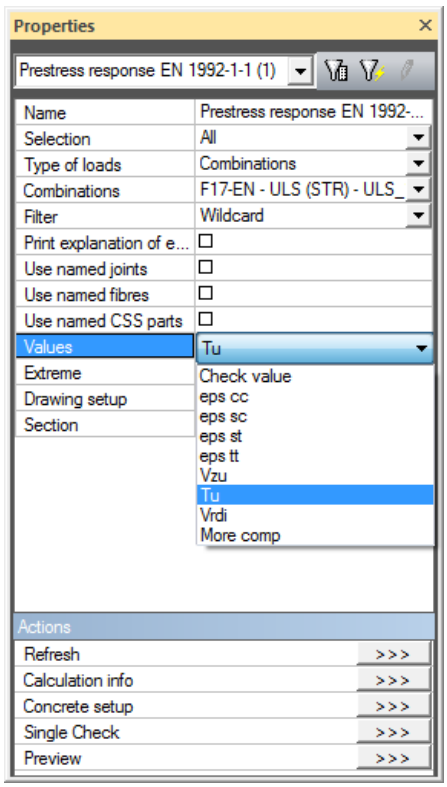
Member	d_x [m]	Case	V_{Ed} [kN] N_{Ed} [kN]	stirr dist [mm] transv dist [mm]	diam. [mm] A_{sw} [mm²/m]	$V_{Rd,c}$ [kN] $V_{Rd,max}$ [kN]	V_{Rd} [kN]	$Check_{calc}$ [-] $Check_{lim}$ [-]	Check W/E	Method
B11	15,000	F17-EN-ULS (STR/GEO) Set B/3	-3990,07 -35281,43	0 0	0,0 0	3983,18 0,00	3983,18	1,00 1,00	NOT OK 828	formula 6.2a.b) EN1992-1-1
B10	1,000	F17-EN-ULS (STR/GEO) Set B/2	4729,85 -34625,35	0 0	0,0 0	3933,35 0,00	3933,35	1,20 1,00	NOT OK 828	formula 6.2a.b) EN1992-1-1

7.4.4 Torsion check

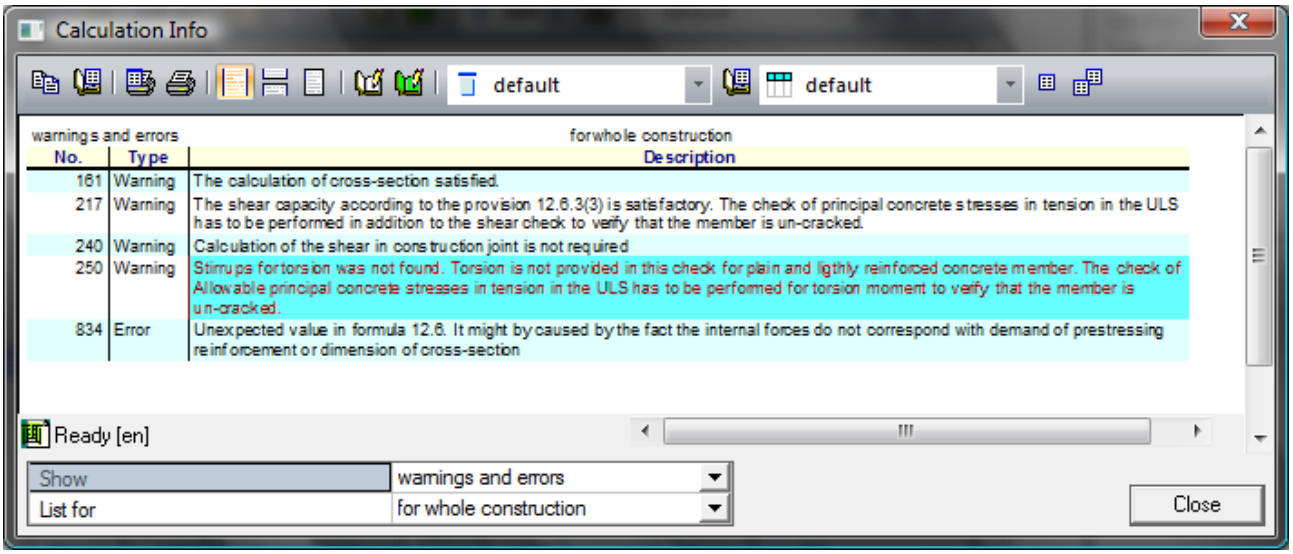
The torsion check is performed in ***Check response*** and ***check capacity*** as value ***Tu*** in property. The calculation is performed according to chapter 6.4. The check of torsion is required if checkbox in ***Concrete>General*** is turned ON.



The shear check for F17-EN-ULS(STR) – ***Tu***.

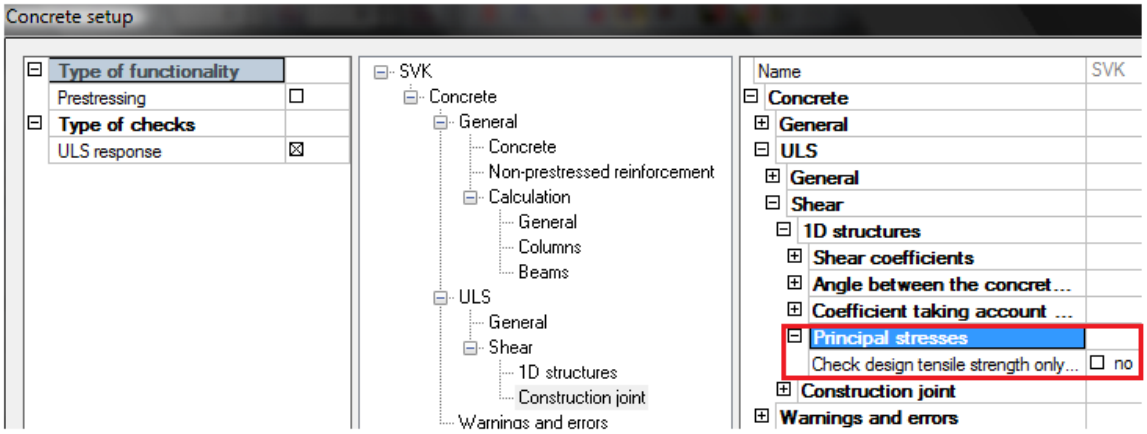


The torsion is checked only if stirrups are defined on the beams, when the stirrups are not defined check of allowable principal stresses is required



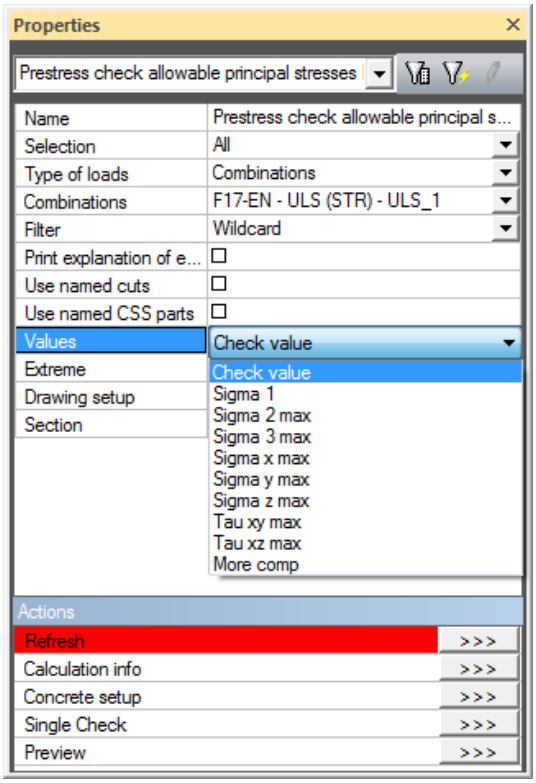
7.4.5 Allowable principal stresses

The check of allowable principal stresses in tension in ULS is performed for verification that CSS is uncracked CSS under acting load. This check is available in ***Concrete>Member check>check of prestressed concrete>Allowable principal stresses***. When the check of tensile stress is required only in compression zone then checkbox ***Concrete setup>ULS>Shear*** has to be checked. The principal stresses are calculated in predefined cuts by user (see 5.3).

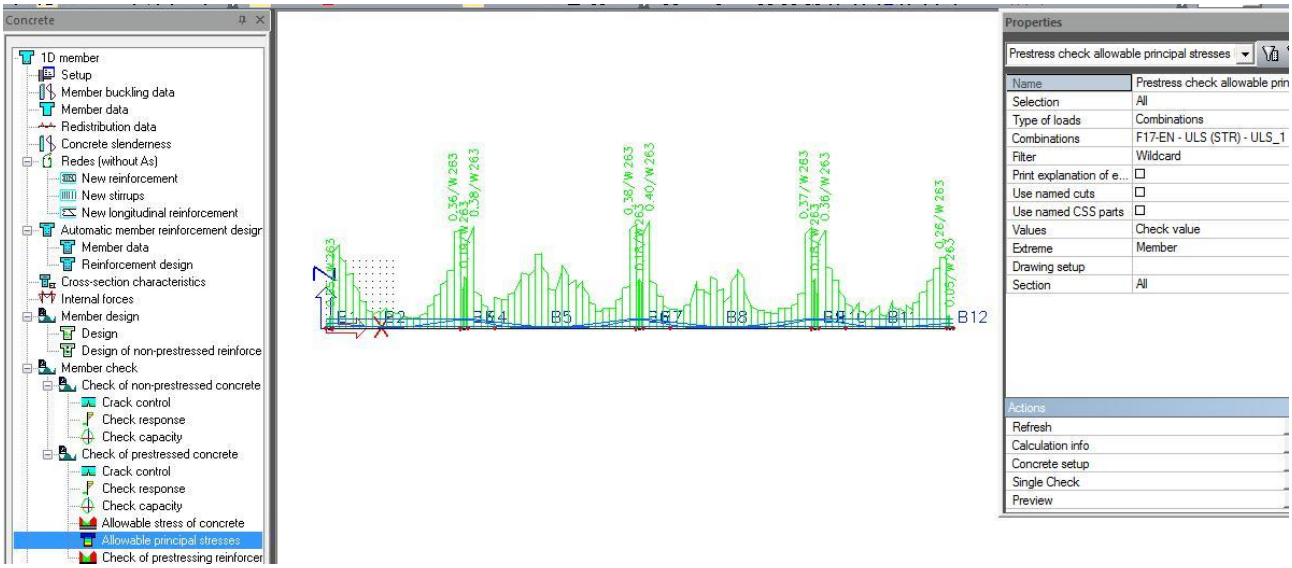


The service of ***allowable principal stresses*** has the property dialog with following values

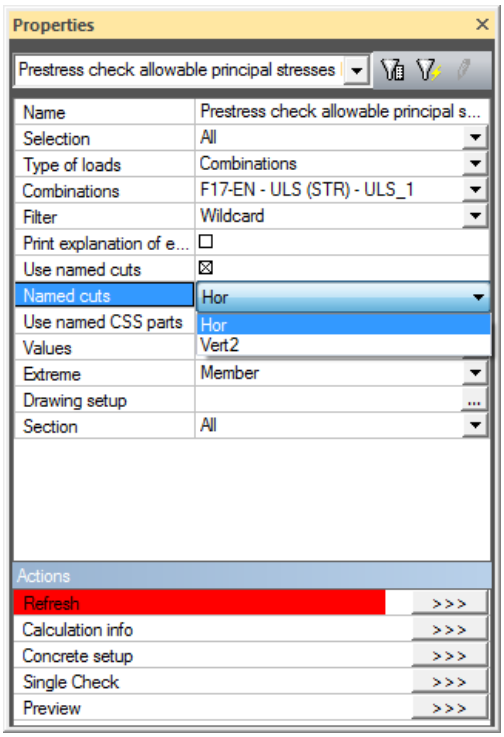
- ***Sigma_1*** – principal stresses 1 for plane state of stresses in 3D
- ***Sigma_2 max*** – principal stresses 2 for plane state of stresses in 3D
- ***Sigma_3 max*** – principal stresses 3 for plane state of stresses in 3D
- ***Sigma_x_max*** – maximal stress in concrete in axis X
- ***Sigma_y_max*** – maximal stress in concrete in axis Y
- ***Sigma_z_max*** – maximal stress in concrete in axis Z
- ***Tau_xy_max*** – maximal shear stress in concrete in plane XY
- ***Tau_xz_max*** – maximal shear stress in concrete in plane XZ



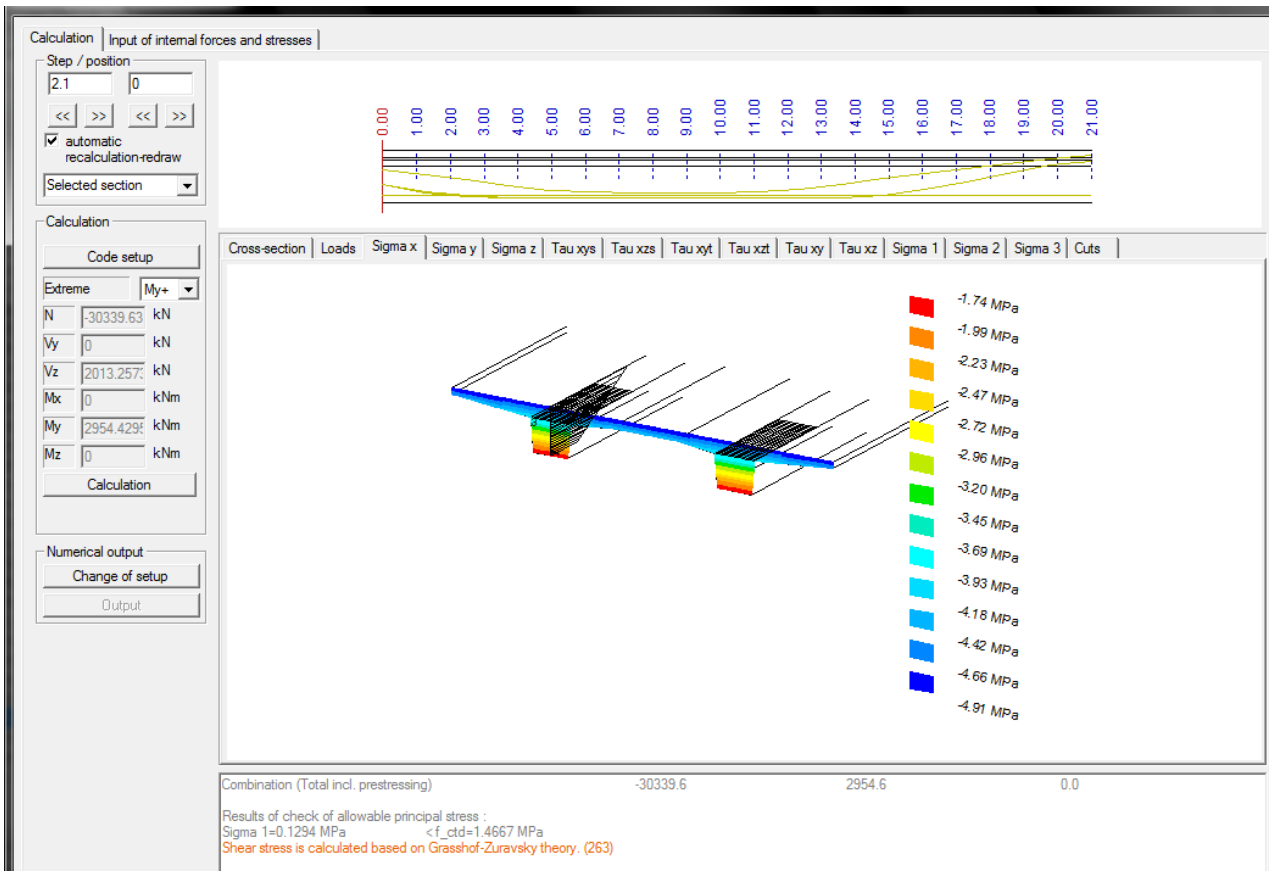
The check value for F17-EN-ULS(STR) is following.



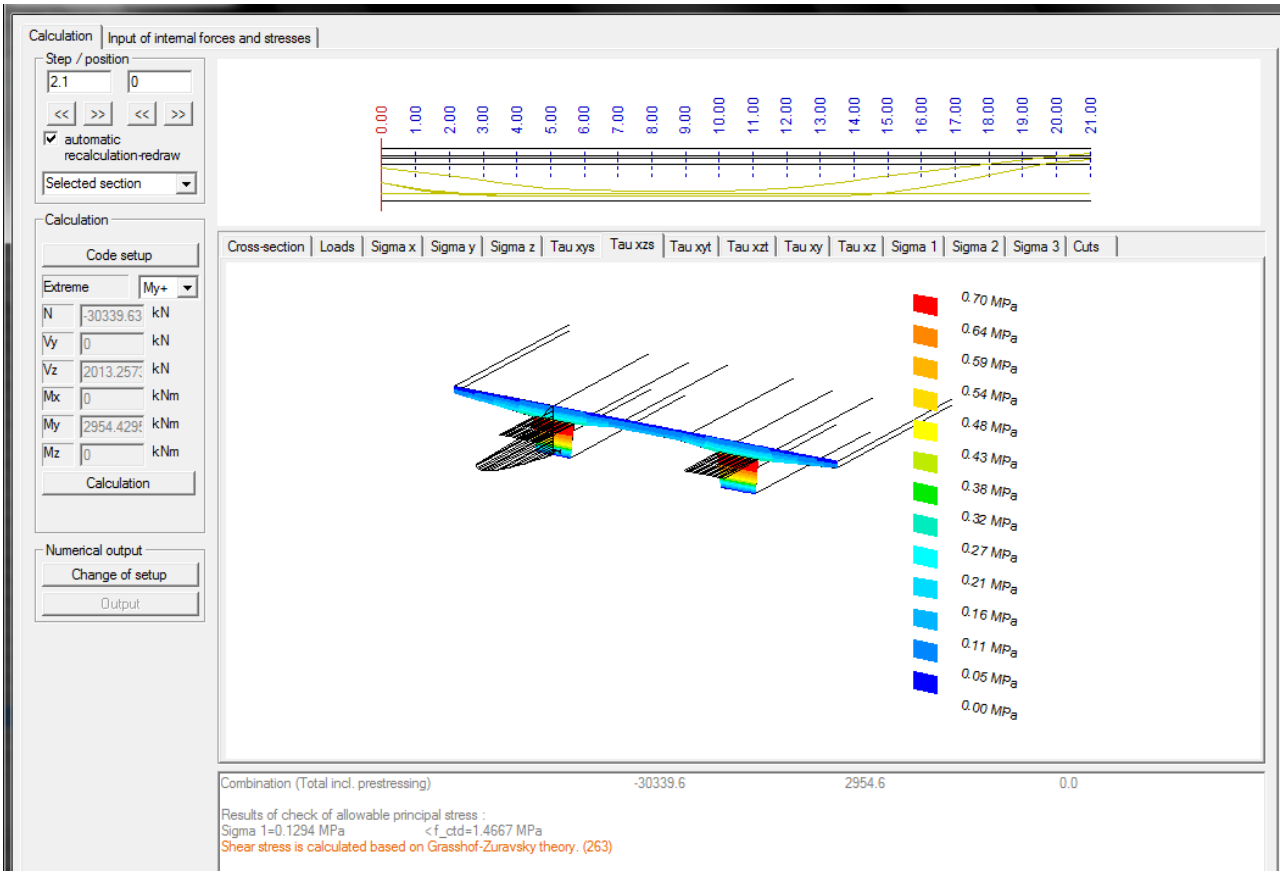
There is possibility to checked only selected named cuts or part of CSS in this service.



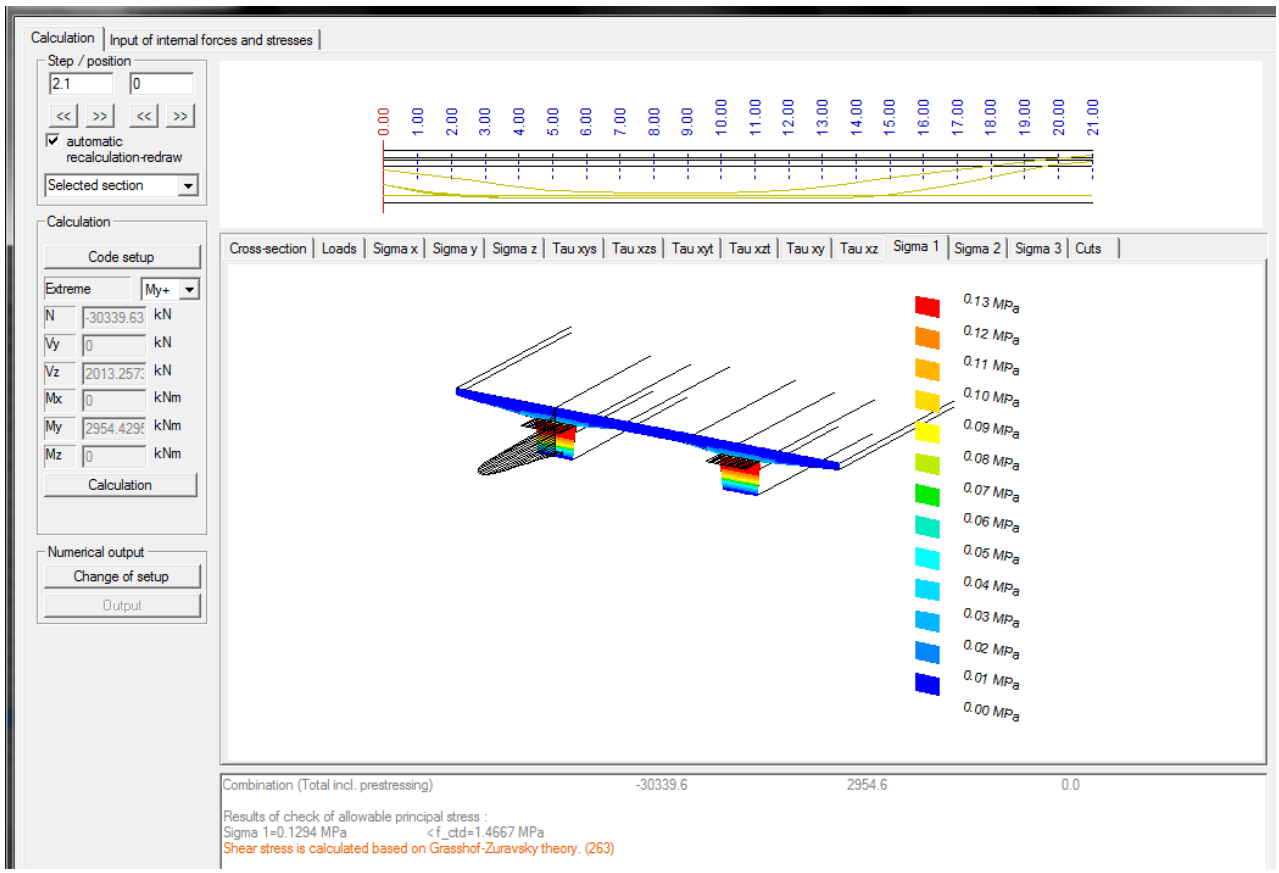
The user has the possibility to see detailed results in selected section along the beam using the button ***Single check***. The stress σ_x for F17-EN-ULS(STR) is following.



The stress τ_{xz} for F17-EN-ULS(STR) is following



The principal stress σ_1 for F17-EN-ULS(STR) is following


Calculation
Input of internal forces and stresses
Step / position
2.1
0
automatic recalculation-redraw
Selected section
Calculation
Code setup
Extreme
My+
N -30339.63 kN
Vy 0 kN
Vz 2013.257 kN
Mx 0 kNm
My 2954.429 kNm
Mz 0 kNm
Calculation
Numerical output
Change of setup
Output
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00 19.00 20.00 21.00
Cross-section Loads Sigma x Sigma y Sigma z Tau xys Tau xzs Tau xyt Tau xzt Tau xy Tau xz Sigma 1 Sigma 2 Sigma 3 Cuts
0.13 MPa
0.12 MPa
0.11 MPa
0.10 MPa
0.09 MPa
0.08 MPa
0.07 MPa
0.06 MPa
0.05 MPa
0.04 MPa
0.03 MPa
0.02 MPa
0.01 MPa
0.00 MPa
Combination (Total incl. prestressing) -30339.6 2954.6 0.0
Results of check of allowable principal stress :
Sigma 1=0.1294 MPa < f_ctd=1.4667 MPa
Shear stress is calculated based on Grasshof-Zuravsky theory. (263)

8 Literature

[1]. EN 1990 Eurocode, Basis of structural design; European Committee for Standardization, December 2002.

[2]. EN 1990/A1. Eurocode: Basis of structural design; European Committee for Standardization, November 2005.

[3]. EN 1991-2 Eurocode 1, Actions on structures – Part 2: Traffic loads on bridges; European Committee for Standardization, November 2003.

[4]. EN 1992-1-1 Eurocode 2, Design of Concrete Structures – Part 1: General rules and rules for buildings, European Committee for Standardization, December 2004.

[5]. EN 1992-2 Eurocode 2, Design of Concrete Structures – Concrete bridges – design and detailing rules; European Committee for Standardization, November 2005.