NEMETSCHEK Scia

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

Autodesign

Global optimization

Scia Engineer

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Introduction

In many cases, the design of a building involves a typical calculation with only some variation in certain predefined parameters, such as the buildings dimensions, loading, boundary conditions, etc. Often, the principle of the analysis in all projects is the same. If all these principles can easily be defined, parameterized and stored, the design of the building can be made much faster than in the traditional way of engineering. In Scia Engineer it is easily possible to parameterize structures and save them in a library for later reuse in other projects. Parameters, such as height of a section, length of a beam/column, span, cross-section data (including built-up sections), etc. can be easily defined without the need for programming or scripting. The designer can choose the required structural element from the library and easily edit its boundary conditions, loads (wind, snow, etc.) according to a chosen code and the code specific combinations are applied automatically to enable the design of the structure. Once the structure is defined, Scia Engineer Autodesign capabilities will automatically run the analysis and find the optimal definition of the structure according to the specific design rules that are chosen by the user.

Steel and concrete members can be designed individually or within a common set of elements to satisfy the criteria of the appropriate code. The Autodesign capabilities in Scia Engineer offer a lot of flexibility. They offer the users different levels of control. They considerably reduce the time needed to select appropriate sections. For example, the user can select the maximum check value and type of cross-section, including I-sections, angles and welded sections. Then Scia Engineer will determine the optimal profile that satisfies the code check. Automatic profile optimization can be applied to all standard and parametric sections. For parametric sections, the user chooses which parameter - whether height, flange thickness or other – should be adapted. The program displays the check values graphically in the 3D view of the structure with colours giving a clear overview of (over-)dimensioned and (un)satisfactory parts of the construction.

Principles of Autodesign

Once a structure has been designed and calculated, it is the time to perform checking and usually a kind of optimisation of the original design. Scia Engineer contains a powerful tool for this task. The optimisation of applied profiles may be done automatically or semi-automatically. The process of Autodesign results in what may be called an economical and good solution.

Autodesign in general represents a complex task. A full, complete and really "optimal" optimisation would usually lead to a long and often recursive process. Therefore, Scia Engineer implements a kind of compromise.

One Autodesign step takes account of a single cross-section only

It is possible to optimise one cross-section at a time. The user selects the cross-section from a list of all cross-sections used in the structure.

One Autodesign step considers only "selected" members

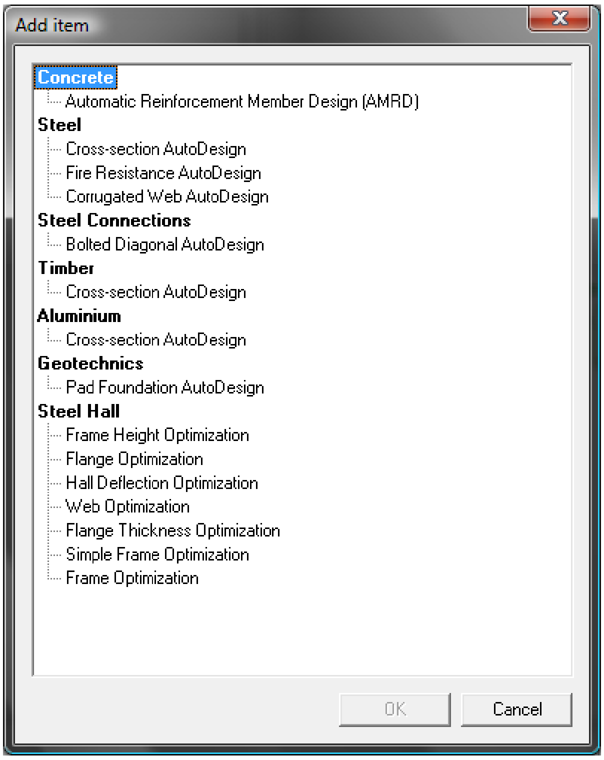
It is possible to limit the Autodesign process to only a set of selected members. The user may make a selection to specify which beams of the given cross-section should be considered for the Autodesign calculations.

One Autodesign step affects the whole structure

Once the optimised cross-section is found, it is applied to ALL members in the structure that are of the specified cross-section. It is of no importance whether the Autodesign calculation was limited to a selected number of beams or not. The final effect of the Autodesign is that the original cross-section is simply replaced with the new, i.e. optimised, cross-section.

Autodesign types

Within Scia Engineer, there are different possibilities that guide you through the optimization process. The basic option is the use of parameters. Again, almost each entity in Scia Engineer can be covered by a parameter. Once a project is defined and analyzed, the user can always save the project as a template for later reuse. More general and very useful tool is the Autodesign tool. This allows the user to optimize different parts of the structure. With the optimization, one has the option to define relations between dimensions and specify iteration steps. Last but not least, the defined optimization groups can be combined in the Overall Autodesign in order to optimize multiple types of members or entire structure.



Scia Engineer enables you to perform an optimisation of the whole structure or of its selected part. The optimisation can be run for steel, concrete, aluminium and timber structures or for steel or timber parts of multi-material projects. Most of the items there concern the default Autodesign (cross-section steel, timber, aluminium, fire resistance, corrugated web check) which is the standard Autodesign of cross-sections that can be found in the appropriate steel, aluminium and other services.
There are several advantages in the overall Autodesign function over the individual Autodesign in services:

- The ability to Autodesign more than one member at a time.
- The ability to run more than one type of Autodesign at a time (steel, timber, concrete, aluminum…etc).
- The ability to use an iterative optimization

There are several different Autodesign procedures mentioned in the following table:

Material	Autodesign item
Concrete	Automatic member reinforcement design (AMRD)
Steel	Cross-section AutoDesign
Steel	Fire resistance AutoDesign
Steel	Corrugated web AutoDesign
Steel	Lapped purlin/girt Autodesign (only IBC code)
Steel connection	Bolted diagonal Autodesign
Timber	Cross-section Autodesign
Aluminium	Cross-section Autodesign

Geotechnics	Pad foundation Autodesign
Steel hall	In-block Autodesign item
Steel hall	Frame - Autodesign manager
Steel hall	Frame – CSS height Autodesign
Steel hall	Frame - deflection Autodesign
Steel hall	Frame - flange Autodesign
Steel hall	Frame – web Autodesign
Steel hall	Frame - flange thickness Autodesign

It is also possible to perform several of the above mentioned optimisation types and then compare the results. And it is up to you to select the cross-section types and bolted diagonal connections that are relevant to your work. It is also your responsibility to think in advance and define and assign to 1D members as many cross-section types as necessary for a proper design and optimisation of the project.

Note: In order to perform the Autodesign, calculation must be already performed.

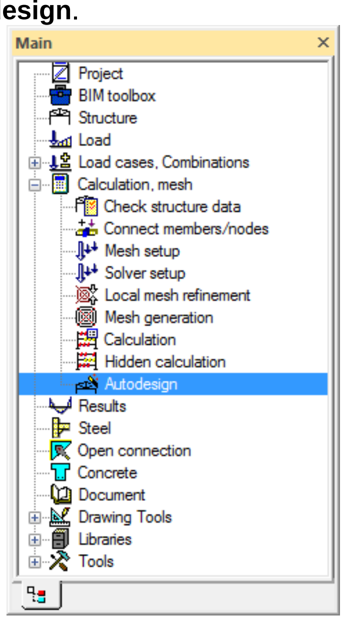
Autodesign manager

As stated in the introduction you may perform several different optimisations. You may run the Autodesign and compare the results for different parts of the structure, for different optimisation types (e.g. standard and fire resistance code check). Therefore, all the defined optimisations are stored in the Autodesign manager. Thus you do not have to define all the Autodesign criteria and parameters again and again. The Autodesign manager is a standard Scia Engineer database manager with usual features and functions.

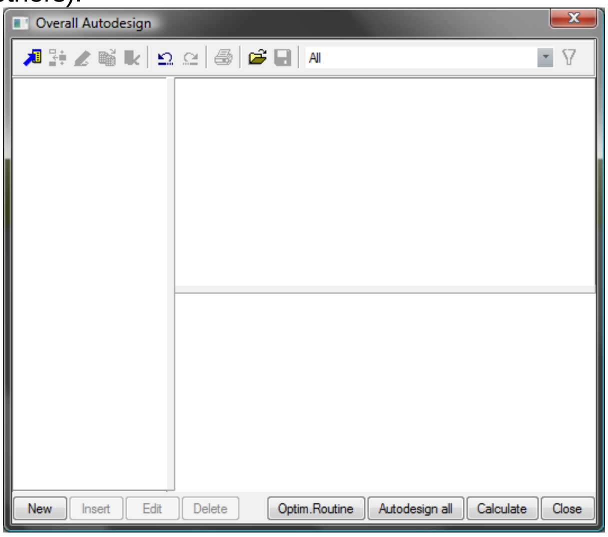
Procedure to open the Autodesign manager

1. Open service **Calculation, Mesh**.

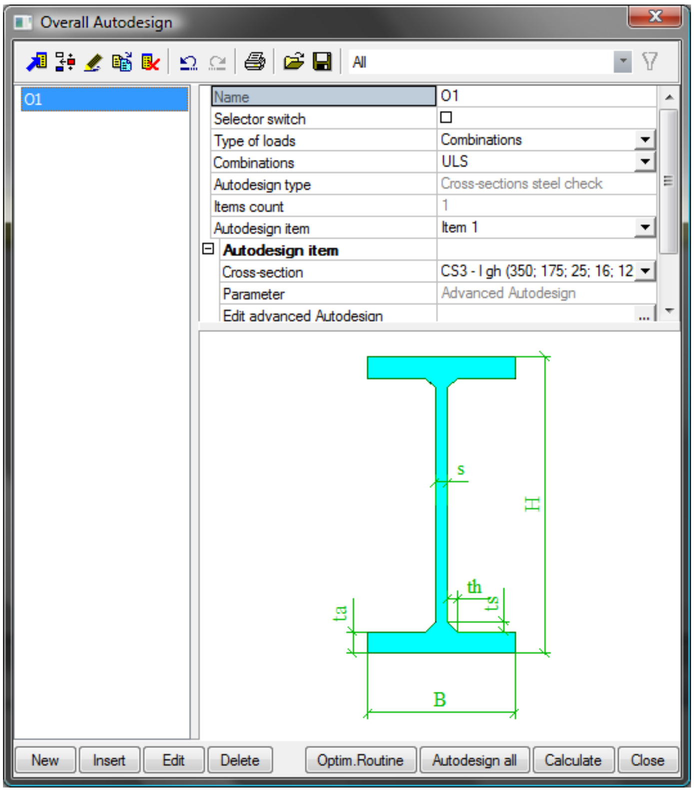
2. Start (double-click) function **Autodesign**.



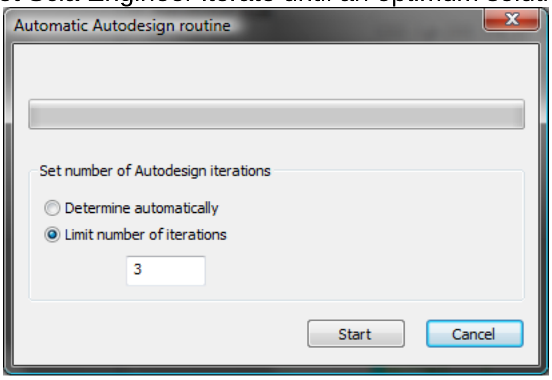
3. Autodesign manager is opened. Initially it is an empty library with standard library functions (read from file, save to file and others).



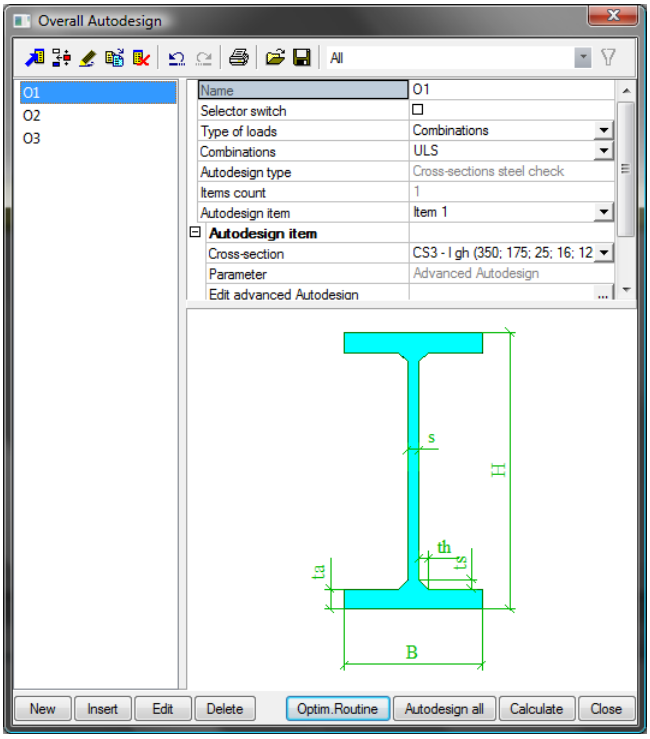
4. After defining the procedure (see next chapter) the following dialogue is displayed.



5. The user is able to optimize the selected Autodesign function using iterative Autodesign clicking on **Optim.Routine**. There are two possibilities how to set the number of Autodesign iterations – **Determine automatically** or input **Limit number of iterations**. We can set a number of iterations for the optimization, or we can let Scia Engineer iterate until an optimum solution is reached.



6. There is also possibility to run all Autodesign functions in one step using **Autodesign all**.

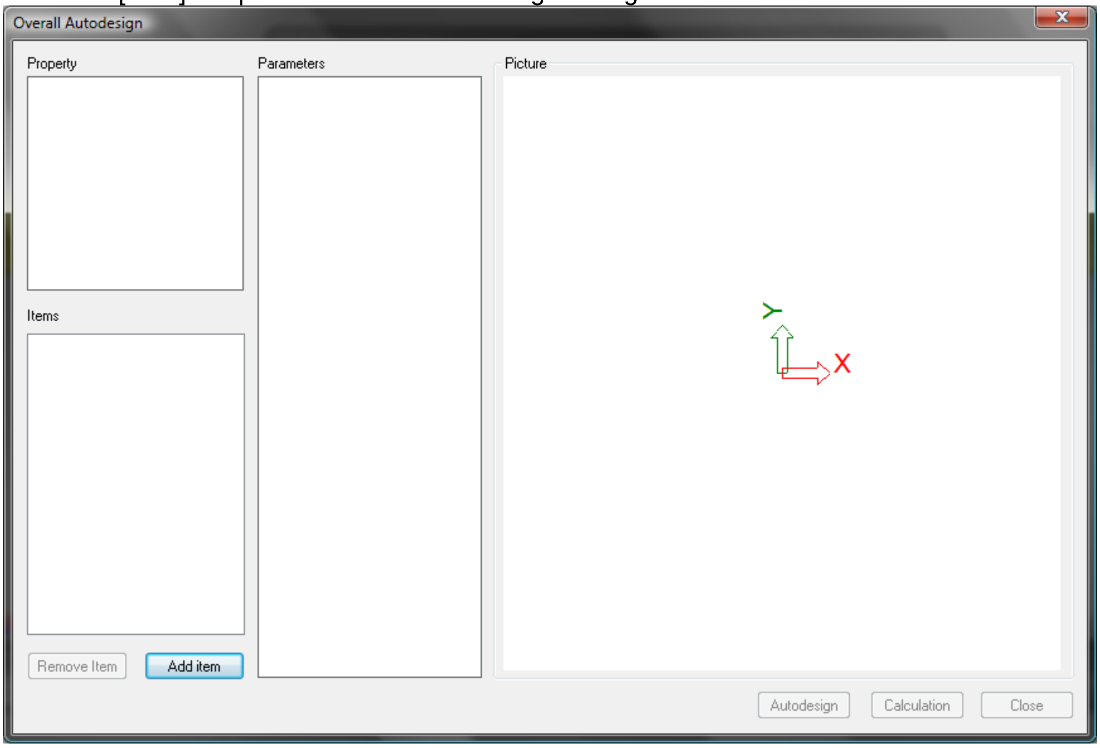

Overall Autodesign
All
O1
O2
O3
Name
O1
Selector switch
Type of loads
Combinations
Combinations
ULS
Autodesign type
Cross-sections steel check
Items count
1
Autodesign item
Item 1
Autodesign item
Cross-section
CS3 - I gh (350; 175; 25; 16; 12
Parameter
Advanced Autodesign
Edit advanced Autodesign
s
H
th
ta
ts
B
New
Insert
Edit
Delete
Optim.Routine
Autodesign all
Calculate
Close

Defining a new optimisation

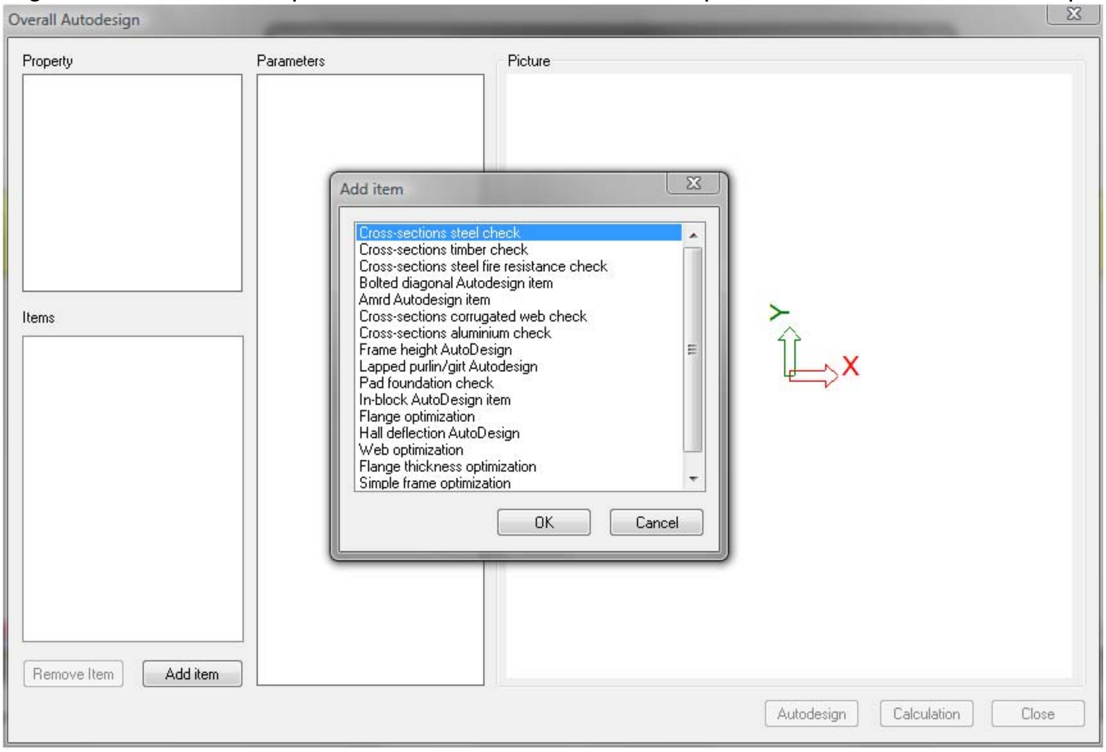
Procedure to define and run a new optimisation

1. Start the Autodesign manager.

2. Click button [New] to open the Overall Autodesign dialogue.

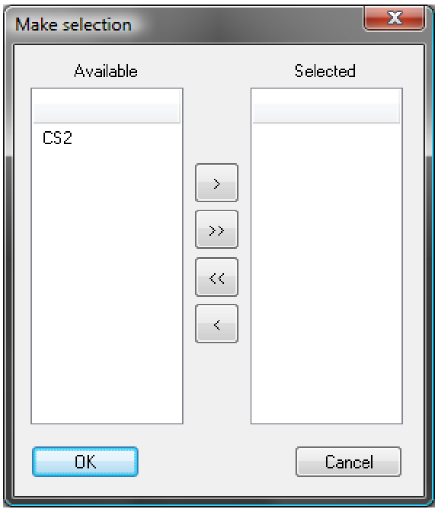


3. Using button Add item it is possible to add a new item of the optimized structure of structural part.

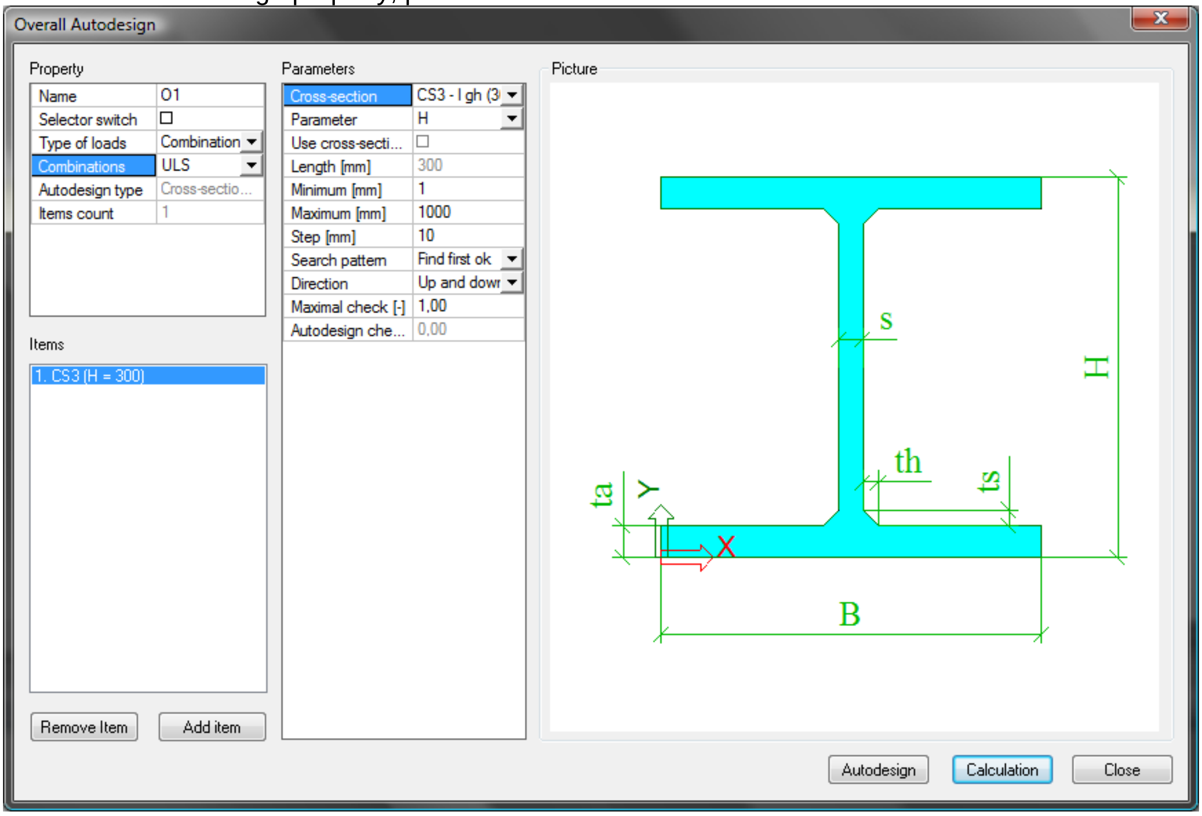


Note – the basic functionality of Autodesign is explained on the first item Cross-sections steel check.

4. The user is asked to select one from the used cross-sections that will be optimized.



5. Define the Autodesign property, parameters and criteria.



6. Click button [Autodesign] to run the calculation and see its result.

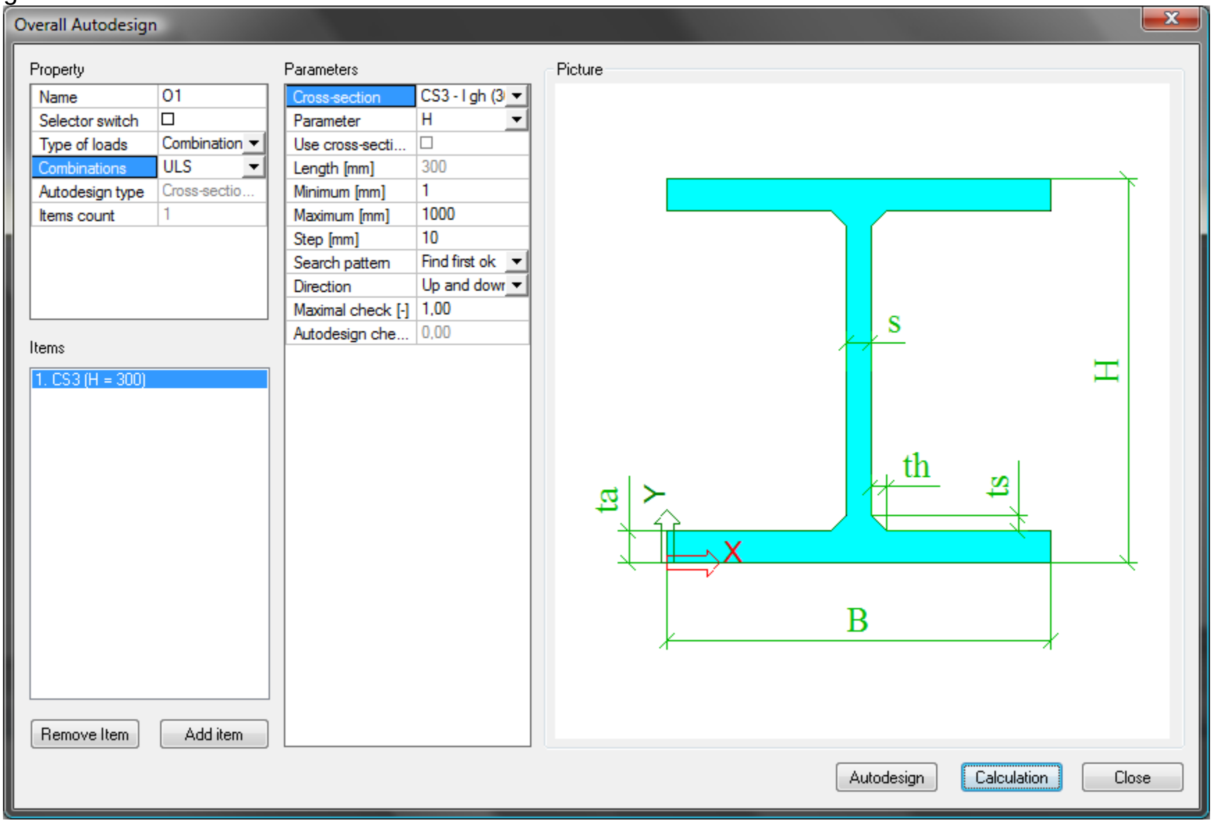
7. If required, click button [Calculation] to re-calculate the model in order to reflect the results of the optimisation.

8. Depending on what you exactly need and want, you may repeat steps 5 to 7 as many times as required.

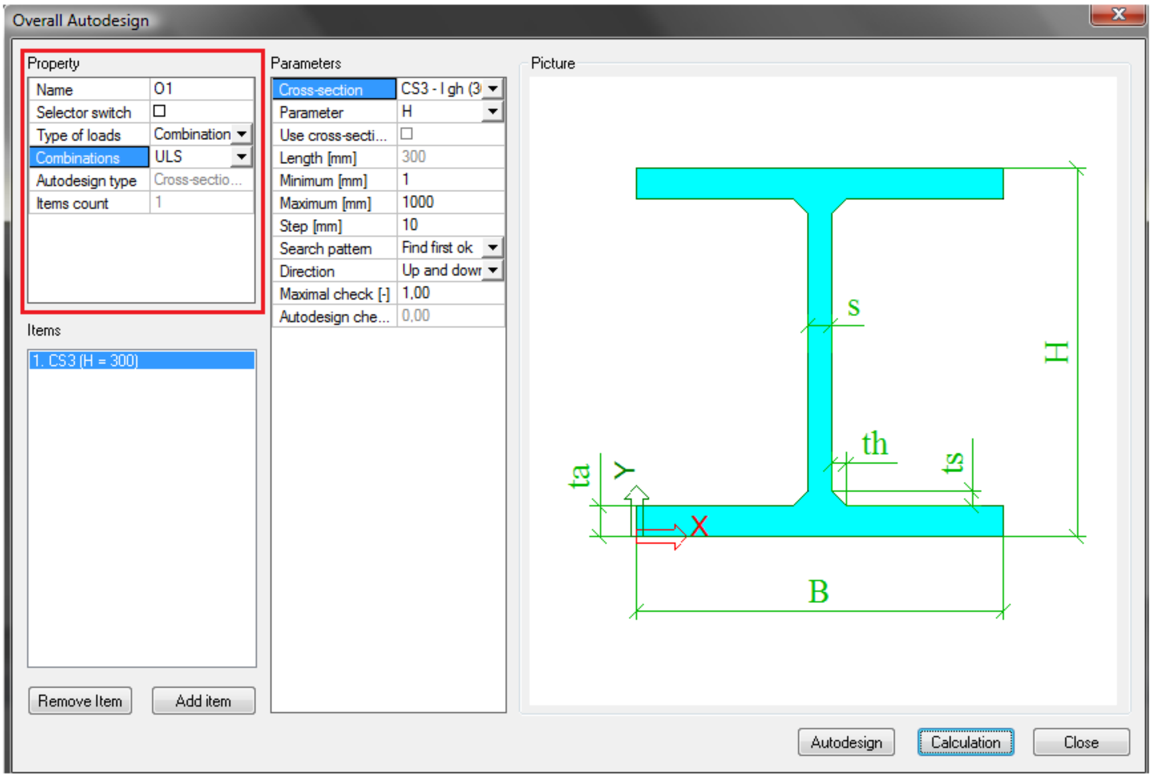
Note: Please note, that pure repetition of Autodesign and Calculation in turns may lead to a "never-ending" cycle. The Autodesign may find cross-section "A" as optimal. When you perform the calculation, the internal forces are redistributed to reflect the Autodesign results. When you run Autodesign now, it may find cross-section "B" as optimal. And another re-calculation once more redistributes the internal forces. And it may happen that the subsequent Autodesign finds the cross-section "A" as optimal once again. And so on, and so on, and so on.

Autodesign parameters and criteria

This chapter describes all buttons, settings and functionality in details for a typical thin-walled geometrical section.



Property

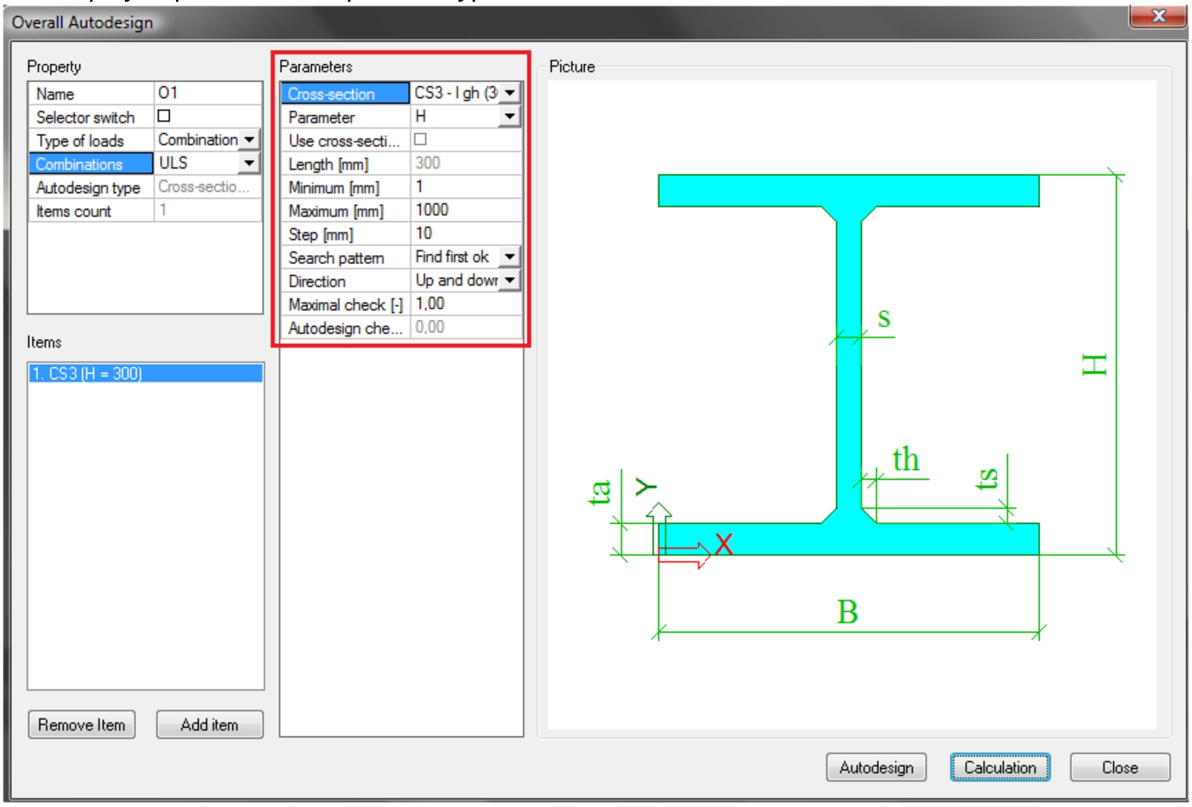


Name Defines the name of the optimisation (criteria).

Selector switch	Enables you to parameterize Autodesign item using a library type of parameter
Type of loads	Autodesign may be performed for load cases, load case combinations, result classes, etc.
Load	Specifies the particular load case, combination, etc. for which the selected cross-section type will be optimised.
Autodesign type (informative)	Tells the type of the optimisation. Cross-section steel check in this case
Item count (informative)	Shows the number of defined Autodesign items.

Parameters

The displayed parameters depend on type of used cross-section.



Autodesign parameters for rolled and cold-formed cross-sections

The user may control the process of Autodesign by means of a set of parameters.

Check parameter

Maximal check	This parameter tells the program what is the maximal allowable value for a satisfactory check.
Maximum unity check	This item shows the found maximal check result for the optimised cross-section.

Shape parameters for Autodesign

Sort by height	The sequence of cross-sections is based on the height.
Sort by A	(sectional area) The sequence of cross-sections is based on the sectional area.
Sort by Iy	(moment of inertia) The sequence of cross-sections is based on the moment of inertia.

Buttons for manual Autodesign

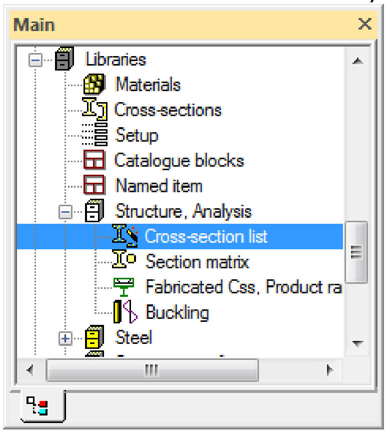
Set value	This button enables the user to set manually the required value of selected dimension (see above).
Next down	This button finds one-step smaller cross-section according to the defined shape parameters (see above).

Next up	This button finds one-step larger cross-section according to the defined shape parameters (see above).

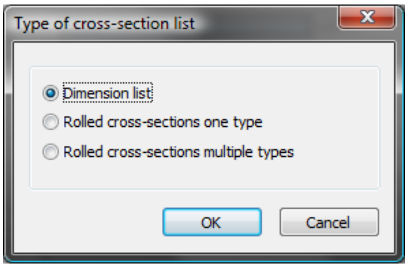
Autodesign parameters for welded and solid cross-sections

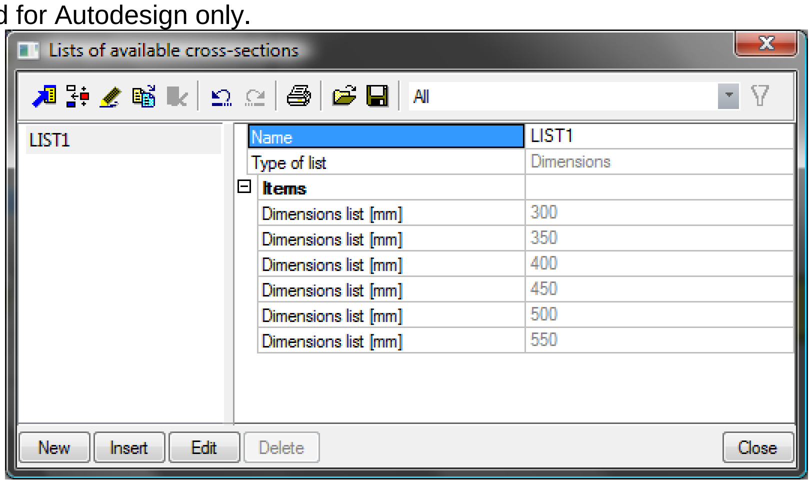
The user may control the process of Autodesign by means of a set of parameters.

Cross-section	Defines the cross-section type to be optimised.
Parameter	Selects the dimension (e.g. section depth, width, etc.) that will be optimised. All dimensions of optimized item are offered for selection. The optimized item is displayed in the part Items according to the selected parameters (see above CS3 (H=300)). There is also possibility to select **Advanced Autodesign** (for more information see chapter Edit Advanced Autodesign).
Use cross-section list	Enables you to use predefined values of one dimension according to the list defined in the Cross-section list library. This library is stored in **Libraries > Structure, analysis > Cross-section list**.



There is a possible to define three types of cross-section list (see the following figure). Cross-section list type Dimension list can be used for Autodesign only.



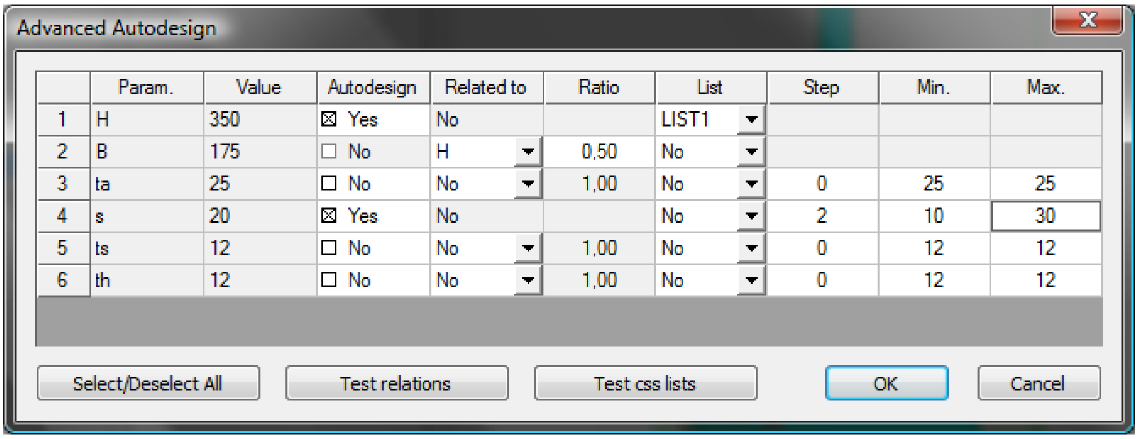


Length (informative)	Shows the current size of the selected dimension.
Minimum	Defines the minimal applicable size for the optimised parameter.
Maximum	Defines the maximal applicable size for the optimised parameter.
Step	Defines the step for the Autodesign.
Search pattern	Combobox (**Find first OK / Find from all**) - option enabling to find first solution which fits the requirements or the best from all the solutions.

Direction	Combobox (**Up and down / Up**) – option that specifies the direction of searching for the optimized solution.
Maximal check	Defines the maximal acceptable value of the unity check of the optimised cross-section.
Autodesign check (informative)	Shows the unity check for the optimised connection.

Edit Advanced Autodesign

This option is seen only if **Advanced Autodesign** is selected as the parameter. Advanced Autodesign enables to optimize several or all parameters of a cross-section in one step. It is possible to use dependencies between parameters and use cross-section list as well.

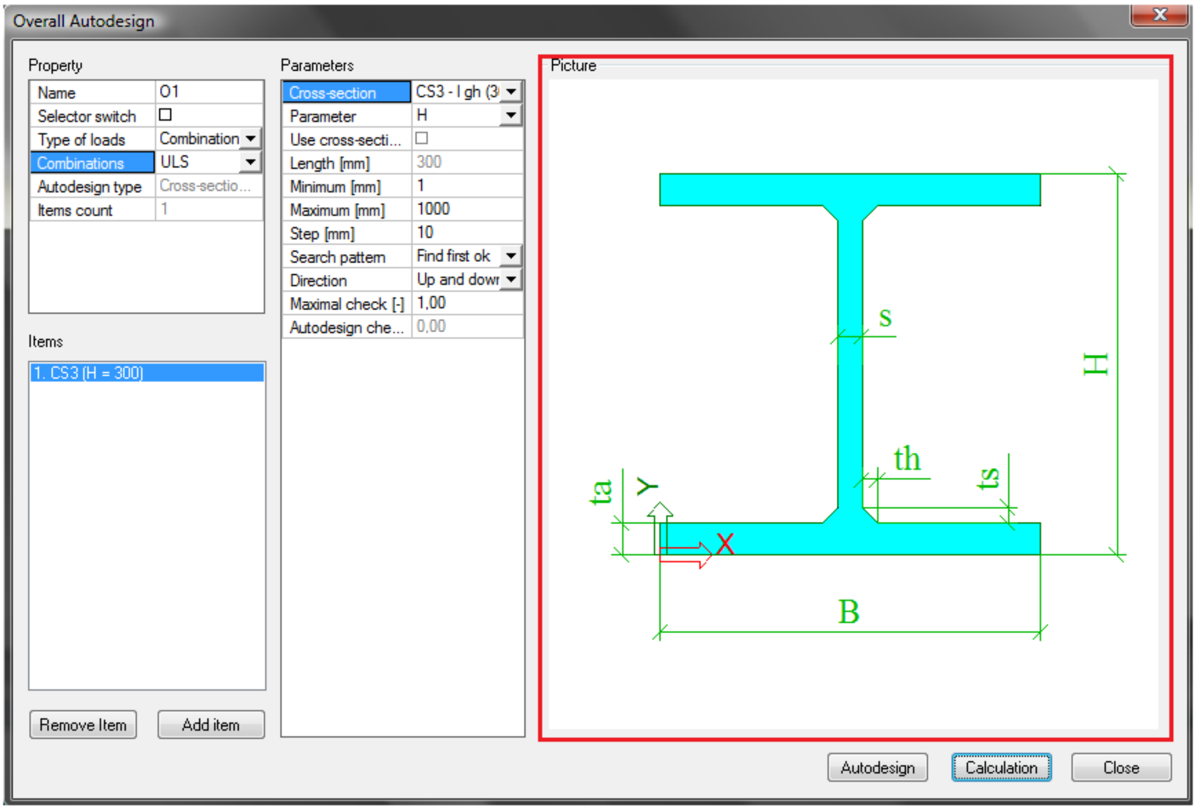


All items are described in the following table.

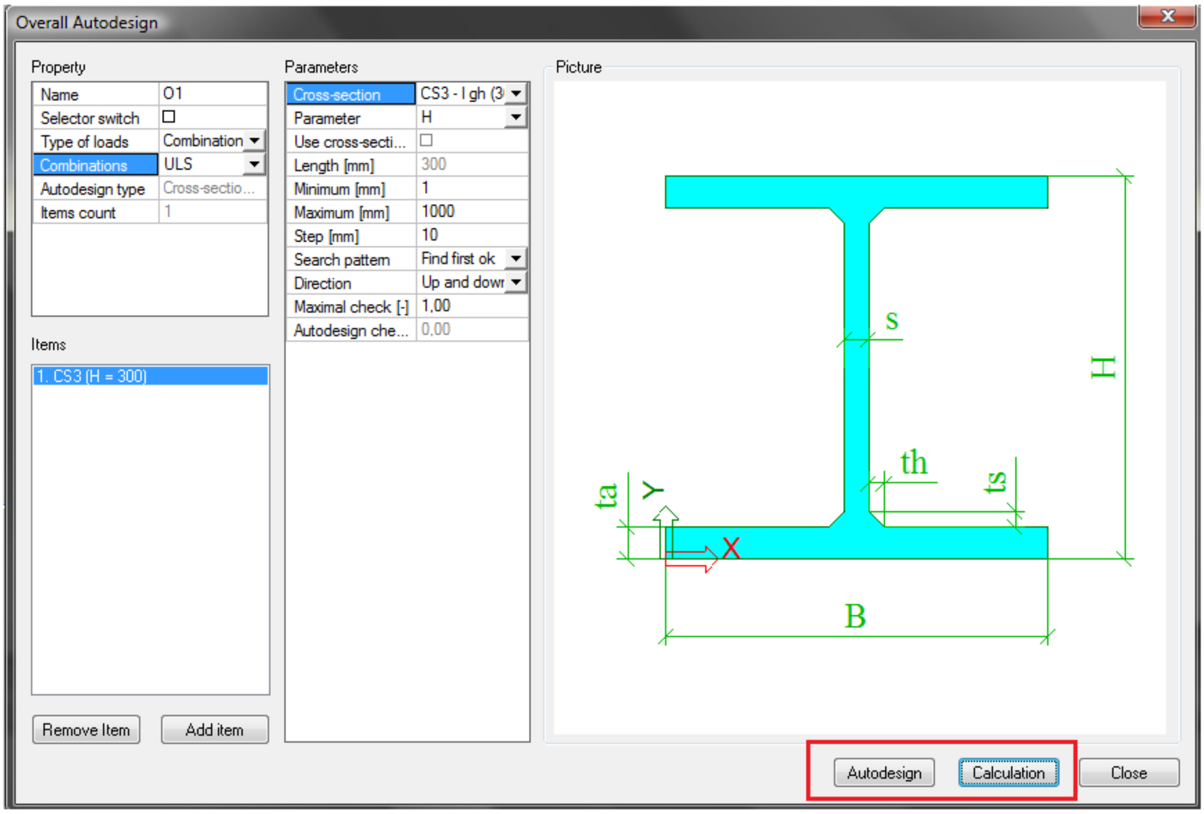
Item	Description
Parameter	Parameter which needs to be optimized
Value	Value of the optimized parameter
Autodesign	Checkbox if the parameter should be optimized or not. Inactive when Related to is assigned to some parameters
Related to	Relation between parameters. Selected (dependent) parameter can be optimized depending on the optimization of other parameter. Inactive when Autodesign is YES.
Ratio	Ratio gives the relation between the optimized parameter and dependent parameter, see above (value B calculated as 0.5 * optimized value H). Inactive when Related to is No.
List	Link to Cross-section list library. The selected parameter can be optimized according to the requirements stored in the Cross-section list library (dimension list)
Step	Defines the step for Autodesign
Min.	Defines the minimal applicable size for the optimised parameter
Max	Defines the maximal applicable size for the optimised parameter

Picture

The picture shows the shape of the optimised item (cross-section, pad foundation or the symbol of the bolted diagonal connection etc).



Control buttons

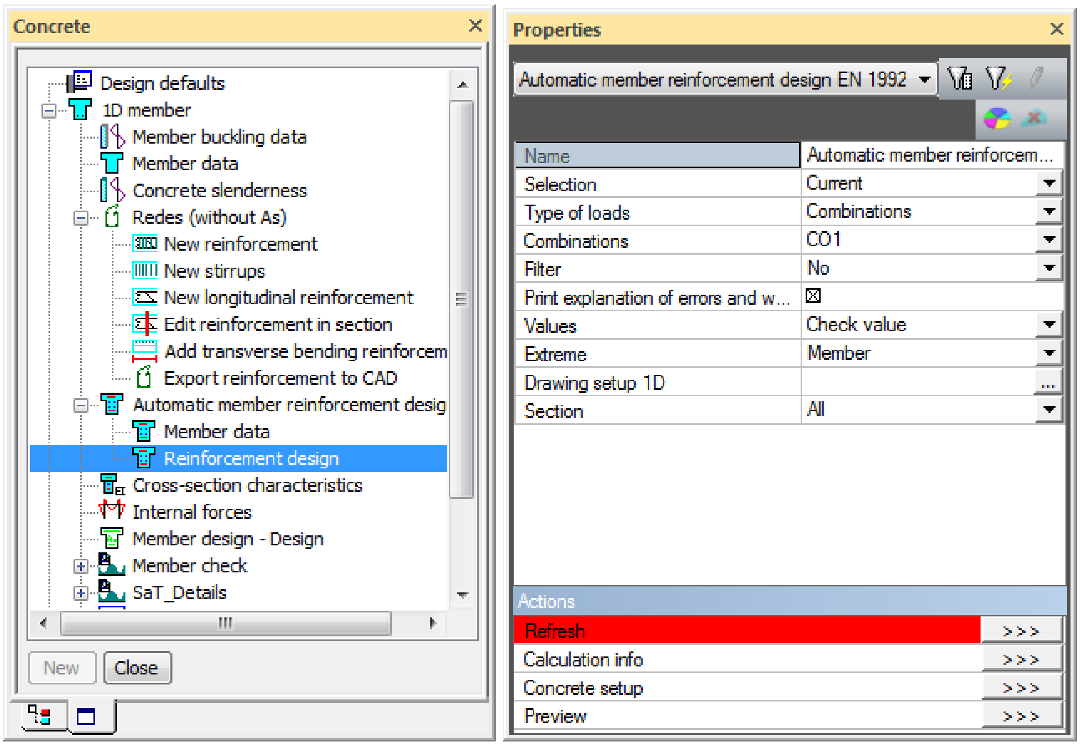


Autodesign	Performs the optimisation for the defined Autodesign items.
Calculation	Carries out the calculation for the optimised model.

Concrete – Automatic member reinforcement design (AMRD)

Autodesign of concrete section is the same part as the Reinforcement design performed in the standard Concrete > Automatic member reinforcement design > Reinforcement design

Autodesign in Concrete service



When the user clicks on action button Refresh then the same procedure of Autodesign is performed. For concrete cross-section the procedure is called Automatic Member Reinforcement Design (AMRD). The non-prestressed reinforcement is designed in selected beam. Both longitudinal reinforcement and stirrups are designed.

Theoretical background for AMRD

The non-prestressed reinforcement in beams can be defined manually by the user or it can be calculated automatically by the program.
The latter designs the reinforcement on the basis of parameters defined in:

- reinforcement template,
- setup dialogue of service Concrete,
- member data related to the automatic design,
- practical reinforcement defined manually.

The automatic design takes into account the combination of bending moments and axial force and shear forces. It does not include torsion and deflections. It works within the ultimate limit state. The automatic design can be used for loads cases, ULS (not SLS) combinations and classes with ULS or ULS+SLS combinations. Concerning the parameters mentioned above, the practical reinforcement is of the highest priority. That means, if some reinforcement has been defined, the automatic design uses in the first step the diameter of this practical reinforcement. There is no output to the document. The results of the automatic design can be reviewed only on the screen in the graphical window and/or in the Preview window. Of course, the bill of reinforcement can be inserted into the document in order to show the reinforcement that has been automatically designed. The automatic design uses only the layers of the reinforcement marked in the reinforcement template. The automatic design is not capable of adding a new layer in the situation when the required reinforcement cannot be put into just one layer. Therefore, it may happen that the automatic design can fail.
The basic procedure is the following:

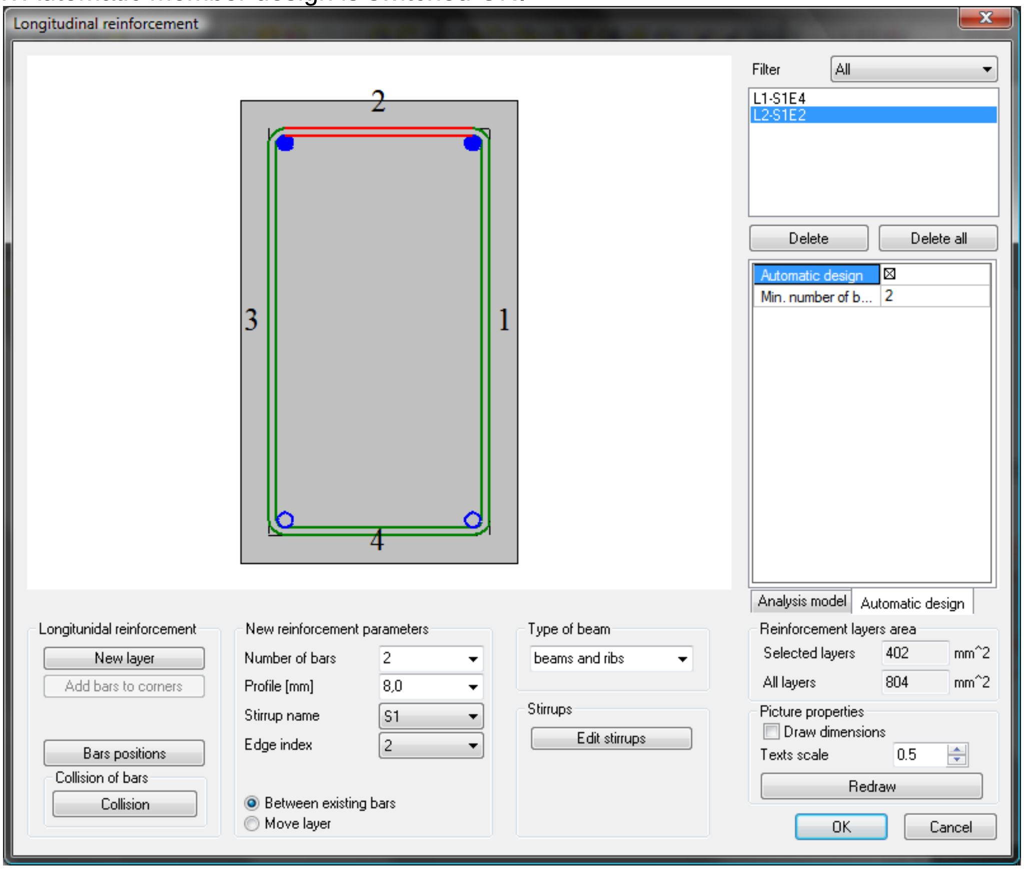
- First, the parameters that may affect the automatic design should be defined. It is necessary to define reinforcement template for longitudinal reinforcement, which layers can be optimise during the automatic reinforcement procedure,
- Specify the default parameters in

- o Setup dialogue of service Concrete affecting and controlling the procedure for the automatic design,
- o member data related to the automatic design, if required. These data overwrites the default values by member data that are specific for a particular beam.

- During Autodesign the standard design of reinforcement for combination N+My+Mz is performed (maximal bending moments along whole member are considered for design of reinforcement). The maximal amount of upper and lower reinforcement is designed.
- The designed reinforcement template is used for checks (Interaction diagram, detailing provisions). The calculation is evaluated based on the maximal utilisation (check value) in concrete setup. When the calculated check value is still less than the defined utilisation, then bars are deleted to achieve the optimal utilisation.

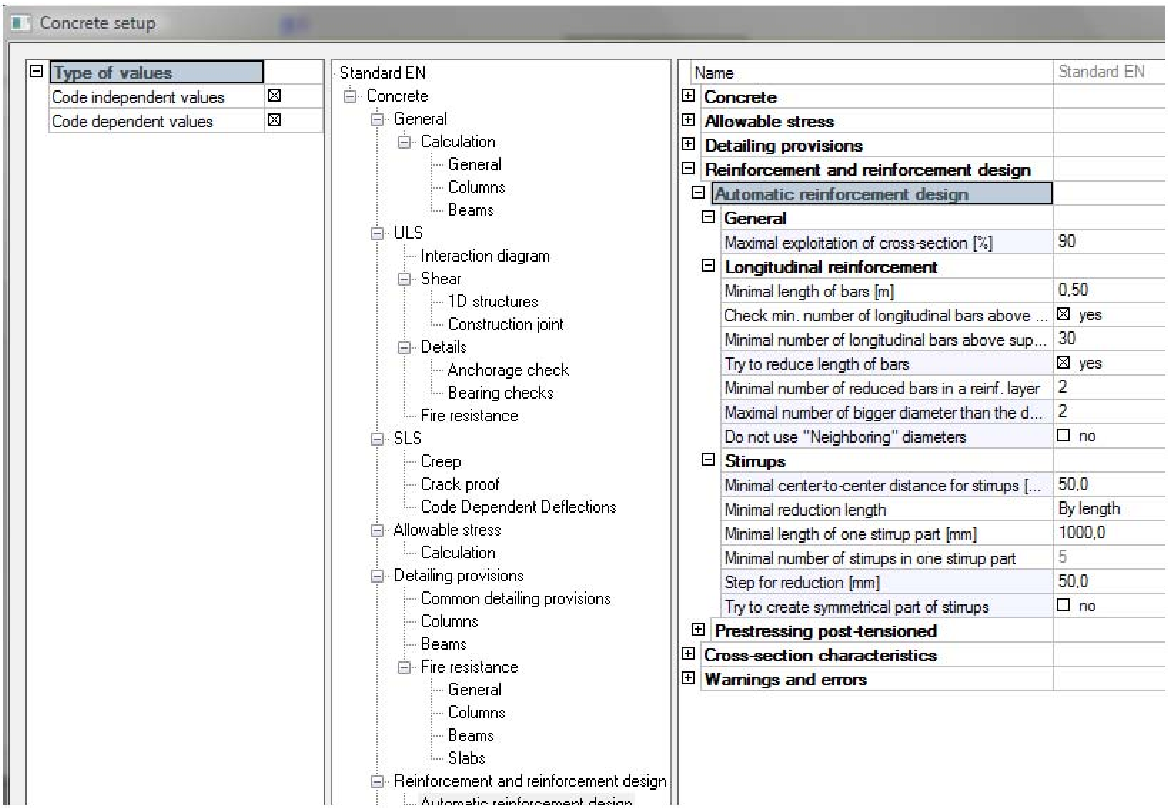
Template preparation

The template used for the Autodesign is prepared in a standard way. One difference is that the checkbox Automatic member design is switched ON.



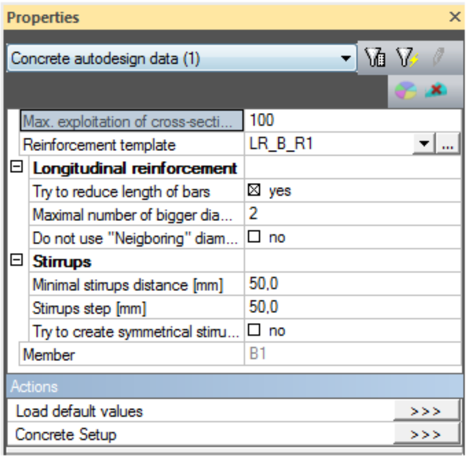
Concrete setup

The default settings used for Autodesign are stored in Concrete setup.



Member data for the automatic reinforcement design

The member data used for AMRD looks like this:



General

Max. exploitation of cross-section	Specifies the maximal utilisation of the cross-section in the automatically reinforced beam. The value may be between 1 and 100%.
Reinforcement template	Shows the used reinforcement template. Note: This item appears in the dialogue ONLY when the already defined member data are edited. If the member data are being assigned to a new member, this item is not accessible.

Longitudinal reinforcement

Try to reduce length of bars	If OFF, the program uses only bars that extent over the whole length of the beam.

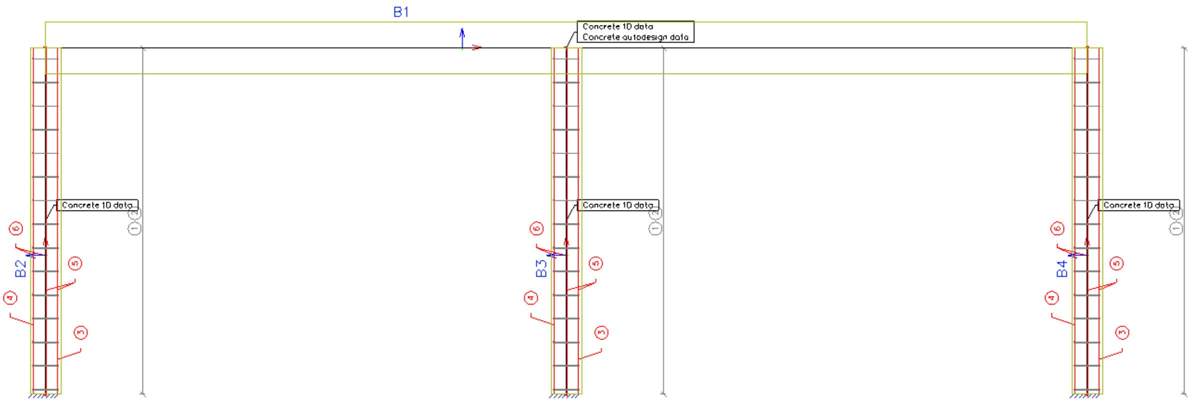
	If ON, some bars may be shortened if the unity check is satisfied without them.
Maximal number of bigger diameters than the default	Defines how many different (bigger) diameters of the reinforcement can be used for the optimisation. Let us assume that the default diameter specified in the Design default tab is 10mm. If this parameter is set to 2, the program can use diameters 10, 12 (i.e. +1 item in the manufacturing programme) and 14 (i.e. +2 item in the manufacturing programme) for the design.
Do not use "Neighbouring" bars	Some standards recommend that "neighbouring" profiles from the manufacturing programme should not be used in one beam (in order to avoid unintentional interchange of the profiles). Let us assume that the default diameter specified in the Design default tab is 10mm. Further assume that Maximal number of bigger diameters than the default is set to 2. If this option is ON, the following bars can be inserted into the beam: (i) either 10mm, (ii) or 12mm, (iii) or 14mm, (iv) or 10mm and 14mm can be combined together. 10mm and 12mm are not permitted to be combined in one beam

Stirrups

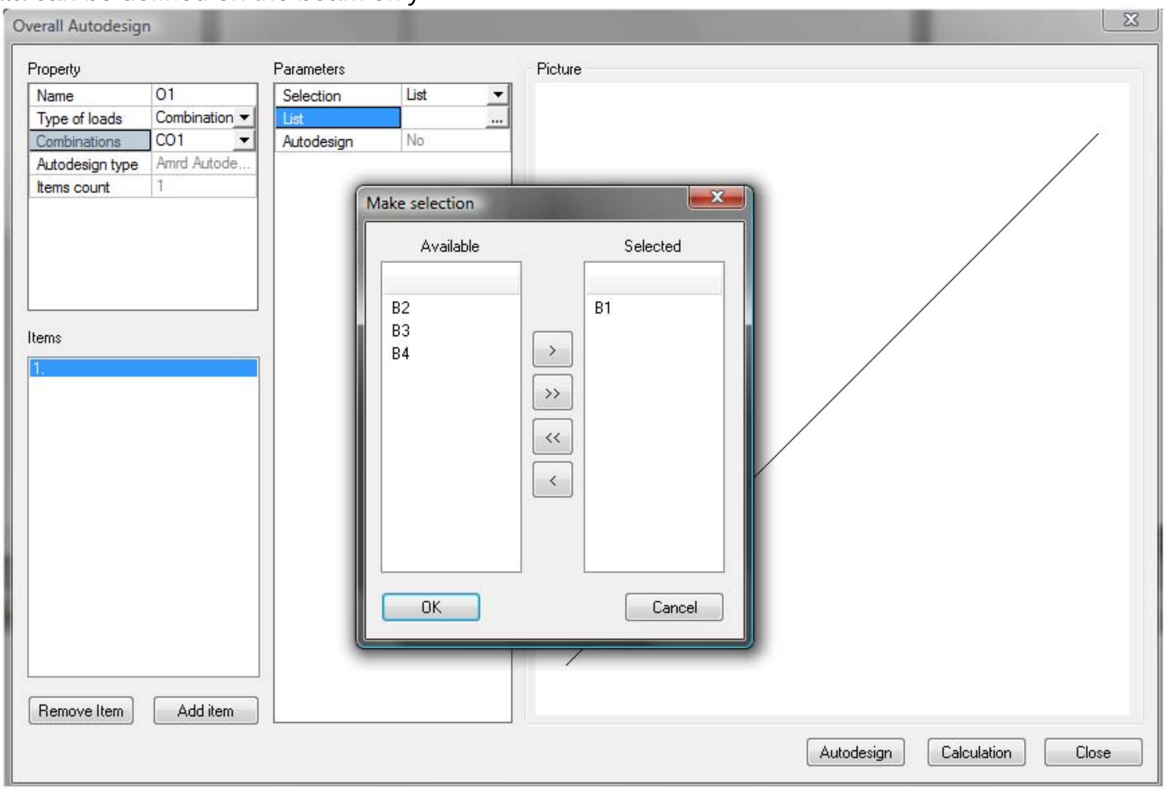
Minimal stirrups distance	Specifies the minimal distance between stirrups measured from the centre of a bar to the centre of an adjacent bar.
Stirrups step	Defines the step for the reduction of the distance between two adjacent stirrups. This ensures that the distance between stirrups is always a "rounded" number – e.g. 200mm, then 250mm, then 300mm, etc. (and not e.g. 200, 246mm, 298mm, etc.).
Try to create symmetrical stirrups parts	This parameter may enforce that the stirrup parts are symmetrical along the length of the beam.
Member (informative only)	Shows the name of the beam where the member data are assigned to

Illustrative example

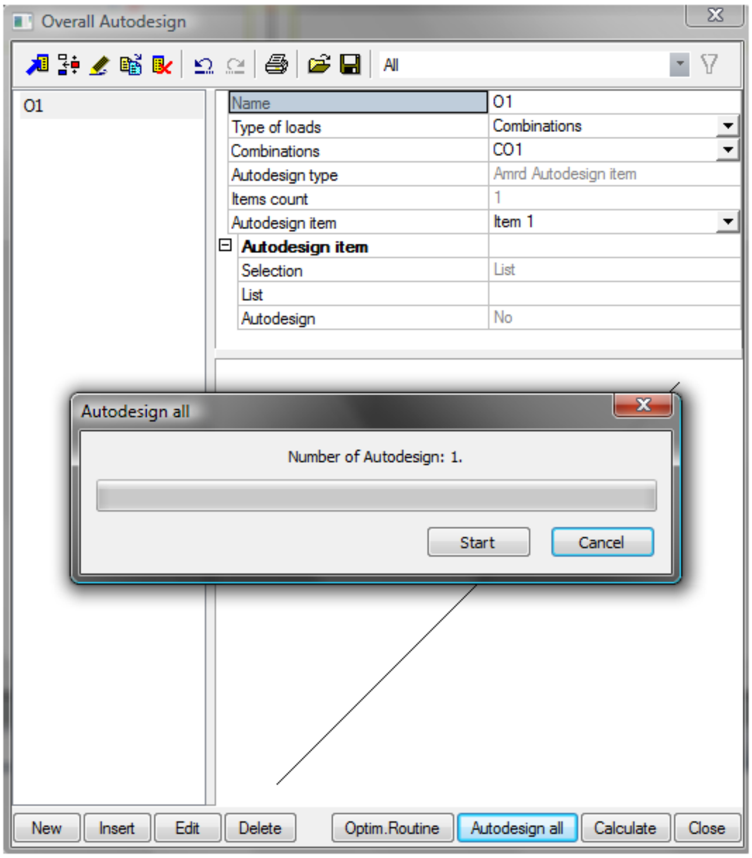
Let us consider a very simple example of concrete frame. The structure is subjected to several loads (selfweight, permanent, variable, wind etc.). The aim of this example is to find the optimal reinforcement pattern in the continuous horizontal member of the frame.



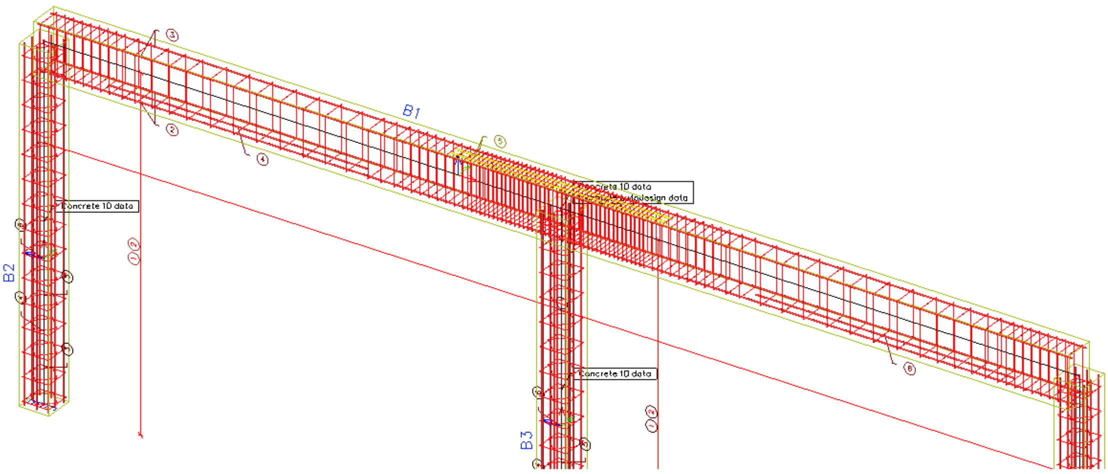
One Autodesign function with type AMRD Autodesign is defined and reinforcement pattern for beam B1 is optimized. No additional settings related to parameters are defined for this case. Possibly AMRD data can be defined on the beam only.



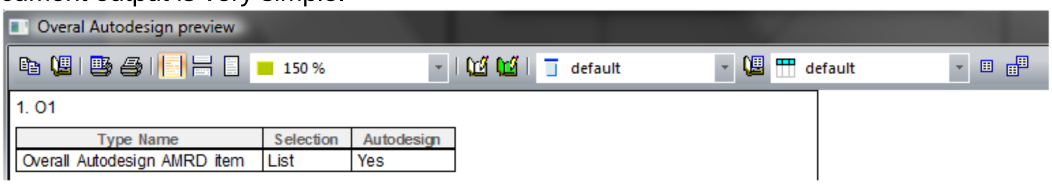
Autodesign starts after pressing button **Autodesign all**.



The obtained results of designed reinforcement for beam B1 are the following. The reinforcement is automatically designed and input on beam B1. You can see higher density of stirrups near the supports and additional longitudinal bars in the span and above the middle support.

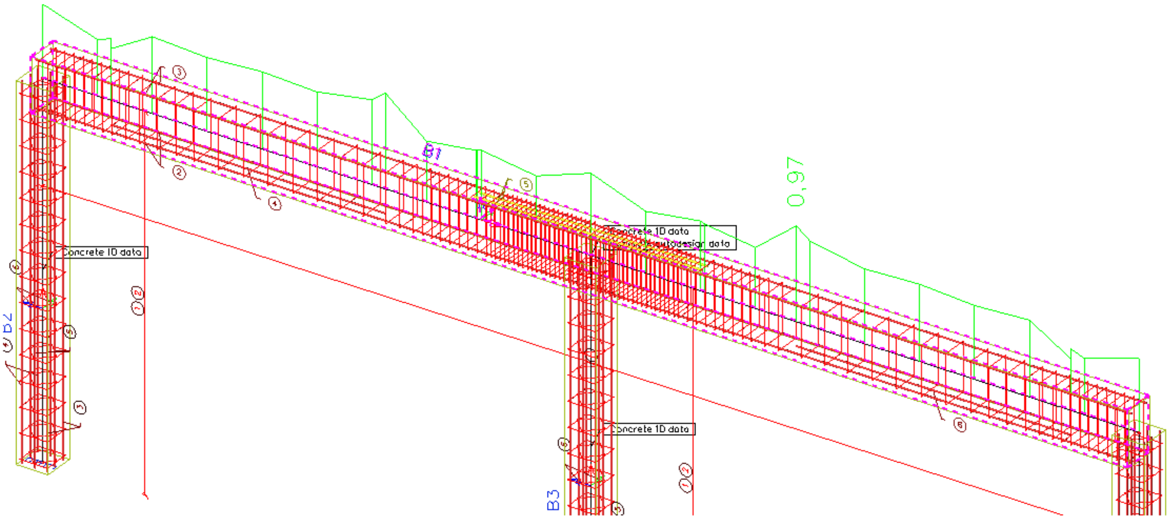


The document output is very simple.

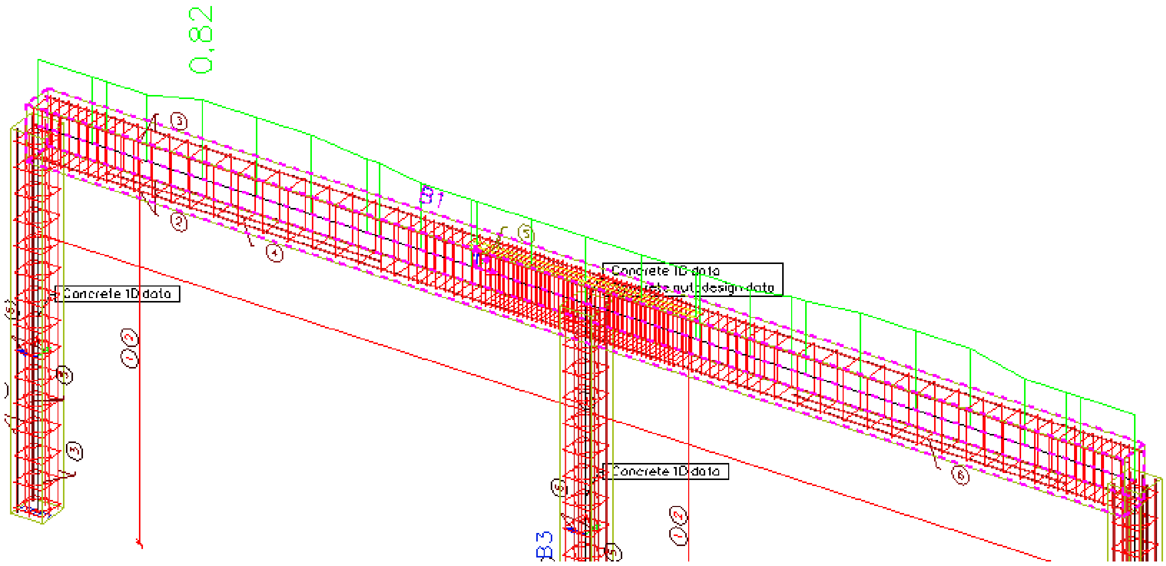


The results can be verified in the standard concrete checks:

- Check capacity (max check value 0,97)



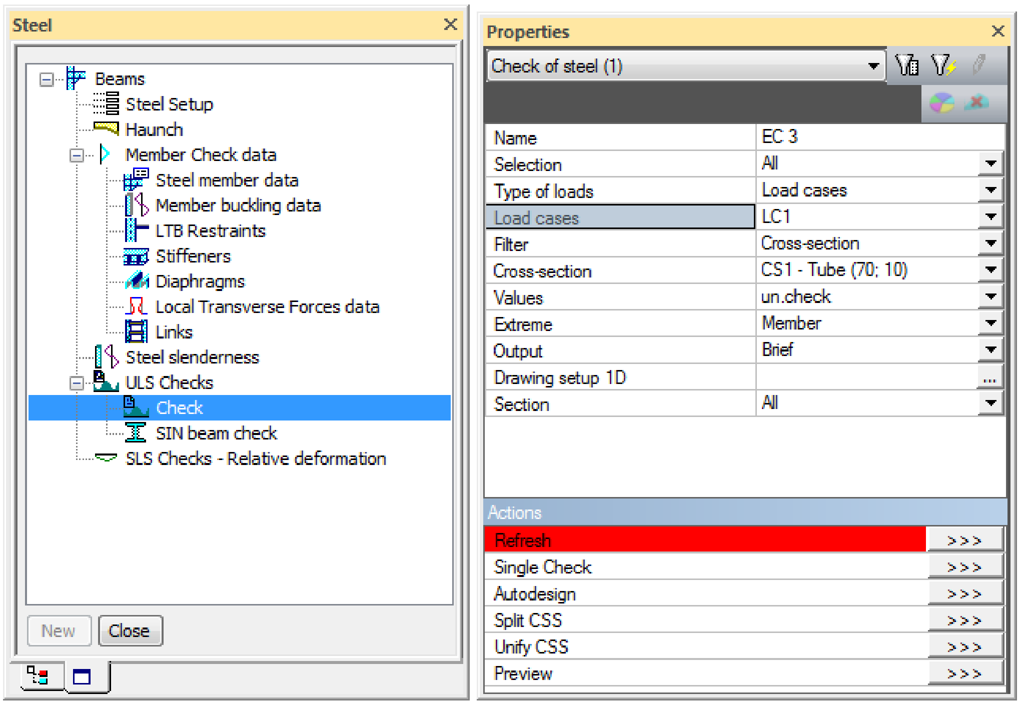
- Detailing provision (max check value 0,82)



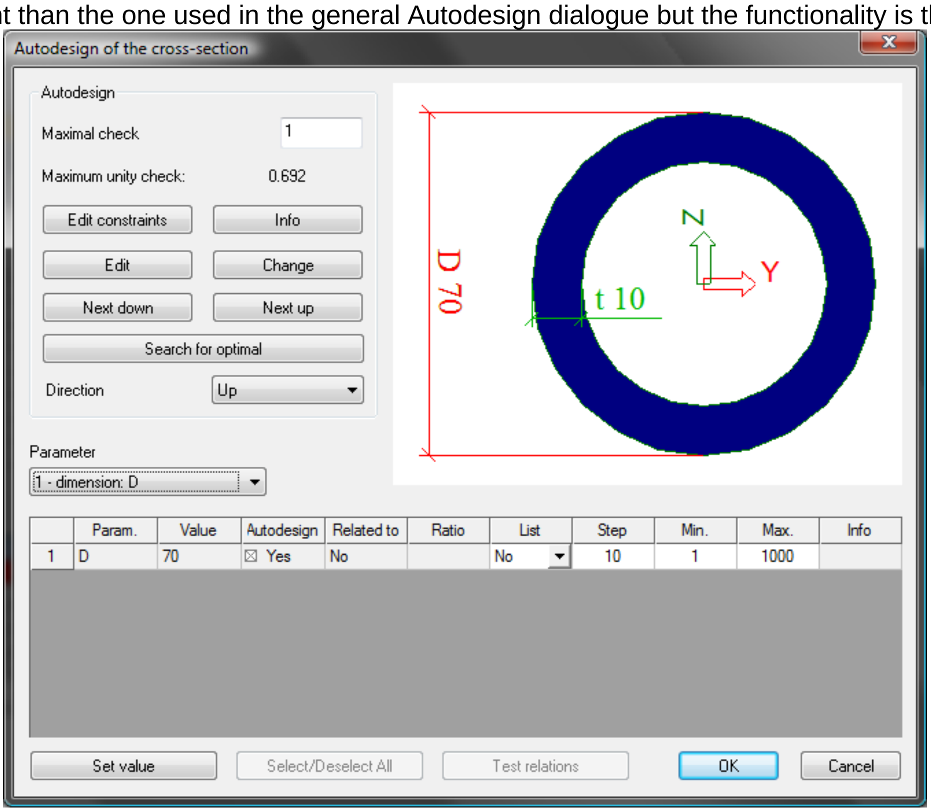
Steel – Cross-section AutoDesign

Autodesign of cross-section steel check is the same part as the Autodesign located in the standard Steel >ULS Check> Check.

Autodesign in Steel service



When user clicks on action button Autodesign then the following dialogue is displayed. The dialogue is a bit different than the one used in the general Autodesign dialogue but the functionality is the same.

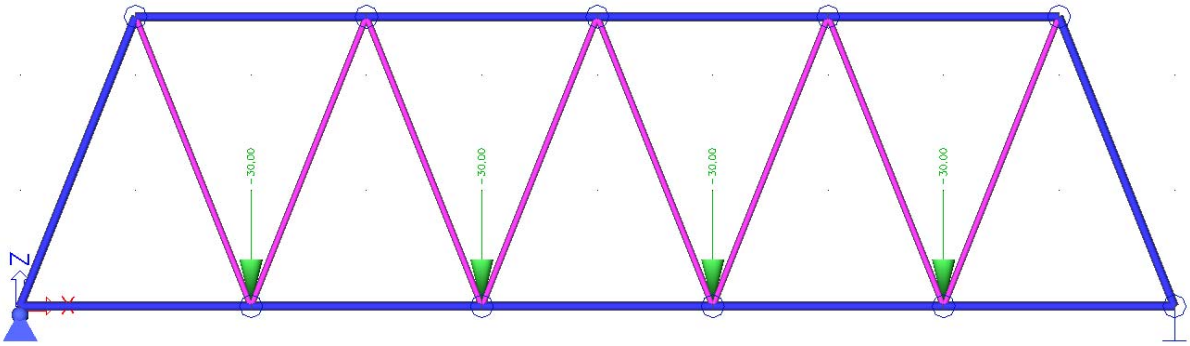


We will focus on Autodesign running from Autodesign service in this case. Generally, results based on the same settings in Autodesign and the individual service have to be the same.

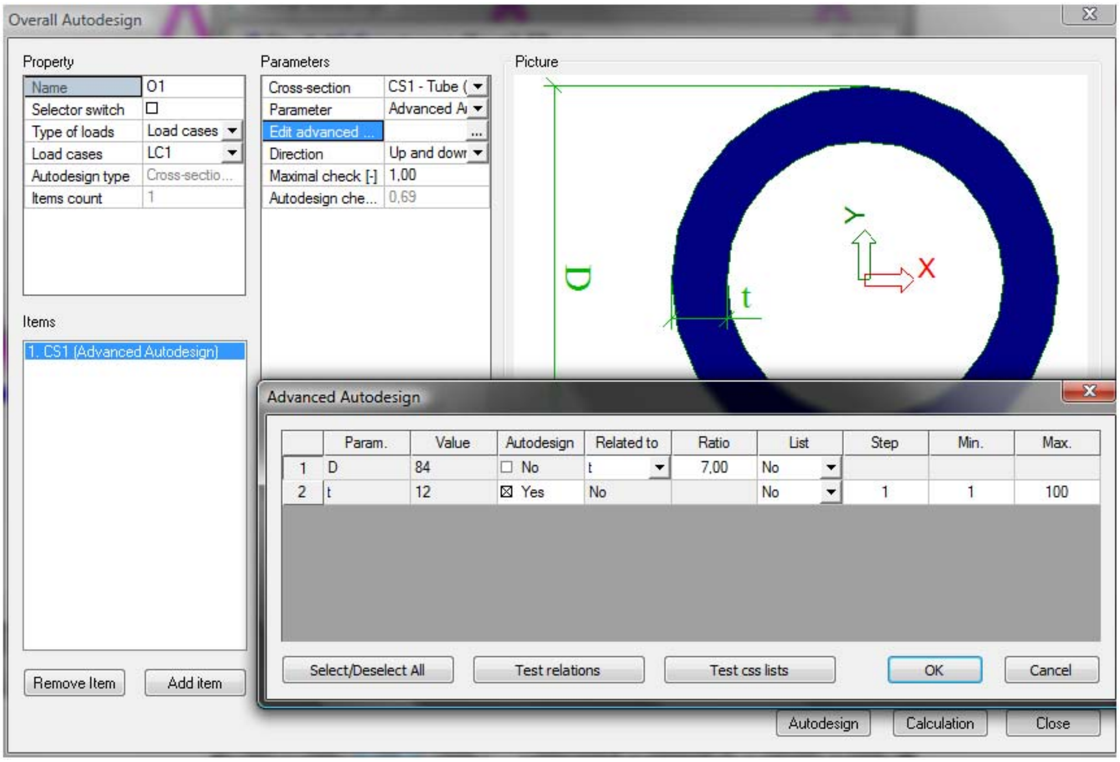
Illustrative example

Let us consider a very simple example of a steel truss girder for Autodesign. The structure is shown in the following figure. The structure is subject to four point loads acting on the bottom chord. The aim of this example is to find the optimal dimensions of two tubular cross-sections. The initial dimensions of the tubular cross-sections are:

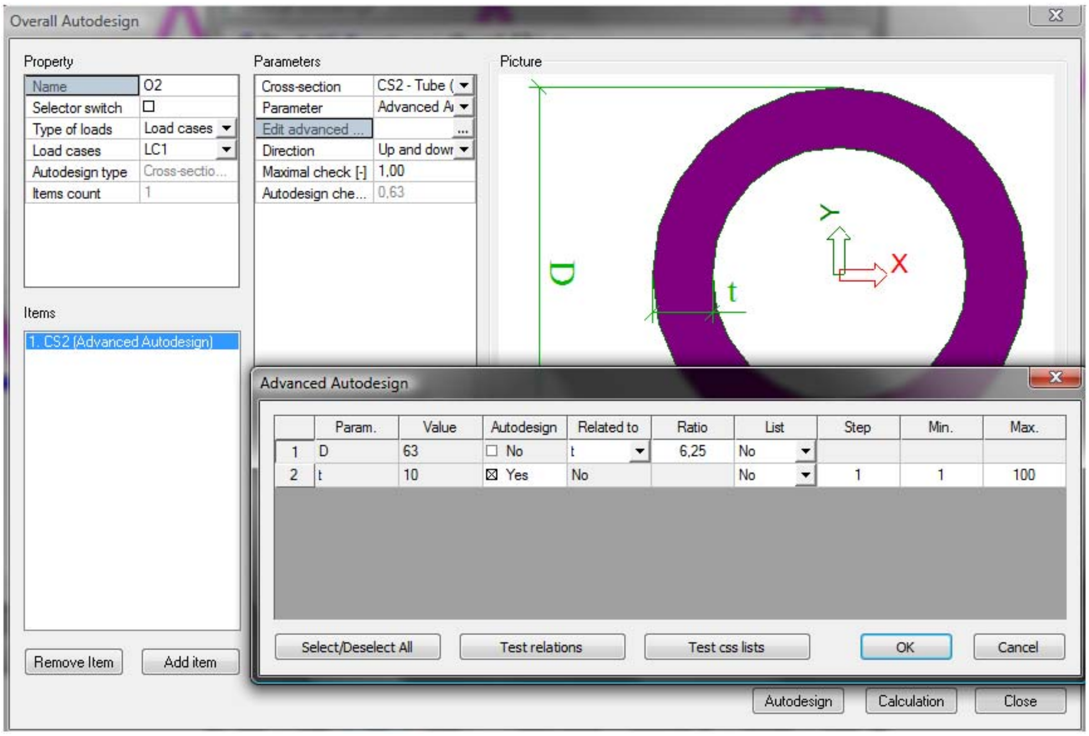
Cross-section	t [mm]	D [mm]
CS1 - tube	12	84
CS2 - tube	10	62.5



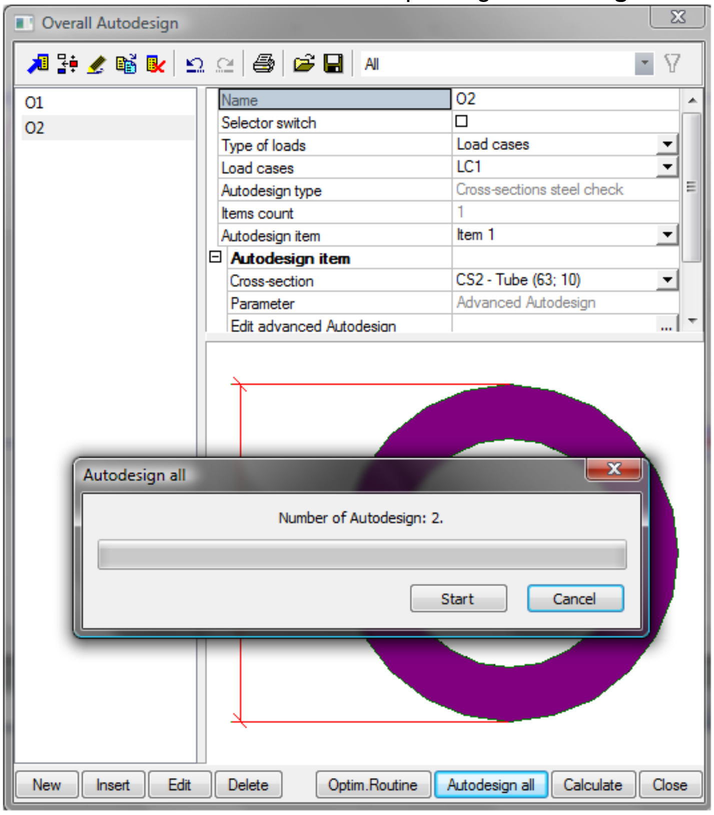
The Autodesign function is defined for each of the cross-sections. You can see the settings for CS1 – Tube,



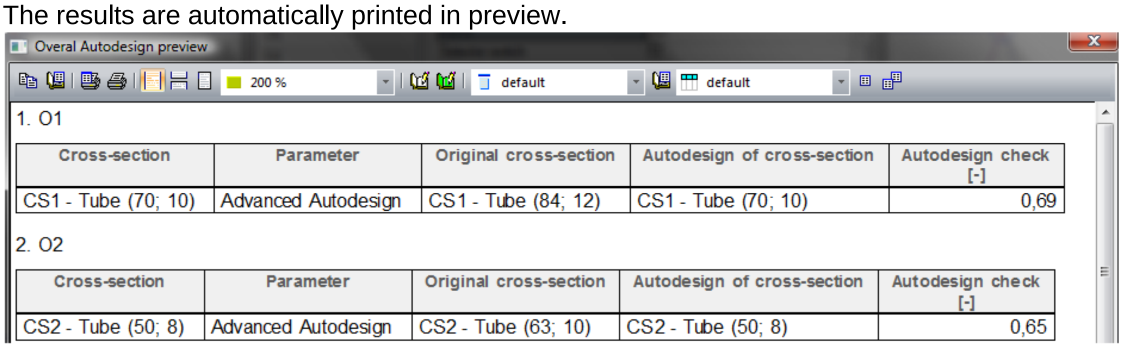
and for the CS2 – Tube. The advanced Autodesign is used for both cross-sections. Thickness of the tube (t) is optimized (Autodesign is YES) and the diameter (D) depends on the thickness (Related to t through the defined ratio).



Autodesign of both cross-sections can be run in one step using **Autodesign all**..



The results are automatically printed in preview.



1. O1

Cross-section	Parameter	Original cross-section	Autodesign of cross-section	Autodesign check [-]
CS1 - Tube (70; 10)	Advanced Autodesign	CS1 - Tube (84; 12)	CS1 - Tube (70; 10)	0,69

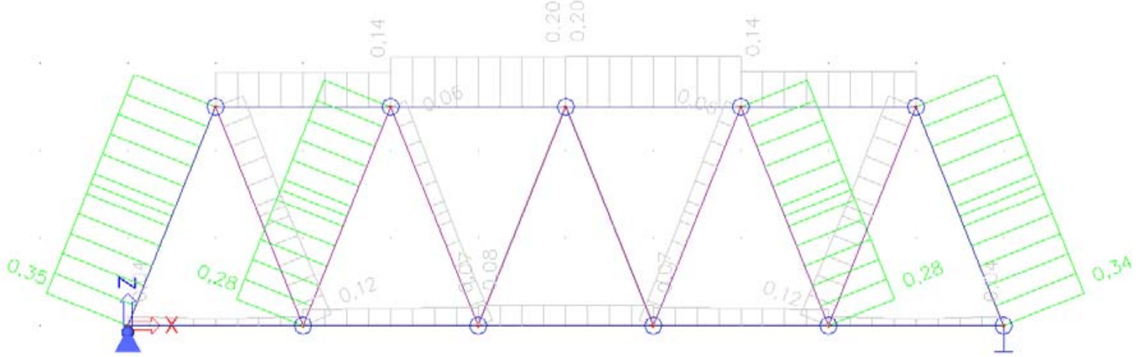
2. O2

Cross-section	Parameter	Original cross-section	Autodesign of cross-section	Autodesign check [-]
CS2 - Tube (50; 8)	Advanced Autodesign	CS2 - Tube (63; 10)	CS2 - Tube (50; 8)	0,65

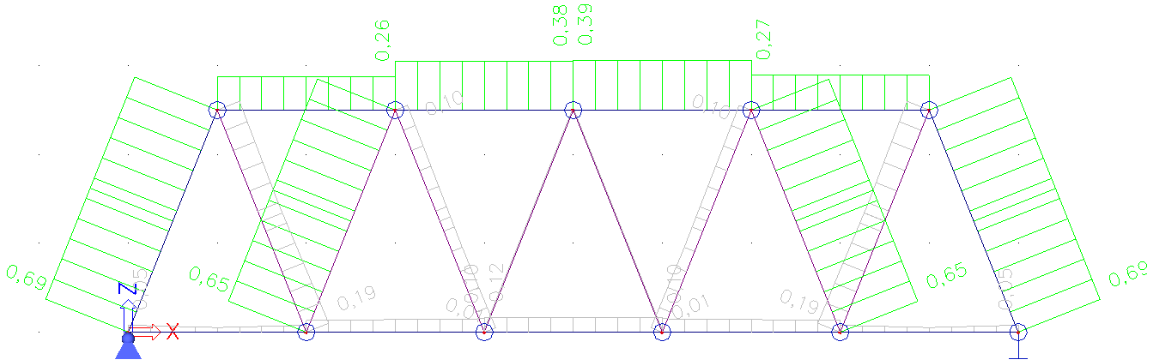
The comparison of the dimensions is in the following table.

Cross-section	Initial		Optimized	
	t [mm]	D [mm]	t [mm]	D [mm]
CS1 - tube	12	84	10	70
CS2 - tube	10	62.5	8	50

Evaluation of the steel unity check along the beam is compared in the following figures.



Evaluation of steel check for initial cross-section dimensions

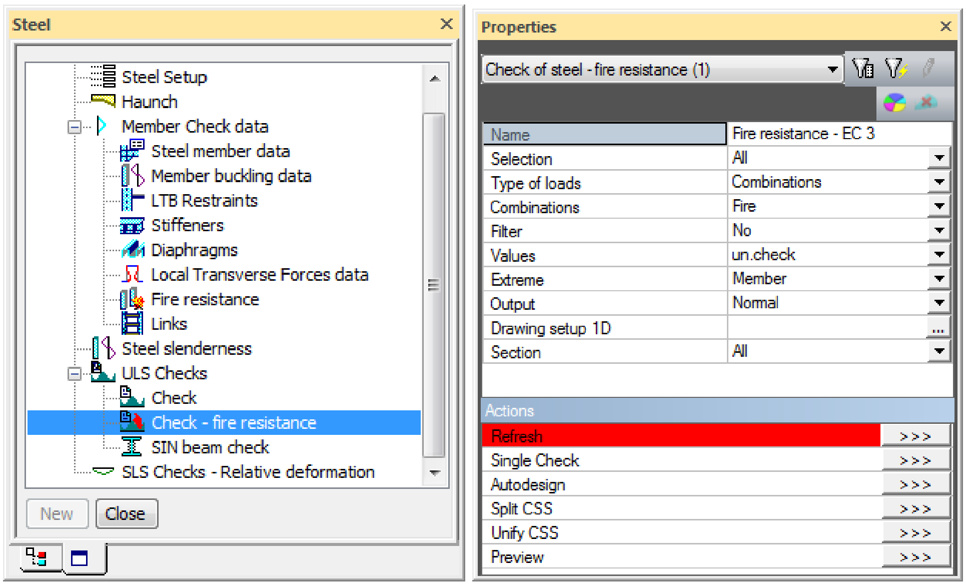


Evaluation of steel check for optimized cross-section dimensions

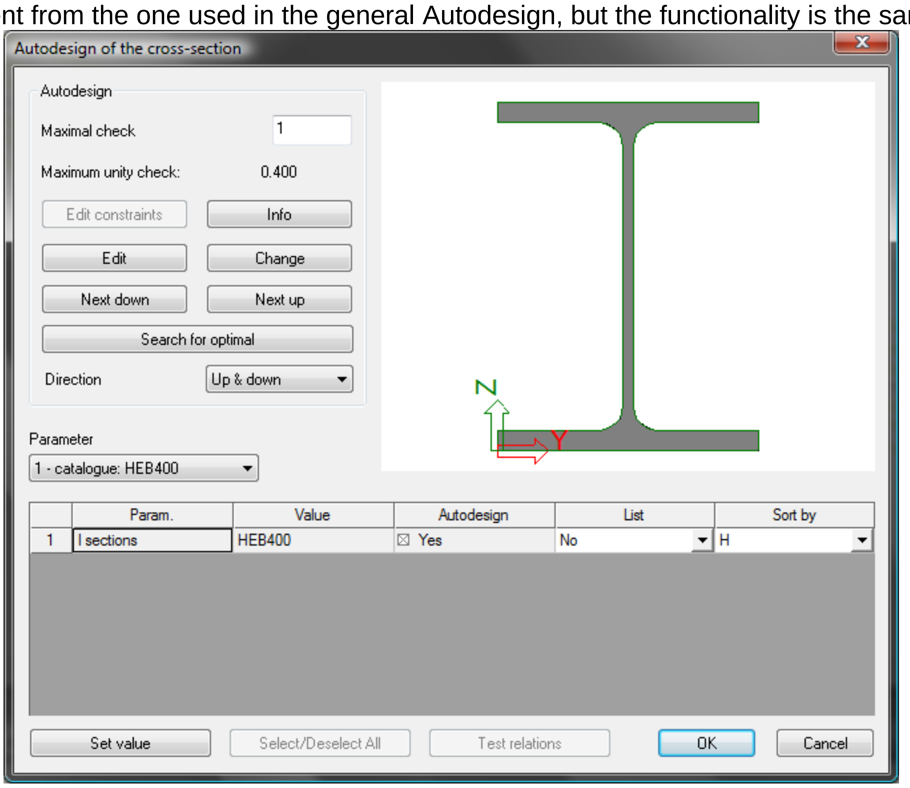
Steel - Fire resistance AutoDesign

Autodesign of steel fire resistance check is the same part as the Autodesign located in the standard Steel > ULS Check > Check - Fire resistance.

Autodesign in Steel service

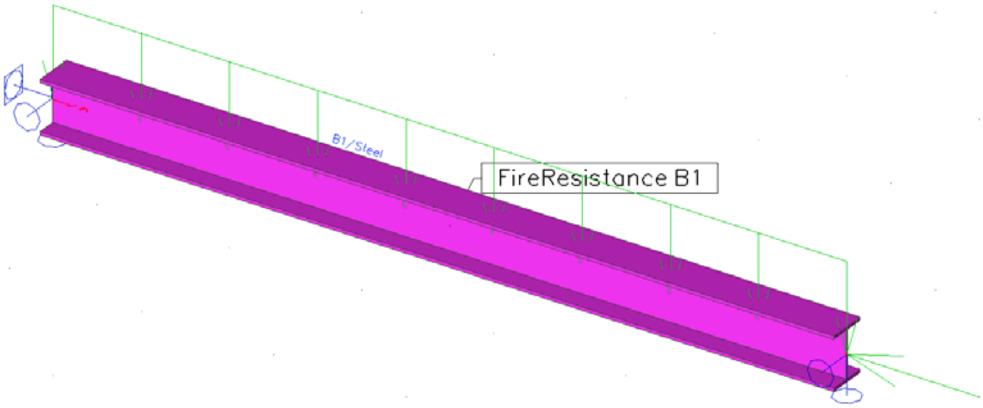


When the user clicks on action button Autodesign then the following dialogue is opened. The dialogue is a bit different from the one used in the general Autodesign, but the functionality is the same.

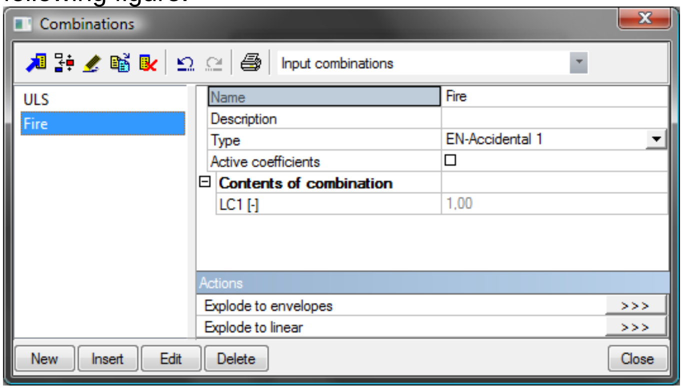


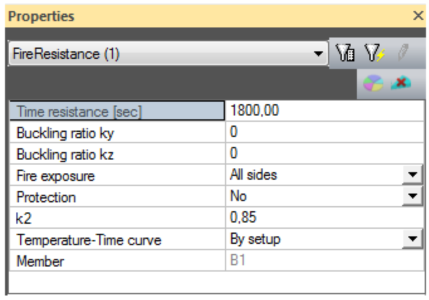
Illustrative example

Let us consider a very simple example of a steel beam with HEB400 cross-section for Autodesign. The structure is subject to the uniform load and to the axial force at one end. The aim of this example is to find the optimal height of the cross-section.

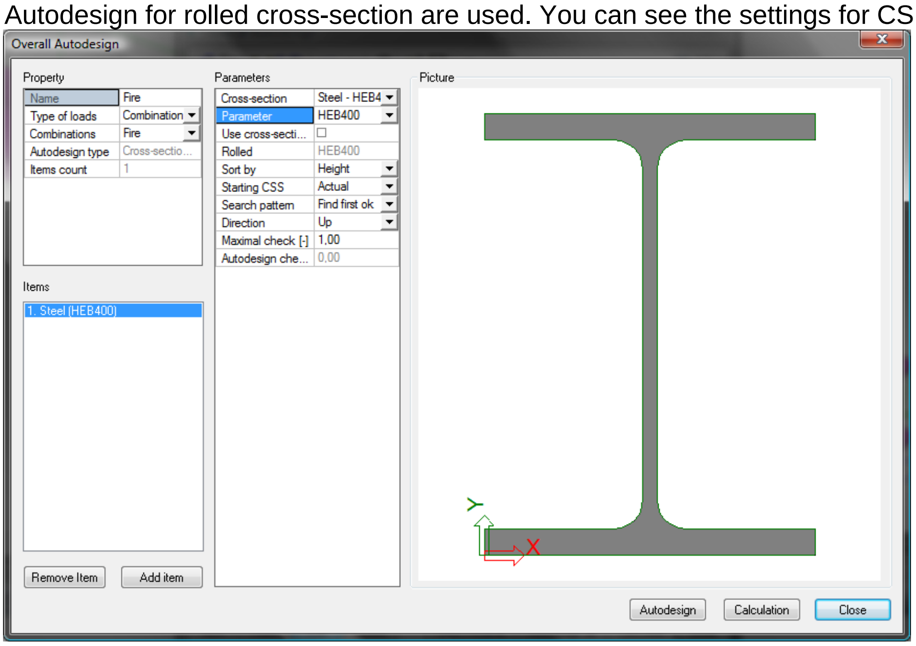


The accidental combination has to be defined. The fire resistance data are used as defined on the following figure.

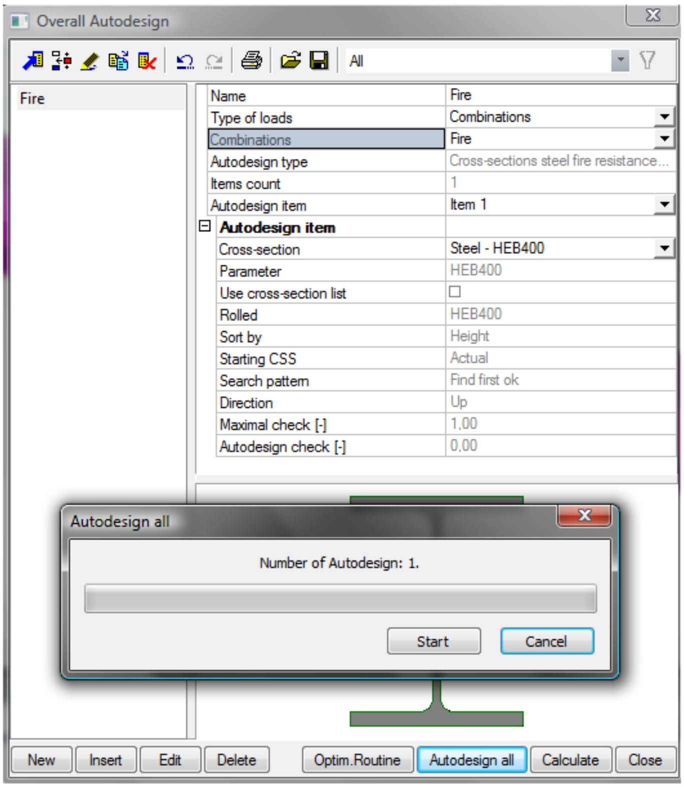




The Autodesign function is defined for HEB400 cross-section. The cross-section is rolled therefore the properties of Autodesign for rolled cross-section are used. You can see the settings for CS1 – Tube,



Autodesign of both cross-sections can be run in one step using **Autodesign all**.

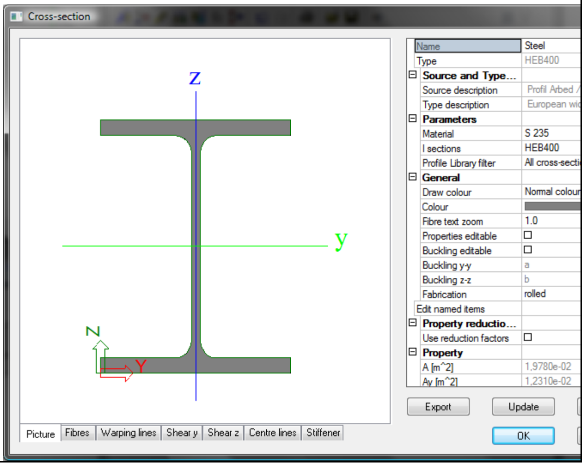
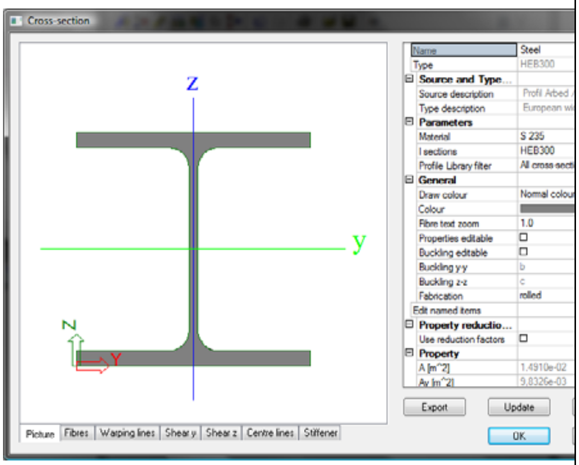


The results are automatically printed in preview.

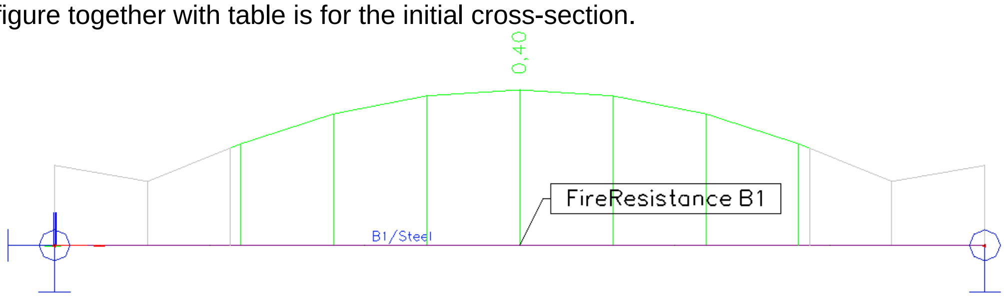
1. Fire

Cross-section	Parameter	Sort by	Original cross-section	Autodesign of cross-section	Autodesign check [-]
Steel - HEB300	HEB300	Height	Steel - HEB300	Steel - HEB300	0,86

The comparison of initial and optimized values of cross-section is clear from the following table. Initially HEB400 was used and the optimal cross-section is HEB300.

Initial	Optimized
	

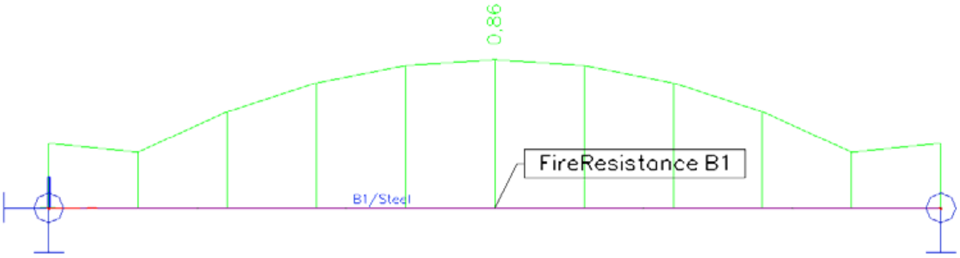
Evaluation of the rolled cross-section unity check along the beam is compared in the following figures. The first figure together with table is for the initial cross-section.



Check of steel - fire resistance

Type Name	Case	Member	css	mat	dx [m]	un.check [-]	sec.check [-]	stab.check [-]
Check of steel - fire resistance	Fire/1	B1	Steel - HEB400	S 235	3,000	0,40	0,33	0,40

The second figure together with table is for the optimized cross-section.



Check of steel - fire resistance

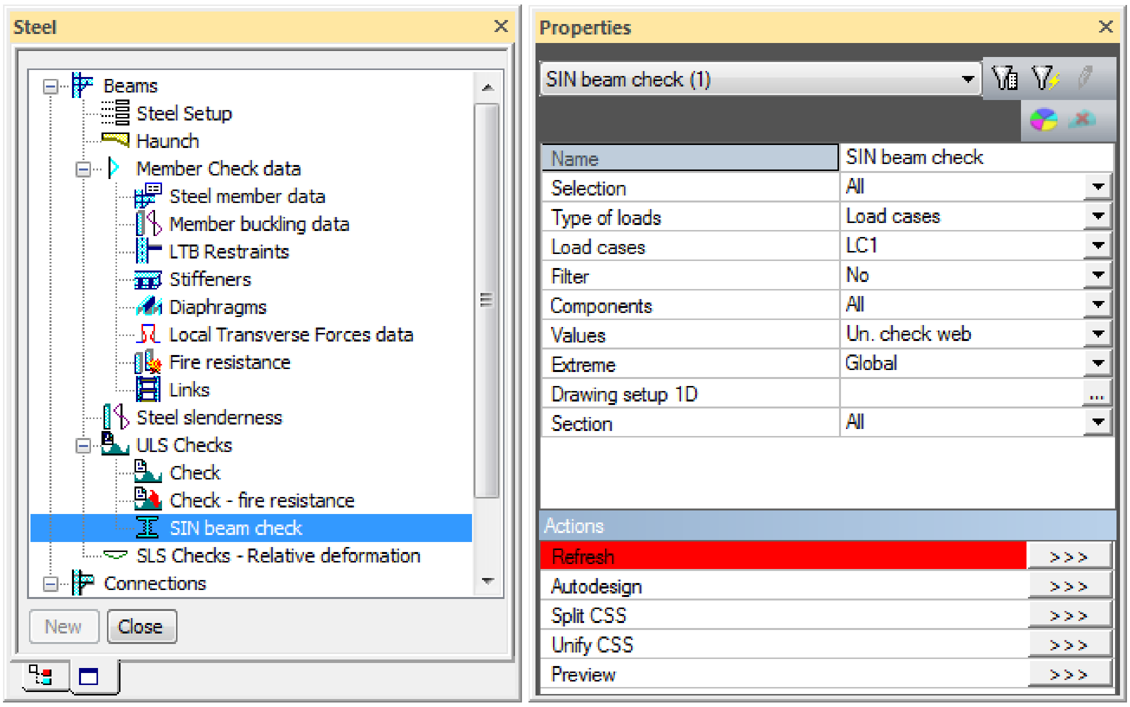
Type Name	Case	Member	css	mat	dx [m]	un.check [-]	sec.check [-]	stab.check [-]
Check of steel - fire resistance	Fire/1	B1	Steel - HEB300	S 235	3,000	0,86	0,70	0,86

Evaluation of steel check for optimized cross-section dimensions

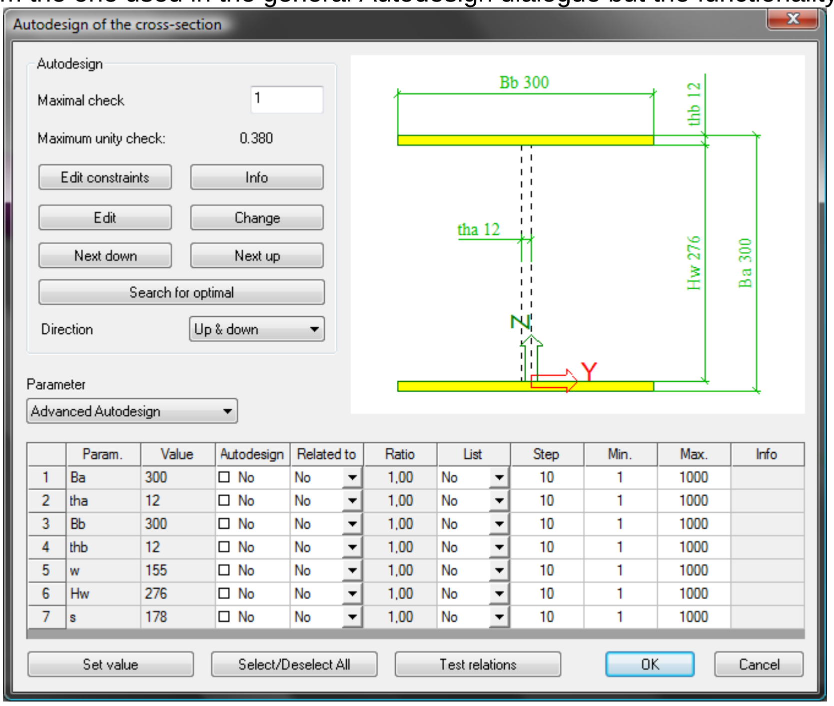
Steel - Corrugated web AutoDesign

Autodesign of corrugated cross-section check is the same part as the Autodesign located in the standard Steel > ULS Check > SIN beam check.

Autodesign in SIN beam check service



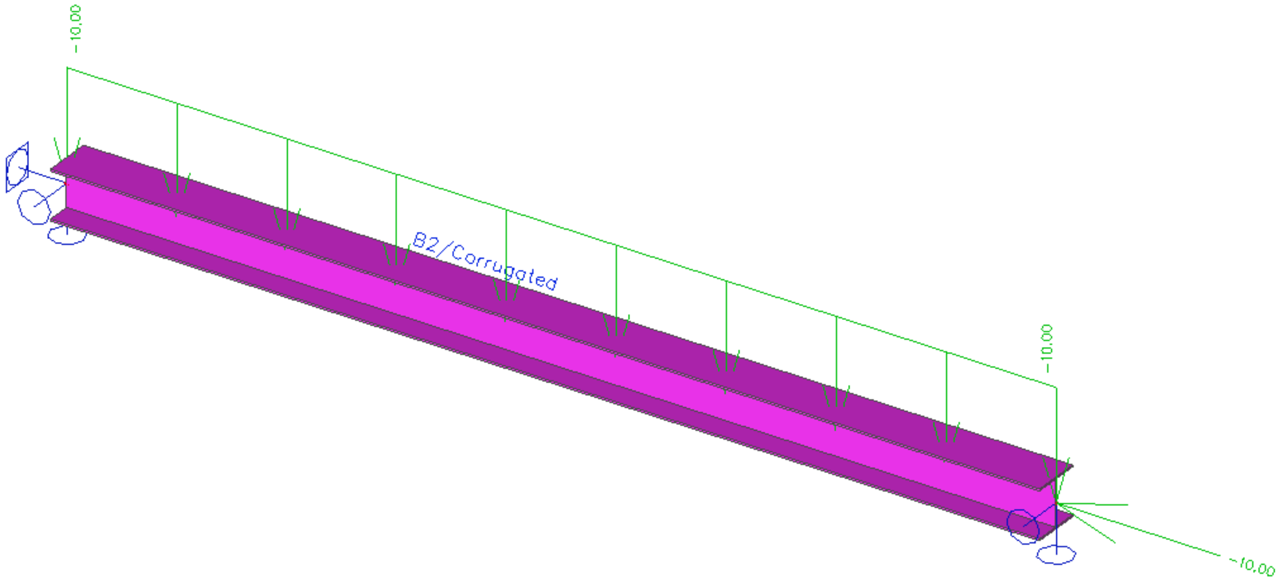
When the user clicks on action button Autodesign then the following dialogue appears. The dialogue is a bit different from the one used in the general Autodesign dialogue but the functionality is the same.



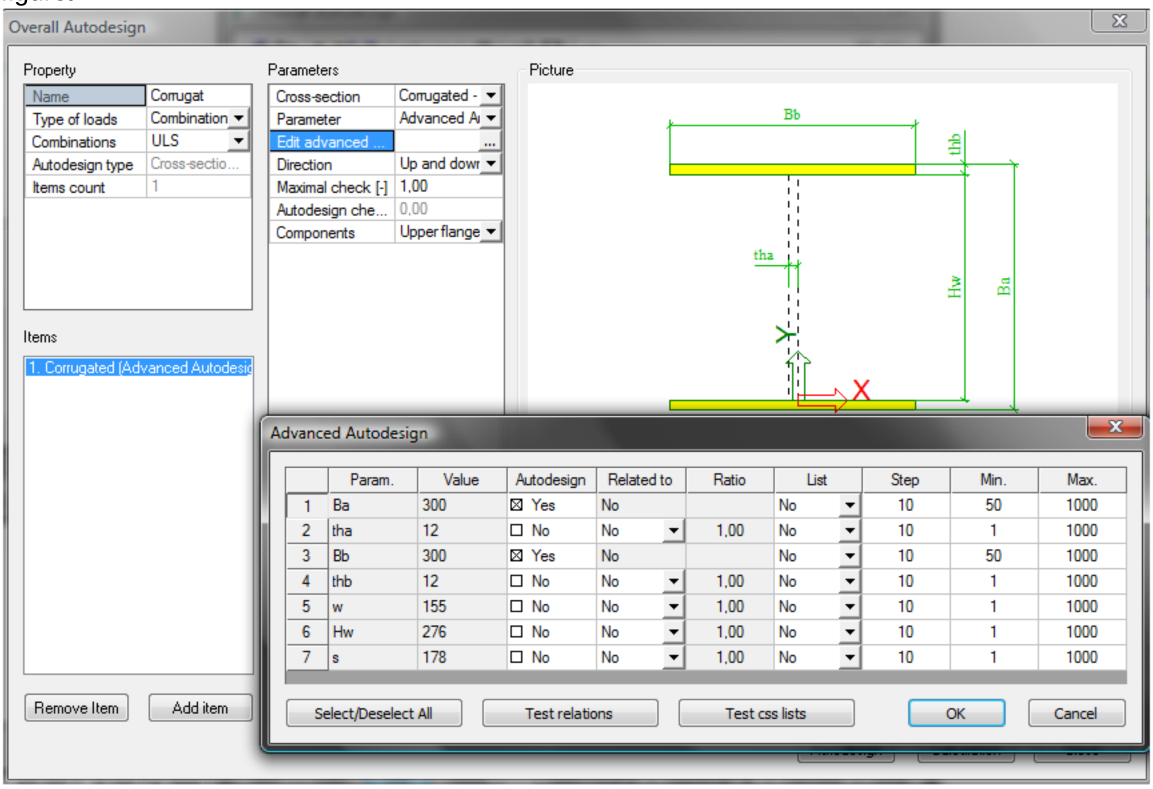
We will focus on Autodesign running from the Autodesign service in this case. Generally, results based on the settings in Autodesign and in the individual service have to be the same.

Illustrative example

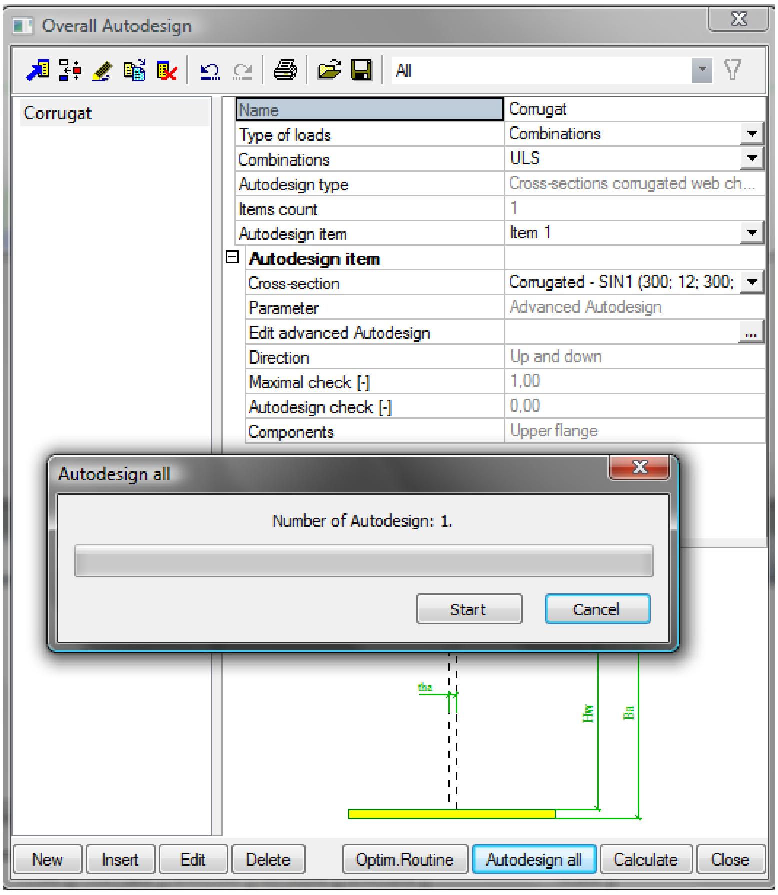
Let us consider a very simple example of a steel beam with corrugated cross-section for Autodesign. The structure is subject to the uniform load and to the axial force at one end. The aim of this example is to find the optimal dimensions of the corrugated SIN cross-section.



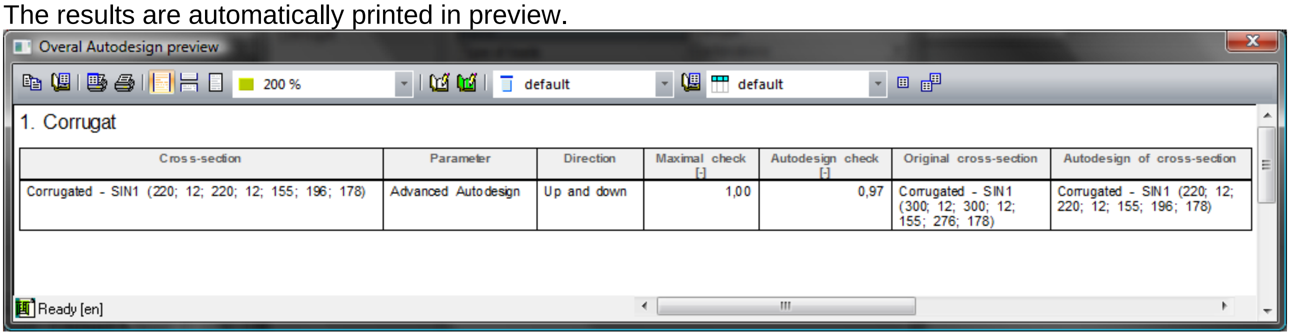
The Autodesign function is defined for this cross-section. You can see the settings on the following figure.



In this case the Advanced Autodesign is selected. The settings are made according to the figure above. The properties are similar to the standard steel code check.
Autodesign can be run in one step using **Autodesign all**.

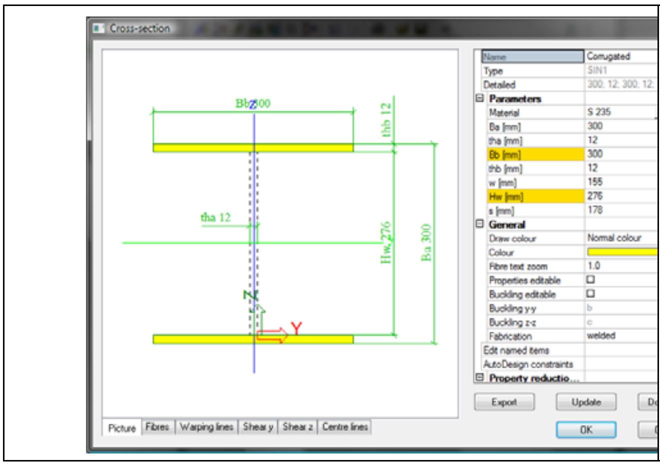


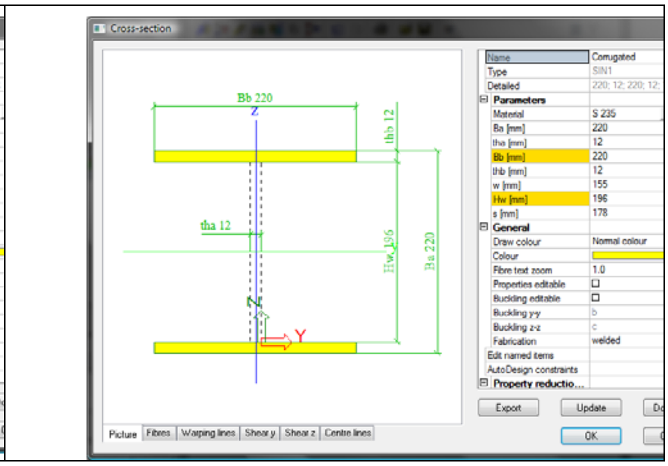
The results are automatically printed in preview.



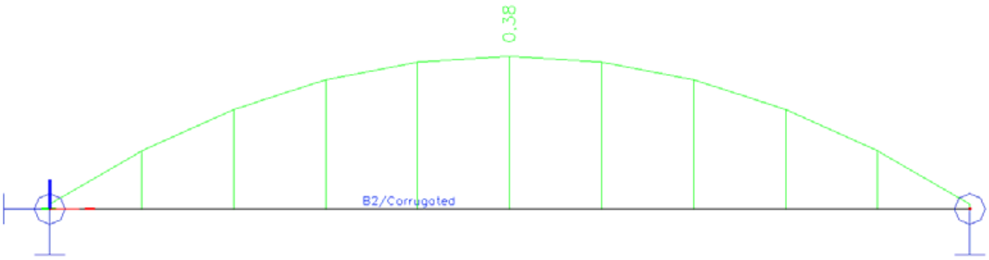
The comparison of the initial and optimized values of the corrugated cross-section is clear from the following table.

Initial	Optimized





Evaluation of the SIN beam unity check along the beam is compared in the following figures. The first figure together with the table is for the initial cross-section.



SIN beam check

Linear calculation, Extreme : Global
Selection : All
Combinations : ULS
SIN beam check

SIN beam checks - outer flange

Member name	Dx [m]	Load case	N,Ed [kN]	My,Ed [kNm]	Vz,Ed [kN]	c top [m]	kc top [-]	Ned - [kN]	Ny [kN]	Ngl [kN]	Nl [kN]	Max unity check [-]
B2	0,000	ULS/1	-13,50	0,00	40,50	6,000	1,00	-6,75	846,00	573,38	846,00	0,01
B2	3,000	ULS/1	-13,50	60,75	0,00	6,000	1,00	-217,69	846,00	573,38	846,00	0,38

SIN beam checks - inner flange

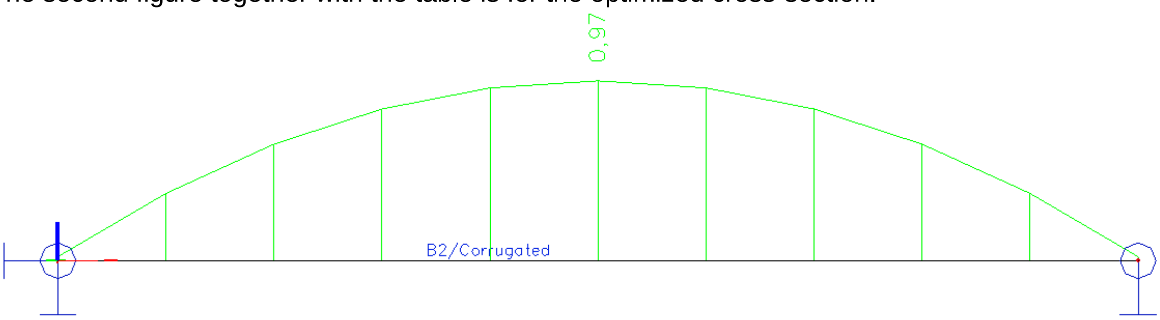
Member name	Dx [m]	Load case	N,Ed [kN]	My,Ed [kNm]	Vz,Ed [kN]	c bot [m]	kc bot [-]	Ned + [kN]	Ned - [kN]	Ny [kN]	Ngl [kN]	Nl [kN]	Max unity check [-]
B2	0,000	ULS/1	-13,50	0,00	40,50	6,000	1,00		-6,75	846,00	573,38	846,00	0,01
B2	3,000	ULS/1	-13,50	60,75	0,00	6,000	1,00	204,19		846,00			0,24

SIN beam checks - web

Member name	Dx [m]	Load case	h [m]	Vz,Ed [kN]	V_web [kN]	Vrd [kN]	Max unity check [-]
B2	0,000	ULS/1	0,288	40,50	40,50	449,36	0,09
B2	3,000	ULS/1	0,288	0,00	0,00	449,36	0,00

SIN beam checks - Summary
Unity Check - OK - satisfies. (0.380)

The second figure together with the table is for the optimized cross-section.



SIN beam check

Linear calculation, Extreme : Global
Selection : All
Combinations : ULS
SIN beam check
SIN beam checks - outer flange

Member name	Dx [m]	Load case	N,Ed [kN]	My,Ed [kNm]	Vz,Ed [kN]	c top [m]	kc top [-]	Ned - [kN]	Ny [kN]	Ngl [kN]	Nl [kN]	Max unity check [-]
B2	0,000	ULS/1	-13,50	0,00	40,50	6,000	1,00	-6,75	620,40	308,35	620,40	0,02
B2	3,000	ULS/1	-13,50	60,75	0,00	6,000	1,00	-298,82	620,40	308,35	620,40	0,97

SIN beam checks - inner flange

Member name	Dx [m]	Load case	N,Ed [kN]	My,Ed [kNm]	Vz,Ed [kN]	c bot [m]	kc bot [-]	Ned + [kN]	Ned - [kN]	Ny [kN]	Ngl [kN]	Nl [kN]	Max unity check [-]
B2	0,000	ULS/1	-13,50	0,00	40,50	6,000	1,00		-6,75	620,40	308,35	620,40	0,02
B2	3,000	ULS/1	-13,50	60,75	0,00	6,000	1,00	285,32		620,40			0,46

SIN beam checks - web

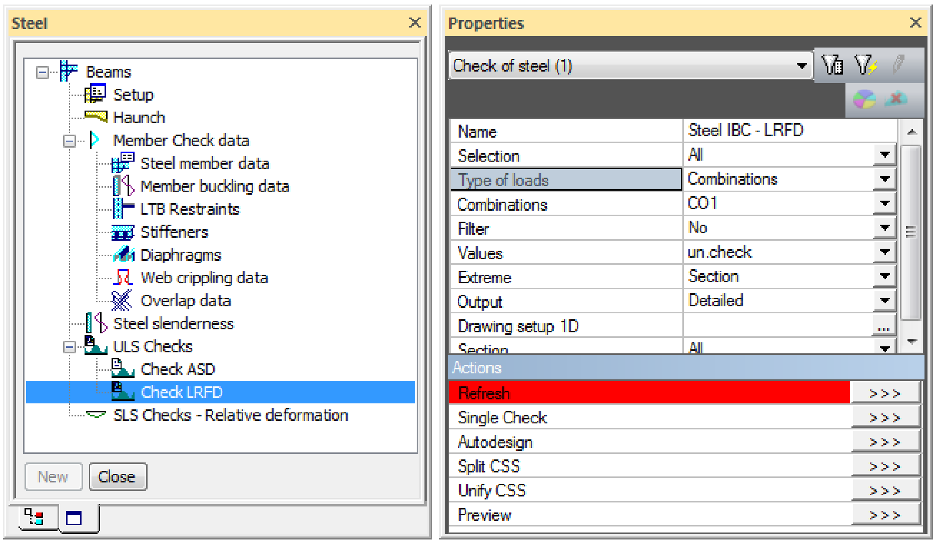
Member name	Dx [m]	Load case	h [m]	Vz,Ed [kN]	V_web [kN]	Vrd [kN]	Max unity check [-]
B2	0,000	ULS/1	0,208	40,50	40,50	319,11	0,13
B2	3,000	ULS/1	0,208	0,00	0,00	319,11	0,00

SIN beam checks - Summary
Unity Check - OK - satisfies. (0.969)

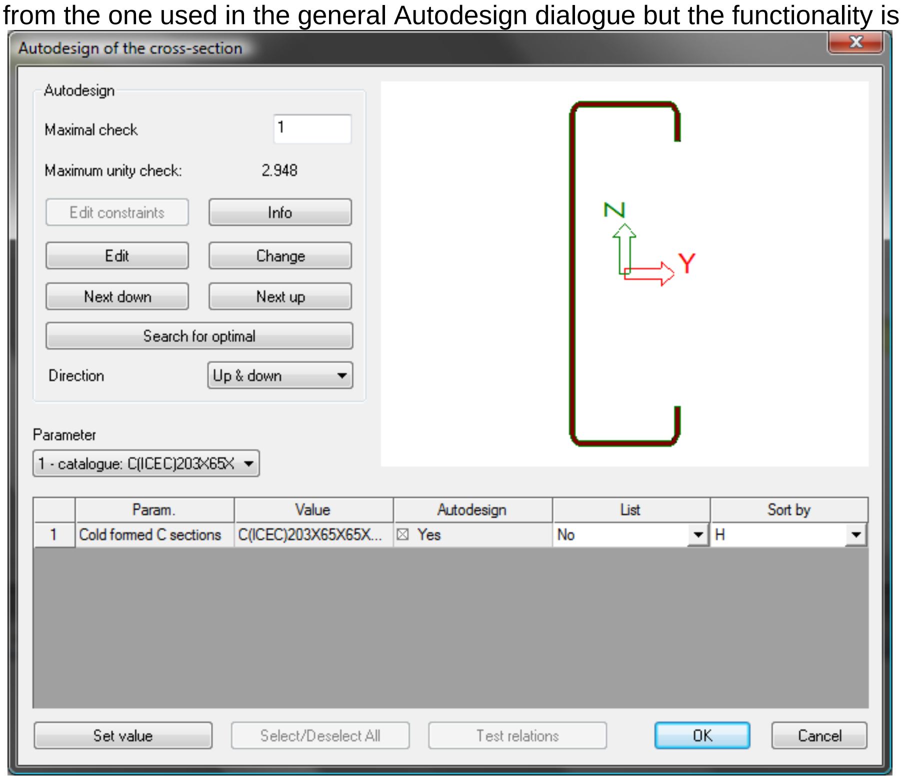
Steel - Lapped purlin/girt AutoDesign (only IBC code)

Generally, there is special Autodesign available only for NAS 2007 check for purlins (ASD or LRFD code). The algorithm changes either the cross-section or the length of the overlap. The Autodesign of lapped purlins is the same part as the Autodesign located in the standard Steel > ULS Check > Check LRFD resistance.

Autodesign in Check LRFD service

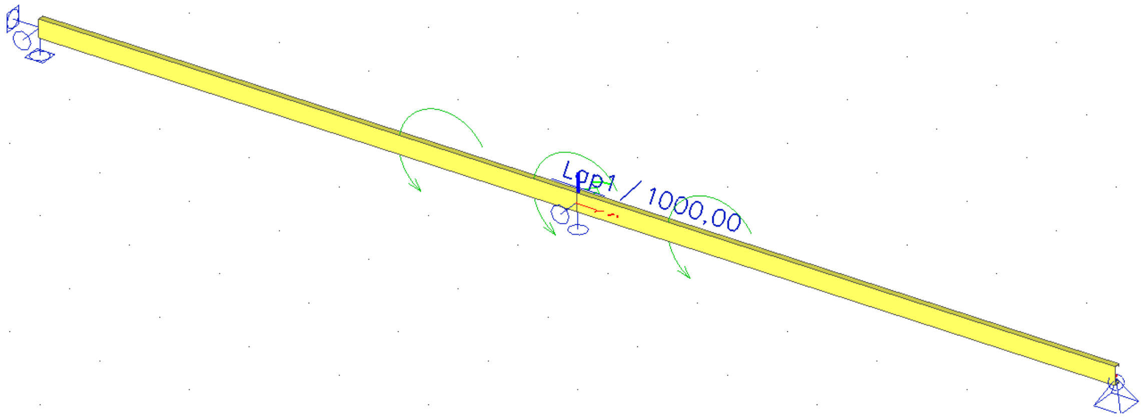


When the user clicks on action button Autodesign then the following dialogue is shown. The dialogue is a bit different from the one used in the general Autodesign dialogue but the functionality is the same.

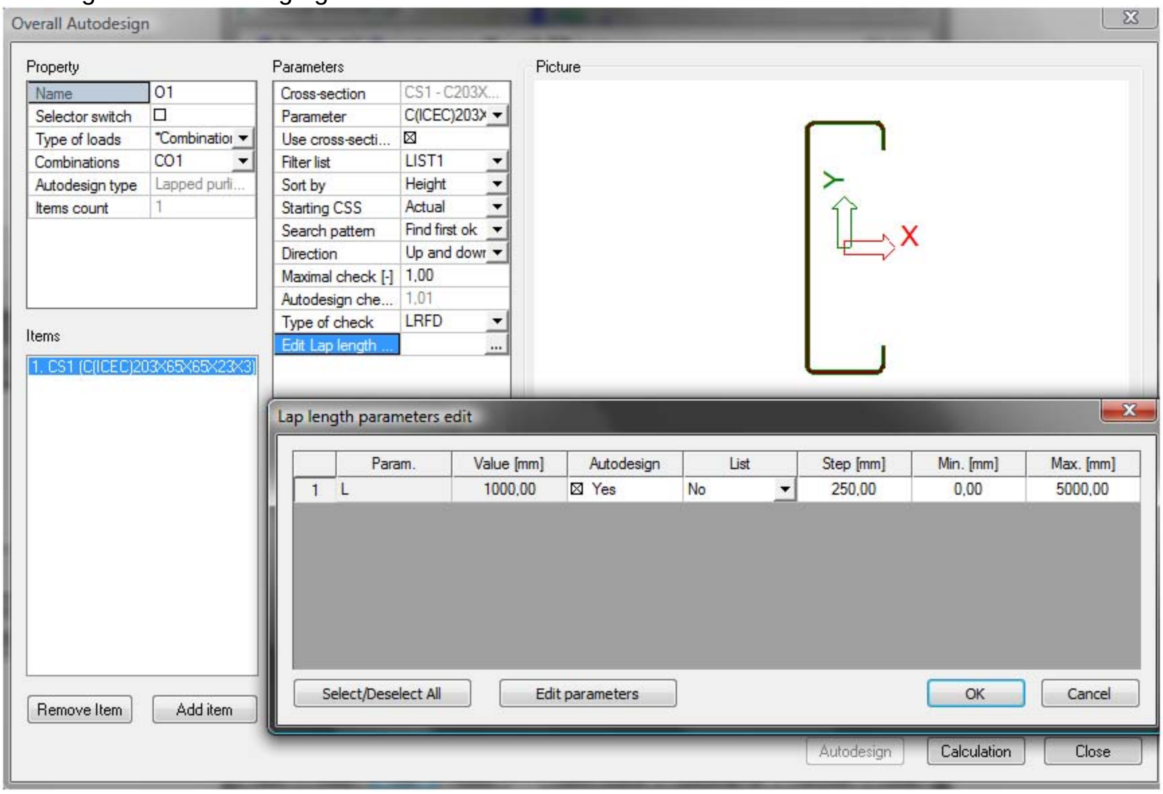


Illustrative example

Let us consider a very simple example of a continuous steel purlin made of a cold formed C section for Autodesign. The purlin overlap should be designed for bending moment 20kNm. The aim of this example is to find the optimal height of the cross-section or length of the overlap.



The Autodesign function is defined for the cold-formed C section. The cross-section is cold formed therefore the properties of Autodesign for rolled and cold formed cross-section are used. You can see the settings in the following figure.

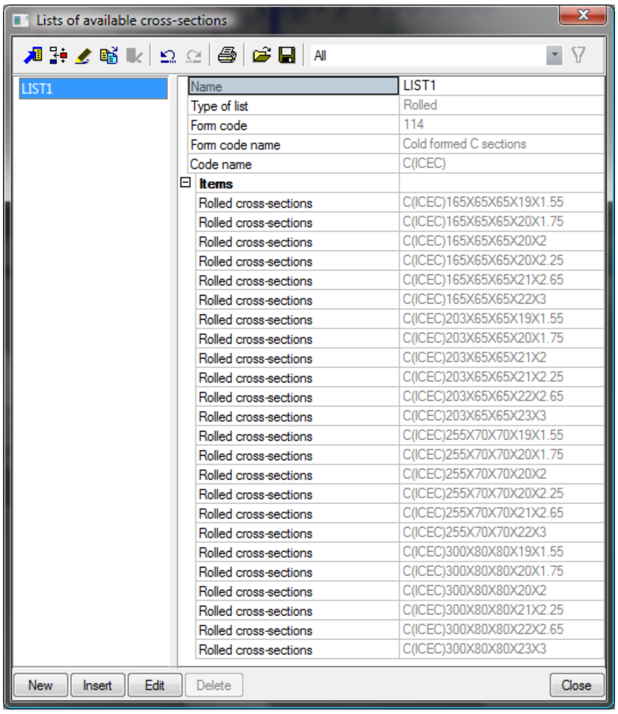


The additional properties are:

Type of check it is possible to select between ASD code and LRFD code

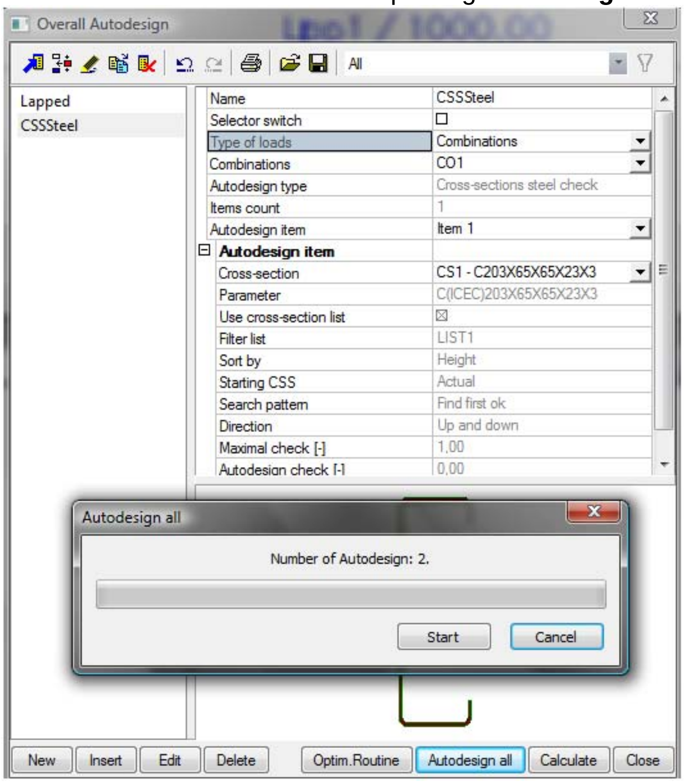
Edit Lap length Autodesign settings for the overlap

The following cross-sections are inserted to the Cross-section list.



In fact the lapped purlin Autodesign decides between the cross-section change and length change. The cross-section optimization of the whole member is already included. Note that in the example, a fixed list was used to avoid a change in cross-section so specifically the change in length could be tested.

Autodesign of both cross-sections can be run in one step using **Autodesign all**.



The results are automatically printed in preview.

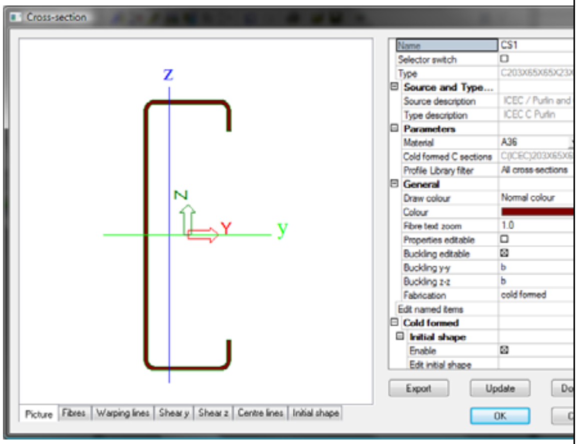
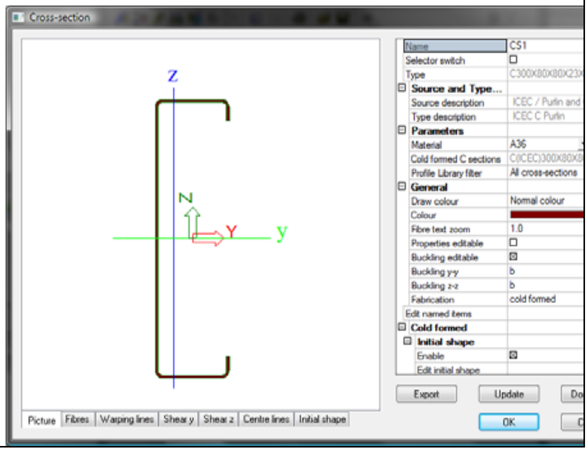
1. Lapped

Cross-section	Parameter	Sort by	Filter list	Autodesign check [-]	Type of check
CS1 - C300X80X80X23X3	C(ICEC)300X80X80X23X3	Height	LIST1	0,91	LRFD

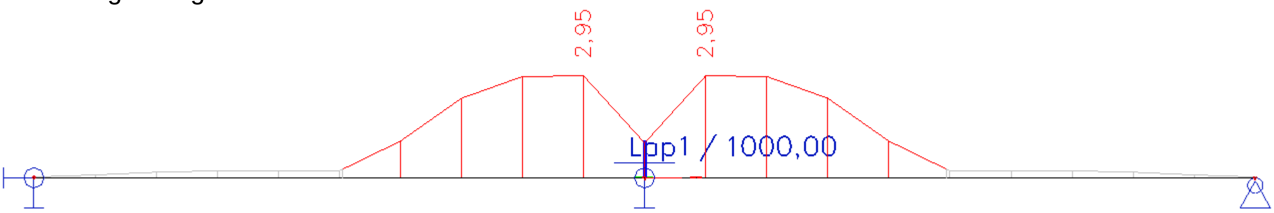
2. CSSSteel

Cross-section	Parameter	Sort by	Filter list	Original cross-section	Autodesign of cross-section	Autodesign check [-]
CS1 - C300X80X80X23X3	C(ICEC)300X80X80X23X3	Height	LIST1	CS1 - C255X70X70X21X2.65	CS1 - C300X80X80X23X3	0,96

The comparison of the initial and optimized values of the cross-section is clear from the following table.
The length of the overlap increased from 1000 to 2500mm.

Initial	Optimized
	

Evaluation of the rolled cross-section unity check along the beam is compared in the following figures.
The first figure together with the table is for the initial cross-section.

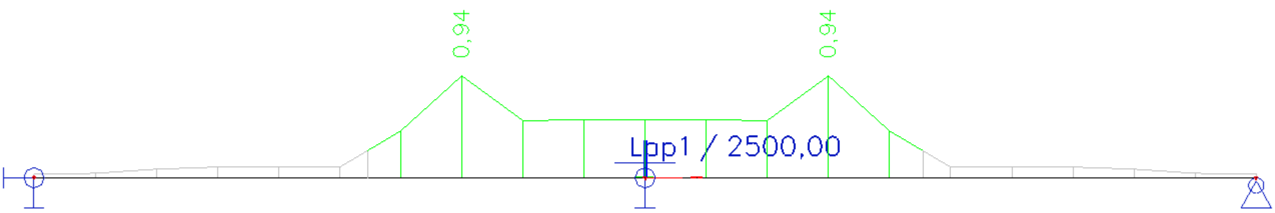


Check of steel

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

Case	Member	css	mat	dx [m]	un.check [-]
CO1/1	B1	CS1 - C(ICEC)203X65X65X23X3	A36	5,400	**2,95**
CO1/1	B2	CS1 - C(ICEC)203X65X65X23X3	A36	0,600	**2,95**

The second figure together with the table is for the optimized cross-section.



Check of steel

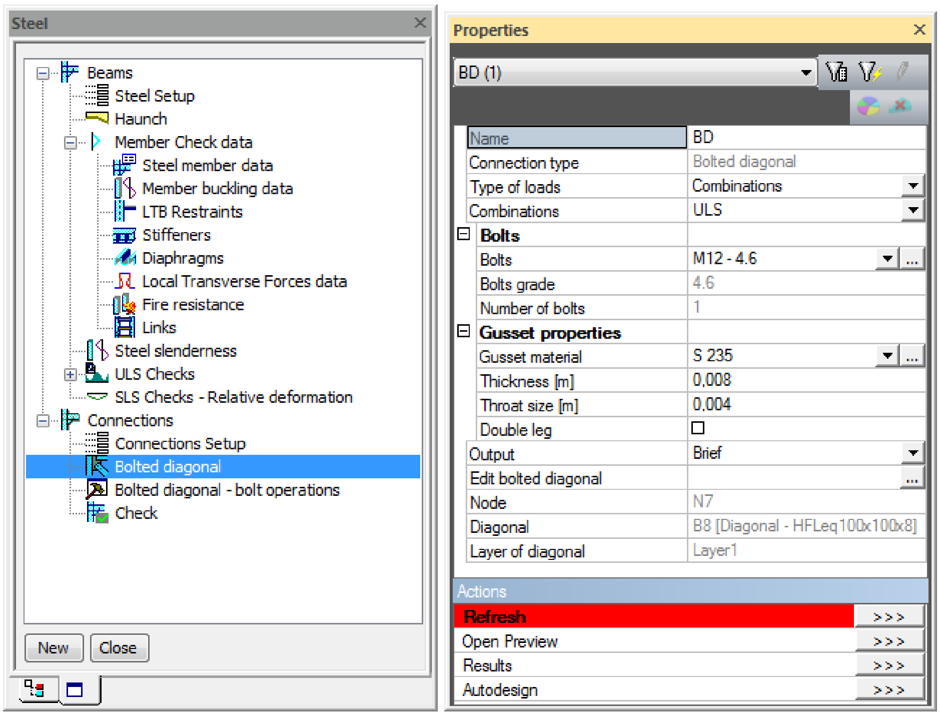
Linear calculation, Extreme : Member
Selection : All
Combinations : CO1

Case	Member	css	mat	dx [m]	un.check [-]
CO1/1	B1	CS1 - C(ICEC)300X80X80X23X3	A36	4,200	0,94
CO1/1	B2	CS1 - C(ICEC)300X80X80X23X3	A36	1,800	0,94

Steel connection - Bolted diagonal AutoDesign

Autodesign of bolted diagonal is the same part as the Autodesign located in the standard Steel > Connections > Bolted diagonal.

Autodesign in Bolted diagonal service

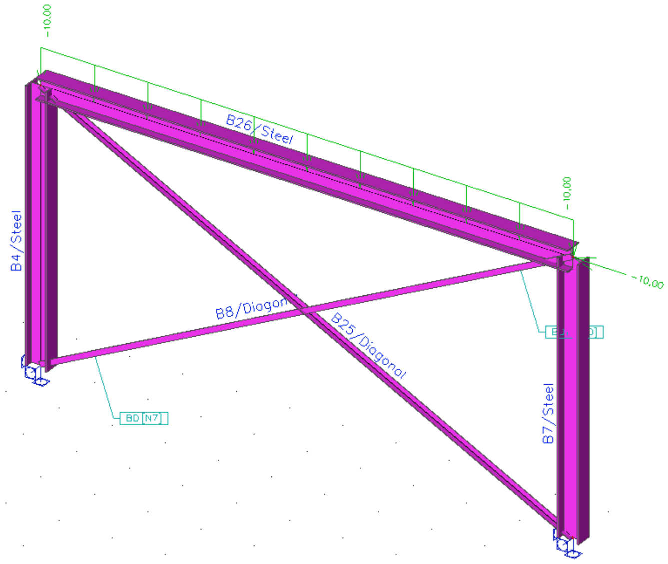


When the user clicks on action button Autodesign then the following dialogue appears. The dialogue is a bit different than the one used in the general Autodesign dialogue but the functionality is the same.

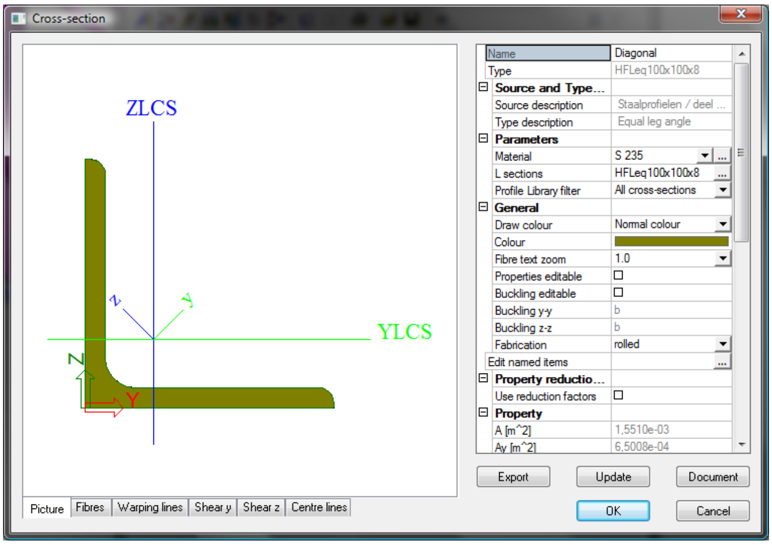
We will focus on Autodesign running from Autodesign service in this case. Generally, results based on the same settings in Autodesign and in the individual service have to be the same.

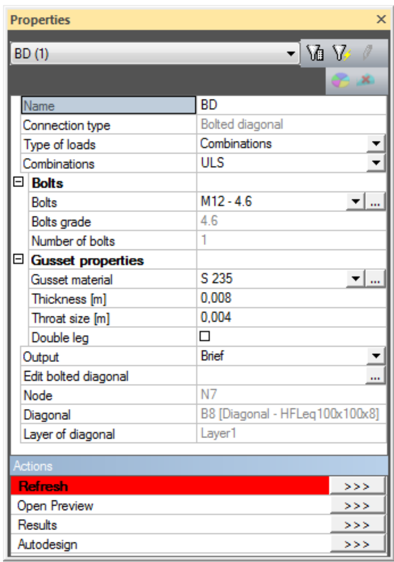
Illustrative example

Let us consider a very simple example of a steel frame with bolted diagonals for Autodesign. The structure is subject to the uniform load and to the axial force at the end. The aim of this example is to find the optimal dimensions of the bolted diagonal connection.

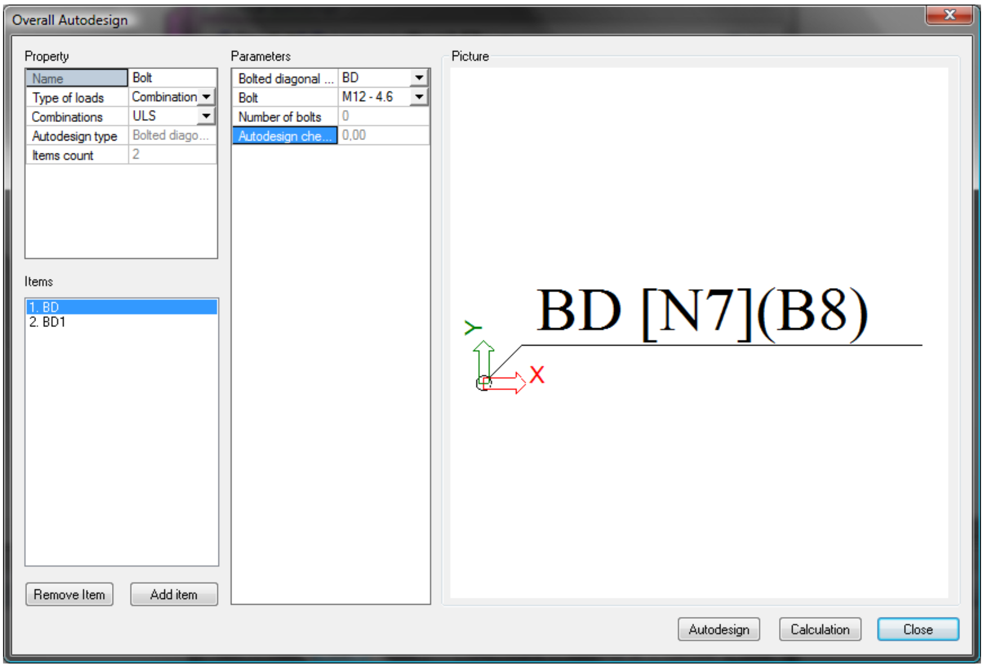


Bolt diagonal has the following cross-section. The parameters of bolted connection are shown in the following figure.





The Autodesign function is defined for this cross-section. You can see the settings on the following figure.



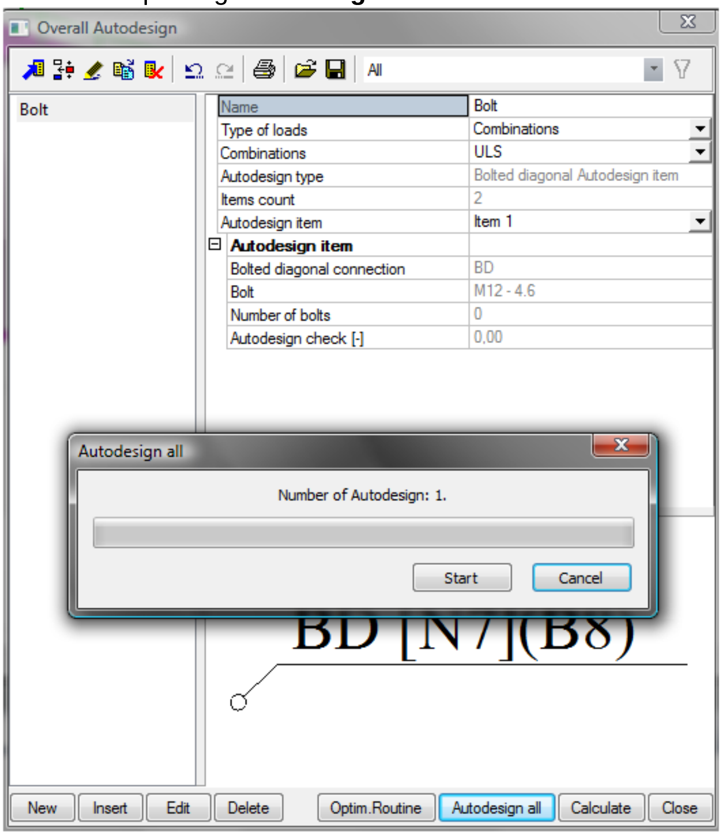
The settings are shown in the figure above.

Bolted diagonal Specifies the bolted diagonal to be optimised.

Bolt Specifies the bolt used.

Optimised check (informative) Shows the unity check for the optimised connection.

Autodesign can be run in one step using **Autodesign all**.



The results are automatically printed in preview. One bolt for each connection is enough. Instead of originally designed four bolts.

1. Bolt

Type Name	Bolted diagonal connection	Bolt	Number of bolts	Autodesign check [-]
Overall Autodesign bolted diagonal item	BD	M12 - 4.6	1	0,49
Overall Autodesign bolted diagonal item	BD1	M12 - 4.6	1	0,49

The comparison of initial and optimized values of bolted connections is clear from the following table.

Initial

BD

Name	BD1
NplRd - [kN]	364,49
NuRd - [kN]	207,22
FbRd - [kN]	32,09
FvRd [kN]	5,66
NplRd - [kN]	94,00
NuRd - [kN]	74,65
FbRd - [kN]	32,09
Connection check [-]	0,12
Member check [-]	0,11
Connection result FvRd [kN]	16,19

Optimized

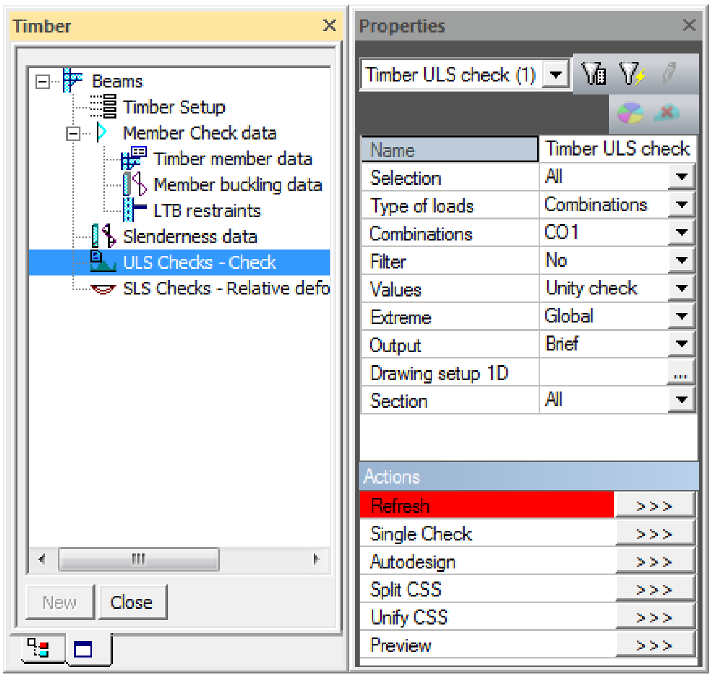
BD

Name	BD
NplRd - [kN]	364,49
NuRd - [kN]	198,00
FbRd - [kN]	58,47
FvRd [kN]	16,46
NplRd - [kN]	150,40
NuRd - [kN]	120,27
FbRd - [kN]	58,47
Connection check [-]	0,04
Member check [-]	0,07
Connection result FvRd [kN]	47,04

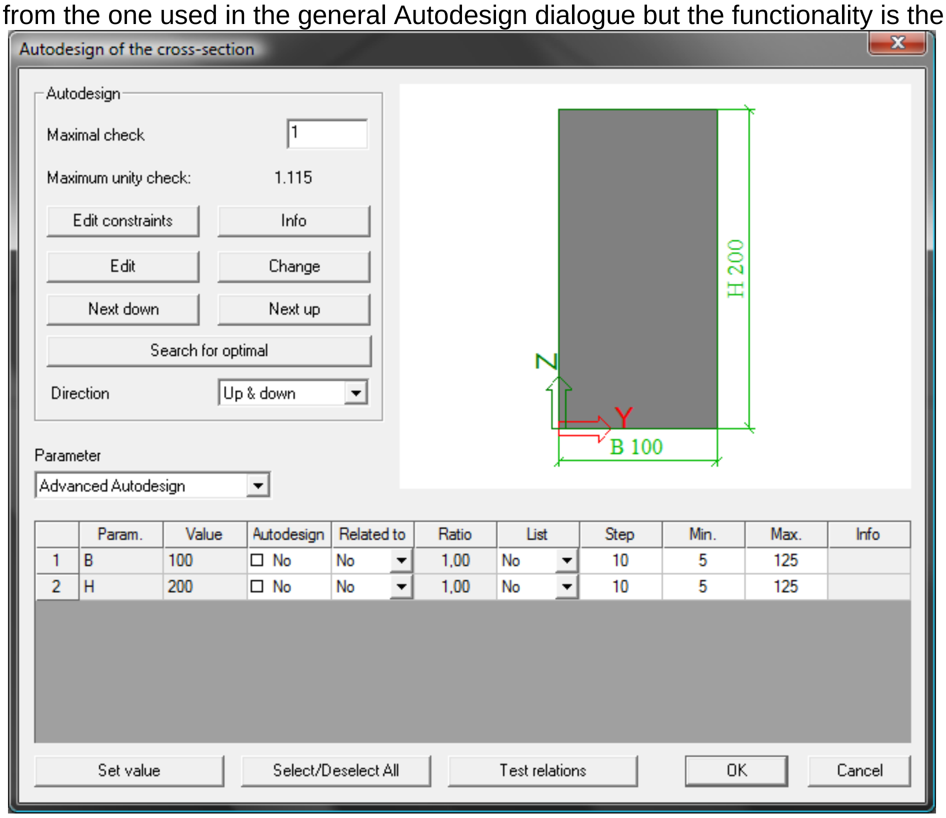
Timber – Cross-section AutoDesign

Autodesign of cross-section timber check is the same part as the Autodesign placed in the standard Timber > ULS Checks - Check.

Autodesign in Timber service



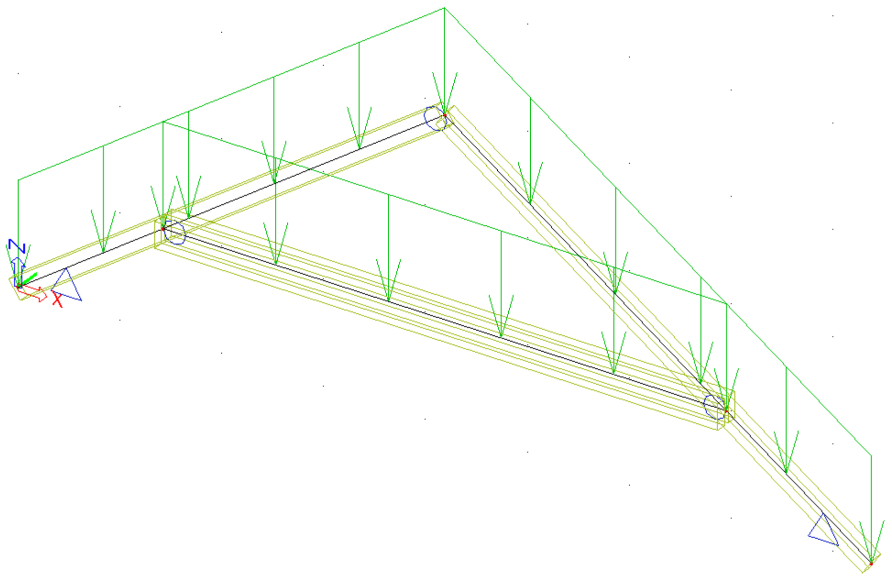
When the user clicks on action button Autodesign the following dialogue is displayed. The dialogue is a bit different from the one used in the general Autodesign dialogue but the functionality is the same.



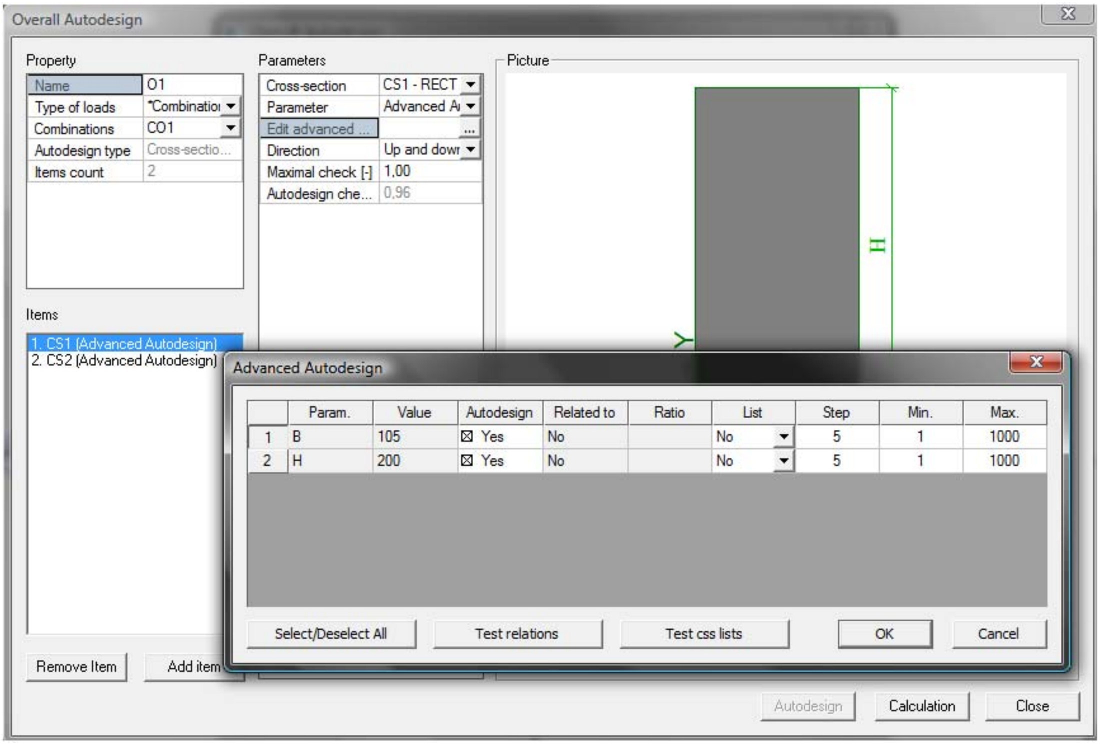
We will focus on Autodesign running from Autodesign service in this case. Generally results based on the same settings in Autodesign and the individual service have to be the same.

Illustrative example

Let us consider a very simple example of timber roof structure with rectangular cross-sections for Autodesign. The structure is subject to self-weight, uniform permanent load, wind and snow load. The aim of this example is to find the optimal dimensions of cross-sections.



The Autodesign function is defined for each cross-section. You can see the settings for CS1.The settings are completely the same as for the steel check. The advanced Autodesign is used for both cross-sections.



Autodesign of both cross-sections can be run in one step using **Autodesign all**.

Overal Autodesign preview

1. Routine step: 1

1.1. O1

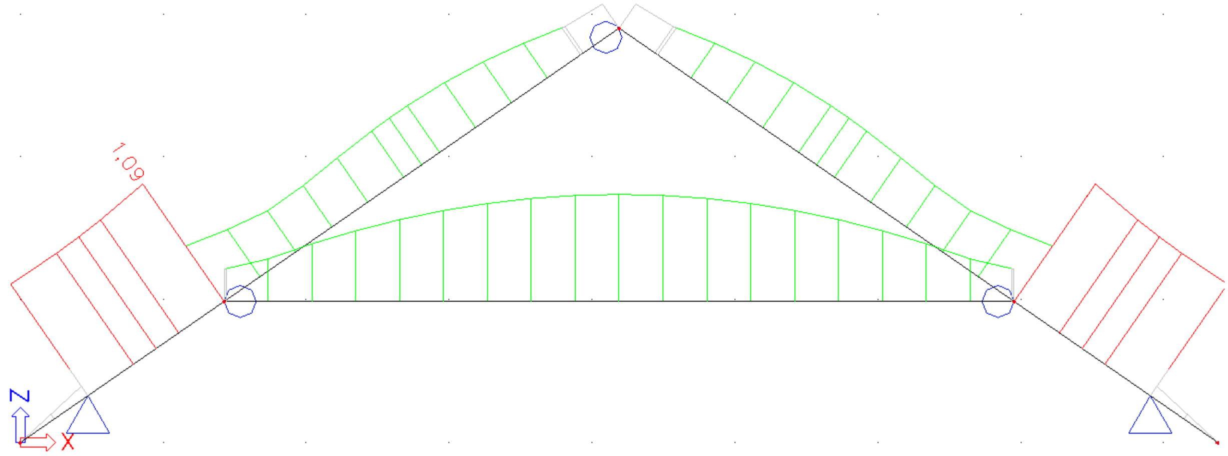
Cross-section	Parameter	Original cross-section	Autodesign of cross-section	Autodesign check [-]
CS1 - RECT (105; 200)	Advanced Autodesign	CS1 - RECT (100; 200)	CS1 - RECT (105; 200)	0,95
CS2 - 2 Rect (80; 160; 100)	Advanced Autodesign	CS2 - 2 Rect (80; 160; 100)	CS2 - 2 Rect (80; 160; 100)	0,81

2. Routine step: 2

Cross-section	Parameter	Original cross-section	Autodesign of cross-section	Autodesign check [-]
CS1 - RECT (105; 200)	Advanced Autodesign	CS1 - RECT (105; 200)	CS1 - RECT (105; 200)	0,96
CS2 - 2 Rect (80; 160; 100)	Advanced Autodesign	CS2 - 2 Rect (80; 160; 100)	CS2 - 2 Rect (80; 160; 100)	0,81

Ready [en]

Evaluation of the timber unity check along the beam is compared in the following figures. The first figure and table are for the initial structure.

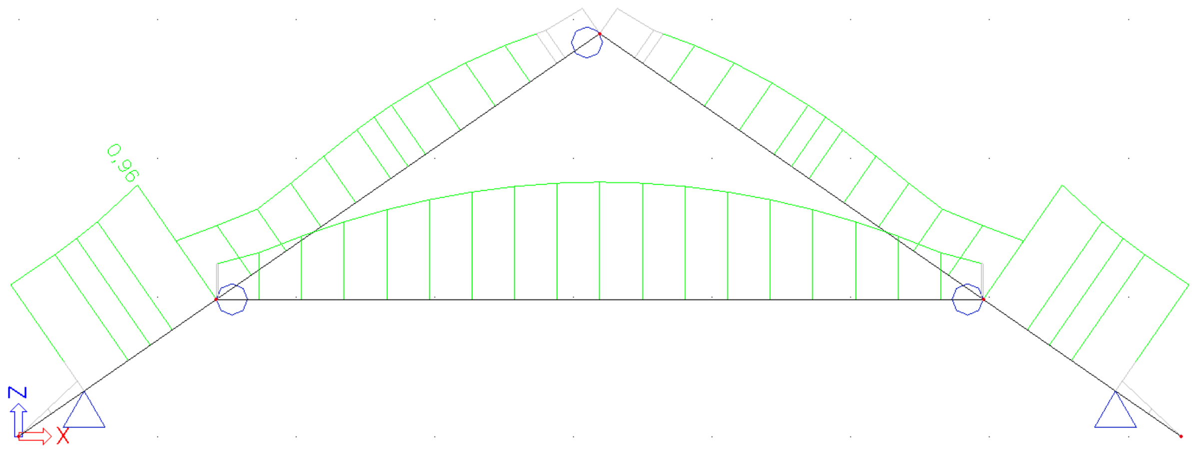


Timber ULS check

Linear calculation, Extreme : Global
Selection : All
Combinations : CO1
Cross-section : CS1 - RECT (100; 200)

Beam	Cross-section	Material	dx [m]	Load case	Unity check [-]	Section check [-]	Stability check [-]
B1	CS1 - RECT	C22	1,734	CO1/1	**1,09**	0,22	1,09

The second ones are for the optimised structure.



Timber ULS check

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

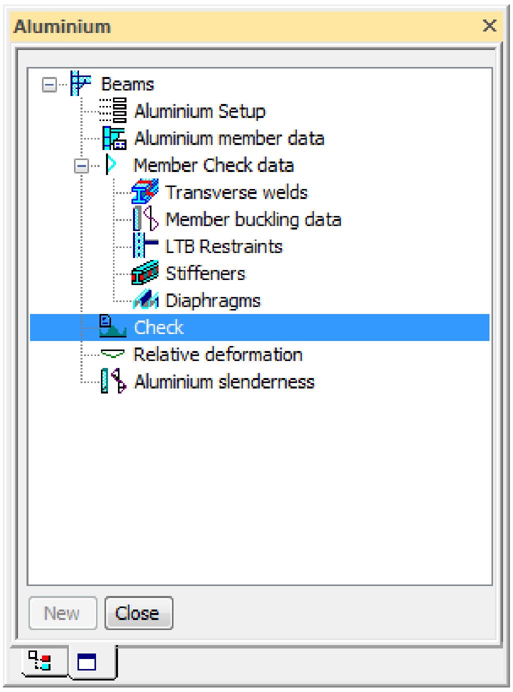
Beam	Cross-section	Material	dx [m]	Load case	Unity check [-]	Section check [-]	Stability check [-]
B1	CS1 - RECT	C22	1,734	CO1/1	**0,96**	0,21	0,96

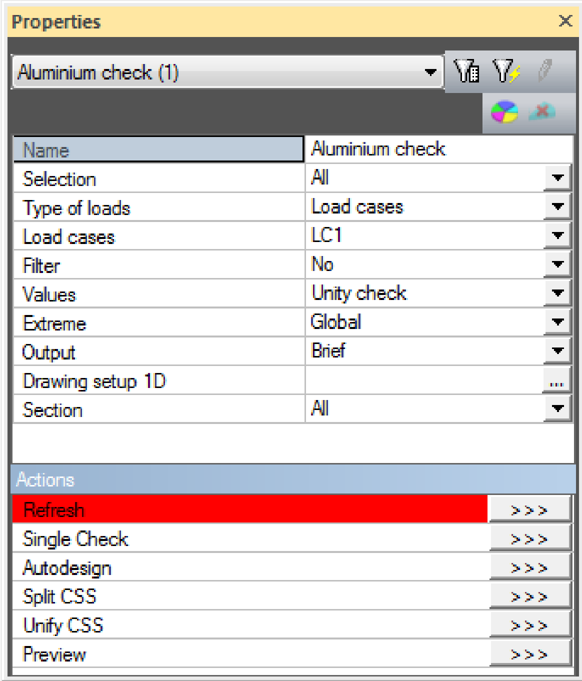
The width of rafters were optimised from 100 to 105mm.

Aluminium – Cross-section AutoDesign

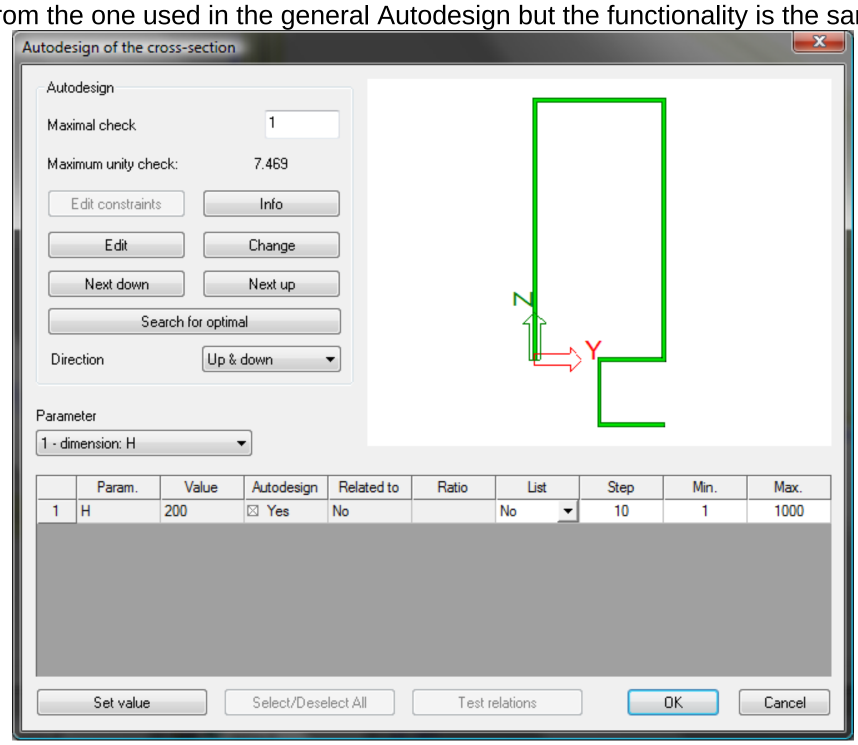
Autodesign of cross-section steel check is the same part as the Autodesign locates in the standard Aluminium > Check.

Autodesign in Aluminium service





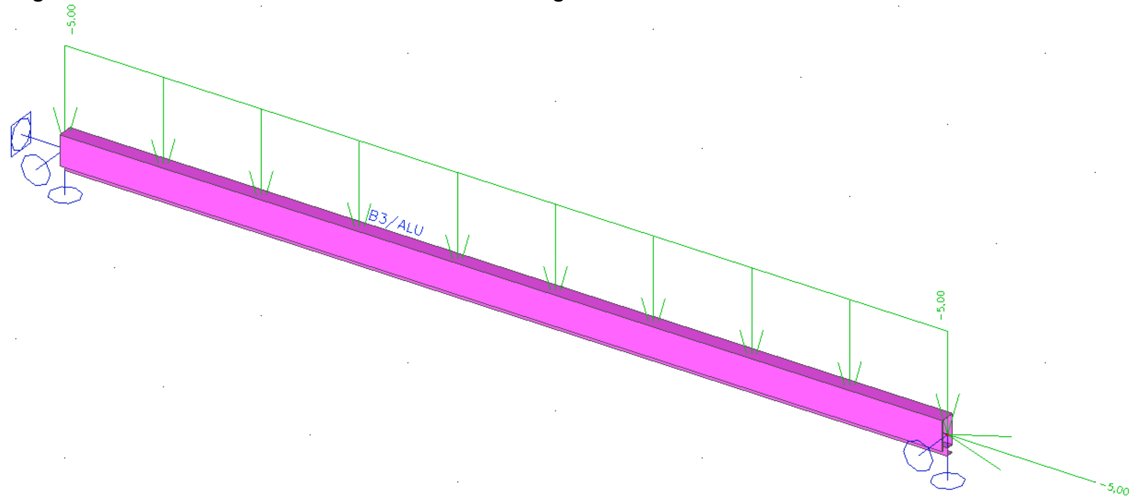
When the user clicks on action button Autodesign then the following dialogue appears. The dialogue is a bit different from the one used in the general Autodesign but the functionality is the same.



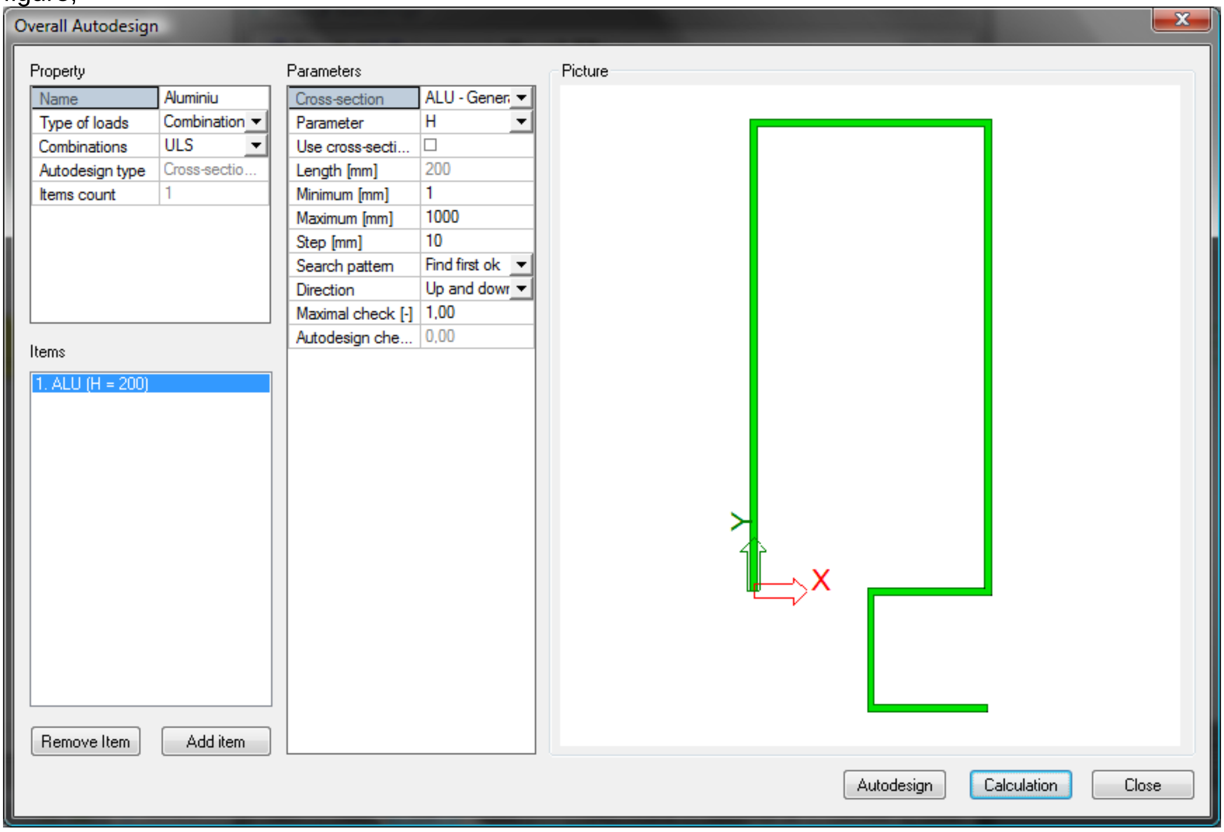
We will focus on Autodesign running from Autodesign service in this case. Generally results based on the same settings in Autodesign and the individual service have to be the same.

Illustrative example

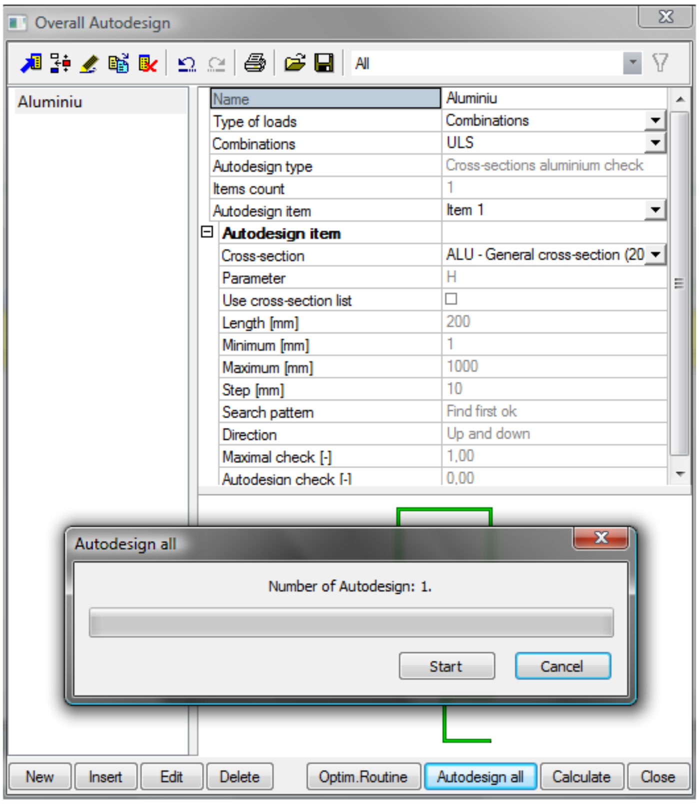
Let us consider a very simple example of an aluminium beam for Autodesign. The structure is subject to the uniform load and to the axial force at the end. The aim of this example is to find the optimal height of aluminium cross-section defined as a general cross-section.



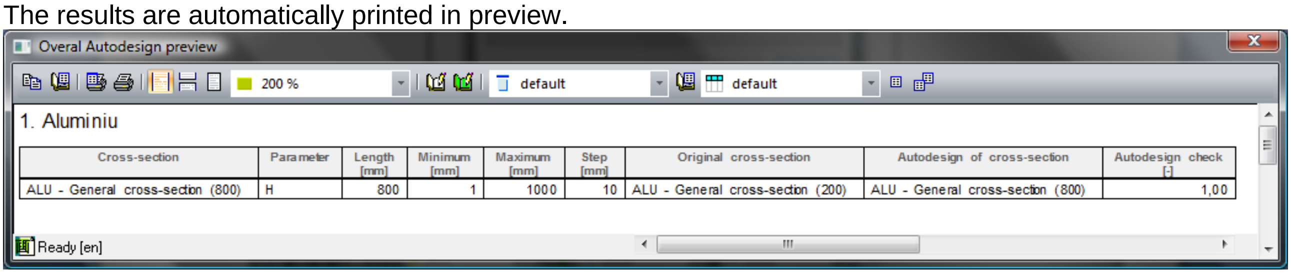
The Autodesign function is defined for this cross-section. You can see the settings in the following figure,



In this case only one parameter (height of cross-section) is available. Therefore advance Autodesign is not used. Other settings are the same as for the standard steel Autodesign.
Autodesign can be run in one step using **Autodesign all**.

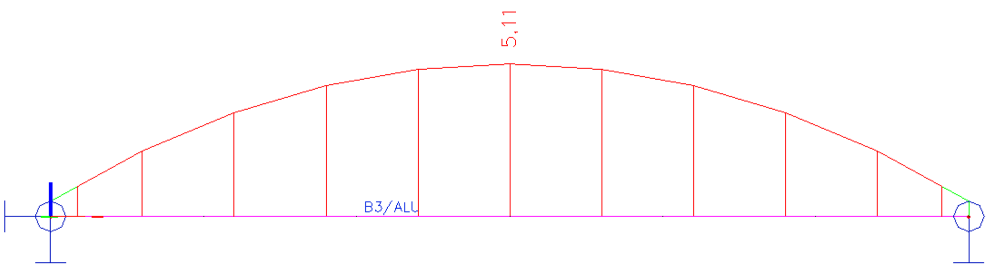


The results are automatically printed in preview.



Cross-section	Parameter	Length [mm]	Minimum [mm]	Maximum [mm]	Step [mm]	Original cross-section	Autodesign of cross-section	Autodesign check [-]
ALU - General cross-section (800)	H	800	1	1000	10	ALU - General cross-section (200)	ALU - General cross-section (800)	1,00

Evaluation of the aluminium unity check along the beam is compared in the following figures. The initial height of the cross-section was 200mm. The optimized value is 800mm. Evaluation of the steel check for the initial cross-section dimensions.

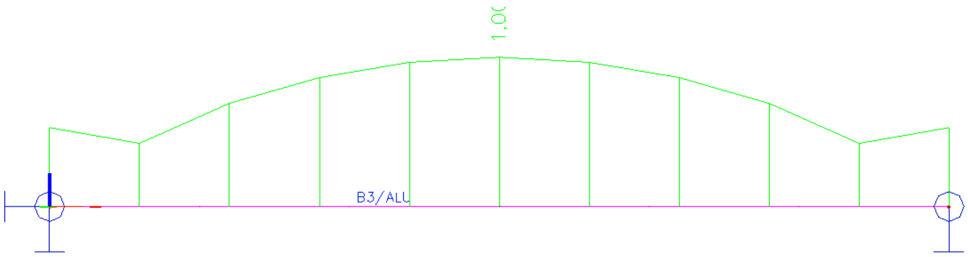


Aluminium check

Linear calculation, Extreme : Global
Selection : All
Combinations : ULS
Cross-section : ALU - General cross-section (200)

Beam	Case	Css	Material	dx [m]	Unity check [-]	Section check [-]	Stability Check [-]
B3	ULS/1	ALU - General cross-section	EN-AW 6005A (EP/O,ER/B) T6 (0-5)	3,000	**5,11**	1,92	5,11

Evaluation of the steel check for the optimized cross-section dimensions.



Aluminium check

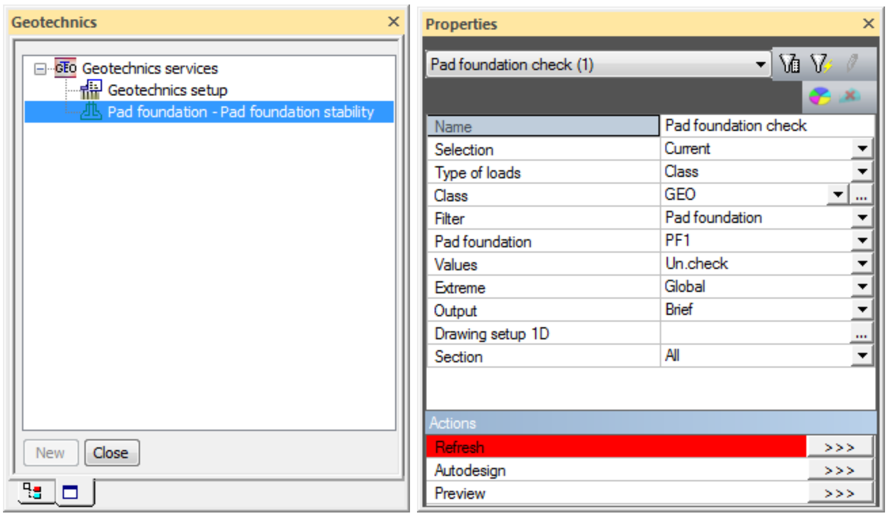
Cross-sections were changed during Autodesign. The structure has to be recalculated !
Linear calculation, Extreme : Global
Selection : All
Combinations : ULS
Cross-section : ALU - General cross-section (800)

Beam	Case	Css	Material	dx [m]	Unity check [-]	Section check [-]	Stability Check [-]
B3	ULS/1	ALU - General cross-section	EN-AW 6005A (EP/O,ER/B) T6 (0-5)	3,000	**1,00**	0,55	1,00

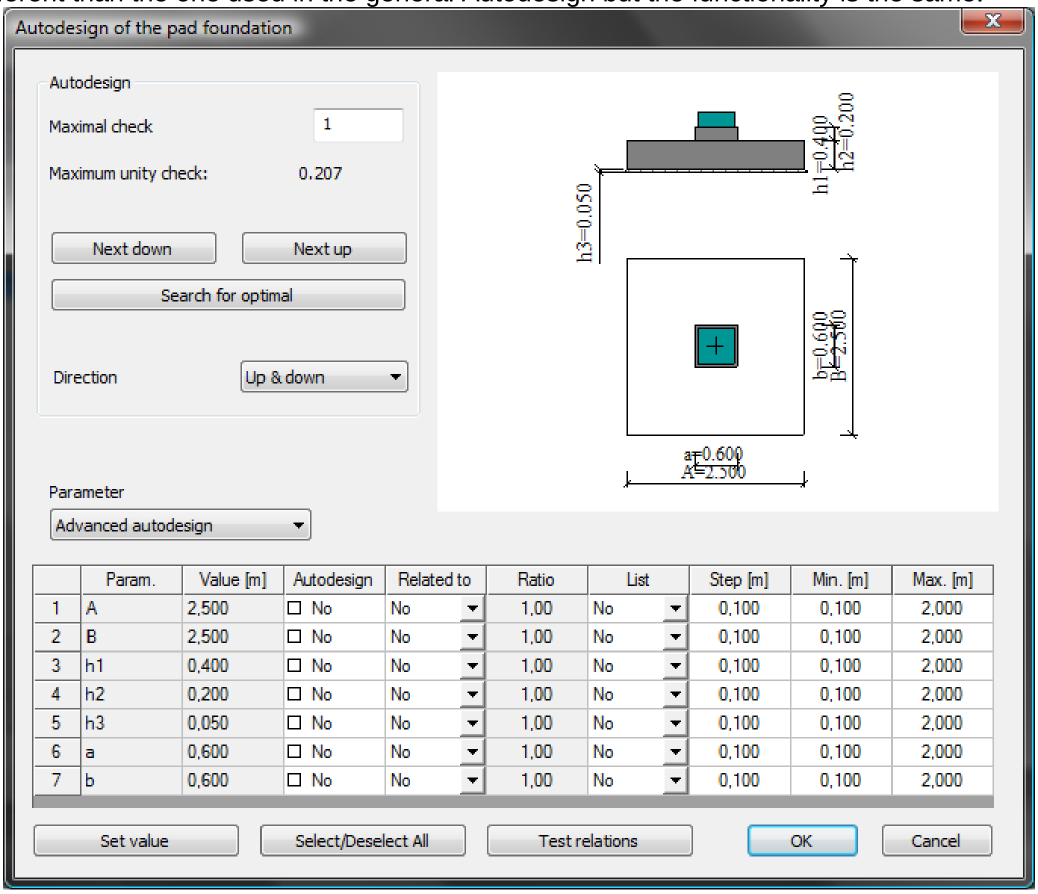
Geotechnics – Pad foundation AutoDesign

Autodesign of a concrete pad foundation is the same part as the Autodesign located in the standard Geotechnics > Geotechnics services > Pad foundation – stability check.

Autodesign in Geotechnics service

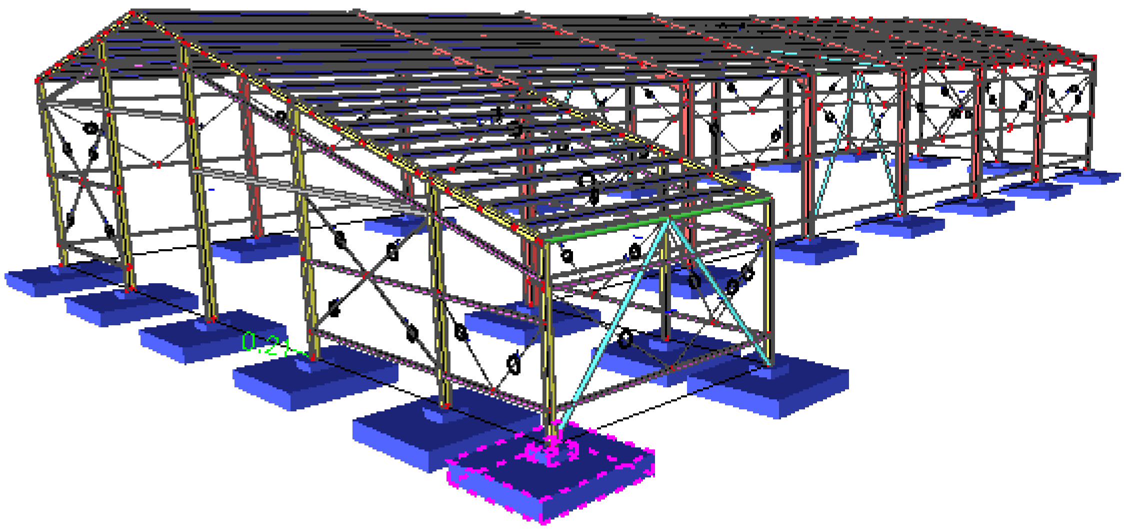


When the user clicks on action button Autodesign then the following dialogue is shown. The dialogue is a bit different than the one used in the general Autodesign but the functionality is the same.

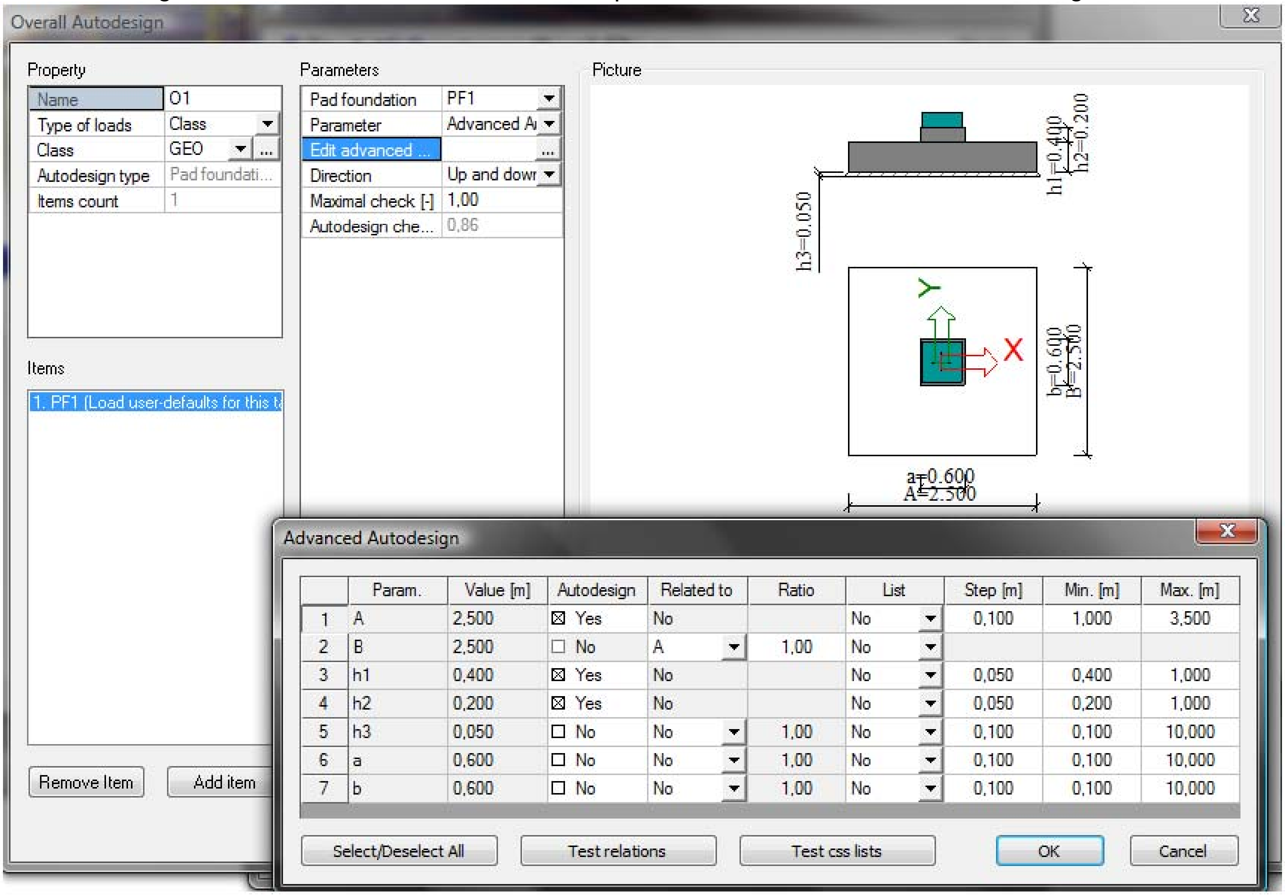


Illustrative example

Let us consider a very simple example of a steel hall laid on concrete pad foundations. The aim of this example is to find the optimal dimensions of one pad foundation. The structure is shown in the following figure.

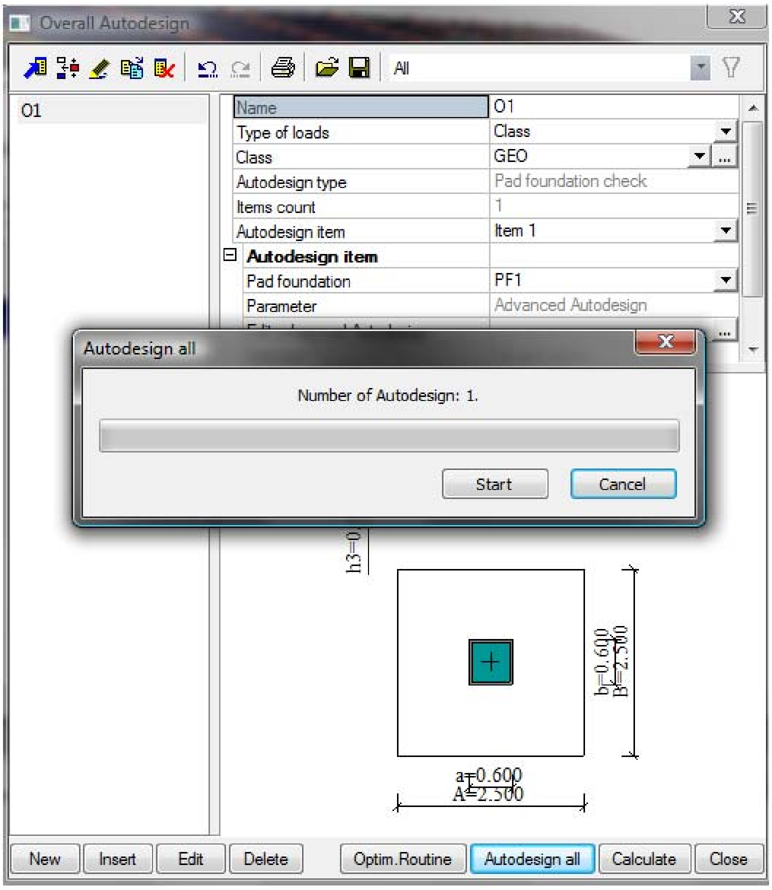


The Autodesign function is defined for one selected pad foundation. You can see the settings.

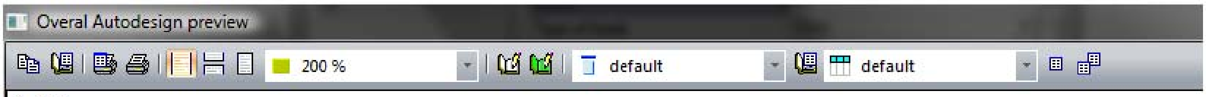


The advanced Autodesign is used. Dimensions A and B are considered to be the same.

Autodesign of both cross-sections can be run in one step using **Autodesign all**..



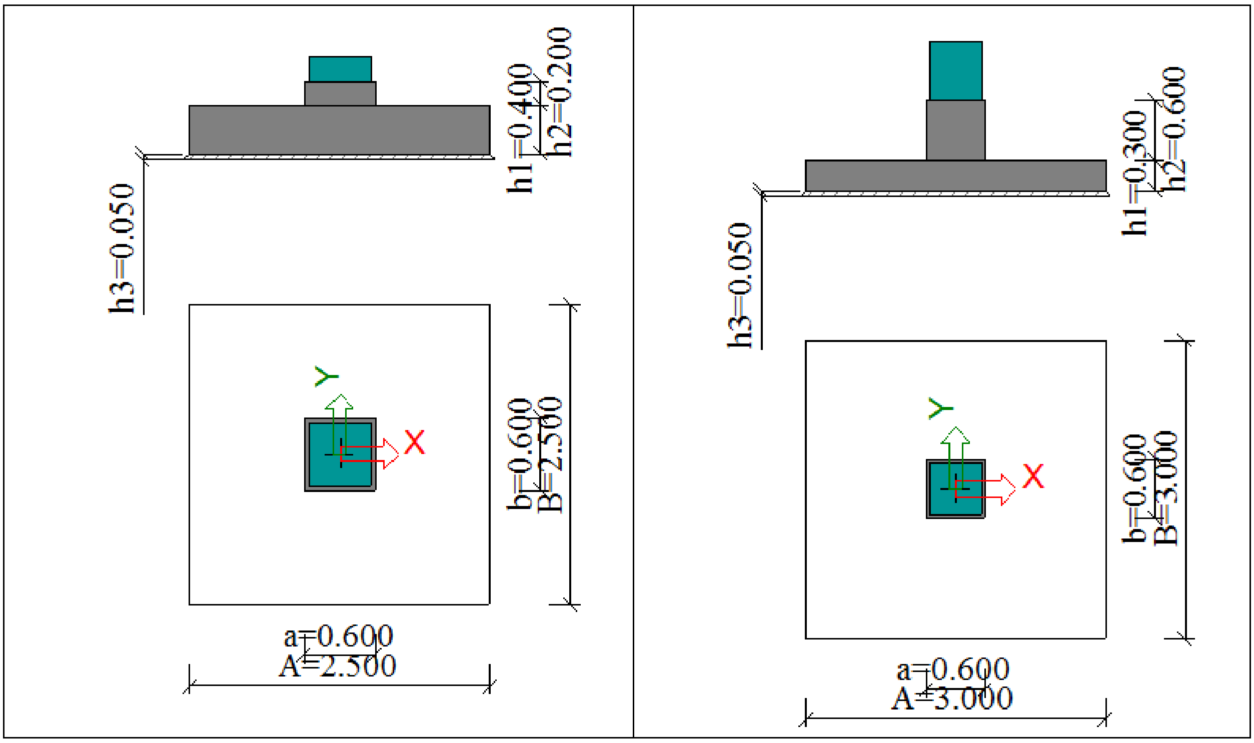
The results are automatically printed in preview.



1. O1

Pad foundation	Parameter	Direction	Maximal check [-]	Autodesign check [-]	Original pad foundation	AutoDesign of pad foundation
PF1	Advanced Autodesign	Up and down	1,00	0,98	PF1 - (2,500; 2,500; 0,400; 0,200; 0,050; 0,600; 0,600)	PF1 - (3,000; 3,000; 0,300; 0,600; 0,050; 0,600; 0,600)

Initial	Optimized

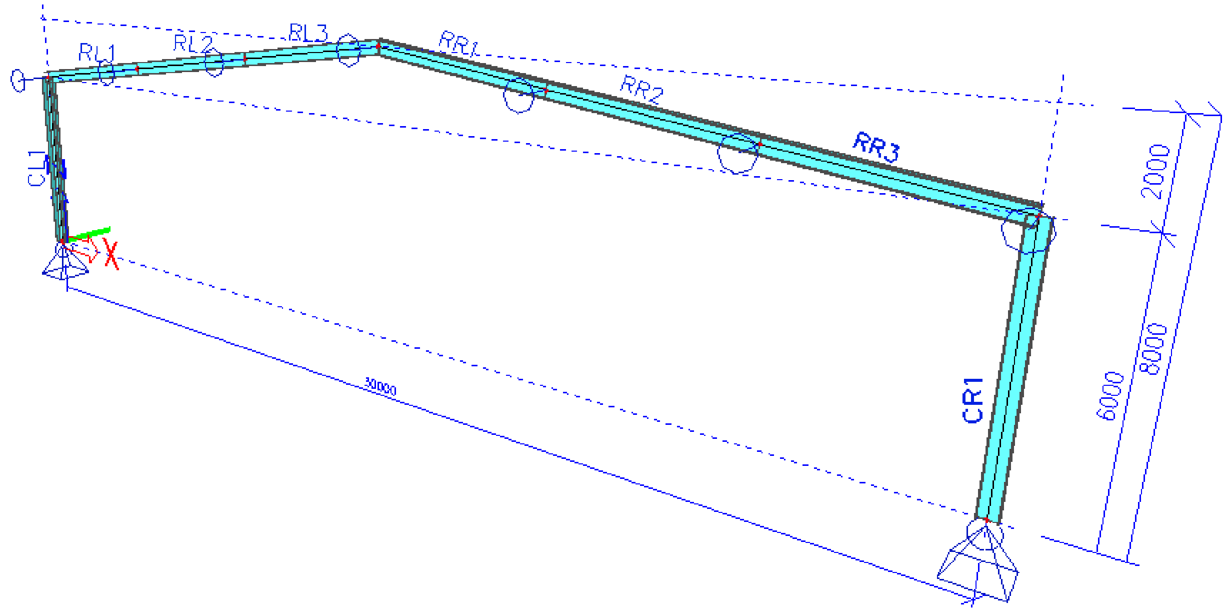

h1=0.400
h2=0.200
h3=0.050
Y
X
b=0.600
B=2.500
a=0.600
A=2.500
h1=0.300
h2=0.600
h3=0.050
Y
X
b=0.600
B=3.000
a=0.600
A=3.000

Steel hall - Frame Autodesign

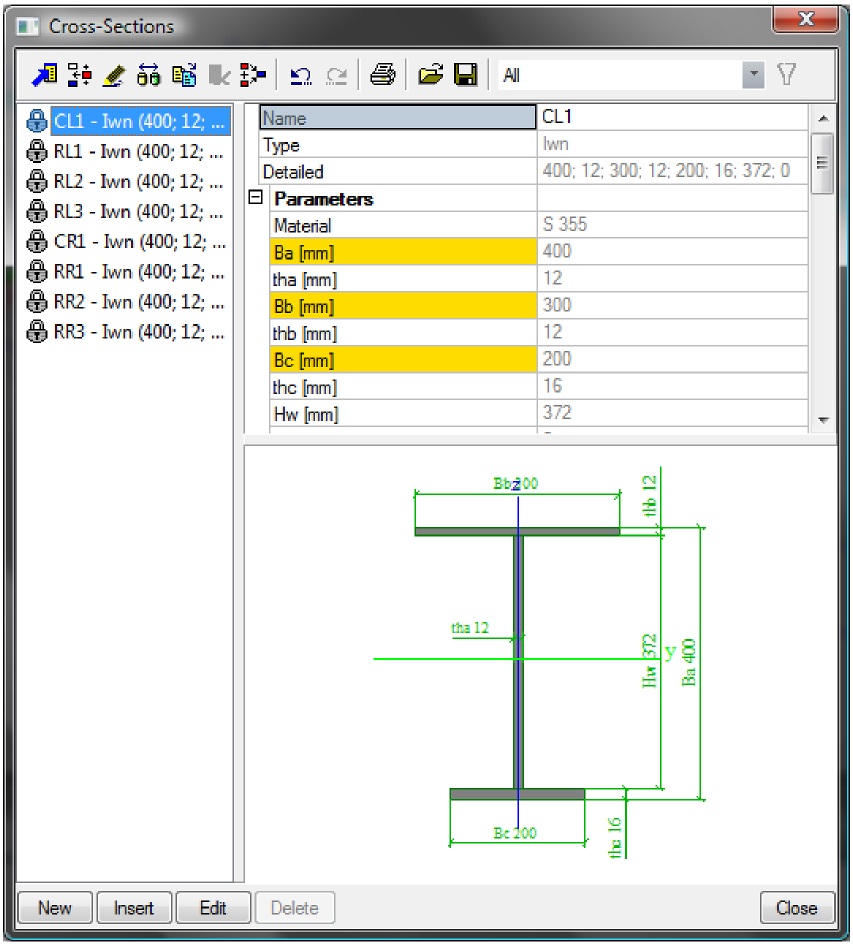
Most of Autodesign items are related to the optimal design of steel frames or halls. The following items are related to the frame design:

- Frame - Autodesign manager
- Frame – CSS height Autodesign
- Frame - deflection Autodesign
- Frame - flange Autodesign
- Frame – web Autodesign
- Frame - flange thickness Autodesign

All items mentioned above are demonstrated on a simple steel frame (S355) made of Iwn cross-sections. The frame is 30m long with 6.0m high columns. The top point is 2.0 above the head of the columns. The structure is subject to self-weight, permanent load (-3kN/m), variable load (-5kN/m) and automatically generated climatic load (wind, snow) according to EN.

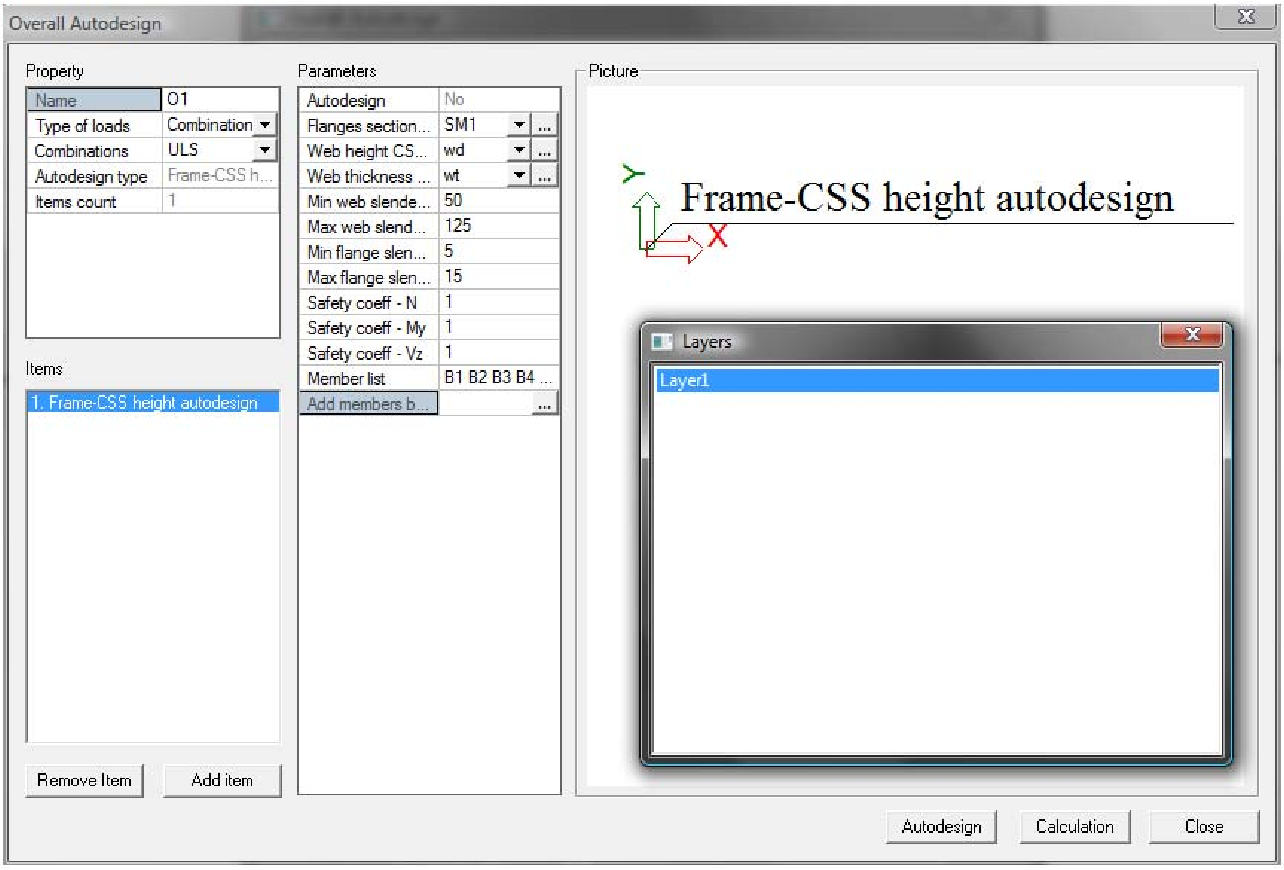


Eight different cross-sections are used (two for columns and six for rafters). All cross-sections are welded.


Cross-Sections
All
CL1 - Iwn (400; 12; ...
RL1 - Iwn (400; 12; ...
RL2 - Iwn (400; 12; ...
RL3 - Iwn (400; 12; ...
CR1 - Iwn (400; 12; ...
RR1 - Iwn (400; 12; ...
RR2 - Iwn (400; 12; ...
RR3 - Iwn (400; 12; ...
Name CL1
Type Iwn
Detailed 400; 12; 300; 12; 200; 16; 372; 0
Parameters
Material S 355
Ba [mm] 400
tha [mm] 12
Bb [mm] 300
thb [mm] 12
Bc [mm] 200
thc [mm] 16
Hw [mm] 372
Bb 300
thb 12
tha 12
Hw 372
y
Ba 400
Bc 200
thc 16
New
Insert
Edit
Delete
Close

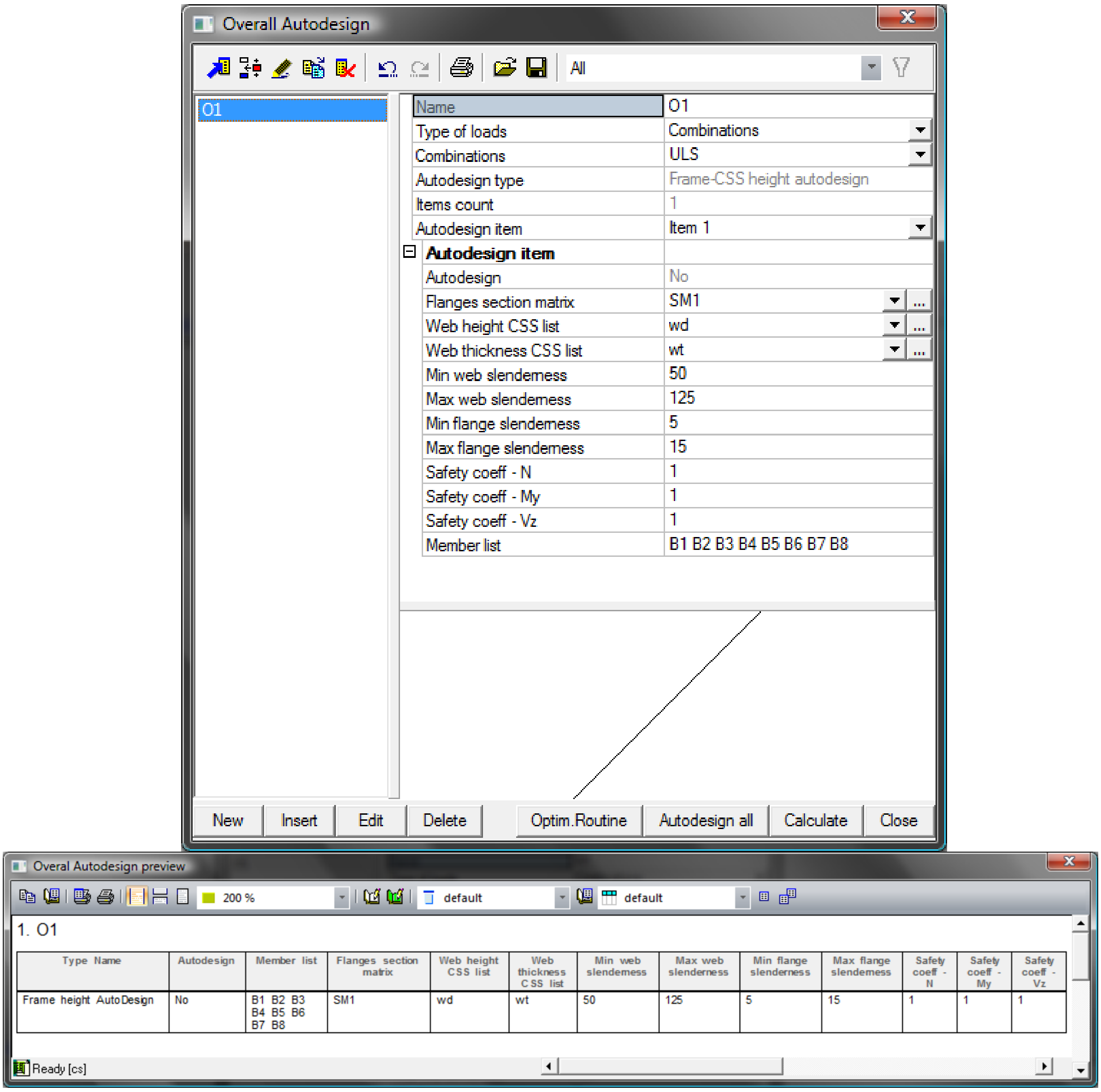
Frame – CSS height Autodesign

CSS height Autodesign is the first of steel frame AutoDesigns. To simplify the design procedure, the height design optimization is based on a symmetrical cross section. The height design is based on the interaction formula for combined bending and compression.



The property of this Autodesign is the following:

Flanges section matrix	link to library of section matrices
Web height CSS	link to library of cross-section lists
Web thickness	link to library of cross-section lists
Min web slenderness	minimal slenderness of the web working as constraint
Max web slenderness	maximal slenderness of the web working as constraint
Min flange web slenderness	minimal slenderness of the flange working as constraint
Max flange web slenderness	maximal slenderness of the flange working as constraint
Safety coeff – N	**XXX**
Safety coeff - My	**XXX**
Safety coeff – Mz	**XXX**
Member list	list of Autodesigned members
Add members by layer	link to layer database for selection of a layer

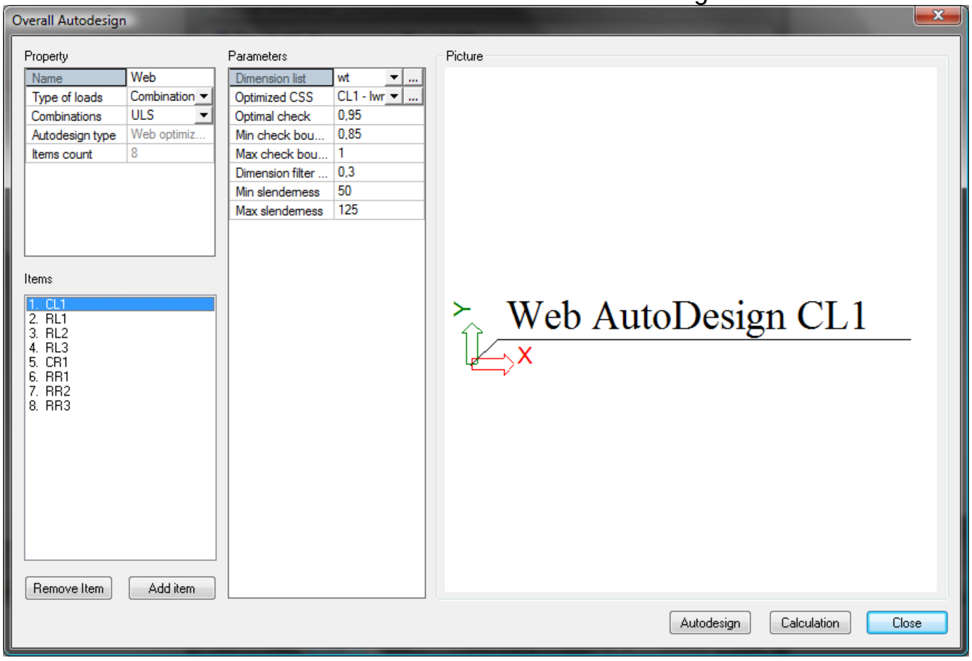


The height of the cross-section is Autodesigned.

Frame – web Autodesign

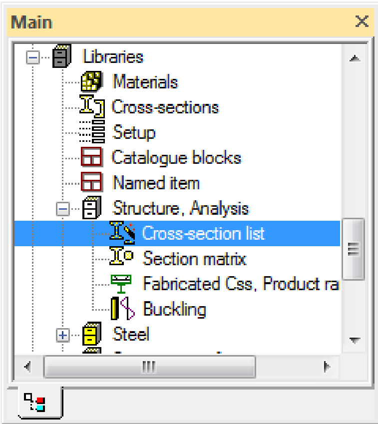
Web optimization is the second step of the steel frame design. The goal of this item is the web thickness. The Autodesign function of the web optimization type is defined for each cross-section. The program is automatically looking for the smallest web thickness from the defined **Thickness list** with satisfying steel check. It works only with the CSS shear check and web thickness. It means that the values of steel shear check are verified in each section (default value is 10 on a member) for the load class/combination which is set by the user. The program checks the web slenderness to make sure that the Autodesign does not set a web thickness which is outside the defined range. The starting web thickness of this Autodesign is the value after the CSS height design. It checks the value of the shear check for this thickness.

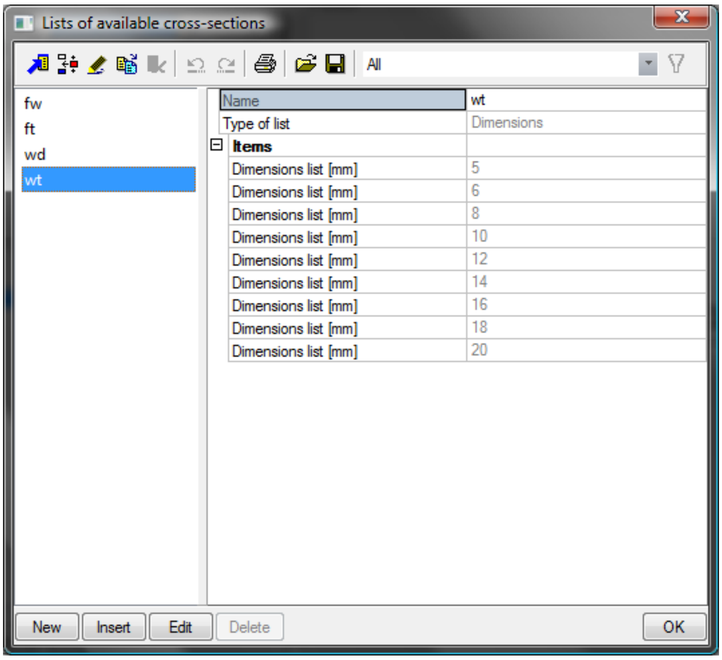
- If the value of the check is bigger than 1 then it finds in the list the first thickness which has the check lower than 1.
- If the value of the check is smaller than 1 then it tries all thicknesses from the list which are smaller than the current one and returns the thickness which gives the check closest to 1.



The optimal (0.95), minimal (0.85) and maximal (1.0) check values are the same as for the flange optimization. Minimal (50) and maximal (125) slenderness of web parts are different. This web optimization has different properties than the flange optimization:

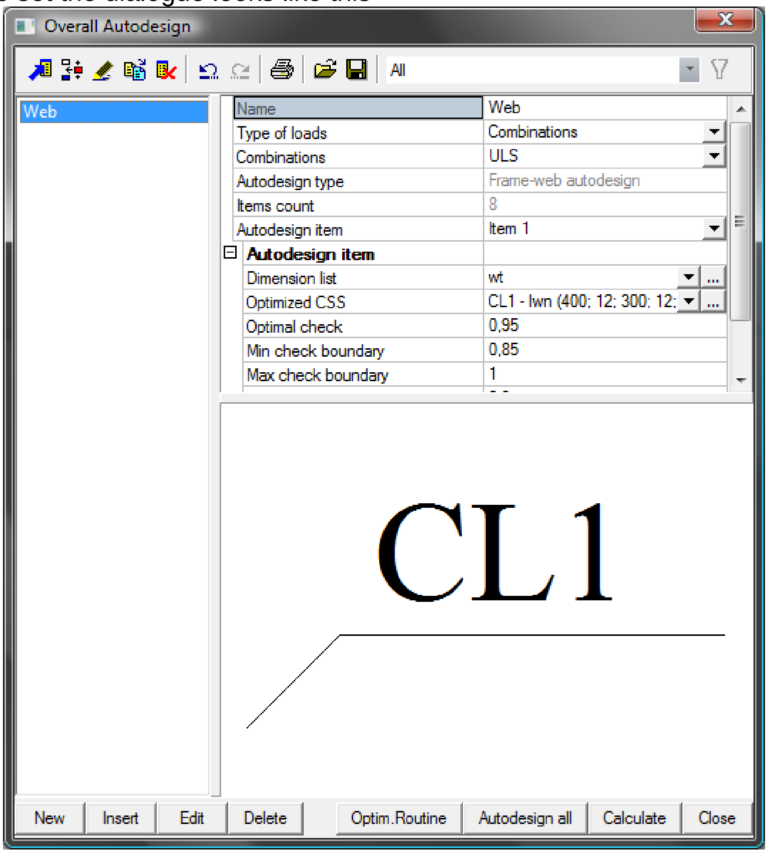
Dimension list	Enables the user to use predefined values of one dimension according to the list defined in the Cross-section list library. This library is stored in **Libraries > Structure, analysis > Cross-section list**.



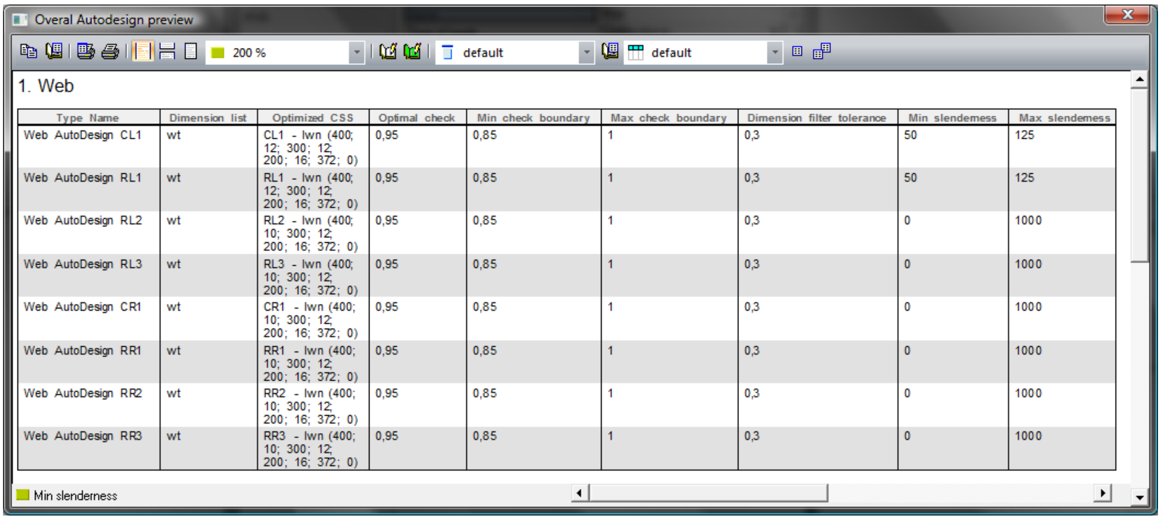


It is possible to define three types of cross-section lists (see the following figure). Cross-section list of type Dimension list can be used for Autodesign only. The dimension list **wt** is used for optimization.

When all values are set the dialogue looks like this



The results preview is printed



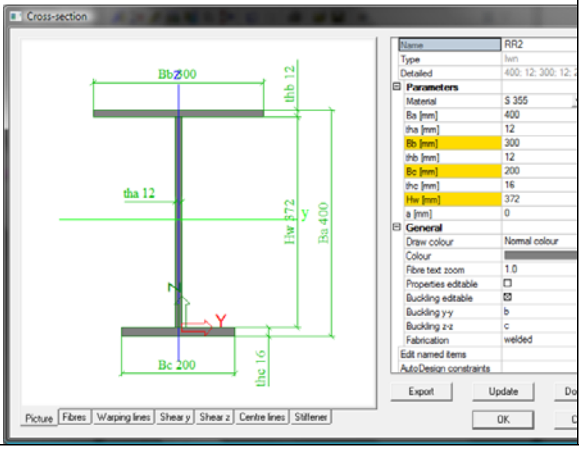
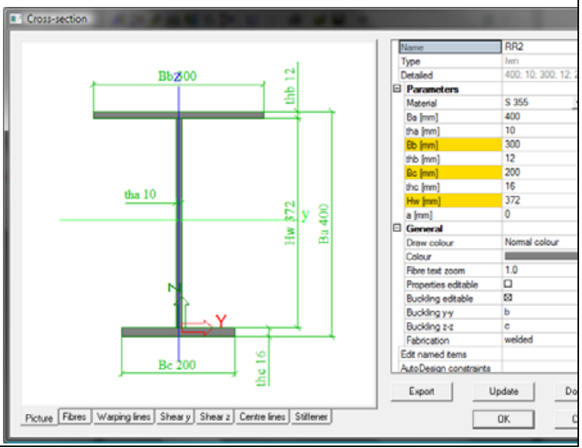
Overal Autodesign preview

1. Web

Type Name	Dimension list	Optimized CSS	Optimal check	Min check boundary	Max check boundary	Dimension filter tolerance	Min slendemess	Max slendemess
Web AutoDesign CL1	wt	CL1 - Iwn (400; 12; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	50	125
Web AutoDesign RL1	wt	RL1 - Iwn (400; 12; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	50	125
Web AutoDesign RL2	wt	RL2 - Iwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000
Web AutoDesign RL3	wt	RL3 - Iwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000
Web AutoDesign CR1	wt	CR1 - Iwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000
Web AutoDesign RR1	wt	RR1 - Iwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000
Web AutoDesign RR2	wt	RR2 - Iwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000
Web AutoDesign RR3	wt	RR3 - Iwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000

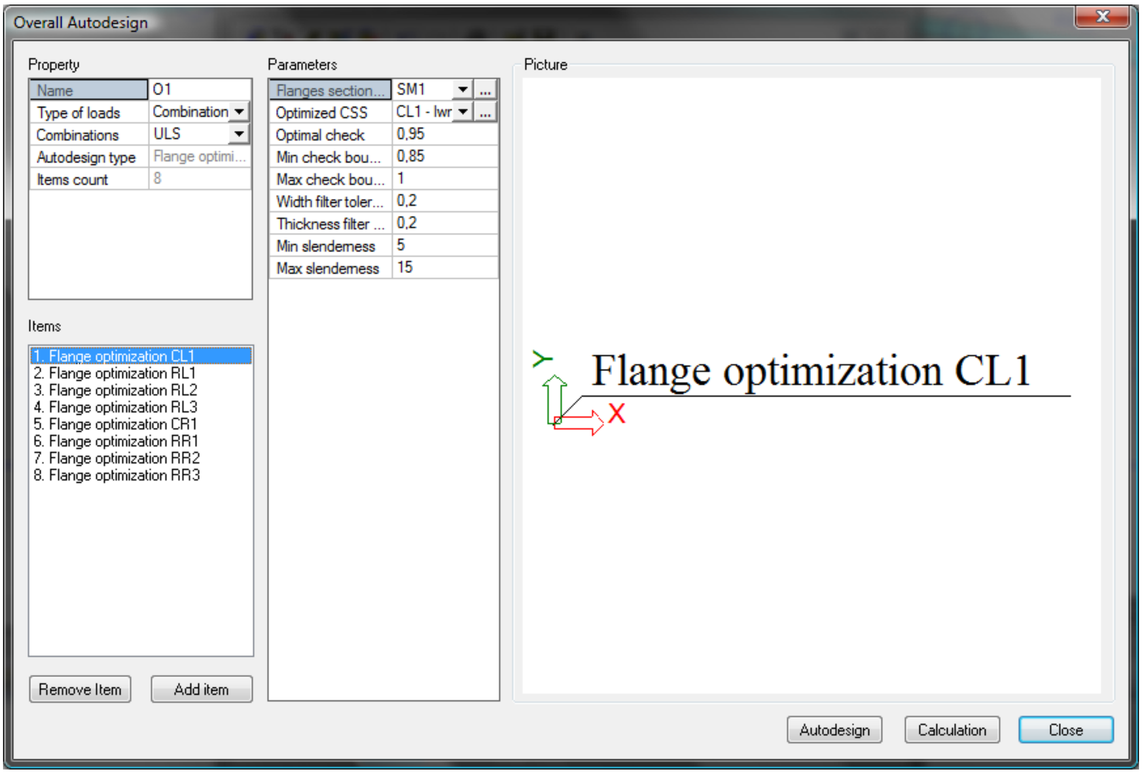
Min slenderness

The comparison of the initial and optimized values of the cross-section is clear from the following table. Web thickness decreased from 12 to 10mm.

Initial	**Optimized**
	

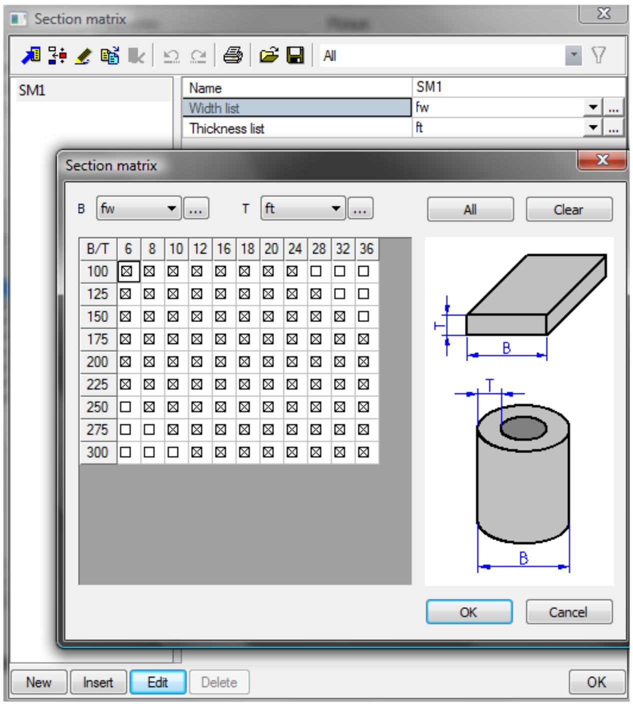
Frame - flange Autodesign

The goal of this item is to design the optimal dimension of flange parts of steel cross-sections. The Autodesign function of the Flange optimization type is defined for each cross-section.
In this step the CSS is designed as symmetrical which implies that the top and bottom flanges have the same geometry. The program is automatically looking for the lightest geometry of the flange from the defined **Flange section matrix**. It takes all defined combinations of flange widths and thicknesses and sorts them by the flange area. Then the program looks for the first item from this list with CSS check smaller than 1.



This Flange optimization has different properties:

Flanges section	here is the link to Section matrix library. Section matrix library is defined in Libraries > Structure, Analysis> Section matrix. Generally, the section matrix is the matrix of the defined sets of flange width and thickness. It can be defined by the user and it can represent the manufacturing possibilities of the steel provider. The section matrix used for this example is displayed in the following figure.



Optimized CSS Link to the cross-section which should be optimized from library. For each optimized cross-section a different Autodesign item is created. (8 items of flange optimization type).

The following items work as constraints.

Optimal check check values which should be achieved for the structure with optimal dimensions

Min. boundary check minimal check value which is accepted for the optimal configuration of the structure

Max. boundary check maximal check value which is accepted for the optimal configuration of the structure

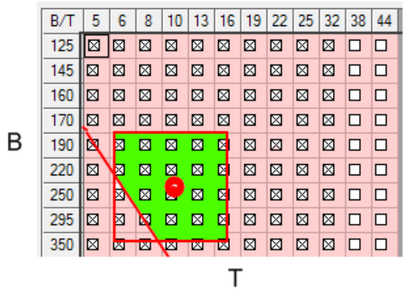
Width filter tolerance Used tolerance for width parameters

Thickness filter tolerance Used tolerance for thickness parameter

Min slenderness minimal slenderness of the flange of the cross-section

Max slenderness maximal slenderness of the flange of the cross-section

The tolerance is defined relatively, from the actual definition only those inside the range are checked. Graphically it can be interpreted as shown in the following picture.



- The red dot in the picture shows the flange geometry as a result of the height design. The flange geometry of the matrix which most closely matches this result is used. Using the tolerance parameters from the design setup, a range of widths and thicknesses is defined as illustrated with the red rectangle.

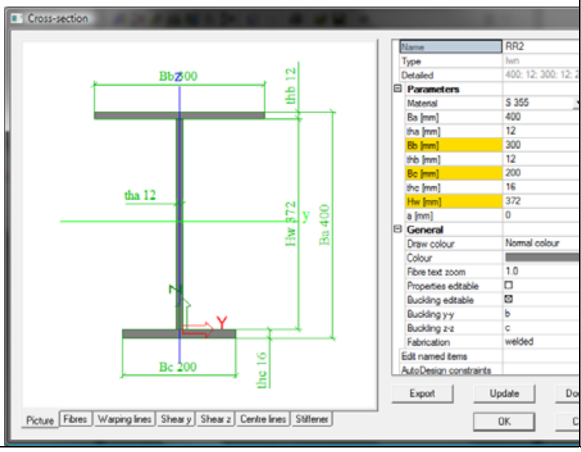
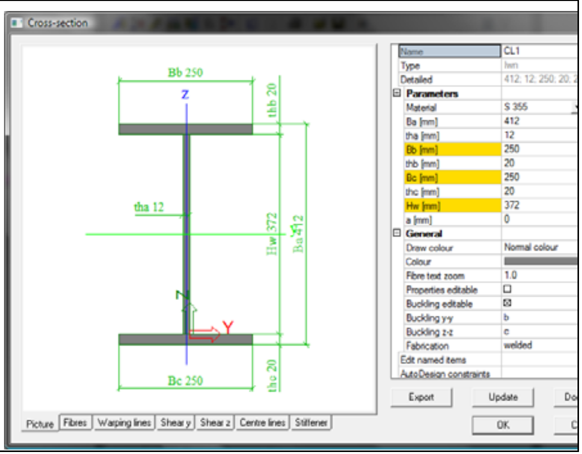
- In addition to the previous tolerance, the flange slenderness limit set in the relative limitations is accounted for. This is illustrated in the picture by the inclined line.

- The final set of flange geometries taking into account both the tolerance and the slenderness limit is shown in the picture in green.

When all values are set for each optimized cross-section then the overall Autodesign can run.

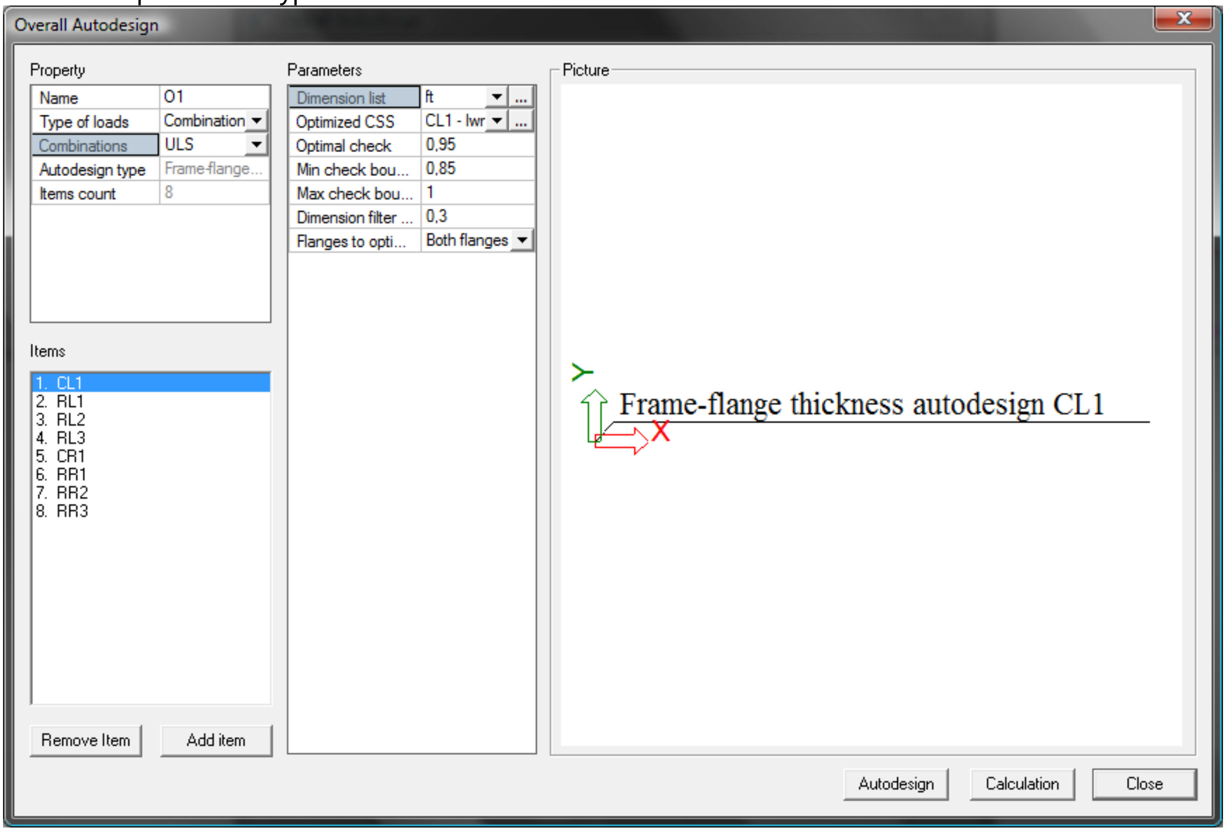
It is not recommended to use the flange optimization only. In that case the I cross-section is transformed to flange cross-section which is a non-sense.

The comparison of the initial and optimized values of the cross-section is clear from the following table. The initial flange dimensions for upper (12x300mm) and for lower (16x200mm) flange changed to 20x250mm for upper and lower respectively.

Initial	Optimized
	

Frame - flange thickness Autodesign

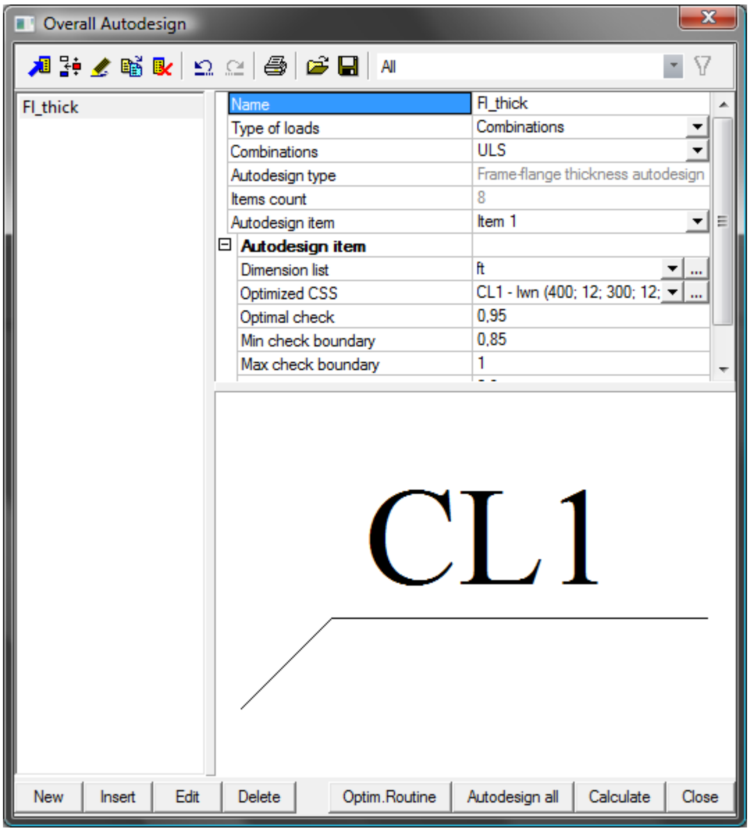
Flange thickness optimization is the next step in the Autodesign of steel frame cross-sections. The goal of this item is to design the optimal dimension of the flange. The Autodesign function of the Flange thickness optimization type is defined for each cross-section.



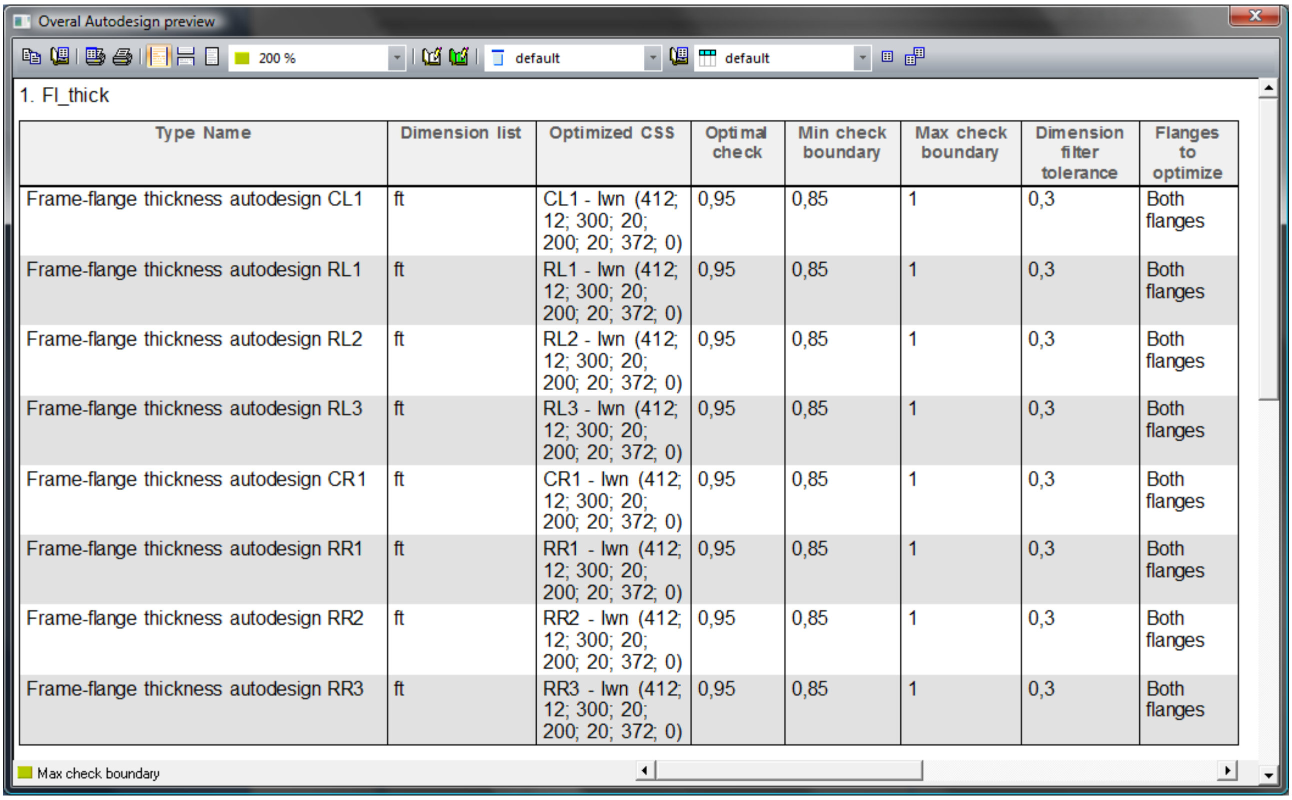
The optimal (0.95), minimal (0.85) and maximal (1.0) check values are the same as for the flange optimization. The dimension filter tolerance is set to 0.3. There is only one property different for the web and flange Autodesign:

Flange to optimize Selection of Inner / Outer / Both flanges.

When all values are set the dialogue looks like this



It is not recommended to use the flange optimization only. In that case the I cross-section is transformed to flange cross-section which is a non sense.



Overal Autodesign preview

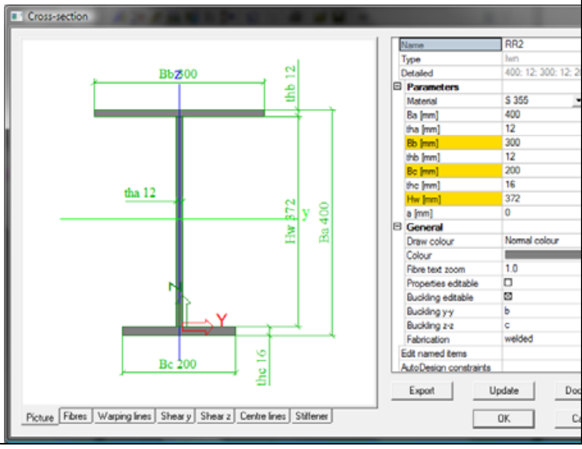
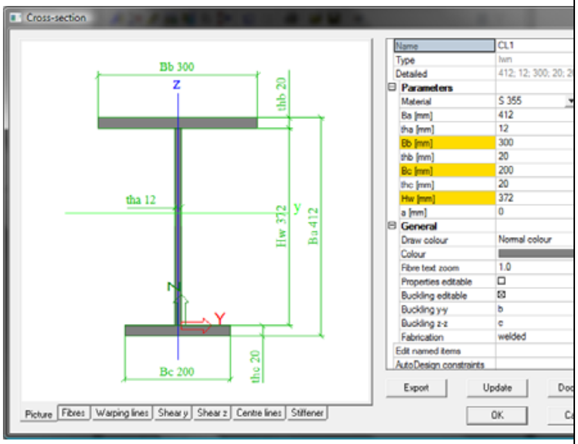
1. Fl_thick

Type Name	Dimension list	Optimized CSS	Optimal check	Min check boundary	Max check boundary	Dimension filter tolerance	Flanges to optimize
Frame-flange thickness autodesign CL1	ft	CL1 - Iwn (412; 12; 300; 20; 200; 20; 372; 0)	0,95	0,85	1	0,3	Both flanges
Frame-flange thickness autodesign RL1	ft	RL1 - Iwn (412; 12; 300; 20; 200; 20; 372; 0)	0,95	0,85	1	0,3	Both flanges
Frame-flange thickness autodesign RL2	ft	RL2 - Iwn (412; 12; 300; 20; 200; 20; 372; 0)	0,95	0,85	1	0,3	Both flanges
Frame-flange thickness autodesign RL3	ft	RL3 - Iwn (412; 12; 300; 20; 200; 20; 372; 0)	0,95	0,85	1	0,3	Both flanges
Frame-flange thickness autodesign CR1	ft	CR1 - Iwn (412; 12; 300; 20; 200; 20; 372; 0)	0,95	0,85	1	0,3	Both flanges
Frame-flange thickness autodesign RR1	ft	RR1 - Iwn (412; 12; 300; 20; 200; 20; 372; 0)	0,95	0,85	1	0,3	Both flanges
Frame-flange thickness autodesign RR2	ft	RR2 - Iwn (412; 12; 300; 20; 200; 20; 372; 0)	0,95	0,85	1	0,3	Both flanges
Frame-flange thickness autodesign RR3	ft	RR3 - Iwn (412; 12; 300; 20; 200; 20; 372; 0)	0,95	0,85	1	0,3	Both flanges

Max check boundary

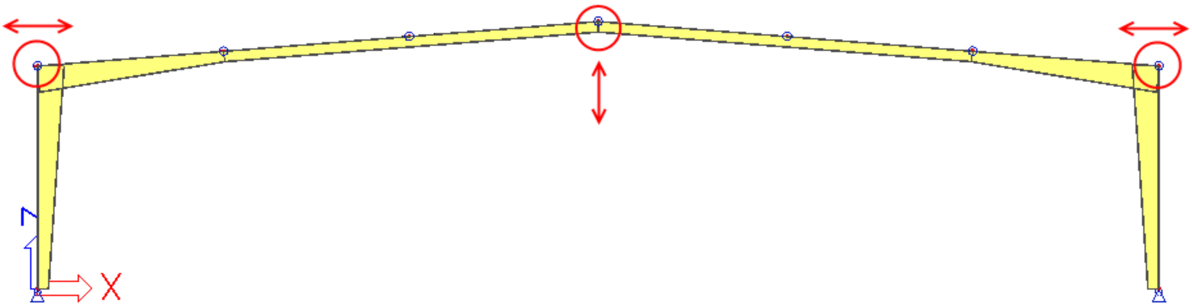
The comparison of the initial and optimized values of the cross-section is clear from the following table. The initial flange dimensions for upper (12x300mm) and lower (16x200mm) flange changed to 20x300mm and 20x200mm for upper and lower respectively.

Initial	**Optimized**

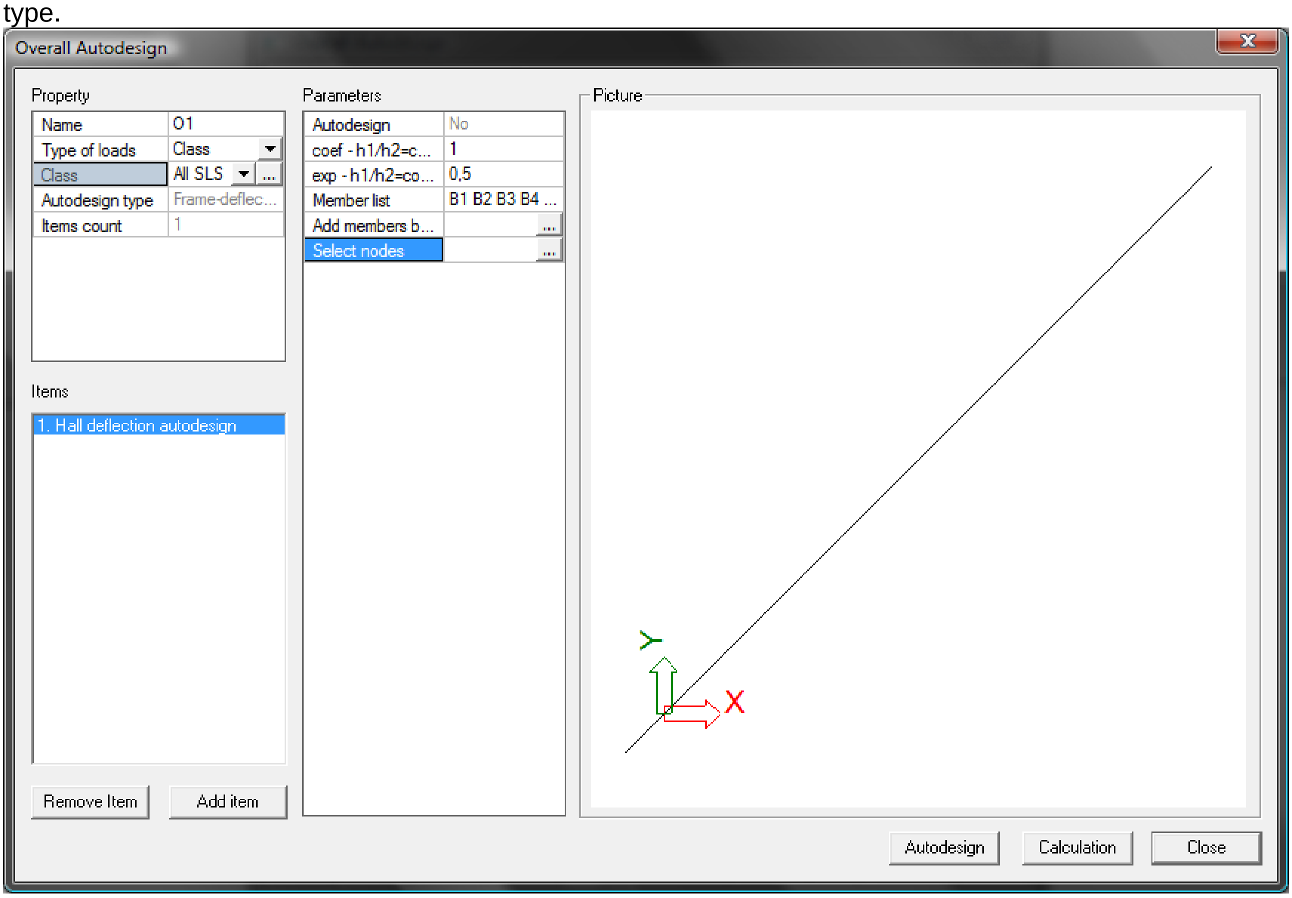

Cross-section
Bb 300
Z
thb 12
tha 12
Hw 372
y
Ba 400
Y
Bc 200
thc 16
Name
RR2
Type
Detailed
Parameters
Material
S 355
Ba [mm]
400
tha [mm]
12
Bb [mm]
300
thb [mm]
12
Bc [mm]
200
thc [mm]
16
Hw [mm]
372
a [mm]
0
General
Draw colour
Normal colour
Colour
Fibre text zoom
1.0
Properties editable
Buckling editable
Buckling y-y
b
Buckling z-z
c
Fabrication
welded
Edit named items
AutoDesign constraints
Export
Update
OK
Picture
Fibres
Warping lines
Shear y
Shear z
Centre lines
Stiffener

Cross-section
Bb 300
Z
thb 20
tha 12
Hw 372
y
Ba 412
Y
Bc 200
thc 20
Name
CL1
Type
Detailed
Parameters
Material
S 355
Ba [mm]
412
tha [mm]
12
Bb [mm]
300
thb [mm]
20
Bc [mm]
200
thc [mm]
20
Hw [mm]
372
a [mm]
0
General
Draw colour
Normal colour
Colour
Fibre text zoom
1.0
Properties editable
Buckling editable
Buckling y-y
b
Buckling z-z
c
Fabrication
welded
Edit named items
AutoDesign constraints
Export
Update
OK
Picture
Fibres
Warping lines
Shear y
Shear z
Centre lines
Stiffener

Frame - deflection Autodesign

First, the program calculates the values of the deflections in all defined nodes. Then it compares these values with the limits of deflections. If the calculated values of deflections are smaller than the limits of deflections then the design of frames is OK and the SLS design stops. Otherwise the program starts a new Autodesign loops. The program checks both horizontal and vertical deflections in all nodes. The following picture shows an example of typical critical nodes of a simple frame.



As specified the program checks the deflections at all nodes since the critical nodes differ per frame type.



There are different properties for this kind of Autodesign:

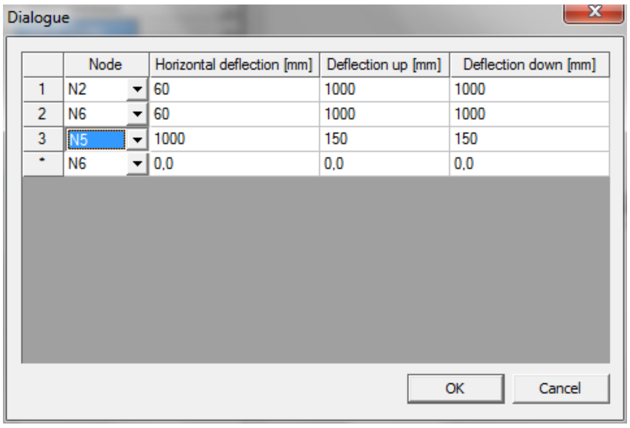
coef – h1/h2=**coef***(check^exp-1)+1	the value used for the optimal design of CS based on the limit deflection (see formula)
exp – h1/h2=coef*(check^**exp**-1)+1	the value used for the optimal design of CS based on the limit deflection (see formula)

It is necessary to use a class as a type of load, otherwise the frame-deflection Autodesign will not work correctly.

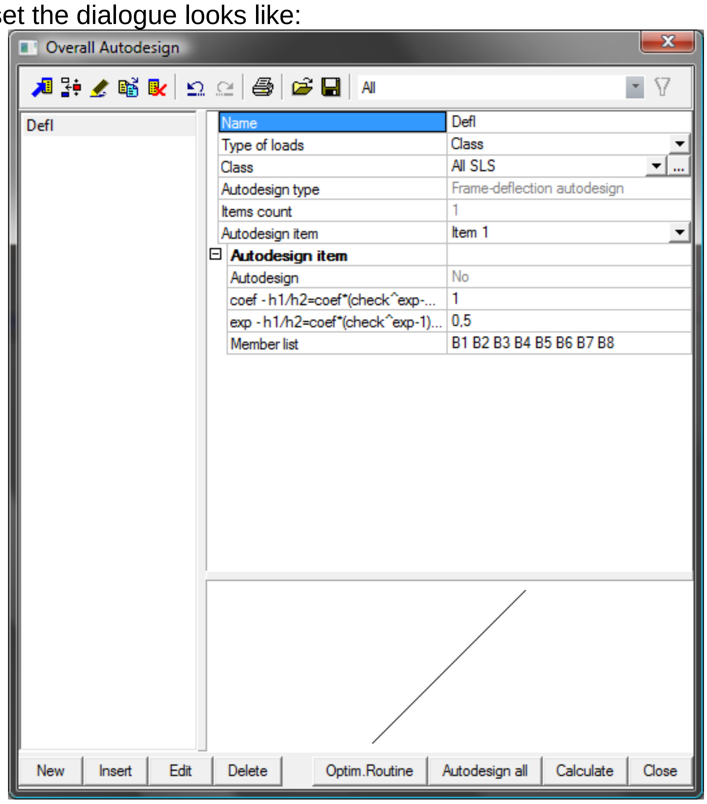
1. Select node **N2** (left eave node) from the first list and set values
   Horizontal deflection = 60mm
   Deflection up = 1000mm (criterion will not be used)
   Deflection down = 1000mm (criterion will not be used)

2. Select node **N6** (right eave node) from the last list and set values
Horizontal deflection = 60mm
Deflection up = 1000mm (criterion will not be used)
Deflection down = 1000mm (criterion will not be used)

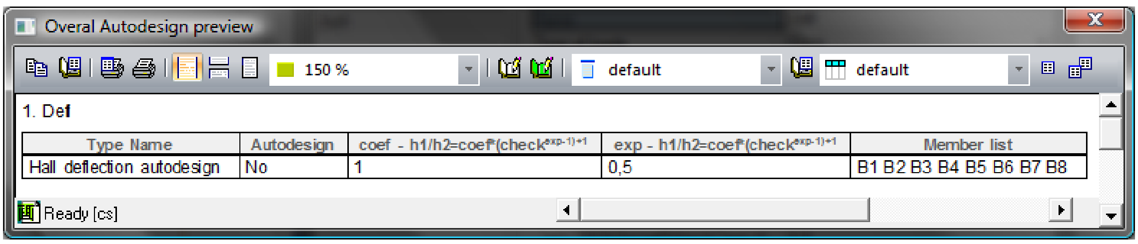
3. Select node **N5** (top node) from the last list and set values
Horizontal deflection = 1000mm (criterion will not be used)
Deflection up = 150mm
Deflection down = 150mm



When all values are set the dialogue looks like:

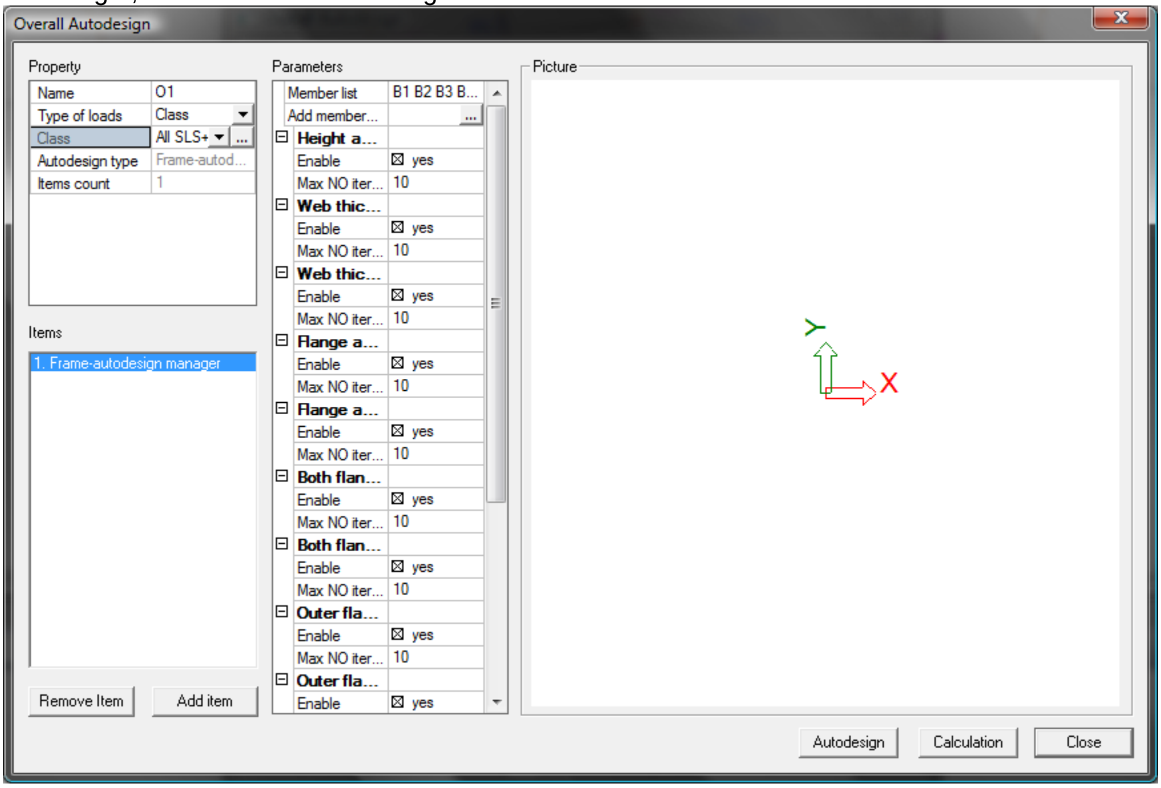


The results preview is printed.



Frame – Autodesign manager

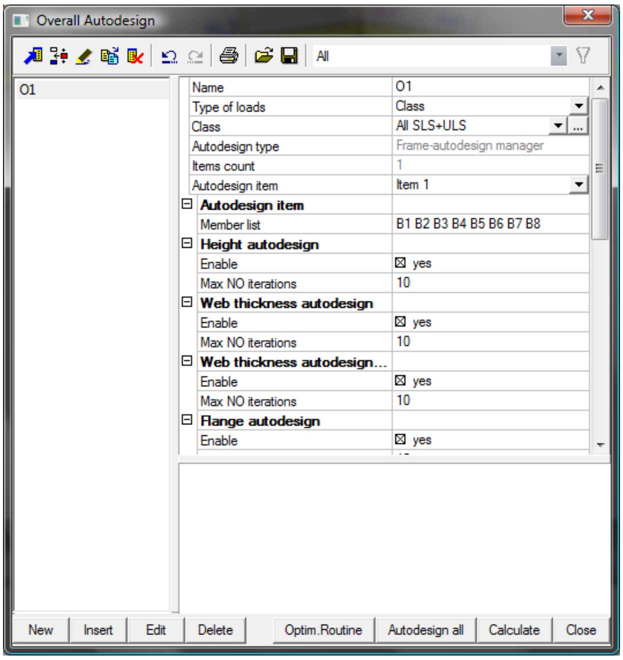
All above-mentioned Autodesign items are used for the optimal design (using special type of Autodesign function (Frame - Autodesign manager). This type includes flange, web, flange thickness, CSS height, and deflection Autodesign.



The property of this Autodesign is the same for particular checks.

Member list	selected members (read only)
Name of the check	name of the used check for Autodesign (height, web thickness, web thickness in deflection, flange, flange in deflection, bottom flange, and bottom flange in deflection, outer flange, outer flange in deflection, inner flange, and inner flange in deflection, internal column, and deflection design)
Enable	option, if this check should be considered on Autodesign or not
Max. NO iteration	maximal number of iterations used for Autodesign

When all values are set the dialogue looks like



The results preview is printed