NEMETSCHEK Scia



Autodesign

Global optimization

Scia Engineer

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Table of contents

Introduction	5
Principles of Autodesign	6
Autodesign types	7
Autodesign manager	9
Defining a new optimisation	12
Autodesign parameters and criteria	14
Property Parameters	. 14 . 15
Edit Advanced Autodesign Picture	. 17
Concrete – Automatic member reinforcement design (AMRD)	. 18 19
Autodesign in Concrete service Theoretical background of AMRD	. 19 . 19 . 22
Steel – Cross-section AutoDesign	. 23 26
Autodesign in Steel service Illustrative example Steel - Fire resistance AutoDesign	. 26 . 27 . 30
Autodesign in Steel service	.30
Illustrative example	.30 34
Autodesign in SIN beam check service Illustrative example Steel - Lapped purlin/girt AutoDesign (only IBC code)	. 34 . 35 39
Autodesign in Check LRFD service Illustrative example Steel connection - Bolted diagonal AutoDesign	. 39 . 39 44
Autodesign in Bolted diagonal service Illustrative example Timber – Cross-section AutoDesign	. 44 . 45 48
Autodesign in Timber service Illustrative example Aluminium – Cross-section AutoDesign	. 48 . 49 52
Autodesign in Aluminium service Illustrative example Geotechnics – Pad foundation AutoDesign	. 52 . 53 . 56
Autodesign in Geotechnics service	. 56 . 56
Steel hall - Frame Autodesign Frame – CSS height Autodesign	60 . 62
Frame – web Autodesign Frame - flange Autodesign Frame - flange thickness Autodesign	64 67 70
Frame - deflection Autodesign	. 73 . 75

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.

Add item		x
Concrete Automatic Reinforcement Member Des Steel Cross-section AutoDesign Corrugated Web AutoDesign Steel Connections Bolted Diagonal AutoDesign Timber Cross-section AutoDesign Aluminium Cross-section AutoDesign Geotechnics Pad Foundation AutoDesign Steel Hall Frame Height Optimization Hall Deflection Optimization Hall Deflection Optimization Hall Deflection Optimization Flange Thickness Optimization Frame Optimization Frame Optimization Frame Optimization	isign (AMRD)	
	OK Cancel	

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).

Over	all Autode	esign						×
1	26	k Ω	_ @	6	AI			• 7
New	Insert	Edit	Delete		Optim.Routine	Autodesign all	Calculate	Close

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

Overall Autodesign		
🏓 🤮 🗶 😫 🔛	2. 🖂 🚑 🖨 🔚 Al	• 7
01	Name	01
	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	🔻
	ta	B
New Insert Edit	Delete Optim.Routine	Autodesign all Calculate Close

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.

<u> </u>		
Automatic Autodesign routine		×
Set number of Autodesign iterations		
O Determine automatically		
 Limit number of iterations 		
3		
	Start	Cancel
	Start	Cancer

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



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.
 - Overall Autodesign

o terain natione sign		
Property	Parameters	Picture
Items		×
Remove Item Add item		Autodesign Calculation Close

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

Contrain Autobesign	And a second	
Property Items	Parameters Picture Add item Image: Cost of the cost of	
Remove Item Add item	Autodesign Calculation Close	

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.

Make selection	
Available	Selected
CS2	>><<<<
ОК	Cancel

5. Define the Autodesign property, parameters and criteria.

Overall Autodesign		
Property	Parameters	Picture
Name 01	Cross-section CS3 - I gh (3	-
Selector switch	Parameter H	-
Type of loads Combination -	Use cross-secti	
Combinations ULS -	Length [mm] 300	
Autodesign type Cross-sectio	Minimum [mm] 1	
Items count 1	Maximum [mm] 1000	
	Step [mm] 10	
	Search pattern Find first ok	
	Direction Up and dowr	
	Maximal check [-] 1,00	
llene	Autodesign che 0,00	
1. CS3 (H = 300)		E B
Remove Item Add item		
		Autodesign Calculation Close

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,

Autodesign parameters and criteria

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

Overall Autodesign			~
Property	Parameters	Picture	
Property Name 01 Selector switch □ Type of loads Combination ▼ Combinations ULS ▼ Autodesign type Cross-sectio Items 1	Parameters Cross-section CS3 - I gh (3 ▼ Parameter H ▼ Use cross-secti □ Length [mm] 300 Minimum [mm] 1 Maximum [mm] 1000 Step [mm] 10 Search pattern Find first ok ▼ Direction Up and dowr ▼ Maximal check [-] 1.00 Autodesign che 0.00	Picture	
Remove Item Add item		Autodesign Calculation Close	

Property

Overall Autodesign		
Property	Parameters	Picture
Name 01	Cross-section CS3 - I gh (3 -	
Selector switch	Parameter H 💌	
Type of loads Combination -	Use cross-secti	
Combinations ULS -	Length [mm] 300	
Autodesign type Cross-sectio	Minimum [mm] 1	
Items count 1	Maximum [mm] 1000	
	Step [mm] 10	
	Search pattern Find first ok 💌	
	Direction Up and dowr	
	Maximal check [-] 1,00	s
Items	Autodesign che 0,00	× × ×
1. CS3 (H = 300) Remove Item Add item		E B
		Autodesign Calculation Close

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 Check parameter	process of Autodesign by means of a set of parameters.
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 Aut	todesign
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 ly	(moment of inertia) The sequence of cross-sections is based on the moment of inertia.
Buttons for manual Autod	esign
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).

Parameter

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.

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.

	Lists of available cross-sections				
	🔊 💱 🏒 📸 🗽 🗠 🖉 🎒 🈂 🖬 🛛 Al				
	LIST1	Name	LIST1		
		Type of list	Dimensions		
		🗆 Items			
		Dimensions list [mm]	300		
Type of cross-section list		Dimensions list [mm]	350		
		Dimensions list [mm]	400		
		Dimensions list [mm]	450		
Oimension list		Dimensions list [mm]	500		
Rolled cross-sections one type		Dimensions list [mm]	550		
Rolled cross-sections multiple types					
OK Cancel	New Insert Edit	Delete	Close		

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.

Ad	vance	ed Autodesig	gn									X
[Param.	Value	Autodesign	Related t	0	Ratio	List		Step	Min.	Max.
	1	Н	350	⊠ Yes	No			LIST1	-			
	2	В	175	🗆 No	Н	•	0,50	No	-			
	3	ta	25	□ No	No	•	1,00	No	•	0	25	25
	4	s	20	⊠ Yes	No			No	-	2	10	30
	5	ts	12	□ No	No	Ŧ	1,00	No	-	0	12	12
	6	th	12	□ No	No	•	1,00	No	-	0	12	12
	Select/Deselect All Test relations Test css lists OK Cancel											

All items are described in the following table.

ltem	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).

Overall Autodesign		
Overall Autodesign Property Name 01 Selector switch □ Type of loads Combination ▼ Combinations ULS ▼ Autodesign type Cross-sectio Items 1	Parameters Cross-section CS3 - I gh (3) ▼ Parameter H ▼ Use cross-secti □ Length [mm] 300 Minimum [mm] 1 Maximum [mm] 1000 Step [mm] 10 Search pattern Find first ok ▼ Direction Up and dowr ▼ Maximal check [-] 1.00 Autodesign che 0.00	Picture
1. CS3 (H = 300) Remove Item		
		Autoussign Calculation Close

Control buttons

Overall Autodesign		
Property	Parameters	Picture
Name 01 Selector switch □ Type of loads Combination ▼ Autodesign type Cross-sectio Items 1 Items 1 Remove Item Add item	Cross-section CS3 - I gh (3) ▼ Parameter H ▼ Use cross-secti □ Length [mm] 300 Minimum [mm] 1 Maximum [mm] 1000 Step [mm] 10 Search pattern Find first ok ▼ Direction Up and dowr ▼ Maximal check [-] 1.00 Autodesign che 0.00	
		Autodesign Calculation Close

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

Concrete ×	Properties	×
Design defaults	Automatic member reinforcement d	esign EN 1992 👻 🏹 🏹 🧷
Member buckling data Member data Member data Concrete slenderness Redes (without As) Member data Key Structure Key Str	Name Selection Type of loads Combinations Filter Print explanation of errors and w Values Extreme	Automatic member reinforcem Current ▼ Combinations ▼ CO1 ▼ No ▼ ⊠ Check value ▼ Member ▼
Automatic member reinforcement desig Member data Reinforcement design Cross-section characteristics	Section	All 💽
Member design - Design	Actions Refresh Calculation info	>>>
	Concrete setup Preview	>>>

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 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

- Setup dialogue of service Concrete affecting and controlling the procedure for the automatic design,
- 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.

Longitudinal reinforcement			the second second	
	3	1		Filter All L1-S1E4 L2-S1E2 Delete Delete all Automatic design Min. number of b 2
	N 17		T (1	Analysis model Automatic design
	New reinforcement parameters		type or beam	Selected layers 402 mm^2
INEW layer	Number of bars 2		beams and ribs 🔹	All Jauers 804 mm^2
Add bars to corners	Fronie (MM) 8,0	-	Stirrups	Picture properties
	Stirrup name S1	_	Edit stimups	Draw dimensions
Bars positions	Edge index 2	_	Editorinapo	Texts scale 0.5 🚔
Collision of bars				Redraw
Collision	Between existing bars			

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:

Pro	Properties ×						
Co	ncrete autodesign data (1)		Va V/ /				
			🌍 🍂				
	Max. exploitation of cross-secti	100					
F	Reinforcement template	LR_B_R1	▼				
	Longitudinal reinforcement						
L .	Try to reduce length of bars	🛛 yes					
L	Maximal number of bigger dia	2					
L .	Do not use "Neigboring" diam	🗆 no					
	Stirrups						
L	Minimal stimups distance [mm]	50,0					
L	Stimups step [mm]	50,0					
	Try to create symmetrical stimu	🗆 no					
N	Member	B1					
Ac	tions						
Lo	ad default values		>>>				
Co	oncrete Setup		>>>				

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.

roperty		Parameters		Picture	
Name Type of loads	01 Combination	Selection	List <u> </u>		/
Autodesign type	Amrd Autode	Autodesign	140		
ems	1		Available Available B2 B3 B4	Selected B1 >>	
Remove Item	Add item		ОК	Cancel	

Autodesign starts after pressing button Autodesign all.

■ Overall Autodesign 🛛 🔯 🕞 🖬 All 🔹 🖓								
01 Name 01								
	Type of loads	Combinations 👻						
	Combinations	CO1 🗸						
	Autodesign type	Amrd Autodesign item						
	Items count	1						
	Autodesign item	Item 1 💌						
	Autodesign item							
	Selection	List						
	List							
	Autodesign	No						
Autodesign all	Number of Autodesign	: 1. Start Cancel						
New Insert Edit	Delete Optim.Routine	Autodesign all Calculate Close						

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 results can be verified in the standard concrete checks:

Yes

• Check capacity (max check value 0,97)

Overall Autodesign AMRD item List



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

Steel ×	Properties	×
Beams	Check of steel (1)	- Vi V/ /
Steel Setup		
Haunch	Name	EC 3
Steel member data	Type of loads	Load cases 💌
LTB Restraints	Load cases Filter	LC1 Cross-section
Diaphragms	Cross-section	CS1 - Tube (70; 10) 🔹
Local Transverse Forces data	Extreme	Member
	Output	Brief
□ ¹ ULS Checks	Section	Al
IN beam check SLS Checks - Relative deformation		
	Actions	
	Refresh Single Check	<u>>>></u>
	Autodesign	>>>
New Close	Split CSS	>>>
	Preview	>>>

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.

Autodesign of the ci	ross-sectio	m							
Autodesign									
Maximal check		1							
Maximum unity che	eck:	0.692							
Edit constraints	\$	Info					N		
Edit		Change		Ð			1È	<u>.</u> Ү	
Next down		Next up		70		t 10		~	
Se	arch for opt	imal							
Direction	Up	I	•						7
Parameter				1					
1 - dimension: D		•							
Param.	Value	Autodesign	Related to	Ratio	List	Step	Min.	Max.	Info
1 D	70	🛛 Yes	No		No 🔻	10	1	1000	
Set value		Select/E	eselect All		Test relation:	s	OH		Cancel

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:



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.
-----------------	---------------	------------	----------

Overal Autodesign preview	v				^
nu 1551	200 %	🗹 🔟 📋 default	👻 🛄 default 💌 🗉		
1. 01					^
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. 02					
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.

	Ini	tial	Optimized		
Cross-section	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.



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

Steel ×	Properties	×
Steel Setup	Check of steel - fire resistan	ce (1) 🔻 🕅 🏹 🧷
Haunch		😤 卷
Member Check data	Name	Fire resistance - EC 3
Steel member data	Selection	All
Member buckling data	Type of loads	Combinations 👻
LTB Restraints	Combinations	Fire 💌
Stiffeners	Filter	No
	Values	un.check 💌
Local Transverse Forces data	Extreme	Member 🗾
Fire resistance	Output	Normal 💌
Links	Drawing setup 1D	
Steel slenderness	Section	All
ULS Checks		
Check	Actions	
Check - fire resistance	Refresh	>>>
SIN beam check	Single Check	>>>
SLS Checks - Relative deformation	Autodesian	>>>
New Close	Split CSS	>>>
	Unify CSS	>>>
19 D	Preview	>>>

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.

Autoc	lesign of the cross-se	ection			×
A	utodesign				
м	aximal check	1			
м	aximum unity check:	0.400			
	Edit constraints	Info			
	Edit	Change			
	Next down	Next up			
	Search fo	r optimal			
D	irection	Up & down 👻	Ν		
			<u>î</u>		
Para 1 ·	ameter catalogue: HEB400	•		, Y	
	Param.	Value	Autodesign	List	Sort by
	Isections	HEB400	⊠ Yes	No	▼ H ▼
	Set value	Select/Deselect All	Test relatio	ins	OK Cancel

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.

Combinations			×			
🎜 🤮 🗶 🛍 💺 🖆	2 🗠 😂 🛛 Input combinations	I	•			
ULS	Name	Fire		Properties		×
Fire	Description					
	Туре	EN-Accidental 1	_	FireResistance (1)	- Vi	V; /
	Active coefficients					<u>~ *</u>
	Contents of combination					•
	LC1 [-]	1,00		Time resistance [sec]	1800,00	
				Buckling ratio ky	0	
				Buckling ratio kz	0	
				Fire exposure	All sides	-
	Actions			Protection	No	-
	Explode to envelopes		>>>	k2	0,85	
	Explode to linear		>>>	Temperature-Time curve	By setup	-
New Insert Edit	Delete		Close	Member	B1	

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,

operty		Parameters		Picture
Name	Fire	Cross-section	Steel - HEB4 -	
Type of loads	Combination -	Parameter	HEB400 💌	
Combinations	Fire 💌	Use cross-secti		
Autodesign type	Cross-sectio	Rolled	HEB400	
tems count	1	Sort by	Height 💌	
		Starting CSS	Actual 🗨	
		Search pattern	Find first ok 💌	
		Direction	Up 💌	
		Maximal check [-]	1,00	
		Autodesign che	0,00	
				×

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	Heiaht	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.



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	un.check	sec.check	stab.check
					[m]	[-]	[-]	[-]
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

Steel	×	Properties	×
Beams		SIN beam check (1)	- Va V/ /
Steel Setup			💞 🈕
		Name	SIN beam check
Steel member data		Selection	All
Member buckling data		Type of loads	Load cases 💌
LTB Restraints		Load cases	LC1 💌
Stiffeners	_	Filter	No
Diaphragms	-	Components	Al
Local Transverse Forces data		Values	Un. check web
Fire resistance		Extreme	Global 💌
Links		Drawing setup 1D	
Steel slenderness		Section	All
ULS Checks			
Check - fire resistance			
I SIN beam check		Actions	
SLS Checks - Relative deformation		Refresh	>>>
Connections		Autodesign	>>>
New Close		Split CSS	>>>
		Unify CSS	>>>
		Preview	>>>

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.





operty		Paramete	ers		Picture							
Vame C	Corrugat	Cross-s	ection C	omugated - 💌								
Type of loads C	Combination 💌	Parame	ter A	dvanced A 💌		<u>بر</u>		ВЬ				
Combinations L	JLS 👤	Edit ad	vanced								쥠	
Autodesign type	Cross-sectio	Directio	n U	p and dowr 💌								
ems count 1	1	Maxima	I check [-] 1.	00								
		Autode	sign che 0,	00				- 11				
		Compor	nents U	pper flange 💌								
							th					
											Ba F	
ns								\succ				
Corrugated (Advar	nced Autodesid											
								19	X			
									~~~			
		(		-		_					<u> </u>	
		Advanc	ed Autodesi	gn							<u> </u>	
		Advanc	ed Autodesi Param.	gn Value	Autodesign	Related to	Ratio	List		Step	Min.	Max.
		Advanc	ed Autodesi Param. Ba	gn Value 300	Autodesign	Related to No	Ratio	List	- -	Step 10		Max. 1000
		Advance 1 2	ed Autodesi Param. Ba tha	gn Value 300 12	Autodesign ⊠ Yes □ No	Related to No No	Ratio	List No No	<u>·</u>	Step 10 10	Min. 50	Max. 1000 1000
		Advance 1 2 3	ed Autodesi Param. Ba tha Bb	gn Value 300 12 300	Autodesign ⊠ Yes □ No ⊠ Yes	Related to No No No	Ratio	List No No No	• • •	Step 10 10 10	Min. 50 1 50	Max. 1000 1000 1000
		Advance 1 2 3 4	ed Autodesi Param. Ba tha Bb thb	gn Value 300 12 300 12	Autodesign ⊠Yes □No ⊠Yes □No	Related to No No No No No No No	Ratio 1,00 1,00	List No No No No	- - - - -	Step 10 10 10 10 10	Min. 50 1 50 1	Max. 1000 1000 1000 1000
		Advance	ed Autodesi Param. Ba tha Bb thb w	gn Value 300 12 300 12 12 155	Autodesign  Ves No Ves No No No No	Related to No	Ratio 1,00 1,00 1,00	List No No No No No No	• • • •	Step 10 10 10 10 10 10	Min. 50 1 50 1 1 1 1	Max. 1000 1000 1000 1000 1000
		Advance 1 2 3 4 5 6	ed Autodesi Param. Ba tha Bb thb thb W Hw	yalue 300 12 300 12 12 155 276	Autodesign  Yes No Yes No No No No No No	Related to No	Ratio 1,00 1,00 1,00 1,00	List No No No No No No No	- - - - - -	Step 10 10 10 10 10 10 10	Min. 50 1 50 1 1 1 1 1	Max. 1000 1000 1000 1000 1000 1000
		Advanc	ed Autodesi Param. Ba tha Bb thb thb W Hw s	gn Value 300 12 300 12 155 276 178	Autodesign  Yes No Yes No No No No No No No	Related to No	Ratio 1,00 1,00 1,00 1,00 1,00	List No No No No No No No No	- - - - - - - -	Step 10 10 10 10 10 10 10 10 10	Min. 50 1 50 1 1 1 1 1 1	Max. 1000 1000 1000 1000 1000 1000 1000
		Advanc 1 2 3 4 5 6 7	ed Autodesi Param. Ba tha Bb thb w Hw s	Value           300           12           300           12           276           178	Autodesign  Yes No Yes No No No No No No No	Related to No No No No No No No No No Vo	Ratio 1,00 1,00 1,00 1,00 1,00	List No No No No No No No No	- - - - - - -	Step 10 10 10 10 10 10 10 10	Min. 50 1 50 1 1 1 1 1 1	Max. 1000 1000 1000 1000 1000 1000 1000
emovelterm	Additem	Advance 1 2 3 4 5 6 7	ed Autodesi Param. Ba tha Bb thb w Hw s	gn Value 300 12 300 12 12 155 276 178	Autodesign  Yes No Yes No No No No No No Toot sola to	Related to No No No No No No No No Vo	Ratio 1,00 1,00 1,00 1,00 1,00	List No No No No No No		Step 10 10 10 10 10 10 10	Min. 50 1 50 1 1 1 1 1	Max. 1000 1000 1000 1000 1000 1000

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**.

Overall Autodesign		<u> </u>
🏓 👫 🥒 📸 💽 🖆	2. 🗠   🚭   🗃 🖬   All	• 7
Corrugat	Name	Corrugat
	Type of loads	Combinations 🔹
	Combinations	ULS 🗸
	Autodesign type	Cross-sections corrugated web ch
	Items count	1
	Autodesign item	Item 1
	Autodesign item	
	Cross-section	Corrugated - SIN1 (300; 12; 300; 💌
	Parameter	Advanced Autodesign
	Edit advanced Autodesign	
	Direction	Up and down
	Maximal check [-]	1,00
	Autodesign check [-]	0,00
	Components	Upper flange
Autodesign all	Number of Autodesign: 1.	Cancel
		Ba
New Insert Edit	Delete Optim.Routine A	utodesign all Calculate Close

The results are automatically printed in preview.

	Overal Autodesign preview	Same of Street, or other		-				x
	🖻 🚇   📑 🚑   📑 🗮 📒 😑 200 %	-   🗹 🖬 🗍 de	efault	👻 🛄 🕂 def	ault 🔹	•		
i	1. Corrugat							
I	C ross-section	Parameter	Direction	Maximal check [-]	Autodesign check [-]	Original cross-section	Autodesign of cross-section	Ξ
I	Corrugated - SIN1 (220; 12; 220; 12; 155; 196; 178)	Advanced Autodesign	Up and down	1,00	0,97	Corrugated - SIN1 (300; 12; 300; 12; 155; 276; 178)	Corrugated - SIN1 (220; 12; 220; 12; 155; 196; 178)	
l	Ready [en]			•	III		4	-

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

|--|


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,E d [kN]	c top [m]	kc top [-]	Ned - [kN]	Ny [kN]	Ngl [kN]	NI [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	Load case	N,Ed	My, Ed	Vz,Ed	c bot	kc bot	Ned +	Ned -	Ny	Ngl	NI	Max unity check
	[m]		[kN]	[kNm]	[kN]	[m]	[-]	[kN]	[kN]	[kN]	[kN]	[kN]	[-]
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	Load case	h	Vz,Ed	V_web	Vrd	Max unity check
	[m]		[m]	[kN]	[kN]	[kN]	[-]
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]	NI [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	Load case	N,Ed	My, Ed	Vz,Ed	c bot	kc bot	Ned +	Ned -	Ny	Ngl	NI	Max unity check
	[m]		[kN]	[kNm]	[kN]	[m]	[-]	[kN]	[kN]	[kN]	[kN]	[kN]	[-]
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	Load case	h	Vz,Ed	V_web	Vrd	Max unity check
	[m]		[m]	[kN]	[kN]	[kN]	[-]
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

Steel ×	Properties		×
Beams Haunch	Check of steel (1)	▼	Vi V/ /
	Selection Type of loads	All Combinations	-
LTB Restraints	Combinations Filter Values	CO1 No un check	
Web crippling data	Extreme Output	Section Detailed	
Steel slenderness  Steel slenderness  ULS Checks  Check ASD	Drawing setup 1D Section Actions	All	
Check LRFD	Refresh Single Check		>>>
New Close	Split CSS Unify CSS		>>>
	Preview		>>>

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.

Autod	esign of the cross-section	on				
Au	todesign					
Ma	ximal check	1				
Ma	ximum unity check:	2.948				
	Edit constraints	Info		N		
	Edit	Change			Y	
	Next down	Next up		<u>س_</u>		
	Search for op	timal				
Di	rection	o & down 🔹				
Bara				1		
1 · c	atalogue: C(ICEC)203X65	< -		$\square$		
	Prom	Value	Autodosian	List		Sothy
1	Cold formed C sections	C(ICEC)203X65X65X	Ves	No	<b>▼</b> H	Joit by ▼
	Set value	Select/Deselect All	Test relation	is 📃	OK	Cancel
_						

## **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.

operty		Parameters		Picture				
Vame	01	Cross-section	CS1 - C203X					
Selector switch		Parameter	C(ICEC)203> -					
Type of loads	*Combination -	Use cross-secti						
Combinations	C01 -	Filter list	LIST1 -					
Autodesign type	Lapped purli	Sort by	Height 💌			$\succ$		
tems count	1	Starting CSS	Actual 👻			12		
		Search pattern	Find first ok				X	
		Direction	Up and dowr 👻				~	
		Maximal check [-]	1,00					
		Autodesign che	1,01					
- 5.12.2		Type of check	LRFD -					
ems . CS1 (C(ICEC)20	)3×65×65×23×3)	Type of check Edit Lap length	LRFD •					
erns . CS1 (C(ICEC)20	J3X65X65X23X3)	Type of check Edit Lap length	neters edit	mm] Autodesign 00 ⊠ Yes	List No _	Step [mm] 250,00	Min. [mm] 0,00	Max. [mm] 5000,00

The additional properties are:

Type of checkit is possible to select between ASD code and LRFD codeEdit Lap lengthAutodesign settings for the overlap

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

🔑 🚛 🔏 🖷 🕷	( <u>n</u> n l 📾 l 🖶 🖻 l	A
LIST1	Name	LIST1
	Type of list	Rolled
	Form code	114
	Form code name	Cold formed C sections
	Code name	C(ICEC)
	🗆 Items	
	Rolled cross-section	C(ICEC)165X65X65X19X1.55
	Rolled cross-section	C(ICEC)165X65X65X20X1.75
	Rolled cross-section	IS C(ICEC)165X65X65X20X2
	Rolled cross-section	IS C(ICEC)165X65X65X20X2.25
	Rolled cross-section	C(ICEC)165X65X65X21X2.65
	Rolled cross-section	C(ICEC)165X65X65X22X3
	Rolled cross-section	c(ICEC)203X65X65X19X1.55
	Rolled cross-section	C(ICEC)203X65X65X20X1.75
	Rolled cross-section	C(ICEC)203X65X65X21X2
	Rolled cross-section	C(ICEC)203X65X65X21X2.25
	Rolled cross-section	C(ICEC)203X65X65X22X2.65
	Rolled cross-section	C(ICEC)203X65X65X23X3
	Rolled cross-section	c(ICEC)255X70X70X19X1.55
	Rolled cross-section	C(ICEC)255X70X70X20X1.75
	Rolled cross-section	IS C(ICEC)255X70X70X20X2
	Rolled cross-section	C(ICEC)255X70X70X20X2.25
	Rolled cross-section	C(ICEC)255X70X70X21X2.65
	Rolled cross-section	IS C(ICEC)255X70X70X22X3
	Rolled cross-section	IS C(ICEC)300X80X80X19X1.55
	Rolled cross-section	IS C(ICEC)300X80X80X20X1.75
	Rolled cross-section	IS C(ICEC)300X80X80X20X2
	Rolled cross-section	IS C(ICEC)300X80X80X21X2.25
	Rolled cross-section	C(ICEC)300X80X80X22X2.65
	Rolled cross-section	IS C(ICEC)300X80X80X23X3

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.



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

Combina	1003 . 001				
Case	Member	CSS	mat	dx	un.check
				[m]	[-]
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	CS S	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

Steel ×	× Properties	×
	BD (1)	• Vi V / « * *
<ul> <li>Member Check data</li> <li>Steel member data</li> <li>LTB Restraints</li> <li>Stiffeners</li> <li>Diaphragms</li> <li>Cocal Transverse Forces data</li> <li>Fire resistance</li> <li>Links</li> <li>Steel slenderness</li> <li>SLS Checks - Relative deformation</li> <li>Connections</li> <li>Connections</li> <li>Bolted diagonal</li> <li>Bolted diagonal - bolt operations</li> <li>Check</li> </ul>	Name Connection type Type of loads Combinations Bolts Bolts Bolts Bolts grade Number of bolts Gusset properties Gusset material Thickness [m] Throat size [m] Double leg Output Edit bolted diagonal Node Diagonal Layer of diagonal Actions Bof reach	BD         Bolted diagonal         Combinations         ULS         M12 - 4.6         4.6         1         S 235         0.008         0,004         Brief         IN7         B8 [Diagonal - HFLeq100x100x8]         Layer1
New Close	Open Preview Results	>>>
	Autodesign	>>>

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.

verall Autodesigr	1			
Property		Parameters		Picture
Name	Bolt	Bolted diagonal BD	-	
Type of loads	Combination -	Bolt M12	4.6 💌	
Combinations	ULS 🔻	Number of bolts 0		
Autodesign type	Bolted diago	Autodesign che 0,00		
Items Courit	2			
Items				
1. BD 2. BD1				- BD [N7](B8)
Remove Item	Add item			
				Autodesign Calculation Close

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.

Overall Autodesign	n	23			
🔎 🦆 🗶 📸 🕏	💁 🗠 🎒 🖨 🖬 🗛	• 7			
Bolt	Name	Bolt			
	Type of loads	Combinations -			
	Combinations	ULS 🗸			
	Autodesign type	Bolted diagonal Autodesign item			
	Items count	2			
	Autodesign item	Item 1			
	Autodesign item				
	Bolted diagonal connection	BD			
	Bolt	M12 - 4.6			
	Number of bolts	0			
	Autodesign check [-]	0,00			
	Number of Autodes	ign: 1.			
Start Cancel					
	BD	[N/](B8)			
	ď				
New Insert E	Edit Delete Optim.Routi	ne Autodesign all Calculate Close			

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		Optimized	
BD		BD	-
Name	BD1	Name	BD
NoIRd - [kN]	364,49	NpIRd - [kN]	364,49
NuBd - IcN1	207.22	NuRd - [kN]	198,00
EbBd - ILNI	32.09	FbRd - [kN]	58,47
EvD4 (NI)	5.66	FvRd [kN]	16,46
	04.00	NpIRd - [kN]	150,40
	34,00	NuRd - [kN]	120,27
NuRd - [kN]	74,65	FbRd - [kN]	58,47
FbRd - [kN]	32,09	Connection check [-]	0,04
Connection check [-]	0,12	Member check [-]	0,07
Member check [-]	0,11	Connection result FvRd [kN]	47,04
Connection result FvRd [kN]	16,19		

# 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.

operty		Parameters		- Pictur	e						
lame	01	Cross-section	CS1 - RECT	-							
Type of loads	*Combination -	Parameter	Advanced A	-							
Combinations	C01 -	Edit advanced									
Autodesign type	Cross-sectio	Direction	Up and dowr	-							
tems count	2	Maximal check [-]	1,00								
		Autodesign che	0,96								
ms CS1 (Advance CS2 (Advance	d Autodesign) d Autodesign) 🛛 🗛	dvanced Autodesic	ın			~	-		_		<b>—</b> x
ms . CS1 (Advance . CS2 (Advance	d Autodesign) d Autodesign) 🛛 Ar	dvanced Autodesig	gn Value	Autodesign	Related to	>-	Liet		Sten	Min	Max
ms <mark>CS1 (Advance</mark> CS2 (Advance	d Autodesign) d Autodesign) A	dvanced Autodesig	yn Value	Autodesign	Related to	>- Ratio	List		Step 5	Min.	Max.
rms <u>CS1 (Advance</u> CS2 (Advance	d Autodesign) d Autodesign) A	dvanced Autodesig Param. 1 B 2 H	7 Value	Autodesign	Related to No	Ratio	List No	•	Step 5	Min.	Max. 1000
rms , <u>CS1 (Advance</u> , CS2 (Advance	d Autodesign) d Autodesign) Ar	dvanced Autodesig Param. 1 B 2 H	Value 105 0 200 0	Autodesign ⊠ Yes ⊠ Yes	Related to No	Ratio	List No No	•	Step 5 5	Min. 1 1	Max. 1000 1000
ms CS1 (Advance CS2 (Advance	d Autodesign) d Autodesign) Ar	dvanced Autodesig Param. 1 B 2 H	n Value   105   200   0	Autodesign ⊠ Yes ⊠ Yes	Related to No No	Ratio	List No No	•	Step 5 5	Min. 1 1	Max. 1000 1000

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

Overal Autodesign preview				<b>X</b>
<b>Þa Q∣ 13</b> ⁄a   <mark> </mark>   H   1	200 %	🧻 default 🛛 👻 🖽 default	· •	
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]		4		

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.

 $\sim$ ĺÌ

### Timber ULS check

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

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

The second ones are for the optimised structure.



0,96

#### **Timber ULS check**

Linear calculation, Extreme : Global Selection : All Combinations : CO1 Beam Cross-section Material Unity check Section check Stability check dx Load case [m] [-] [-] [-] B1 CS1 - RECT C22 1,734 CO1/1 0,96 0,21

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

Aluminium ×	Properties	×
Beams	Aluminium check (1)	▼ 1⁄2 1⁄2 1⁄2 1⁄2 1⁄2 1⁄2 1⁄2 1⁄2 1⁄2 1⁄2
Aluminium member data Member Check data Member Check data Member buckling data LTB Restraints Stiffeners Diaphragms Check Relative deformation	Name         Selection         Type of loads         Load cases         Filter         Values         Extreme         Output	Aluminium check    All    Load cases    LC1    No    Unity check    Global    Brief
New Close	Drawing setup 1D         Section         Actions         Refresh         Single Check         Autodesign         Split CSS         Unify CSS         Preview	All

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.

Autodesign of the cross-s	ection							<b>_</b>
Autodesign								
Maximal check	1							
Maximum unity check:	7.469							
Edit constraints	Info							
Edit	Change							
Next down	Next up			N				
Search fo	or optimal			<b>`</b> }				
Direction	Up & down	•			≓>Y			
Parameter								
1 - dimension: H	•						•	
Param. V	alue Autodesign	Related to	Ratio	List		Step	Min.	Max.
1 H 200	⊠ Yes	No		No	-	10	1	1000
Set value	Select/Dese	lect All	Testr	elations			ОК	Cancel

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,

Overall Autodesign			
Property	Parameters	Picture	
Name Aluminiu	Cross-section ALU - Gener, 🔻	8	
Type of loads Combination -	Parameter H 💌		
Combinations ULS -	Use cross-secti		
Autodesign type Cross-sectio	Length [mm] 200		
Items count 1	Minimum [mm] 1		
· · · · · ·	Maximum [mm] 1000		
	Step [mm] 10		
	Search pattern Find first ok 💌		
	Direction Up and dowr -		
	Maximal check [-] 1,00		
	Autodesign che 0,00		
Items			
1. ALU (H = 200)			
		7	
		4	
		— X	
		±/***	
Remove Item Add item	] [	]	
			alculation

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.

_		/									
	Overal Autodesign preview										x
	• UIB 6 I <mark>I</mark> H I <mark>-</mark>	200 %	Ŧ	🗹 🗹	🧻 default		- 🚇 🎹	default	· II II	_	
	1. Aluminiu										
l	Cross-section	Parameter	Length [mm]	Minimum [mm]	Maximum [mm]	Step [mm]	Original	cross-section	Autodesign of cross-section	Autodesign check	-
I	ALU - General cross-section (800)	Н	800	1	1000	10	ALU - General	cross-section (200)	ALU - General cross-section (800)	1,00	
	📕 Ready [en]						•			•	-

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

Geotechnics ×	Properties	×
Geotechnics services	Pad foundation check (1)	▼ 1a 7⁄2 // 중 ≫
Pad foundation - Pad foundation stability	Name	Pad foundation check
	Selection	Current
	Type of loads	Class 💌
	Class	GEO 🔽
	Filter	Pad foundation 💌
	Pad foundation	PF1 💌
	Values	Un.check 💌
	Extreme	Global
	Output	Brief
	Drawing setup 1D	
	Section	All
	Actions	
New Close	Refresh	>>>
	Autodesign	>>>
	Preview	>>>

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.

Autode	sign of the p	ad foundatio	on								×
Aut	todesign									8	
Ma	ximal check		1				_			_ <del>}</del>	
Ma	ximum unity ch	eck:	0.207							h h h	
	Next down		Next up				₽ ₽ 			ήΓ	
	Se	arch for optim	nal								
Dir	ection	Up 8	k down	•					+	b=0.690 B=2.580	
Par Ad	ameter Ivanced autod	esign	•				ــا ــر	a A	E0.600 ≡2.300	{	
	Param.	Value [m]	Autodesign	Relate	ed to	Ratio	Li	st	Step [m]	Min. [m]	Max. [m]
1	A	2,500	□ No	No	-	1,00	No	-	0,100	0,100	2,000
2	В	2,500	□ No	No	-	1,00	No	-	0,100	0,100	2,000
3	h1	0,400	□ No	No	-	1,00	No	-	0,100	0,100	2,000
4	h2	0,200	□ No	No	-	1,00	No	-	0,100	0,100	2,000
5	h3	0,050	□ No	No	-	1,00	No	-	0,100	0,100	2,000
6	а	0,600	□ No	No	•	1,00	No	-	0,100	0,100	2,000
7	b	0,600	□ No	No	-	1,00	No	-	0,100	0,100	2,000
	Set value		Select/Dese	lect All		Test	relations			ОК	Cancel

### **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.

-P	Lanes.	Paran	meters		Pictu	е							
lame	01	Pad	foundation	PF1	<b>•</b>							8	
ype of loads	Class 💌	Para	ameter	Advanced A	-					2	3	318	
ass	GEO 🔻	Edit	advanced									0.0	
todesign type	Pad foundati	Dire	ction	Up and dowr	-			<del>ا</del>				1 de	
ms count	1	Max	imal check [-]	1.00				50				<u></u>	
		Auto	odesign che	0,86				0.0					
18		1								4	<b>F&gt;^</b>	b=0.6 B=2.	
-F1 (Load user	edefaults for this to	Advanc	ced Autodesi	gn						a <del>∓</del> 0.0 A=2.:	500 500 J	1	
PFT (Load user	r-defaults for this t	Advanc	ced Autodesi	ign Value [m]	Autodesig	Belated	to	Batio		a <u>∓</u> 0.6 A=2.:	500		Max [m]
*1 (Load user	-defaults for this t	Advanc	ced Autodesi Param. A	gn Value [m] 2 500	Autodesigr	n Related	to	Ratio	Lis	a <u>∓</u> 0.0 A≡2.: t	500 500 500 Step [m] 0.100	Min. [m]	Max. [m]
₽1 (Load user	-defaults for this t	Advance 1	ced Autodesi Param. A B	gn Value [m] 2,500 2,500	Autodesigr ⊠ Yes □ No	n Related No A	to	Ratio	Lis No No	a <u>∓</u> 0.0 A=2.: t t	500 500 Step [m] 0,100	Min. [m] 1,000	Max. [m] 3,500
PF1 (Load user	-defaults for this t	Advance 1 2 3	Param. A B h1	ign Value [m] 2,500 2,500 0,400	Autodesigr ⊠ Yes □ No ⊠ Yes	No A No	to •	Ratio	Lis No No	a <u>∓</u> 0.( A=2.: t ▼	500 500 / Step [m] 0,100	 Min. [m] 1,000 0,400	Max. [m] 3,500
PF1 (Load use;	-defaults for this t	Advance 1 2 3 4	Param. A B h1 h2	ign Value [m] 2,500 2,500 0,400 0,200	Autodesign Yes No Yes Yes	No A No No No	to	Ratio	Lis No No No	a <u>+0.0</u> A=2 tt •	500 500 Step [m] 0,100 0,050 0,050	Min. [m] 1,000 0,400 0,200	Max. [m] 3,500 1,000
PF1 (Load use;	-defaults for this t	Advance	Param. A B h1 h2 h3	gn Value [m] 2,500 2,500 0,400 0,200 0,050	Autodesign S Yes No Yes Yes No	n Related No A No No No	to •	Ratio	Lis No No No No	a <u>+0.0</u> A=2 t •	Step [m] 0,100 0,050 0,050 0,050	Min. [m] 1,000 0,400 0,200 0,100	Max. [m] 3,500 1,000 1,000
PF1 (Load use;	-defaults for this t	Advance 1 2 3 4 5 6	Param. A B h1 h2 h3 a	gn Value [m] 2,500 2,500 0,400 0,200 0,050 0,600	Autodesign S Yes No Yes Yes No No	n Related No A No No No No	to v	Ratio 1,00 1,00	Lis No No No No No	a=0.0 A=2 t •	500 500 Step [m] 0,100 0,050 0,050 0,100 0,100	Min. [m] 1,000 0,400 0,200 0,100 0,100	Max. [m] 3,500 1,000 1,000 10,000
PF1 (Load user	Add item	Advance 1 2 3 4 5 6 7	Param. A B h1 h2 h3 a b	ign Value [m] 2,500 2,500 0,400 0,200 0,050 0,600 0,600	Autodesign  Autodesign  Yes  No  Yes  Yes  No  No  No  No	n Related No A No No No No No	to •	Ratio 1,00 1,00 1,00 1,00	Lis No No No No No No	a <u>+0.(</u> A=2.: t t •	500 500 Step [m] 0,100 0,050 0,050 0,100 0,100 0,100	Min. [m] 1,000 0,400 0,200 0,100 0,100 0,100	Max. [m] 3,500 1,000 1,000 10,000 10,000

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..

1	Name	01	
	Type of loads	Class	<u> </u>
	Class	GEO	▼
	Autodesign type	Pad foundation check	
	Items count	1	
	Autodesign item	Item 1	<u> </u>
	Autodesign item	254	
	Pad foundation	PF1	
	Parameter	Advanced Autodesign	_
Autodes	ion all		
	Number of Autod	esign: 1.	
	Number of Autod	esign: 1.	
	Number of Autod	Start Cancel	

The results are automatically printed in preview.

П

Overal Autode	esign preview			-		AT 1 Statement
Þa 🚇 🖪 🛃	9   <b>                 </b> 200	%	- 1 🗹 🗹 1 🗖	default	👻 🛄 🛗 default	· = =
1. 01						
Pad foundation	Parameler	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; 0,550; 0,600; 0,600;	PF1 - (3,000; 3,000; 0,300; 0,600; 0,650; 0,600; 0,600;

Initial	Optimized



# 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 lwn crosssections. 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.



## 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.

Topeny		Parameters		- Picture
Name	01	Autodesign	No	
Type of loads	Combination -	Flanges section	SM1 👻	
Combinations	ULS 👻	Web height CS	wd 🔻	
Autodesign type	Frame-CSS h	Web thickness	wt 🔻	
Items count	1	Min web slende	50	
		Max web slend	125	V V
		Min flange slen	5	
		Max flange slen	15	
		Safety coeff - N	1	
		Safety coeff - My	1	
		Safety coeff - Vz	1	Layers
tems		Member list	B1 B2 B3 B4	Layer1

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 link to layer database for selection of a layer

Add members by layer

	🔳 Ov	erall Autod	lesign							×		
	1	🕂 🗶	<b>k</b> 🖸	<u>e</u>   🖨   🖬	ê 🖬   A	1				7		
	01			Name			01					
				Type of loads	;		Combinati	ons		-		
				Combinations			ULS			-		
				Autodesign ty	pe		Frame-CS	S height auto	odesign			
				Items count			1					
				Autodesign ite	em		Item 1			-		
				Autodesig	n item							
				Autodesign			No					
				Flanges sec	tion matrix		SM1			·		
				Web height	CSS list		wd		•	·		
				Web thickn	ess CSS list		wt		•	·		
				Min web sle	ndemess		50					
				Max web sle	endemess		125					
				Min flange s	lendemess		5					
				Max flange	slendemess		15					
				Safety coeff	F - N		1					
				Safety coeff	f-My		1					
				Safety coeff	- Vz		1					
				Member list			B1 B2 B3	B4 B5 B6 B7	7 B8			
	New	Insert	Edit	Delete	Optim.R	loutine	Autodesign	all Calcu	ulate Clo	ose		
Overal Autodesign previ	ew											×
₽ <b>8 8 8 8 1</b> H	200	%	-   🖬 🖬	丨 🗍 default	- Q	🖁 🎹 defau	ilt	• II II	_			_
1. 01												<b>^</b>
Type Name	Autodesign	Member list	Flanges sec matrix	tion Web height CSS list	Web thickness CSS list	Min web slendemess	Max web slenderness	Min flange slenderness	Max flange slendemess	Safety coeff - N	Safety coeff - My	Safety coeff - Vz
Frame height AutoDesign	No	B1 B2 B3 B4 B5 B6 B7 B8	SM1	wd	wt	50	125	5	15	1	1	1
📕 Ready (cs)					•							<u> </u>

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.

operty	Parameters	Picture
operty lame Web ype of load Combination ♥ ombinations ULS ♥ utodesign type Web optimiz ems count 8 ms CL1 RL2 RL3 CR1 RL2 RL3 CR1 RL3 RL3 CR1 RL2 RL3 CR1 RL3 RL3 CR1 RL3 RL3 CR1 RL3 RL3 CR1 RL3 RL3 CR1 RL3 RL3 CR1 RL3 RL3 CR1 RL3 CR1 RL3 CR1 RL3 CR1 RL3 CR1 RL3 CR1 RL3 CR1 CR1 CR1 CR1 CR1 CR1 CR1 CR1 CR1 CR1	Parameters       Dimension list     wt     •       Optimized CSS     CL1 - Iwr     •       Optimal check     0.95     •       Max check bou     0.85       Max check bou     1       Dimension filter     0.3       Min slendemess     50       Max slendemess     125	Picture Web AutoDesign CL1

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.

	Lists of available cross	-sections	
	🔎 🤮 🗶 🛍 🔣 🖆	2. 🗠   🚭   🗳 🔚   Al	• 7
	fw	Name	wt
		Type of list	Dimensions
	i c	E Items	
	Wu	Dimensions list [mm]	5
	Wt	Dimensions list [mm]	6
		Dimensions list [mm]	8
		Dimensions list [mm]	10
Main ×		Dimensions list [mm]	12
		Dimensions list [mm]	14
Materials		Dimensions list [mm]	16
I Cross-sections		Dimensions list [mm]	18
Satur		Dimensions list [mm]	20
Structure, Analysis			
Section matrix			
Buckling			
E Steel			
9.5 C	New Insert Edit	Delete	OK

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 pr	review								x
🖻 😫 i 📑 🏉 📘	200	%	I 🖾 🚾 I 🔳	default 🔹	🕮 🎹 default	- = =			
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 - lwn (400; 12; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	50	125	
Web AutoDesign RL1	wt	RL1 - lwn (400; 12; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	50	125	
Web AutoDesign RL2	wt	RL2 - lwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000	
Web AutoDesign RL3	wt	RL3 - lwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000	
Web AutoDesign CR1	wt	CR1 - lwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000	
Web AutoDesign RR1	wt	RR1 - lwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000	
Web AutoDesign RR2	wt	RR2 - lwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000	
Web AutoDesign RR3	wt	RR3 - lwn (400; 10; 300; 12; 200; 16; 372; 0)	0,95	0,85	1	0,3	0	1000	
Min slenderness				4				F	-

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.



### 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 The following	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).
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.



## 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.

Overall Autodesign		
Property       Name     01       Type of loads     Combination ▼       Combinations     ULS       Autodesign type     Frameflange       Items     8   Items Ite	Parameters          Dimension list       ft       ▼          Optimized CSS       CL1 - Iwr       ✓          Optimal check       0.95       Min check bou       0.85         Max check bou       1       Dimension filter        0.3         Flanges to opti       Both flanges       ▼	Frame-flange thickness autodesign CL1
		Autodesign Calculation Close

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

Overall Autodesign		
🎜 🤮 🗶 📸 💺	🖸 🗠 😂 😂 🖬 🛙 Al	• 7
FI thick	Name	Fl_thick
-	Type of loads	Combinations 🗨
	Combinations	ULS 🔽
	Autodesign type	Frame-flange thickness autodesign
	Items count	8
	Autodesign item	ltem 1 💌 🗉
	Autodesign item	
	Dimension list	ft 🔍 🗸
	Optimized CSS	CL1 - lwn (400; 12; 300; 12; 💌
	Optimal check	0,95
	Min check boundary	0,85
	Max check boundary	1
		· · ·
	(	CL1

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								x
🗈 💹   📑 🚑   📑 🕂 📘 📒 200 %	-   🗹 🖬   🗍 det	fault 👻	💾 default	-				
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 - lwn (412; 12; 300; 20; 200; 20; 372; 0)	0,95	0,85	1	0,3	Both flanges	
Frame-flange thickness autodesign CR1	ft	CR1 - lwn (412; 12; 300; 20; 200; 20; 372; 0)	0,95	0,85	1	0,3	Both flanges	
Frame-flange thickness autodesign RR1	ft	RR1 - lwn (412; 12; 300; 20; 200; 20; 372; 0)	0,95	0,85	1	0,3	Both flanges	
Frame-flange thickness autodesign RR2	ft	RR2 - lwn (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		1					Þ	-

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.

|--|


## 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.

operty	Parameters	Picture
Vame 01	Autodesign No	
Type of loads Class 💌	coef - h1/h2=c 1	
All SLS V	exp - n 1/n2=co 0,5 Member list B1 B2 B3 B4	
tems count 1	Add members b	
	Select nodes	
	·	
ems		
. Hall deflection autodesign		
Pamaua Itam 1 Add Serv	1	
		Autodesign Calculation Close

alue used for the optimal 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)

- 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)
- 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

	Node	Horizontal deflection [mm]	Deflection up [mm]	Deflection down [mm]
1	N2 -	60	1000	1000
2	N6 -	60	1000	1000
3	N5 🔻	1000	150	150
•	N6 -	0,0	0,0	0,0

When all values are set the dialogue looks like:

Defl		Name		Defl		
		Type of loads		Class		
		Class		AII SLS		-
		Autodesign type		Frame-deflection	on autodesign	
		Items count		1		
		Autodesign item		Item 1		
		Autodesign item				
		Autodesign		No		
		coef - h1/h2=coef*(c	heck^exp	1		
		exp - h1/h2=coef*(ch	eck^exp-1)	. 0,5		
		Member list		B1 B2 B3 B4 B	15 B6 B7 B8	

The results preview is printed.

Overal Autodesign previe	ew				x
<b>₽ ₩   ₽ #     </b> H	150 %	- Maria -	default 💽 📜 🎹	default 👻 🗉 🔡	7
1. Def					-
Type Name	Autodesign	coef - h1/h2=coef*(checkexp-1)+1	exp - h1/h2=coef*(checkexp-1)+1	Member list	
Hall deflection autodesign	No	1	0,5	B1 B2 B3 B4 B5 B6 B7 B8	
📕 Ready [cs]		4			- -

## 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.

operty		Parameters	Picture	
Name	01	Member list B1 B2 B3 B		
Type of loads	Class 🔹	Add member		
Class	All SLS+ 👻 🛄	🗆 Height a		
Autodesign type	Frame-autod	Enable 🖾 yes		
Items count	1	Max NO iter 10		
		Web thic		
		Enable 🛛 yes		
		Max NO iter 10		
		Web thic		
		Enable 🛛 yes	E	
		Max NO iter 10		~
ems		Range a		<b>A</b>
1. Frame-autodesig	n manager	Enable 🛛 yes		1
		Max NO iter 10		ų <u>—</u> ⊳X
		E Flange a		V
		Enable 🛛 yes		
		Max NO iter 10		
		Both flan		
		Enable 🛛 yes		
		Max NO iter 10		
		E Both flan		
		Enable 🛛 yes		
		Max NO iter 10		
		Outer fla		
		Enable 🛛 yes		
		Max NO iter 10		
-	1.115	Outer fla		
Hemove Item	Add item	Enable 🛛 yes	<b>~</b>	
				Autodesign Calculation

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

Member list Name of the check selected members (read only) 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) option, if this check should be considered on Autodesign or not maximal number of iterations used for Autodesign

Max. NO iteration

Enable

When all values are set the dialogue looks like

