

# TUTORIAL

## 1D REINFORCEMENT

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## Introduction

SCIA Engineer enables you to model and check concrete 1D elements. To be able to pass these checks, reinforcement is needed. In SCIA Engineer there are different types of reinforcement:

- Theoretical reinforcement
  - Required reinforcement
  - Provided reinforcement
- Practical/User reinforcement

For 1D elements practical reinforcement will be needed to be able to perform the checks. You can either input the practical reinforcement yourself or convert theoretical reinforcement into practical reinforcement.

This tutorial will explain the different types of reinforcement and discuss an example how to input these to be able to perform the concrete 1D checks.

## Theoretical reinforcement

### Configuration

The theoretical reinforcement is calculated out of the recalculated internal forces. It gives the amount of reinforcement needed to resist the internal forces induced by ULS loads. Since there are several workflows possible to design concrete 1D elements, the theoretical reinforcement design is not mandatory to perform. Experienced users can directly jump to practical reinforcement to perform the checks on, but this theoretical approach gives a good idea of how this practical reinforcement should look like. There are two types of theoretical reinforcement:

- **Required reinforcement:** The required reinforcement is a numerical value ( $\text{mm}^2$ ) of the reinforcement that is necessary in every section of the beam.
- **Provided reinforcement:** The provided reinforcement is a template added to each beam/column consisting of basic and additional reinforcement.

The configuration of theoretical reinforcement can be found in the Concrete settings under Design defaults



Templates of longitudinal reinforcement and stirrups for different shapes of beam are available. The concrete cover can be set for upper, lower, and side faces.

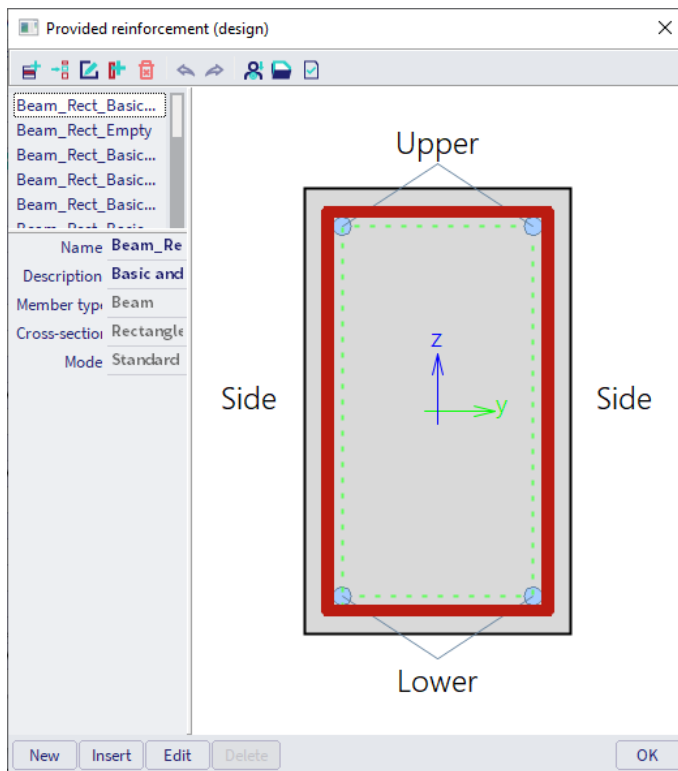
Concrete settings

Views: Design defaults View settings Load default Find National annex

Description	Symbol	Value	Default	Unit	Chapter	Code	Structure	CheckType
<all>	<all>	<all>	<all>	<a...>	<all>	<all>	<all>	Design defa...
Design defaults								
Reinforcement								
Beam / Rib								
Design of provided reinforcement		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			Independent	Beam,Rib	Design defaul...
Rectangular section		Beam_Rect...	Beam_Rect...			Independent	Beam,Rib	Design defaul...
T section		Beam_Tsect...	Beam_Tsec...			Independent	Beam,Rib	Design defaul...
L section		Beam_Lsect...	Beam_Lsec...			Independent	Beam,Rib	Design defaul...
I section		Beam_Isect...	Beam_Isect...			Independent	Beam,Rib	Design defaul...
Other and general		Beam_Othe...	Beam_Othe...			Independent	Beam,Rib	Design defaul...
Longitudinal								
Upper (z+)								
Type of cover		Auto	Auto		4.4.1	EN 1992-1-1	Beam,Rib	Design defaul...
Diameter	$d_{s,u}$	16	16	mm		EN 1992-1-1	Beam,Rib	Design defaul...
Lower (z-)								
Type of cover		Auto	Auto		4.4.1	EN 1992-1-1	Beam,Rib	Design defaul...
Diameter	$d_{s,l}$	16	16	mm		EN 1992-1-1	Beam,Rib	Design defaul...
Side (y±)								
Type of cover		Upper	Upper		4.4.1	EN 1992-1-1	Beam,Rib	Design defaul...
Detailing (det)								
Stirrups (sw)								
Diameter	$d_{ss}$	8	8	mm		EN 1992-1-1	Beam,Rib	Design defaul...
Number of cuts	$n_s$	2,0	2,0			Independent	Beam,Rib	Design defaul...
Angle	$\alpha_s$	90,00	90,00	deg		Independent	Beam,Rib	Design defaul...
Beam slab								

OK Cancel

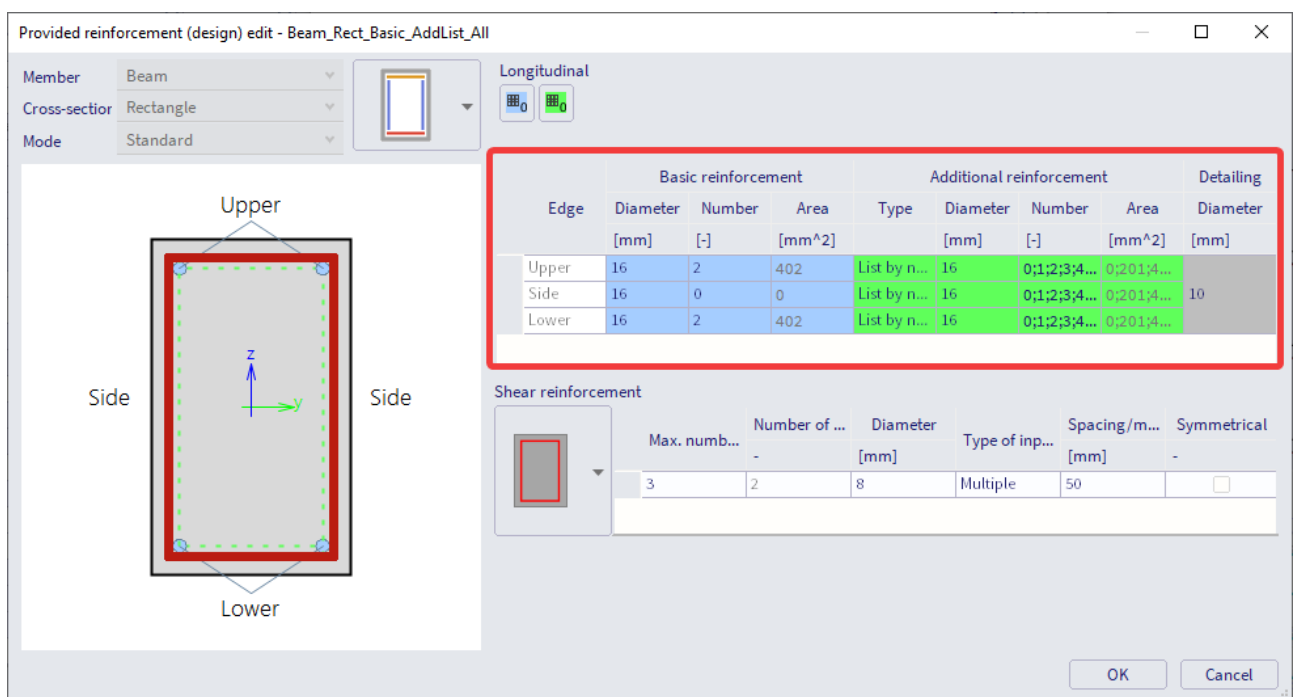
Several default templates for longitudinal reinforcement and stirrups are available for the different section types (provided reinforcement). These can be changed, or new ones can be made.



This template exists of basic, additional and shear reinforcement. The purpose is to compare these templates with the required reinforcement, to model the user reinforcement that is introduced later or to convert it automatically to user reinforcement.

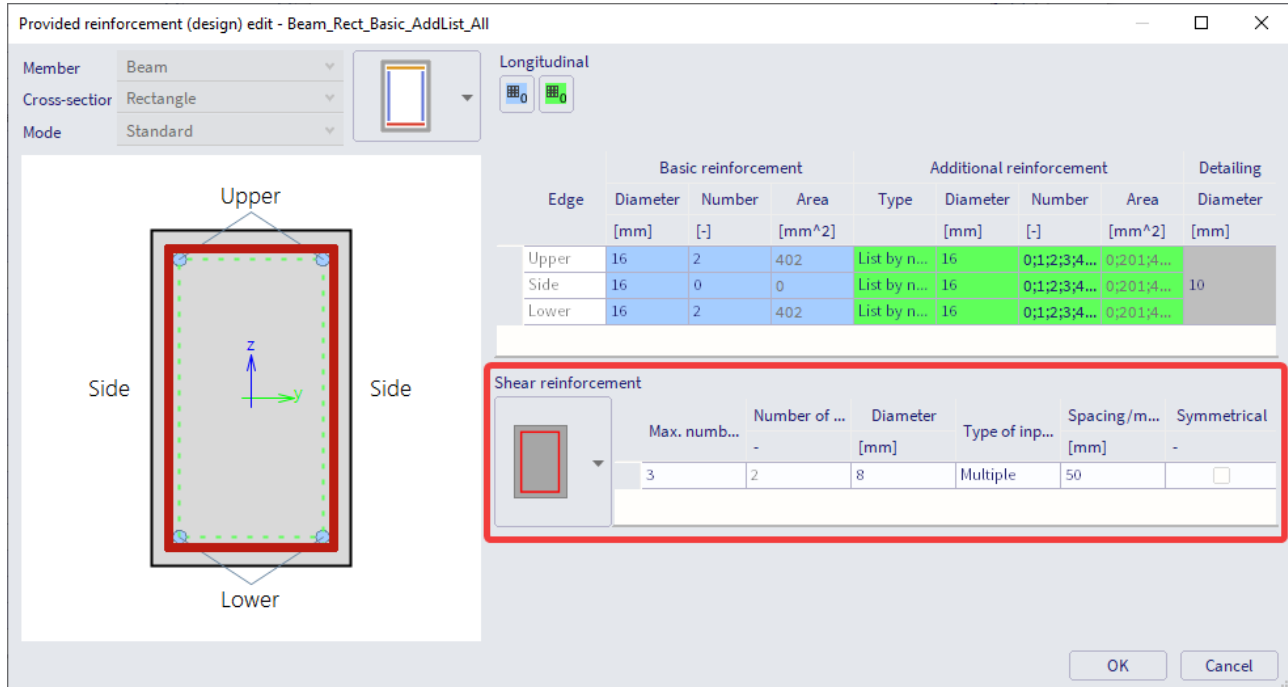
### Longitudinal reinforcement

The basic reinforcement is present along the whole length of the beam; the additional reinforcement is present only at the zones where basic reinforcement is not sufficient to withstand (recalculated) internal forces. A choice can be made between fixed additional bars (diameter and number) or a list with different numbers of bars with a fixed diameter. SCIA Engineer uses the least amount of necessary additional bars or places the maximum if this template is still not sufficient to resist the (recalculated) internal forces. Next to the basic and additional reinforcement you can also set a diameter for the detailing reinforcement. The detailing reinforcement is reinforcement that statically is not required but that needs to be added to the cross-section to fulfil the detailing provisions.

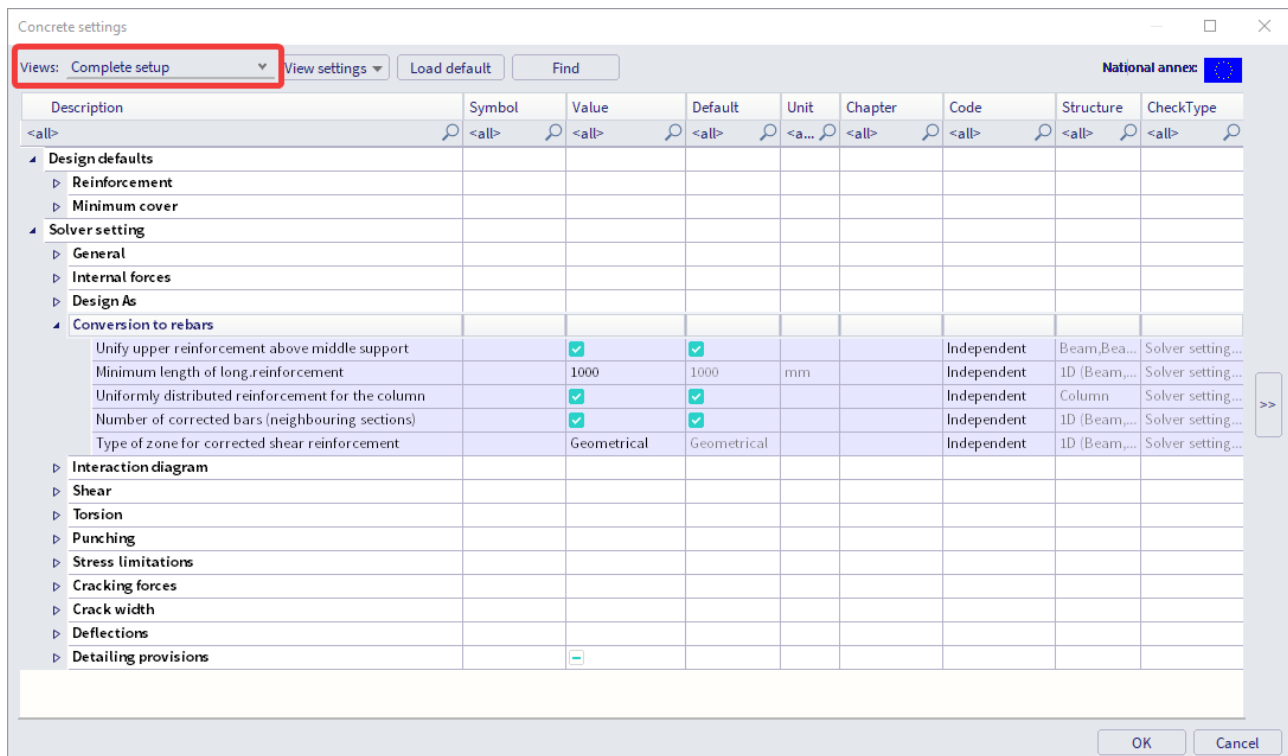


## Shear reinforcement

For the shear reinforcement the number of cuts, the maximum number of stirrup zones, the diameter and the spacing can be set. For the spacing different types of input can be used: Multiple and User defined. Multiple means that the spacing between the stirrups will be the multiple of a set value. With User defined reinforcement the user can set the spacings that can be used. SCIA Engineer will automatically select the spacing depending on this template and the general settings in the design defaults. The option Symmetrical allows the user to define whether the zones in each span will be symmetrical or not.



Extra settings for the theoretical reinforcement can be found under Solver setting > Conversion to rebars:

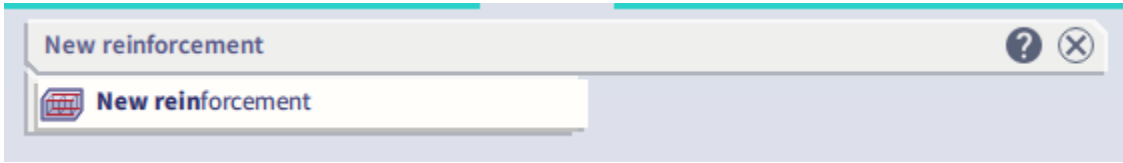


## Practical reinforcement

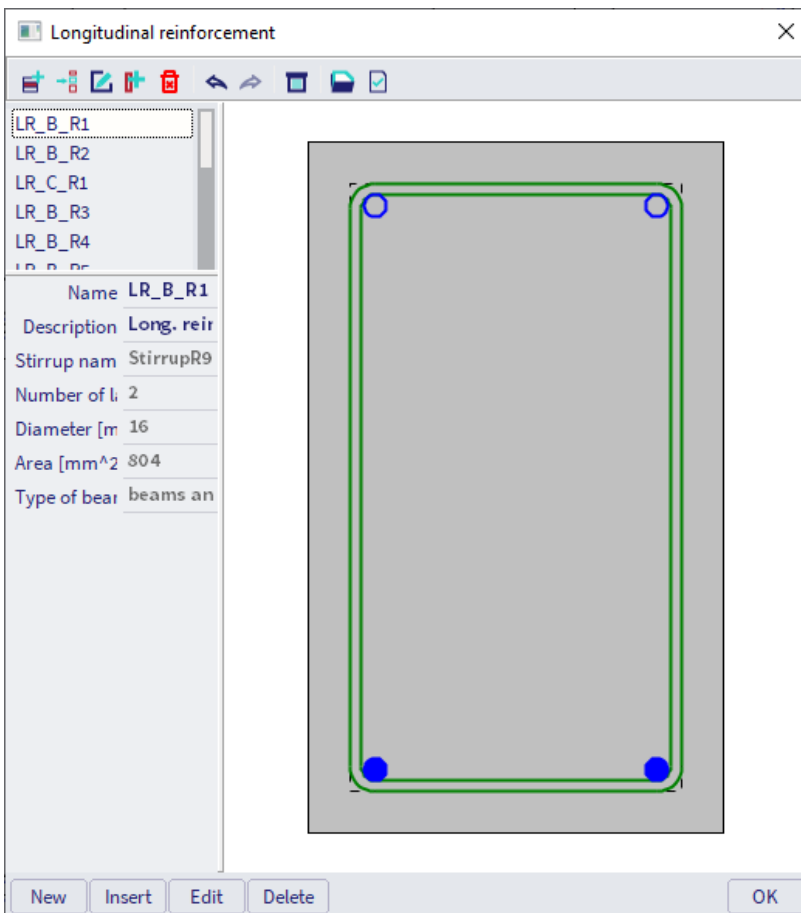
We will now pass on to the level of practical reinforcement. This will allow us to specify the reinforcement locally over the beam.

In the theoretical reinforcement design, we have calculated where reinforcement is needed.

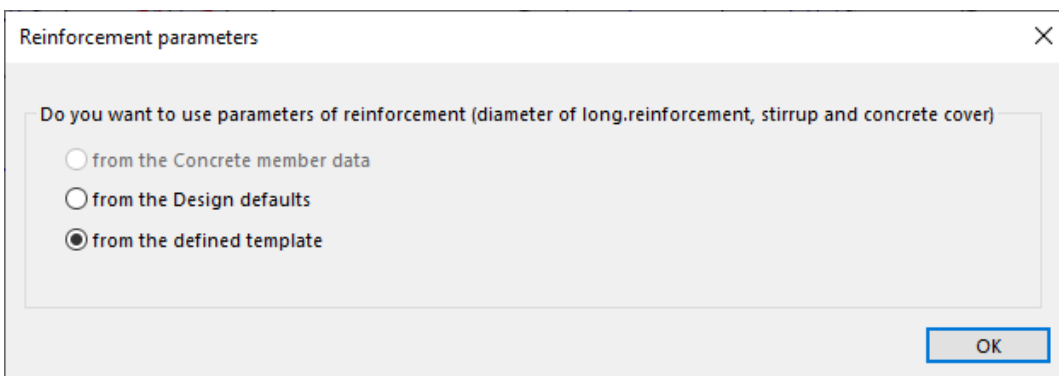
This allows us to input manually the practical reinforcement by adding New reinforcement in the SCIA Spotlight:



We can first select a template for the longitudinal reinforcement:

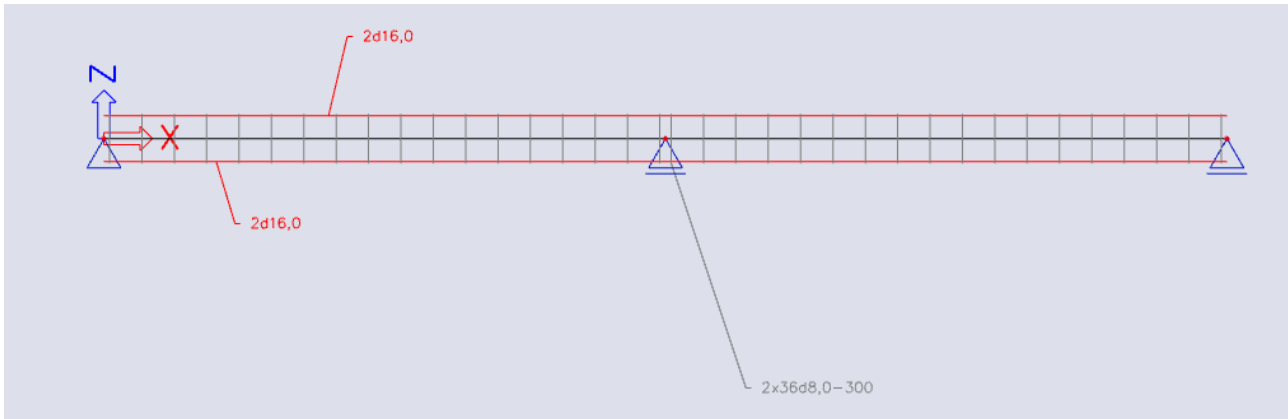


Next, we have to decide where the parameters of reinforcement are coming from:

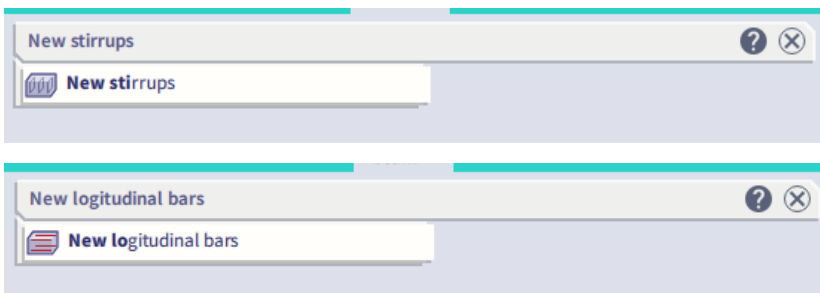




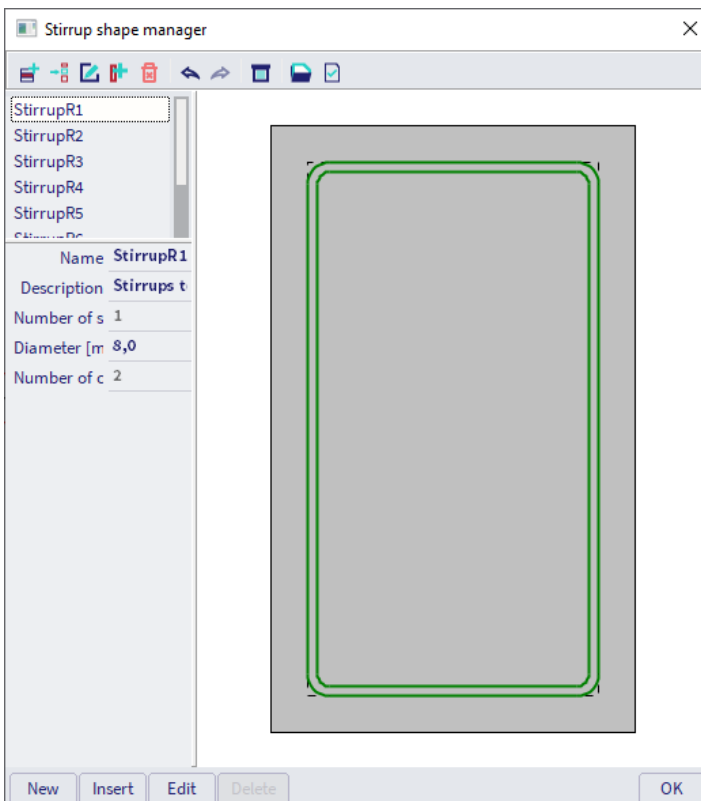
The practical reinforcement is then shown graphically on the screen:



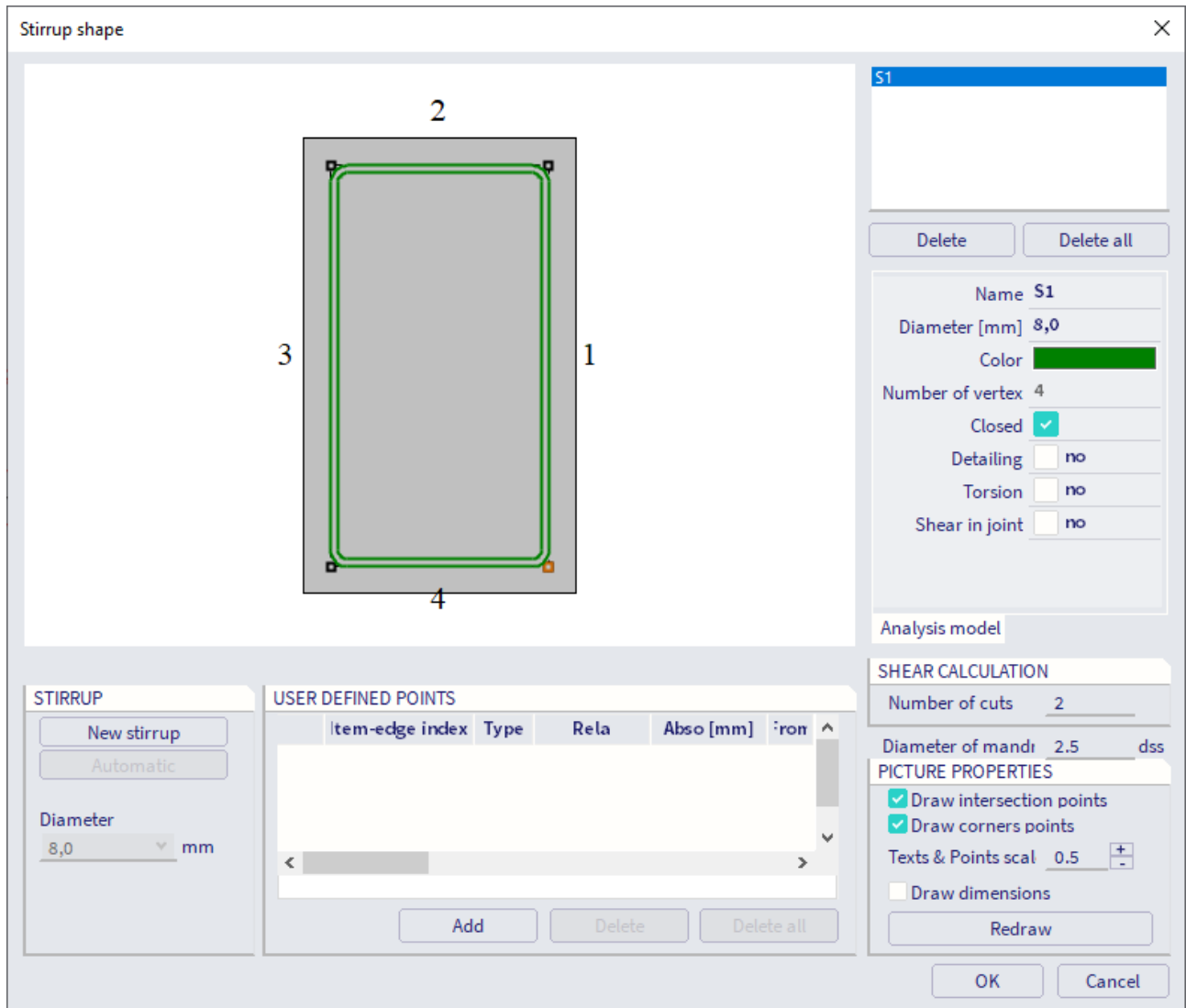
As a user, you can add locally New stirrups or New longitudinal bars.



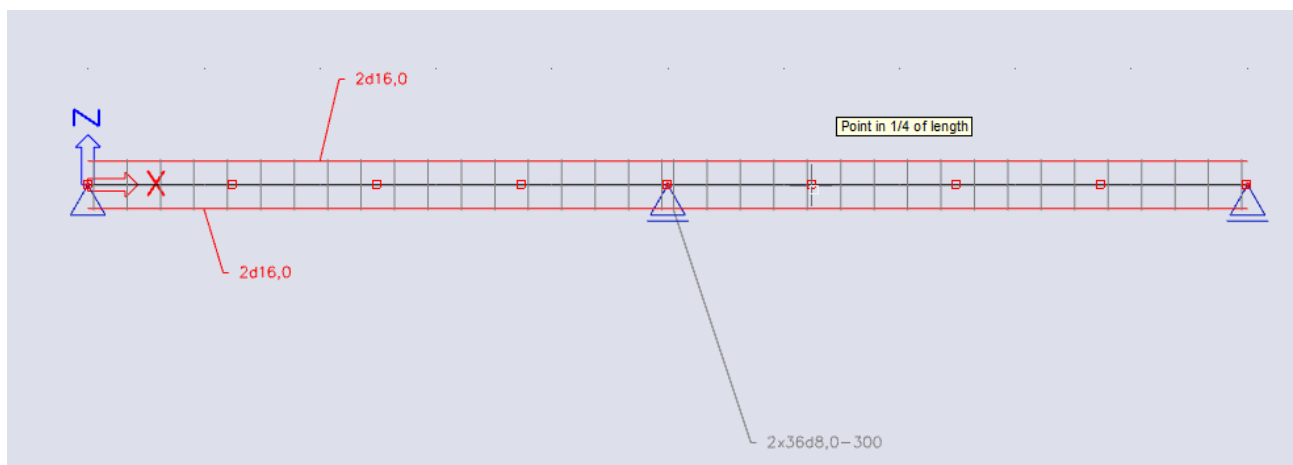
For the stirrups, you can select a certain stirrup shape:



The stirrup shape can be edited or a new one can be made. Therefore, user points may be added.



For the longitudinal reinforcement, we can define precisely where the extra practical reinforcement needs to be putted:



The configuration for the selected zone of the member is shown:

Member S1, Zone from 6,250 m to 8,750 m (0.625 - 0.875)

Filter: All

L1-S1E4  
L2-S1E2

Delete Delete all

Name L2-S1E2  
Position numbe 3  
Material B 600C  
Diameter [mm] 16,0  
Number of bars: 2  
Area [mm<sup>2</sup>] 402  
Layer type Uniform  
Cover type Surface to  
Cover [mm] 0,0  
Left bar Before the  
Right bar Before the

Analysis model Automatic design

REINFORCEMENT LAYERS AREA  
Selected layers 402 mm<sup>2</sup>  
All layers 804 mm<sup>2</sup>

PICTURE PROPERTIES  
Draw dimensions  
Texts scale 0.5  
Redraw

OK Cancel

LONGITUNIDAL REINFOR...  
New layer  
Add bars to corners  
Bars positions  
COLLISION OF BARS  
Collision

NEW REINFORCEMENT PARAMETERS  
Number of bars 2  
Diameter [mm] 8,0  
Stirrup name S1  
Edge index 2

TYPE OF BEAM  
beams and ribs

STIRRUPS  
Edit stirrups  
Edit cover  
Save to template

Between existing bars  
Move layer

Here can be set on which face extra reinforcement needs to be added:

Member S1, Zone from 6,250 m to 8,750 m (0.625 - 0.875)

Filter: All

L1-S1E4  
L2-S1E2  
L3-S1E4

Delete Delete all

Name L3-S1E4  
Position numbe 4  
Material B 600C  
Diameter [mm] 20,0  
Number of bars: 3  
Area [mm<sup>2</sup>] 942  
Layer type No corner  
Cover type Surface to  
Cover [mm] 0,0  
Stirrup name S1  
Edge index 4

Analysis model Automatic design

REINFORCEMENT LAYERS AREA  
Selected layers 942 mm<sup>2</sup>  
All layers 1747 mm<sup>2</sup>

PICTURE PROPERTIES  
Draw dimensions  
Texts scale 0.5  
Redraw

OK Cancel

LONGITUNIDAL REINFOR...  
New layer  
Add bars to corners  
Bars positions  
COLLISION OF BARS  
Collision

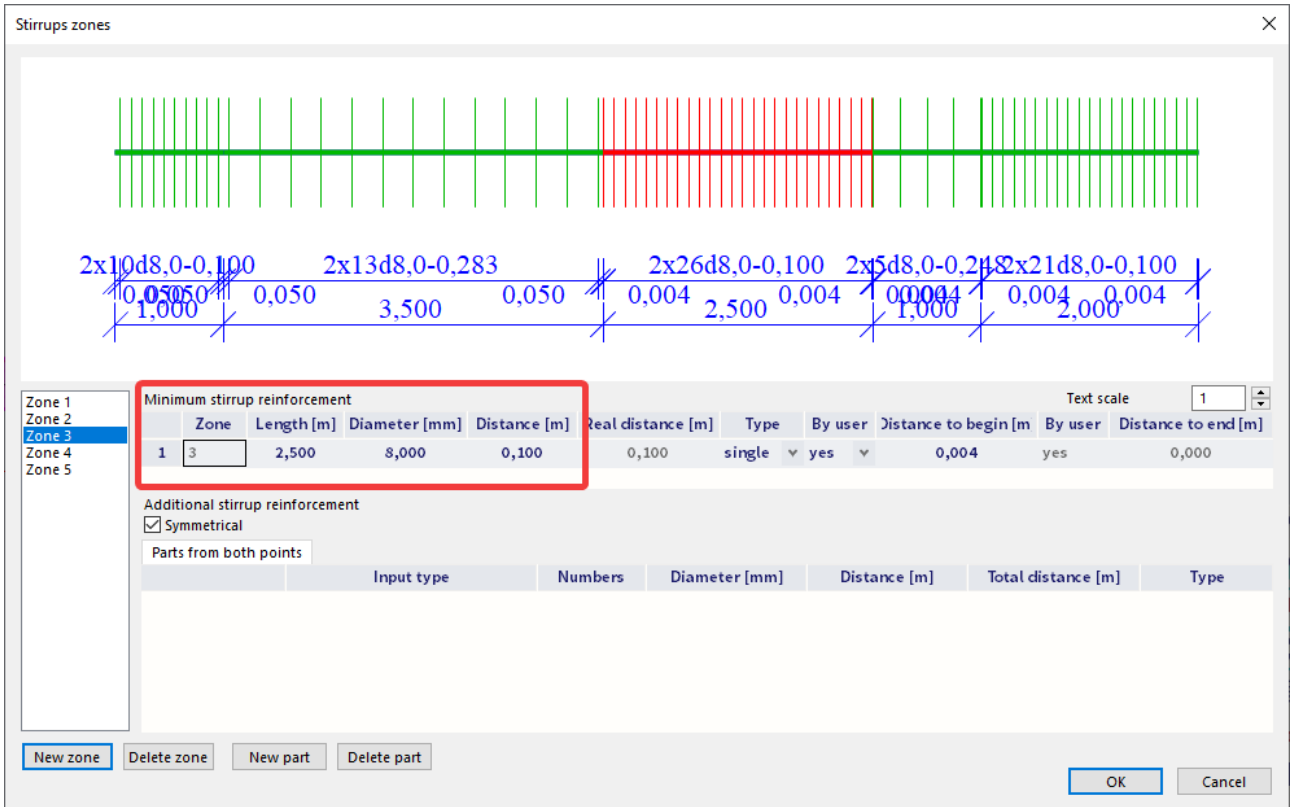
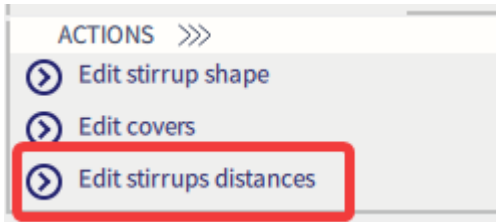
NEW REINFORCEMENT PARAMETERS  
Number of bars 3  
Diameter [mm] 20  
Stirrup name S1  
Edge index 4

TYPE OF BEAM  
beams and ribs

STIRRUPS  
Edit stirrups  
Edit cover  
Save to template

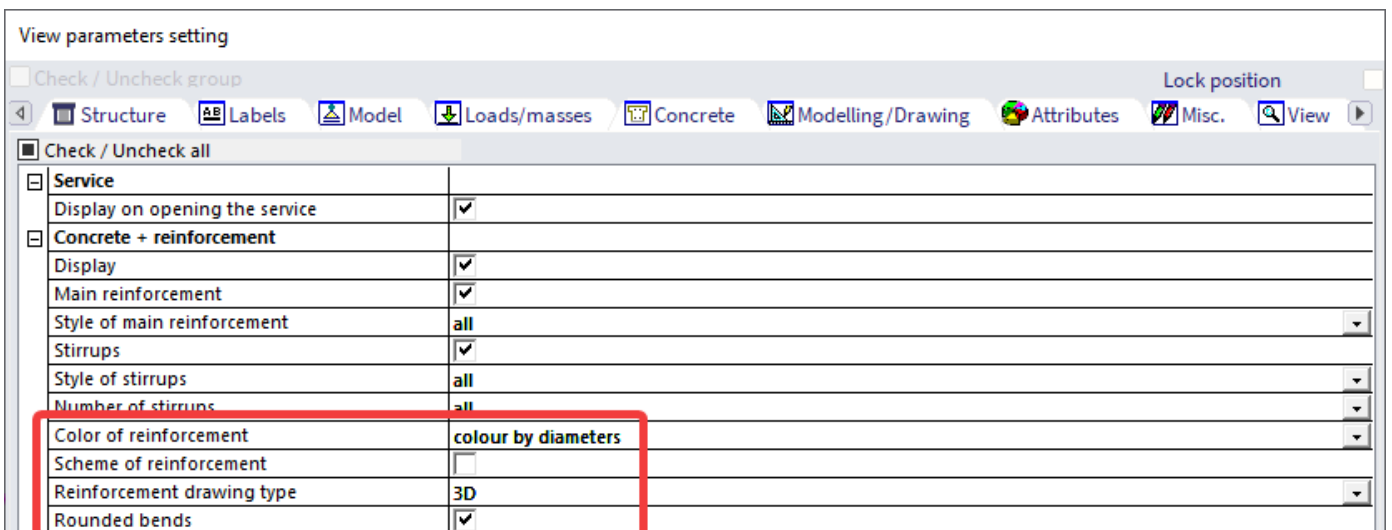
Between existing bars  
Move layer

Different stirrup zones can be created when editing the stirrup distance. First select the stirrups and then choose the action:

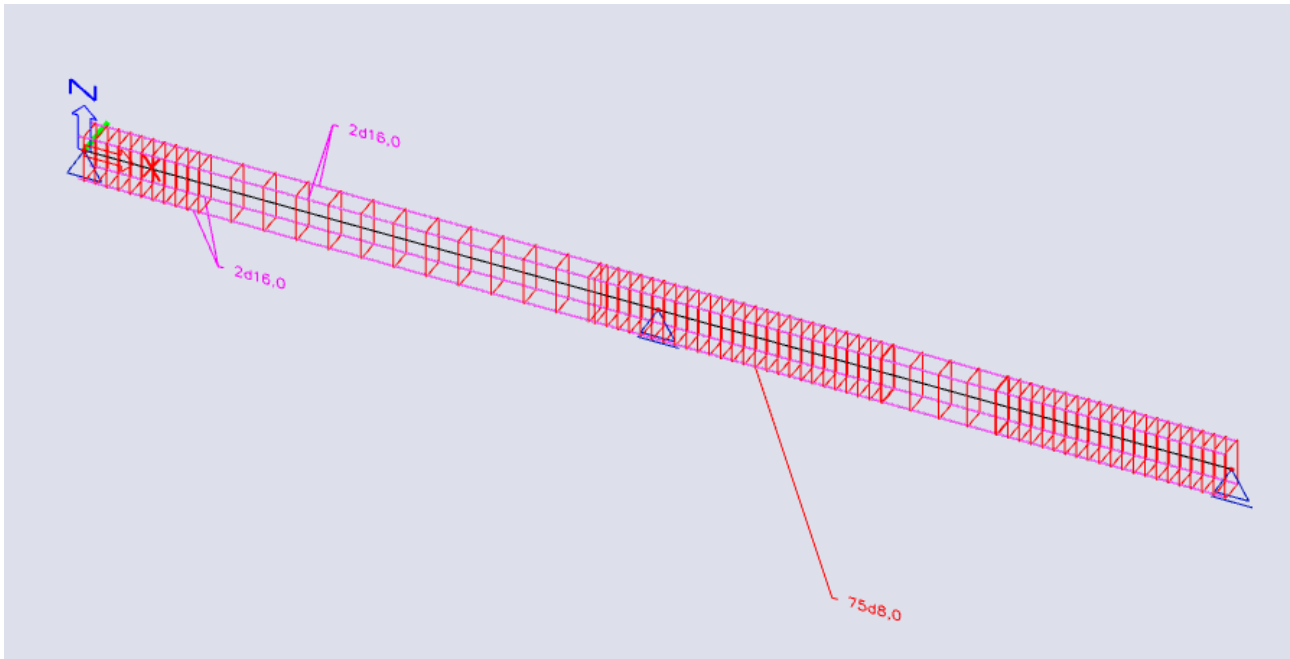


By selecting the reinforcement, it is always possible to change the parameters afterwards through the property window.

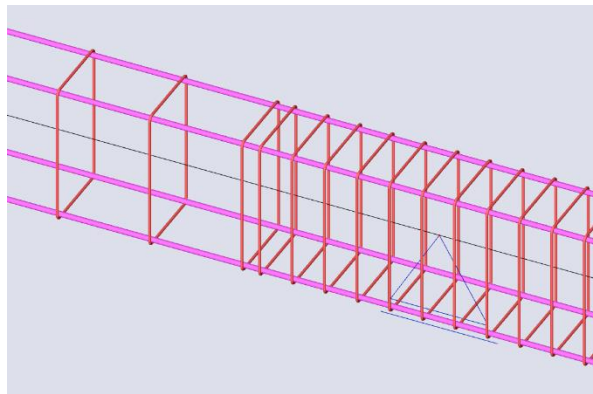
Through view parameter settings a 3D representation of the reinforcement can be obtained:



The total practical reinforcement of the beam is shown below:



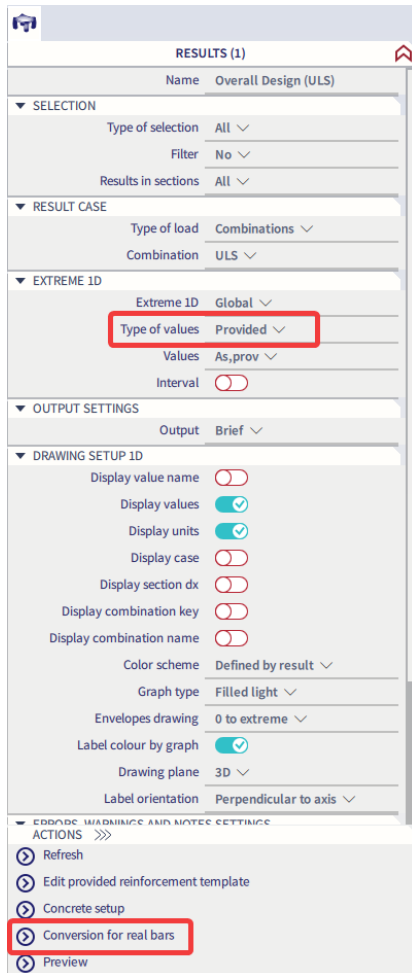
A zoomed view shows the 3D representation:



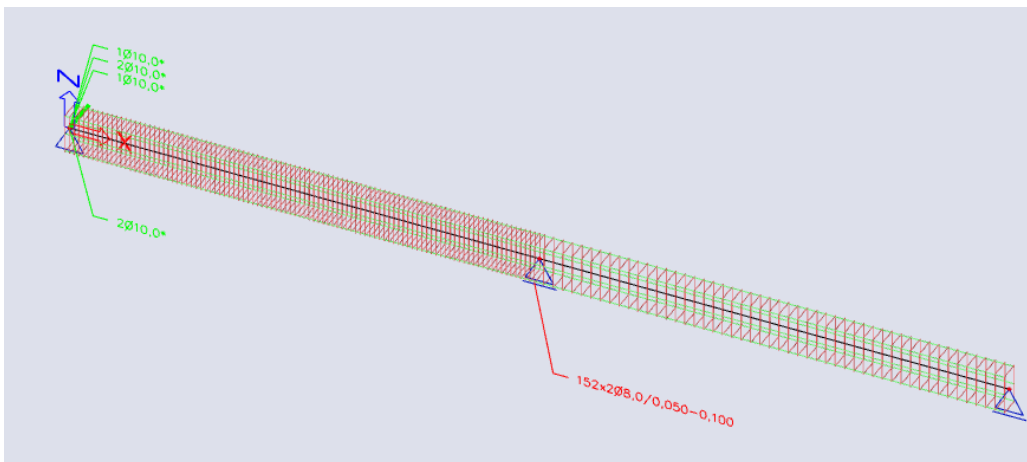
## Conversion of theoretical reinforcement into practical reinforcement

Since SCIA Engineer 19 it is also possible to convert theoretical reinforcement into practical reinforcement. As already mentioned there are two types of theoretical reinforcement: **Required reinforcement** (= mm<sup>2</sup> necessary in each section) and **Provided reinforcement** (= template of reinforcement with various amounts of additional reinforcement possible). It is only possible to convert **Provided reinforcement** into practical (=user) reinforcement.

Go to Reinforcement design and look at the value  $A_{s,prov}$ . This is the provided reinforcement that will be converted into practical reinforcement. Once this is generated, you can convert the provided reinforcement using 'Conversion for real bars' under Actions:



The theoretical provided reinforcement will be converted to practical reinforcement:



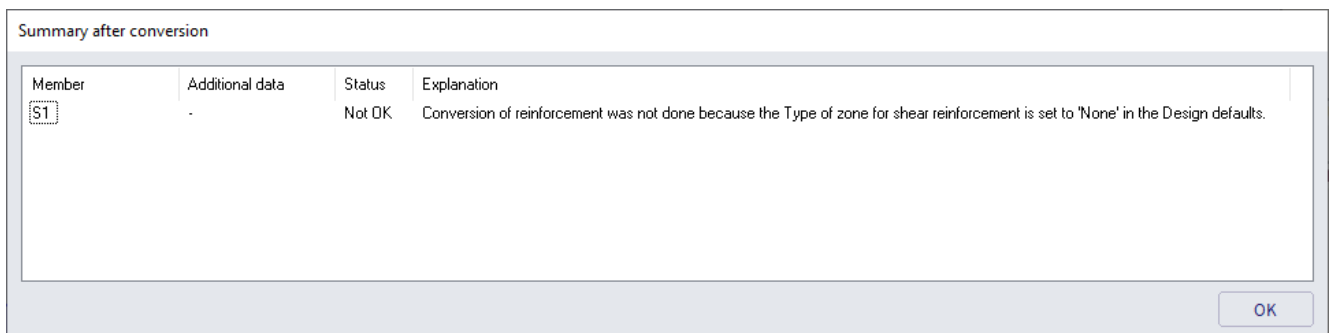
The practical reinforcement is added as reinforcement data. You can edit the reinforcement by selecting it and then click on 'Edit reinforcement'.



Now the parts of the reinforcement that needs edditing can be slected. The diameter, number of bars, length, spacing , ... can be changed in the properties window.

**Remark:**

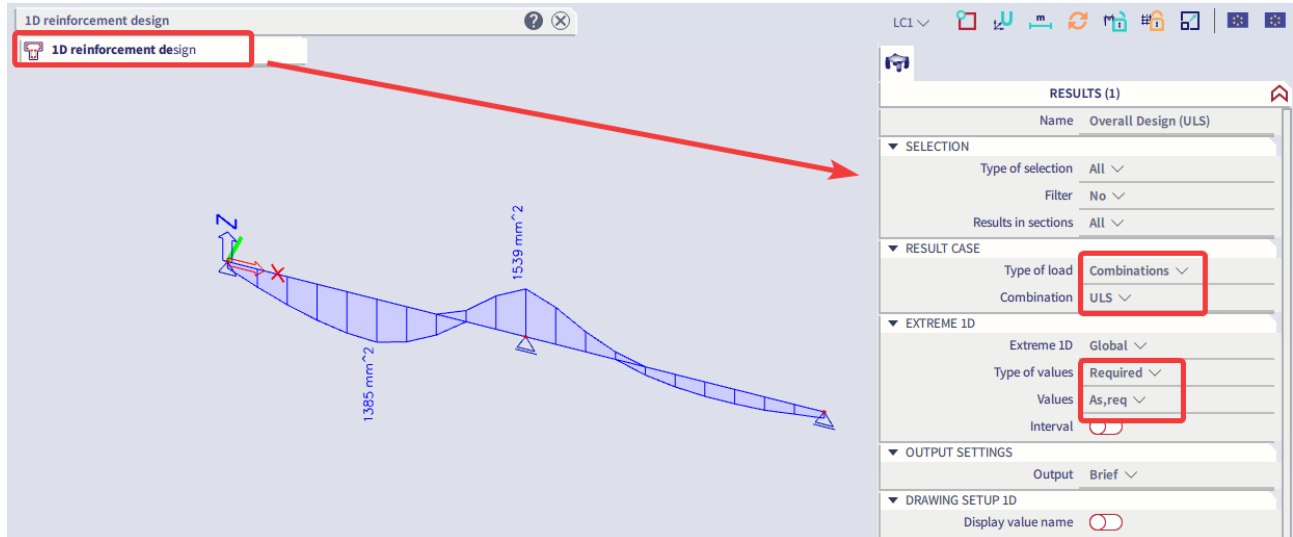
It might occur the error message '**Conversion of reinforcement was not done because the Type of zone of shear reinforcement is set to 'None' in the Design defaults**' appears within the summary after conversion when converting the provided reinforcement into real bars. This behaviour is caused due to the option '**None**' is selected for the setting '**Type of zone for corrected shear reinforcement**' within the design defaults.



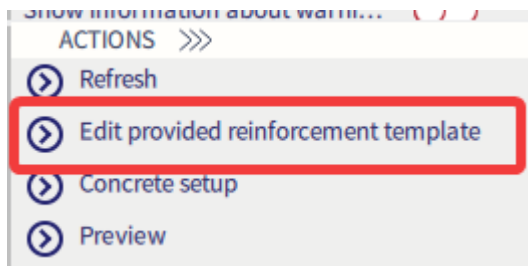
## Example

### Theoretical reinforcement

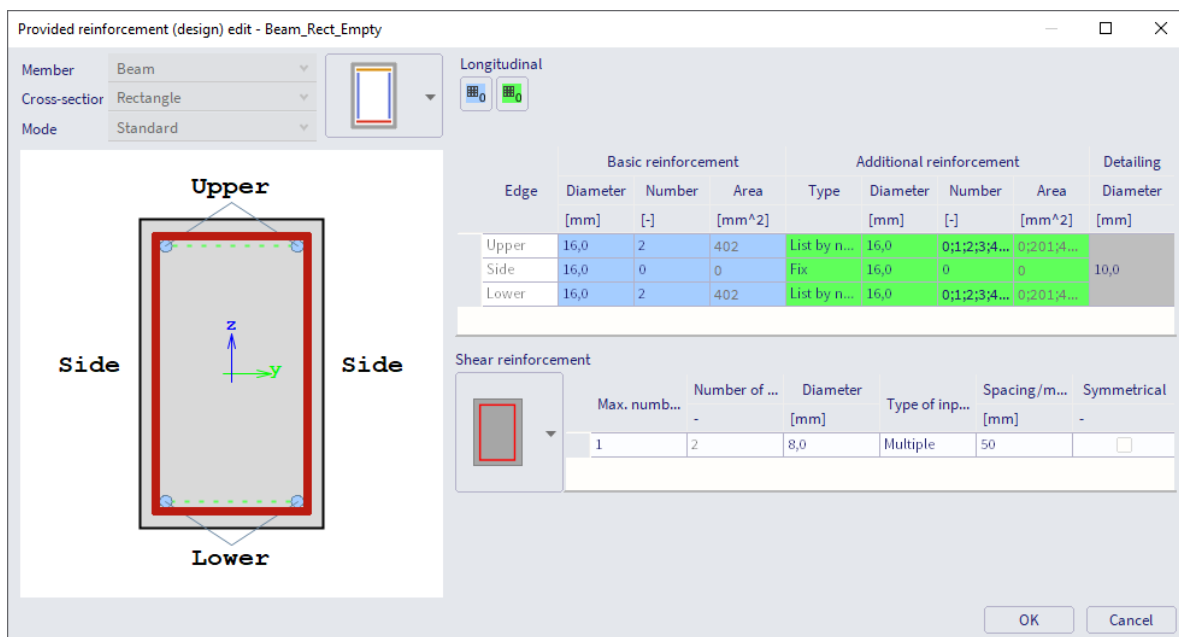
Finally, we are going to explain all of the above once again using a simple example. We start with a simply supported rectangular beam that has some load on it. Looking at the Reinforcement design, we get the following value for the theoretical required reinforcement  $A_{s,req}$ :



You can access the template of the theoretical provided reinforcement of the member by using the action button 'Edit provided reinforcement template' and selecting the member:



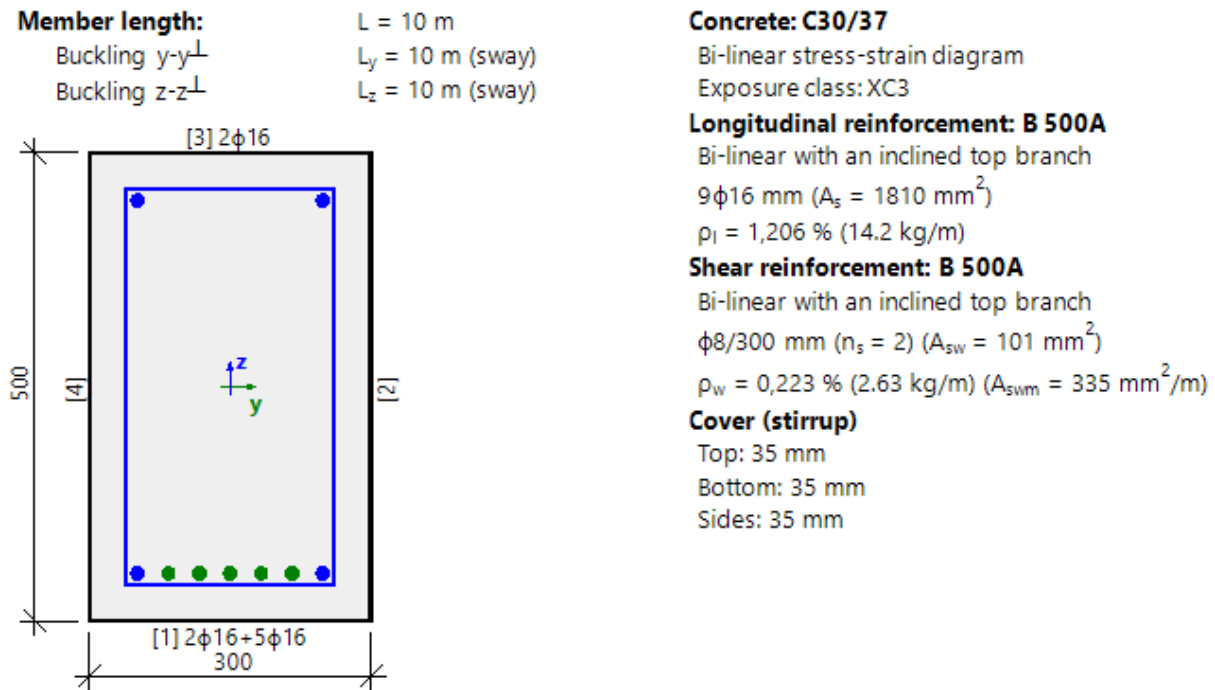
If we take a look at the template of the theoretical provided reinforcement for the beam, we have the following values:





This means that in the provided reinforcement we always have the basic reinforcement of 2 bars – on the upper and lower edge – of diameter 16mm. This can be increased with the values of the additional reinforcement. However, this will only be increased if the provided reinforcement is less than the required reinforcement. This comparison will be done for each section of the beam.

We can now also check in the detailed output how the reinforcement is divided along the beam. Note that this is done per section. For example, for the section  $dx=2.5m$  where the required reinforcement is equal to  $1385mm^2$ , we get the following in the detailed output:



Here we see that on the section  $dx=2.5m$  only lower reinforcement is required. The basic provided reinforcement is equal to 2 bars of diameter 16mm. This value is too low and thus additional provided reinforcement will be inputted. In this case the additional provided reinforcement is equal to 5 bars of diameter 16mm.

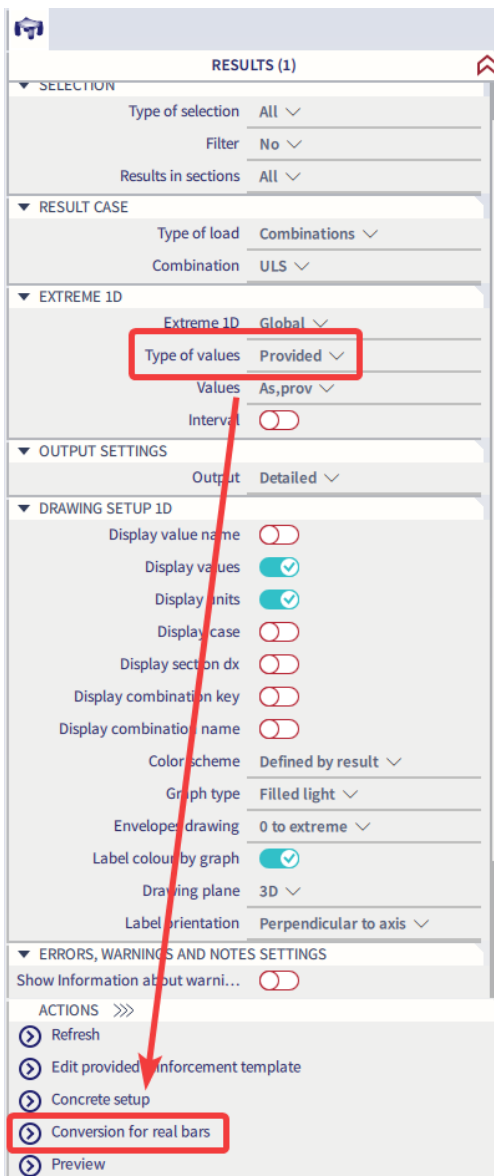
However, the required and provided reinforcement are still theoretical values and thus cannot be used to perform the 1D checks. We will need practical reinforcement.

## Practical reinforcement

In SCIA Engineer you have two options to input practical reinforcement:

### Conversion for real bars

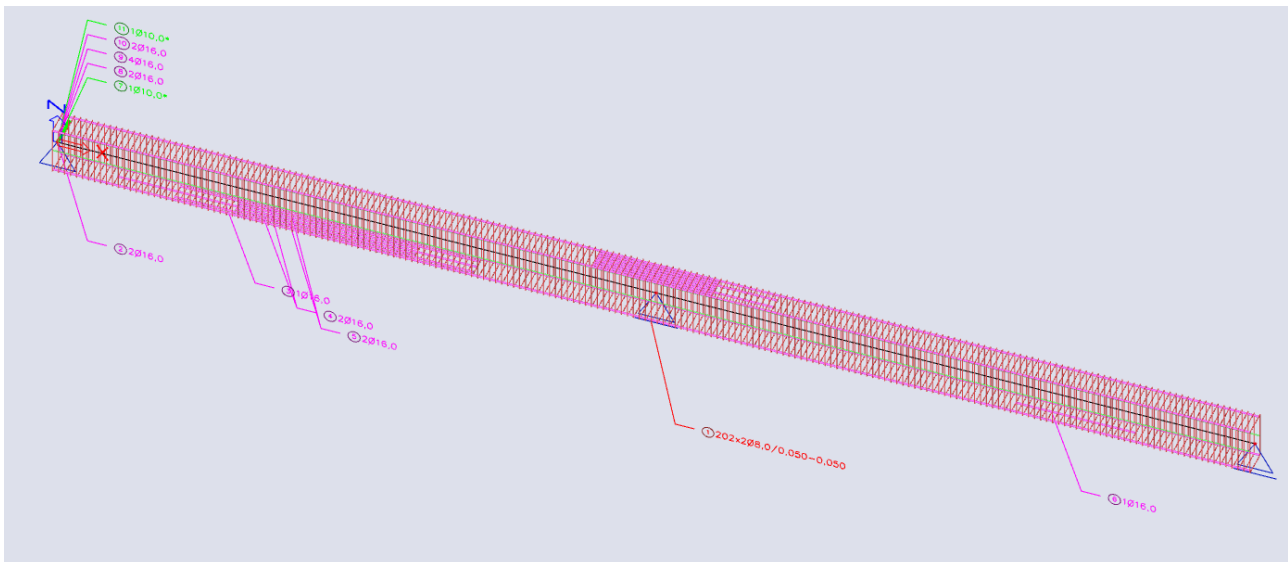
This first option allows you to convert the theoretical provided reinforcement into practical reinforcement. You will need to set 'Type of values' to 'Provided', as you can only convert provided reinforcement to practical reinforcement. This is not possible for required reinforcement. Once the value of the provided reinforcement is available on the beam, you can convert this using 'Conversion for real bars'.



Summary after conversion

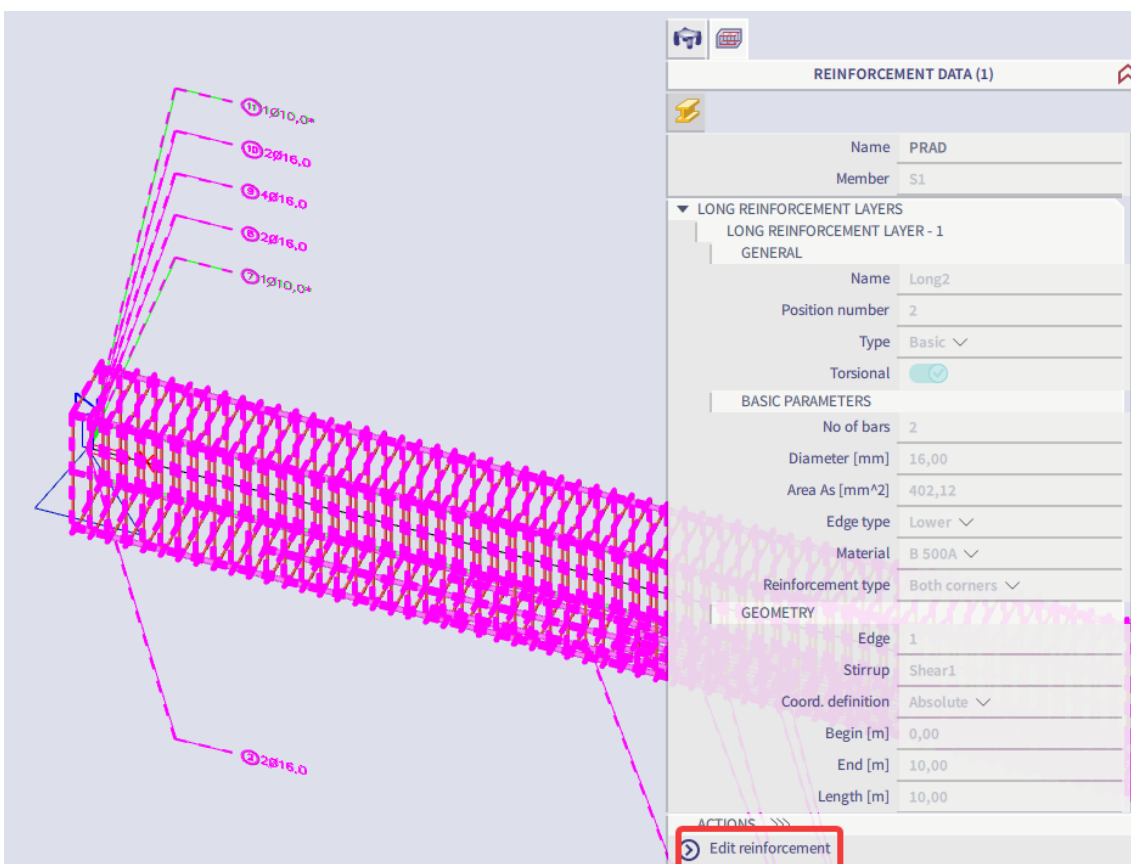
Member	Additional data	Status	Explanation
S1	PRAD	OK	-

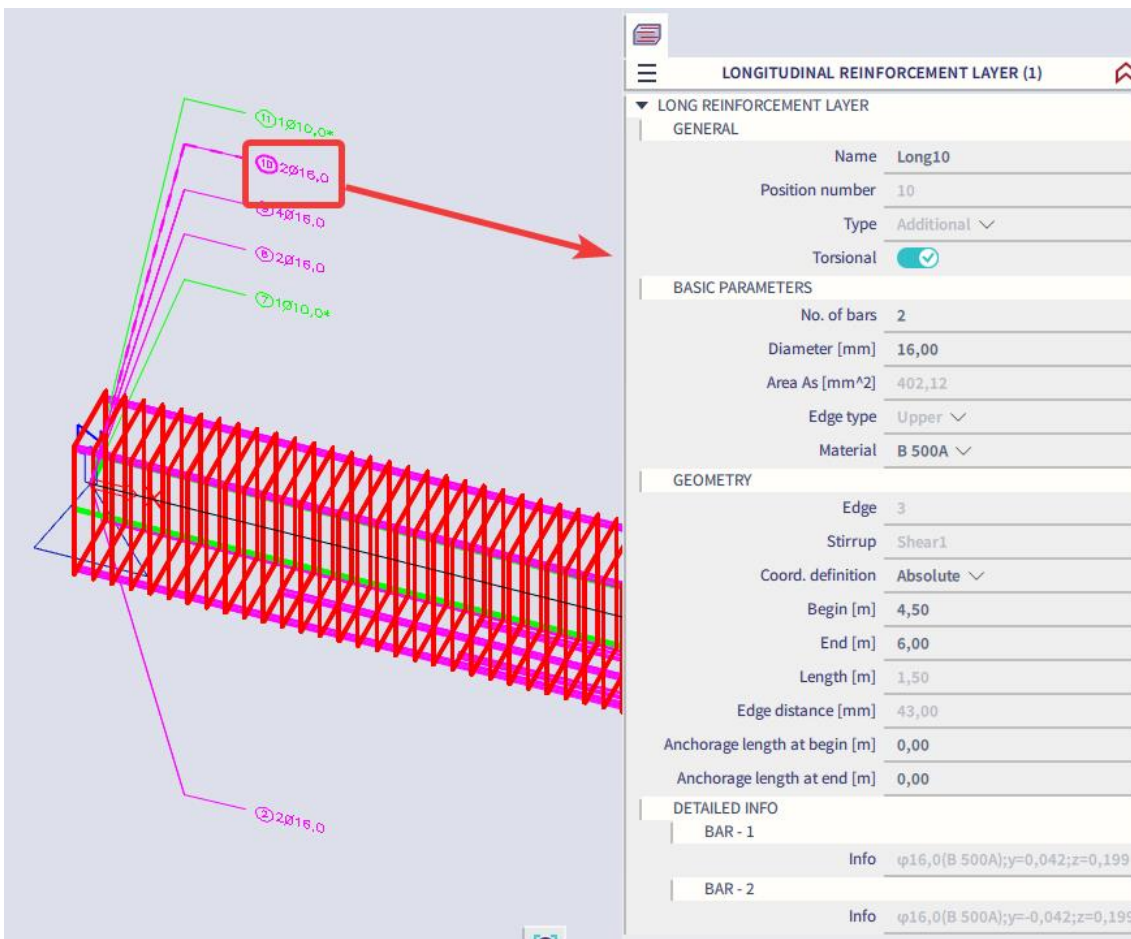
OK



Here we see the basic reinforcement of 2 bars of diameter 16mm along the full length of the beam. On section  $dx=2.5m$  we now have the increased reinforcement of 5 bars of diameter 16mm which is of course coming from additional reinforcement inputted in the template of the provided reinforcement. The values of 1 bar of diameter 10 is the detailing reinforcement that is required to meet the detailing provisions. The shear reinforcement is also presented along the length of the beam.

This practical reinforcement can also be edited if necessary. First, you select the reinforcement. Then you can choose 'Edit reinforcement' under Actions. Finally, you select the reinforcement you want to edit:



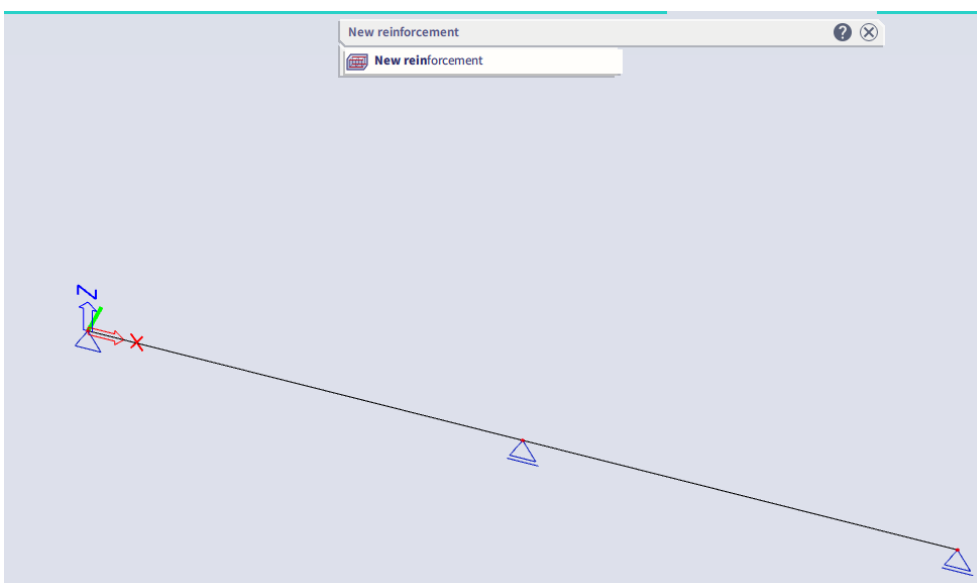


This practical reinforcement will now be used when performing the 1D checks.

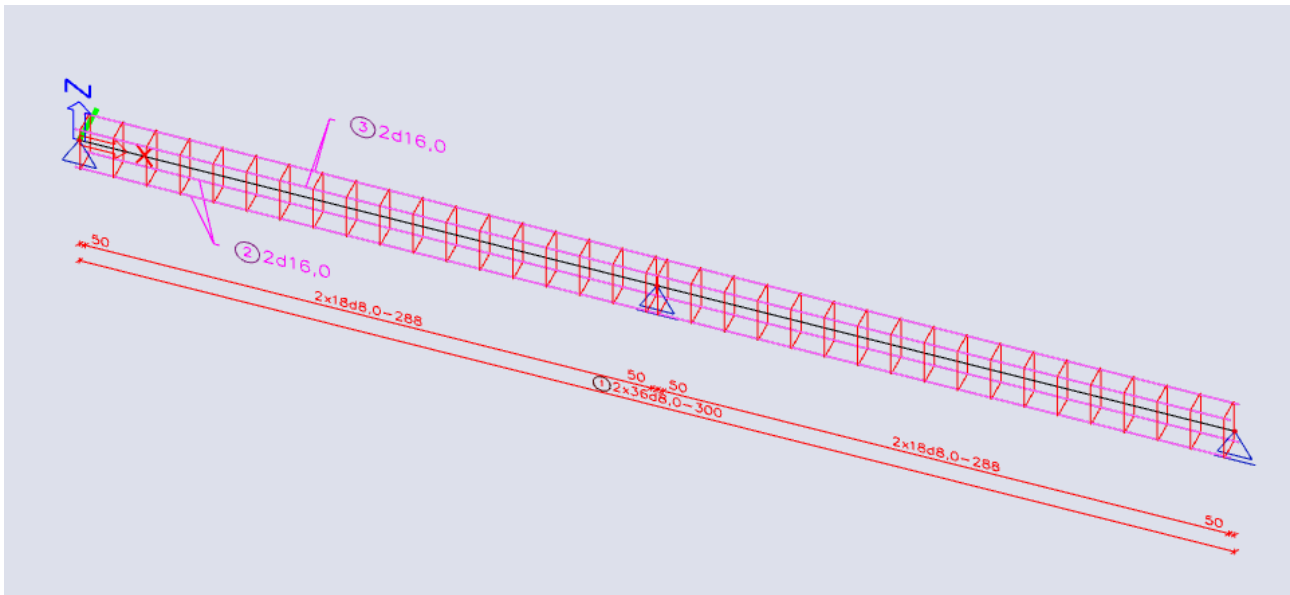
### Input practical reinforcement

This second option allows you to input a template which then automatically will be inputted over the chosen length of the beam. Note that using this option, you can add additional zones of reinforcement, which is (currently) not possible when converting the reinforcement from theoretical to practical.

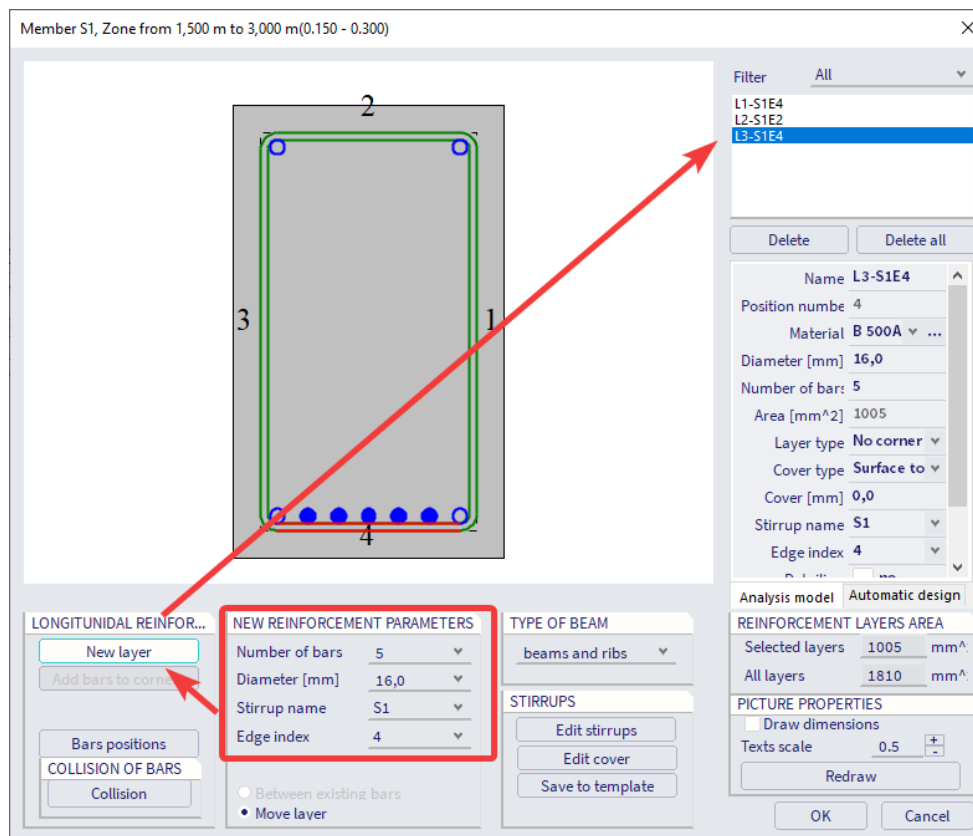
We first choose the option 'New reinforcement' and select a start and end point where the reinforcement will be inputted:

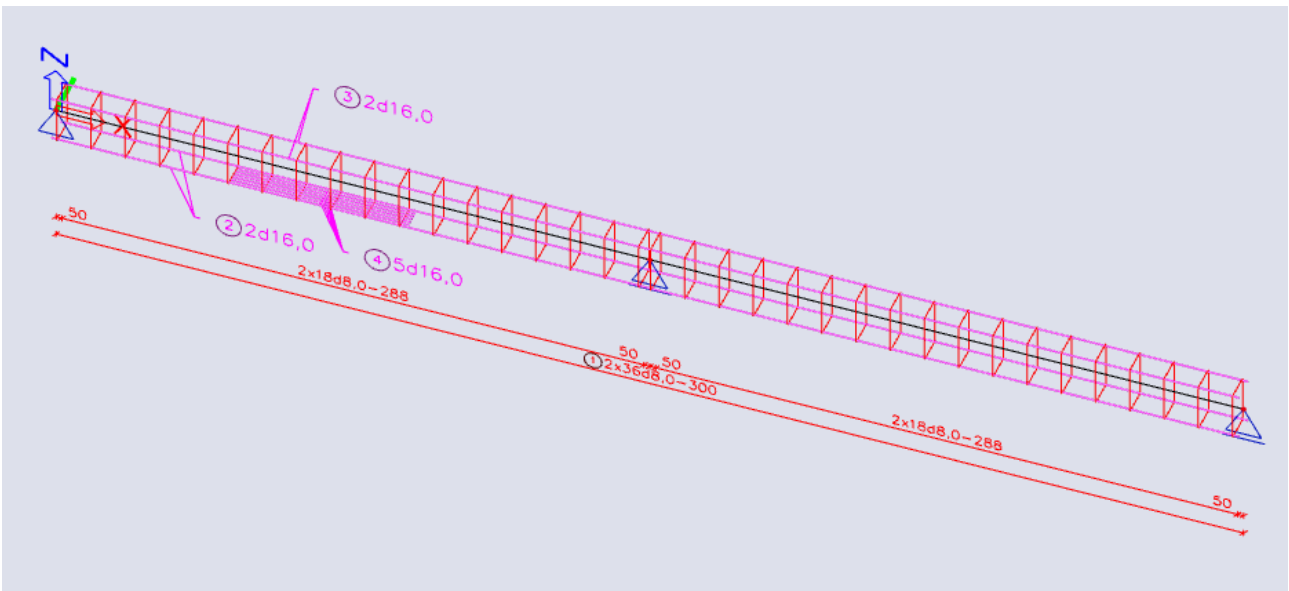


Now we can choose an existing template or make a new one. When making a new one, you first need to select a stirrup or again, make a new one. We will choose the first available template and input this without making any special adjustments:

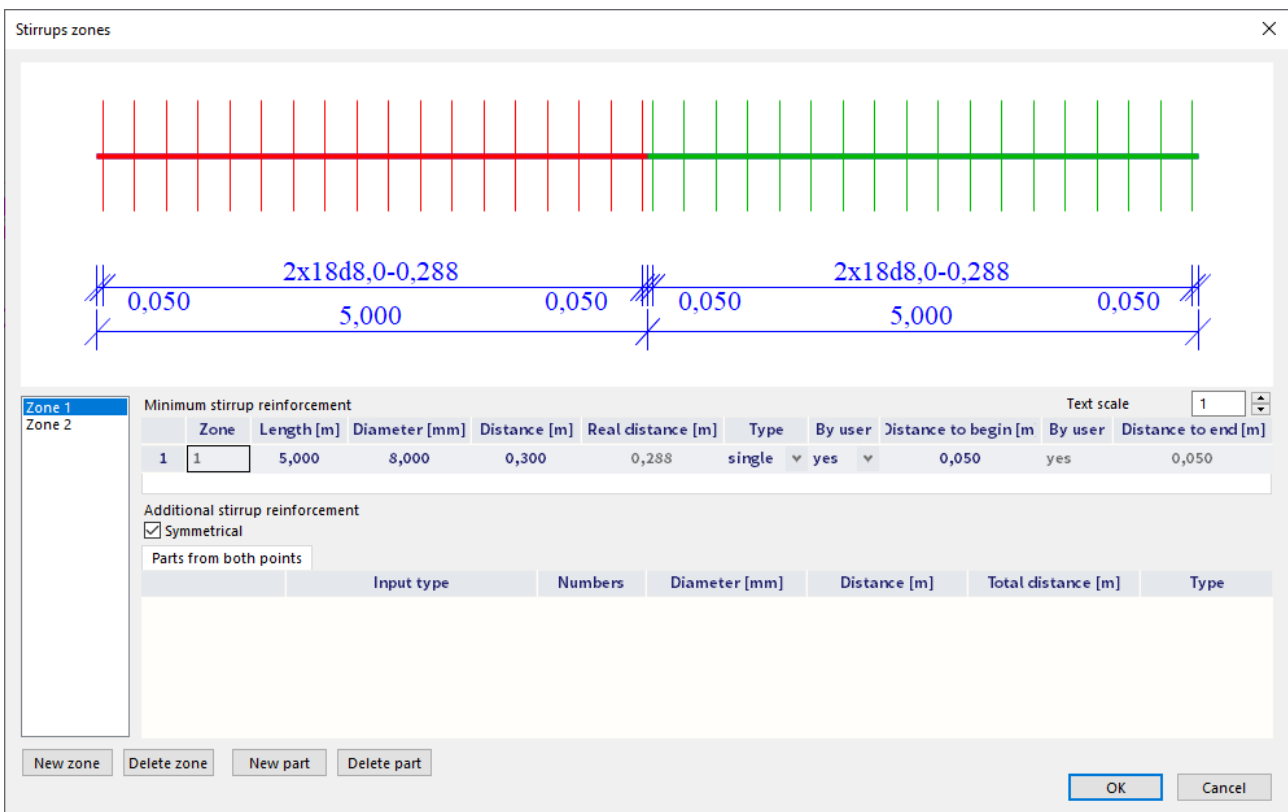


We can also adjust these zones of reinforcement if necessary, by selecting them and changing the parameters in the properties window. However, in this case we want to add the 4 bars of diameter 16 to the middle of the first span. Therefore, we need to choose 'New longitudinal bars' and choose the length of this new zone. We will input the bars over a length of 2m:





The next step is to change the shear reinforcement. First, select the shear reinforcement. Then, choose 'Edit stirrups distances' under Actions and the following window will pop up:



Currently we have two zones over the full length of the beam. We can create a new zone by first making the current zone shorter. Instead of the full length of 10m we will choose 2,5m for this zone. Then we can make new zones of 5m and 2,5m:

Stirrups zones

2x9d8,0-0,300  
0,050 2,500 0,050

2x18d8,0-0,288  
0,050 5,000 0,050

2x10d8,0-0,277  
0,004 2,500 0,004

Zone 1  
Zone 2  
Zone 3

Minimum stirrup reinforcement

Zone	Length [m]	Diameter [mm]	Distance [m]	Real distance [m]	Type	By user	Distance to begin [m]	By user	Distance to end [m]
1	0,300	8,000	0,300	0,300	single	yes	0,050	yes	0,050

Additional stirrup reinforcement

Symmetrical

Parts from both points

Input type	Numbers	Diameter [mm]	Distance [m]	Total distance [m]	Type
------------	---------	---------------	--------------	--------------------	------

New zone Delete zone New part Delete part

OK Cancel

Now we can adjust the distances for each separate zone. For example: Zone 1 = 0,1m; Zone 2 = 0,2m; Zone 3 = 0,3m:

Stirrups zones

2x25d8,0-0,100  
0,050 2,500 0,050

2x26d8,0-0,196  
0,050 5,000 0,050

2x10d8,0-0,277  
0,004 2,500 0,004

Zone 1  
Zone 2  
Zone 3

Minimum stirrup reinforcement

Zone	Length [m]	Diameter [mm]	Distance [m]	Real distance [m]	Type	By user	Distance to begin [m]	By user	Distance to end [m]
1	0,100	8,000	0,2	0,196	single	yes	0,050	yes	0,050

Additional stirrup reinforcement

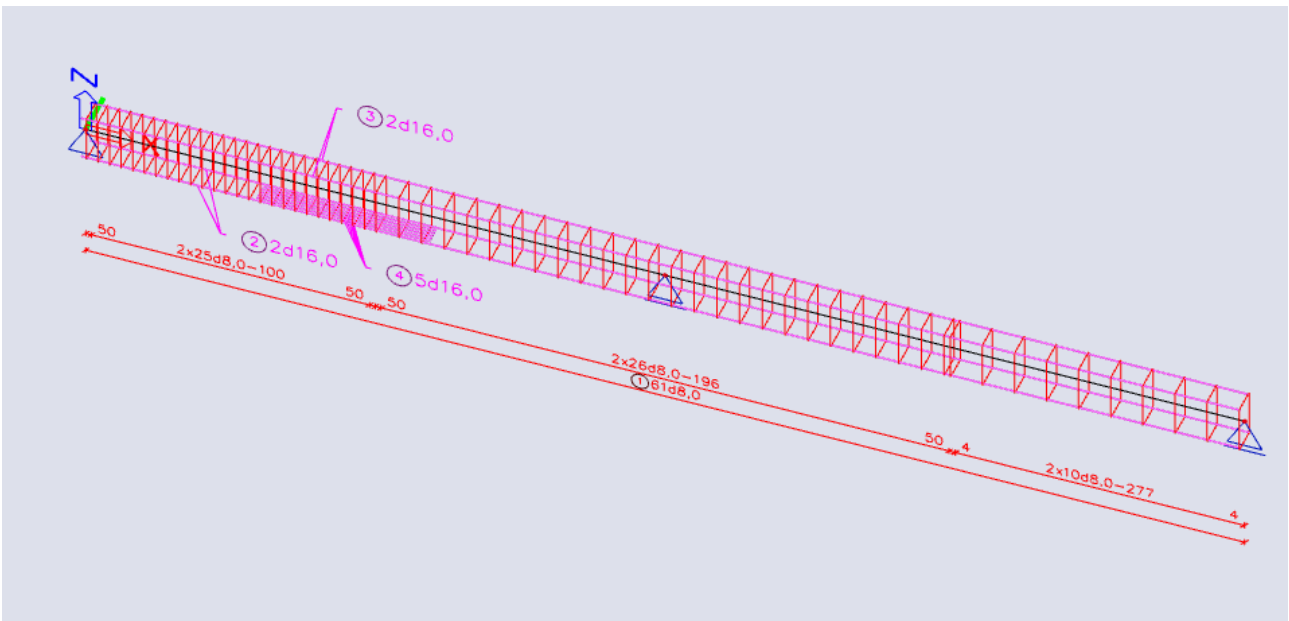
Symmetrical

Parts from both points

Input type	Numbers	Diameter [mm]	Distance [m]	Total distance [m]	Type
------------	---------	---------------	--------------	--------------------	------

New zone Delete zone New part Delete part

OK Cancel



Finally, after all necessary adjustments are made and the practical reinforcement is inputted, this can be used to perform the 1D checks.