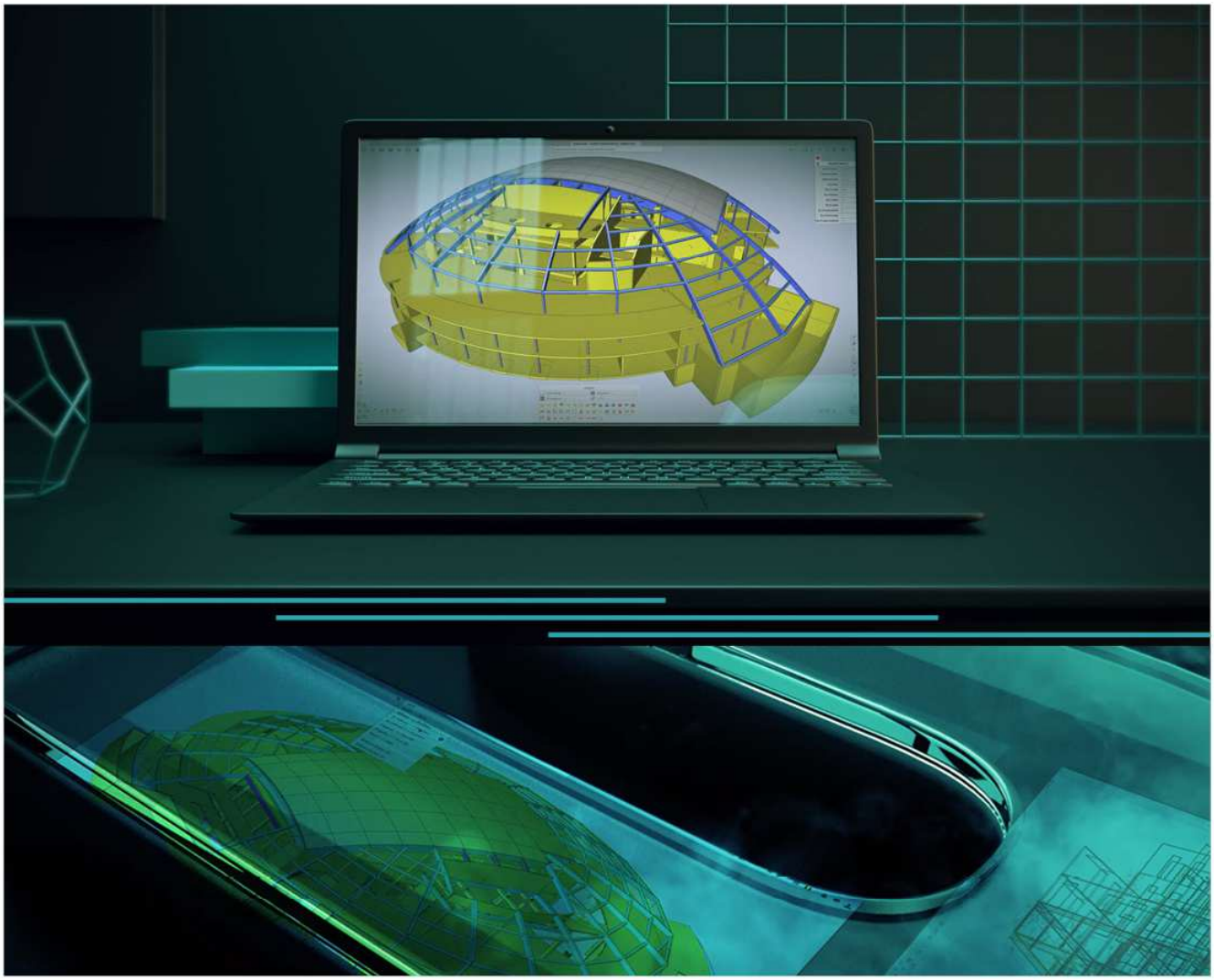
SCIA ENGINEER



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

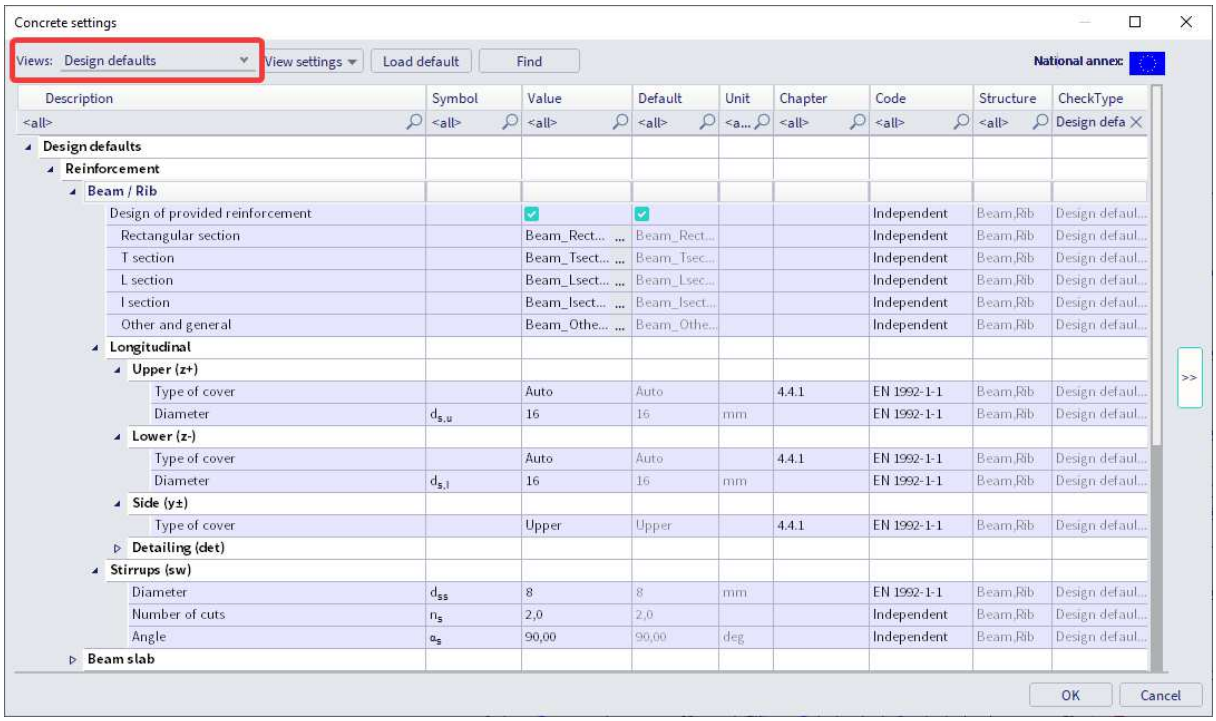
The theoretical reinforcement is calculated out of the recalculated internal forces. It gives the amount of reinforcement needed to resist the internal forces induced by ULS loads. Since there are several workflows possible to design concrete 1D elements, the theoretical reinforcement design is not mandatory 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 (mm²) of the reinforcement that is necessary in every section of the beam.

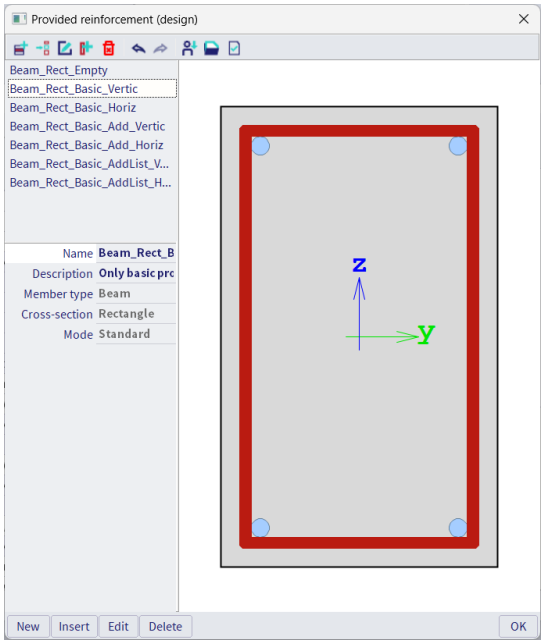
- **Provided reinforcement:** The provided reinforcement is a template added to each beam/column consisting of basic and additional reinforcement.

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.



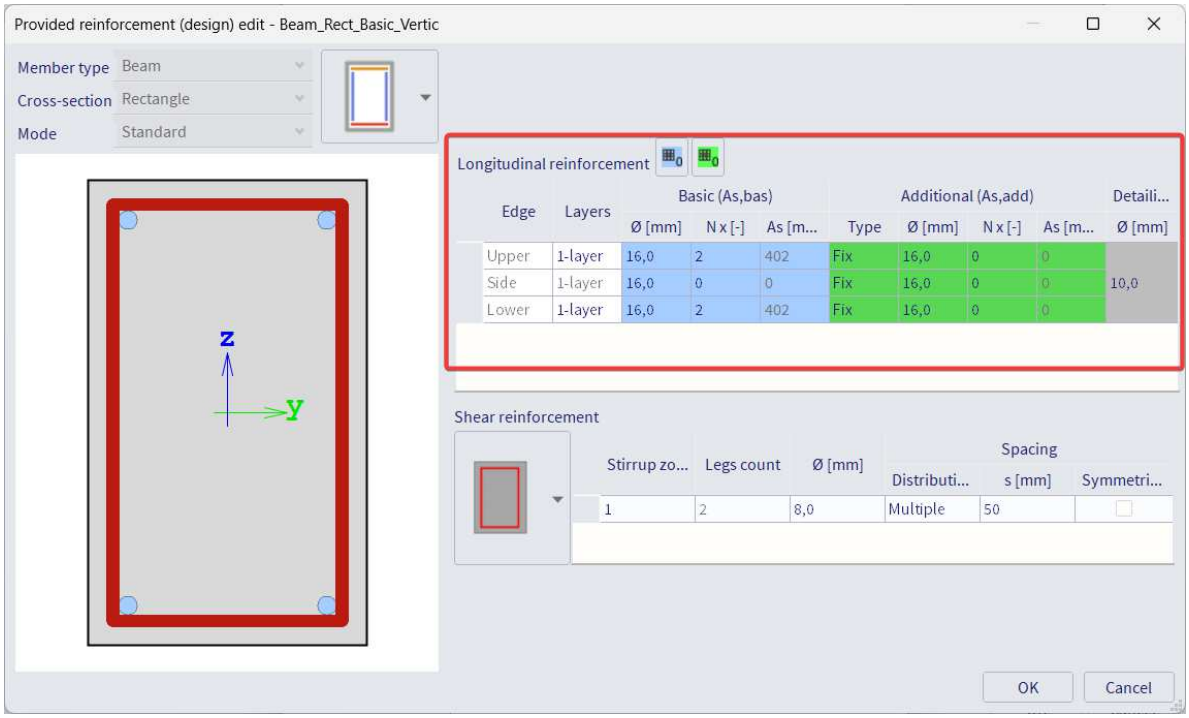
Several default templates for longitudinal reinforcement and stirrups are available for the different section types (provided reinforcement). These can be changed, or new ones can be made.



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.

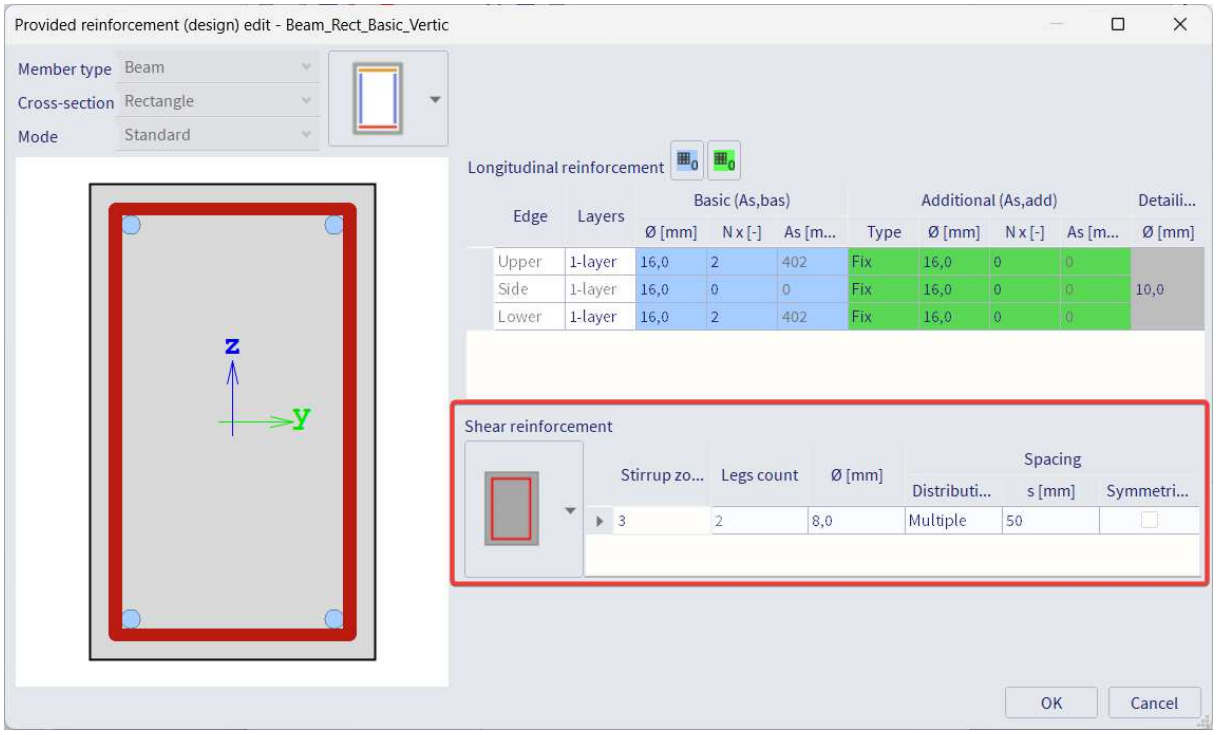
Longitudinal reinforcement

By default, one layer is used. However you have the possibility the set multiple layers where the provided reinforcement will be inputted. 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.

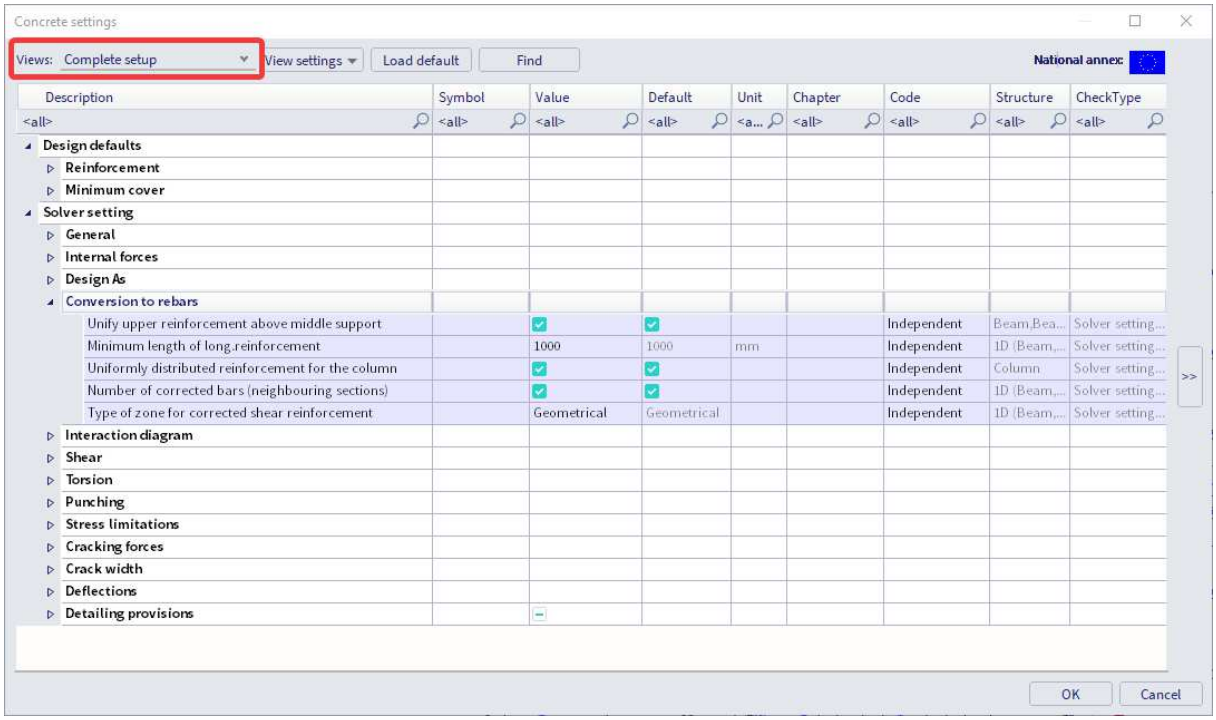


Shear reinforcement

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:

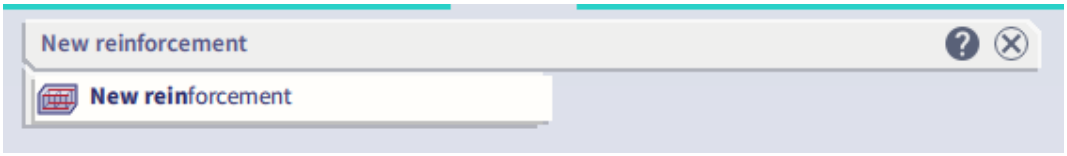


Practical reinforcement

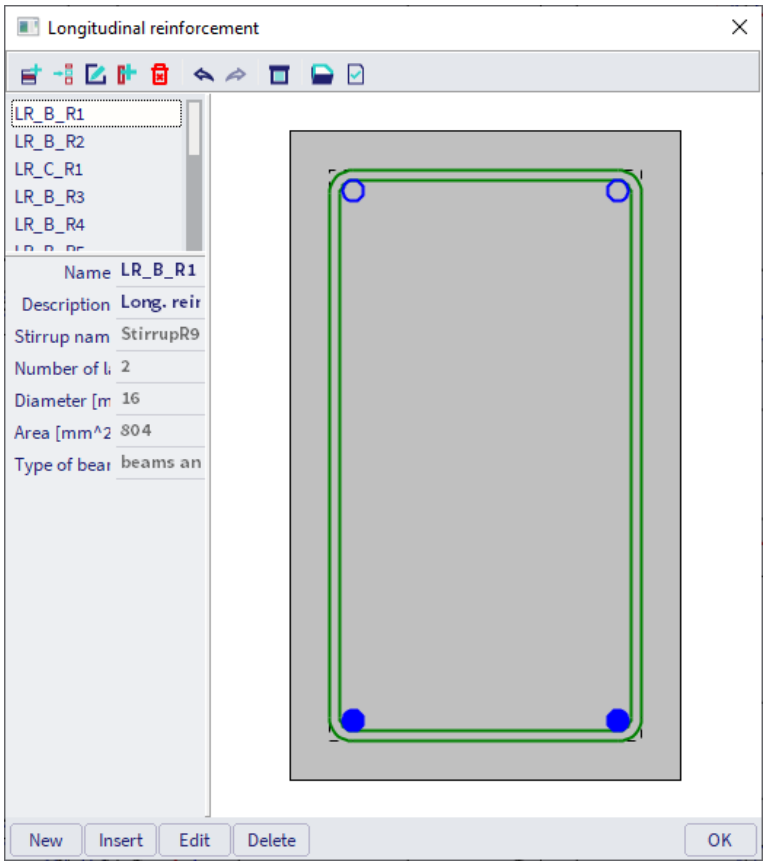
We will now pass on to the level of practical reinforcement. This will allow us to specify the reinforcement locally over the beam.

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

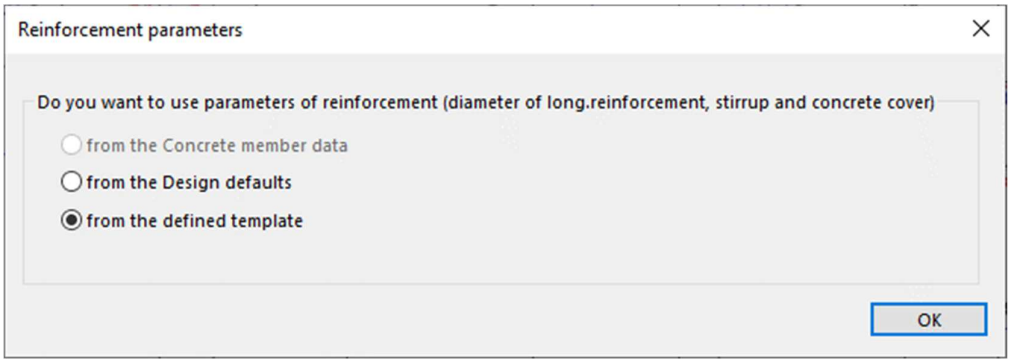
This allows us to input manually the practical reinforcement by adding New reinforcement in the SCIA Spotlight:



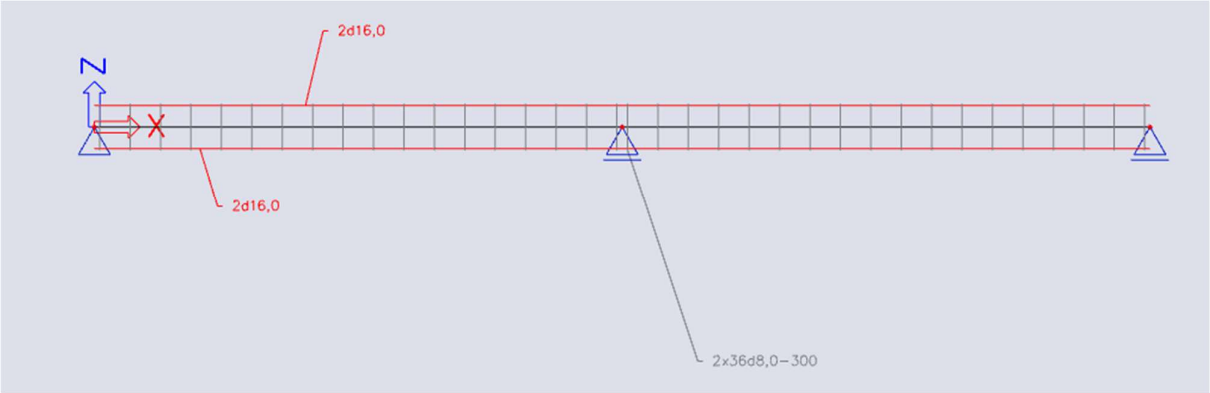
We can first select a template for the longitudinal reinforcement:



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

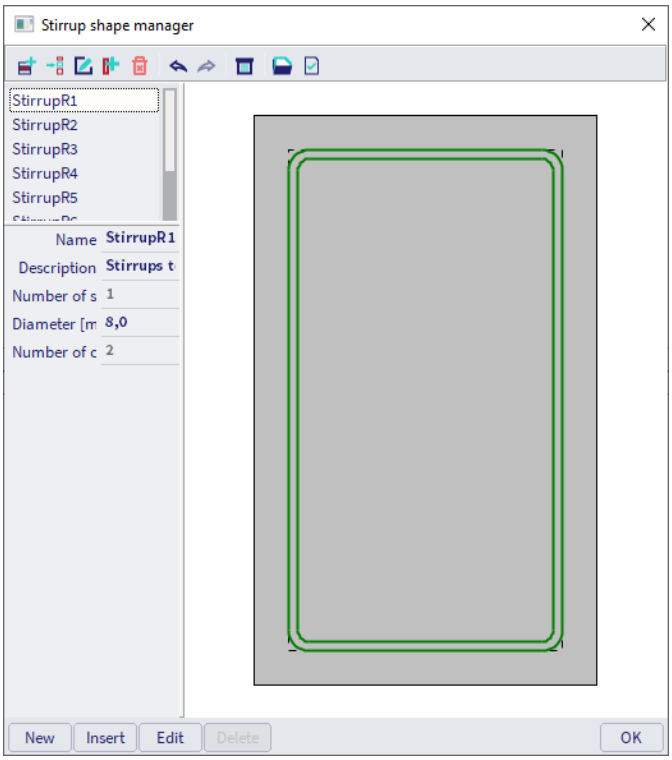


The practical reinforcement is then shown graphically on the screen:

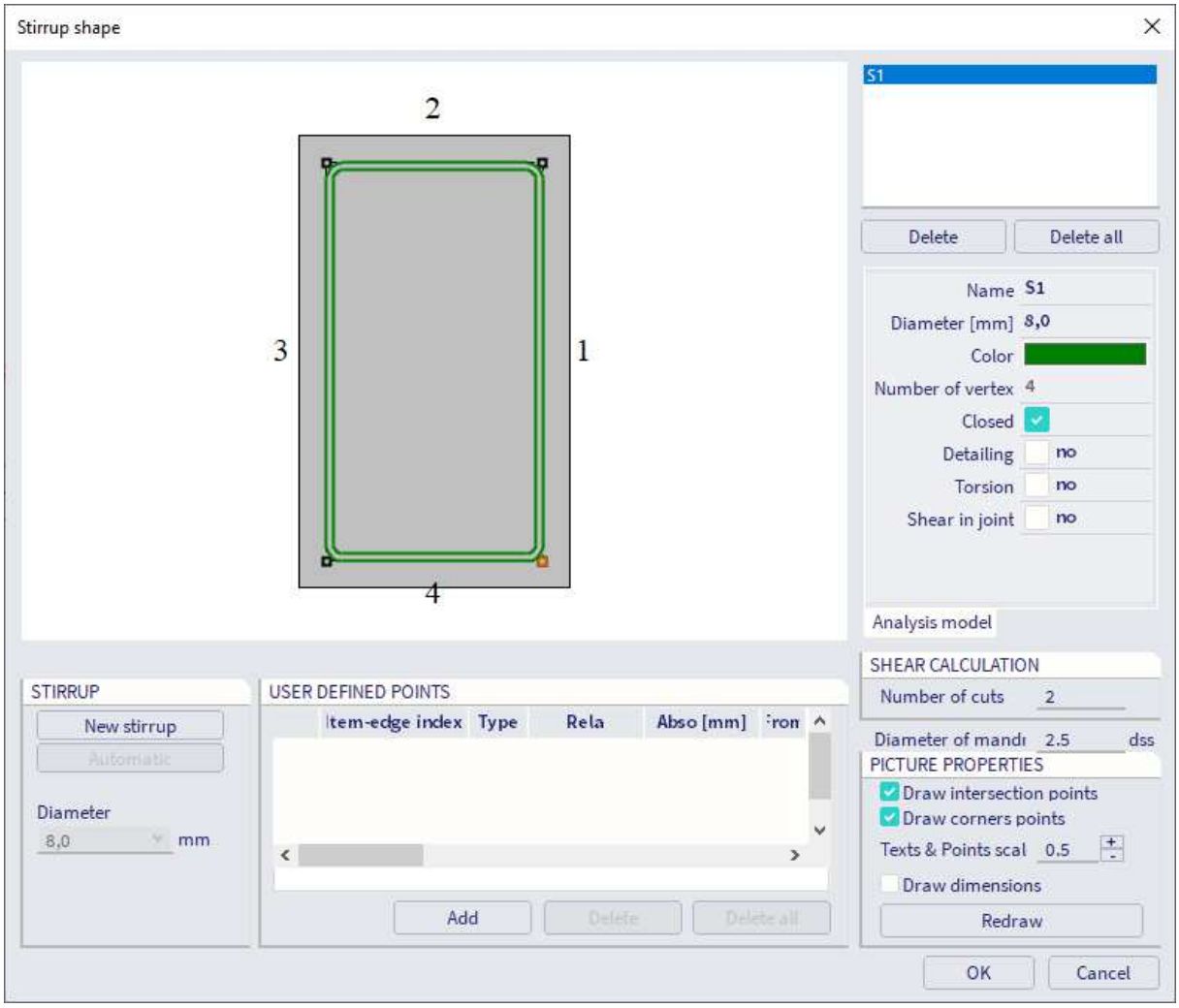


As a user, you can add locally New stirrups or New longitudinal bars.

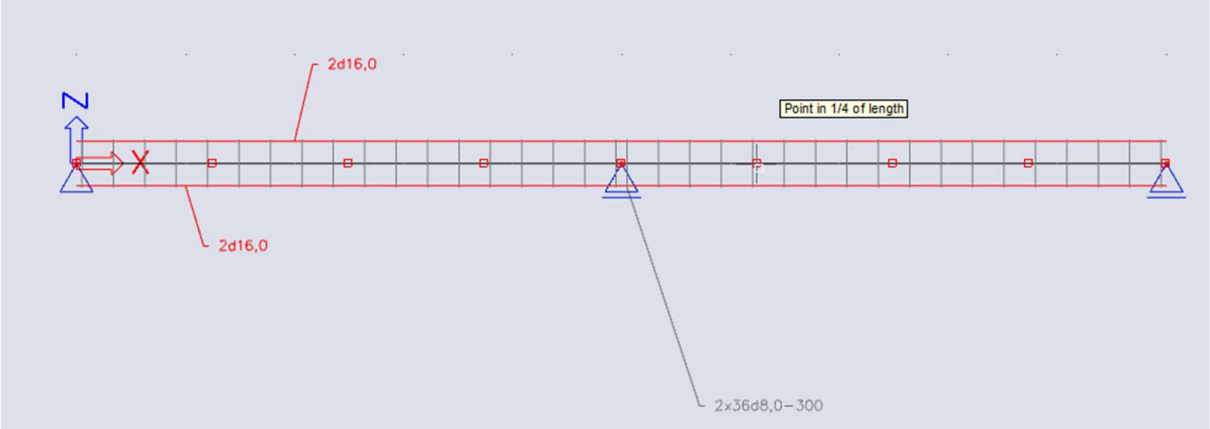
For the stirrups, you can select a certain stirrup shape:



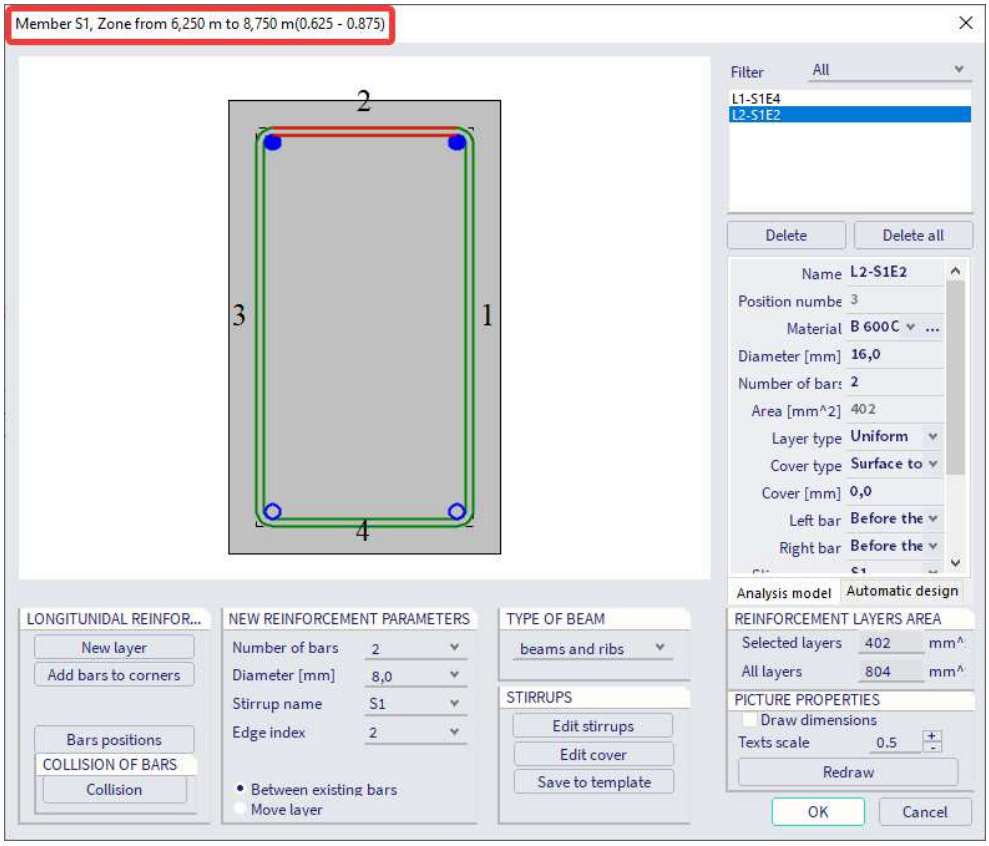
The stirrup shape can be edited or a new one can be made. Therefore, user points may be added.



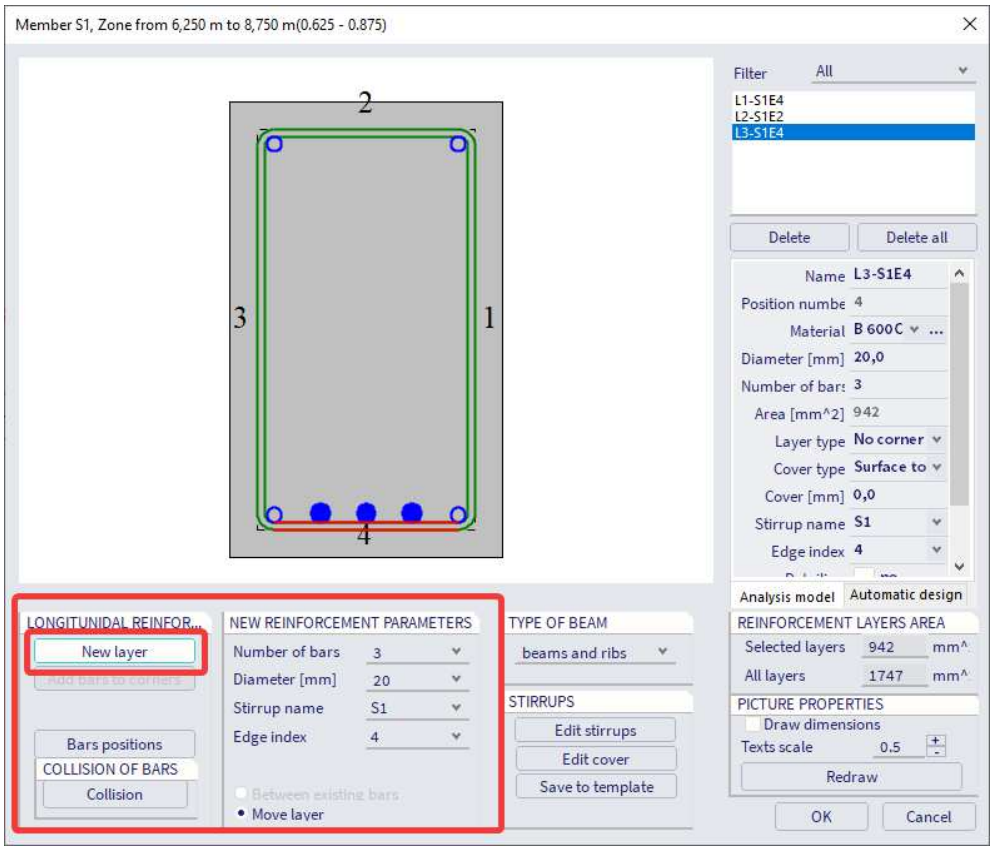
For the longitudinal reinforcement, we can define precisely where the extra practical reinforcement needs to be putted:



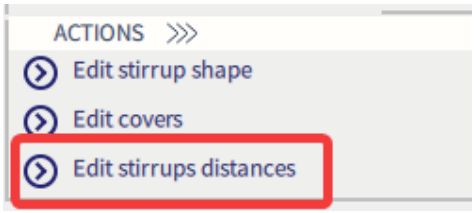
The configuration for the selected zone of the member is shown:

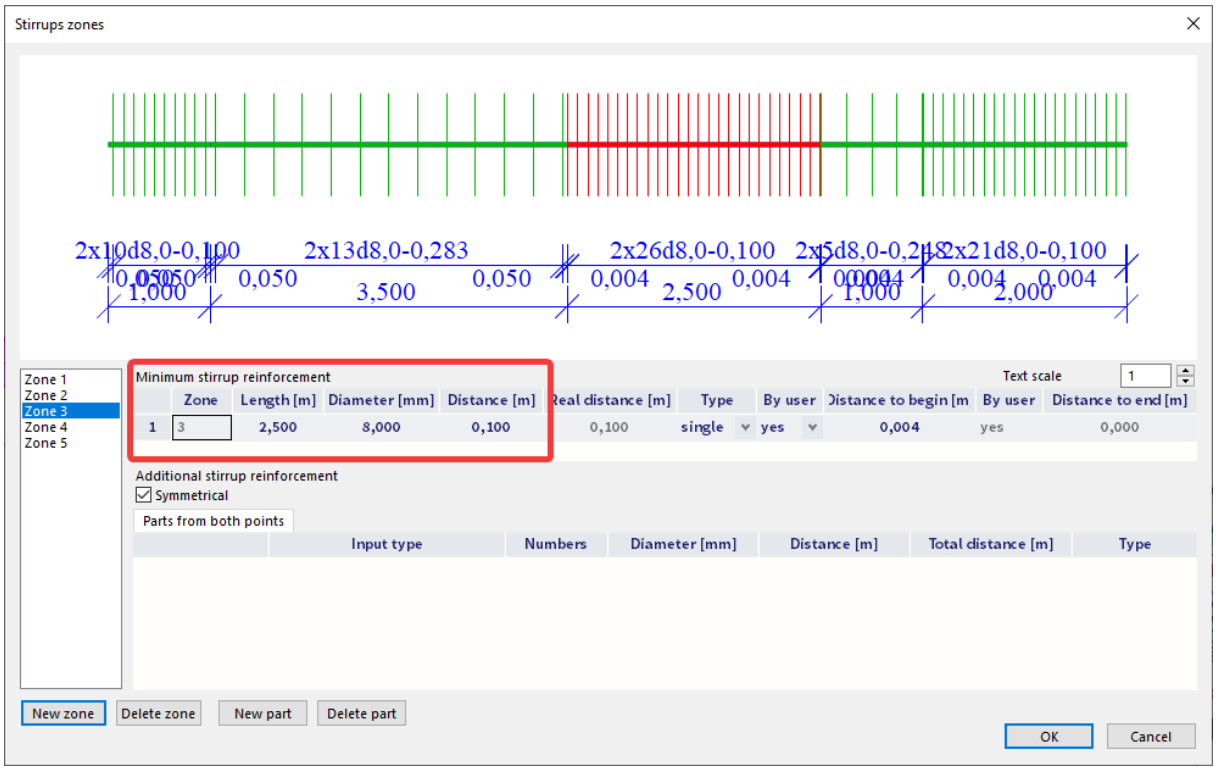


Here can be set on which face extra reinforcement needs to be added:



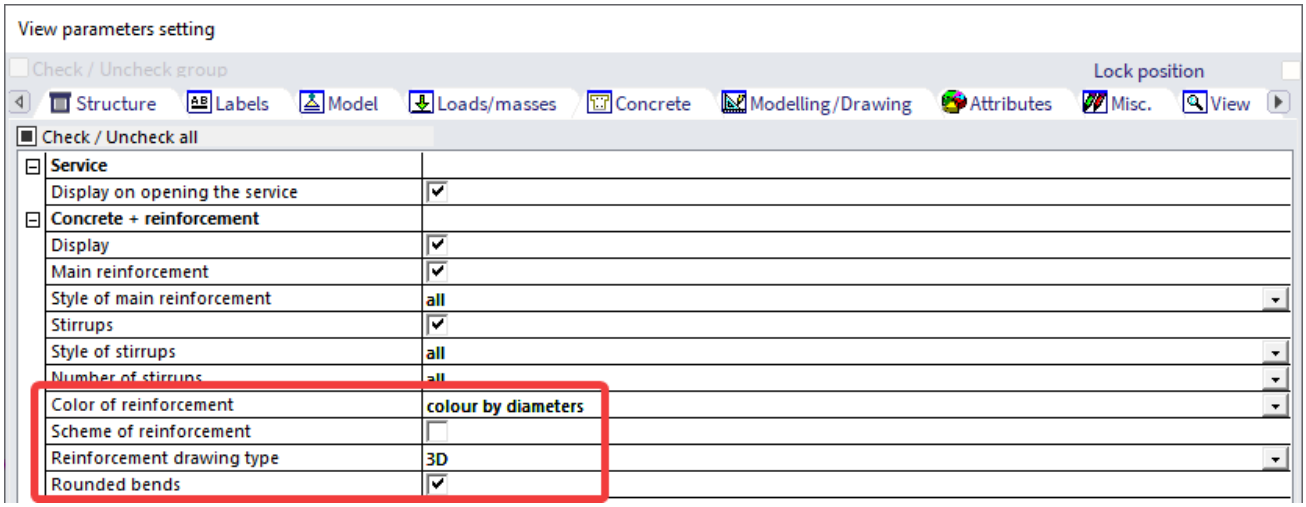
Different stirrup zones can be created when editing the stirrup distance. First select the stirrups and then choose the action:



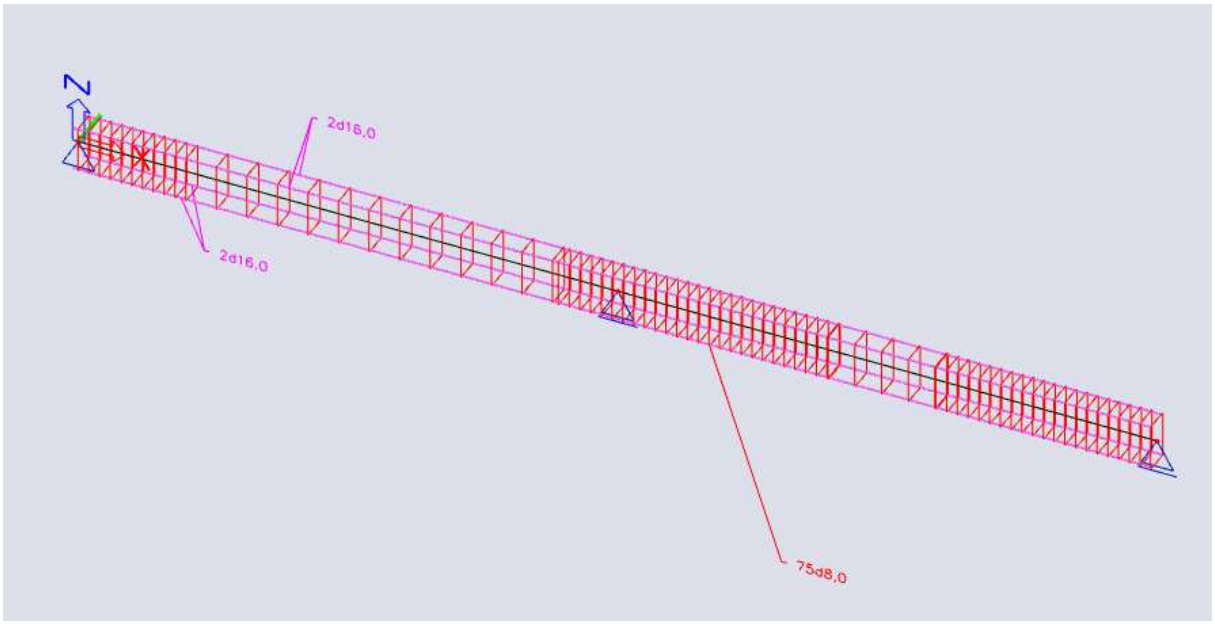


By selecting the reinforcement, it is always possible to change the parameters afterwards through the property window.

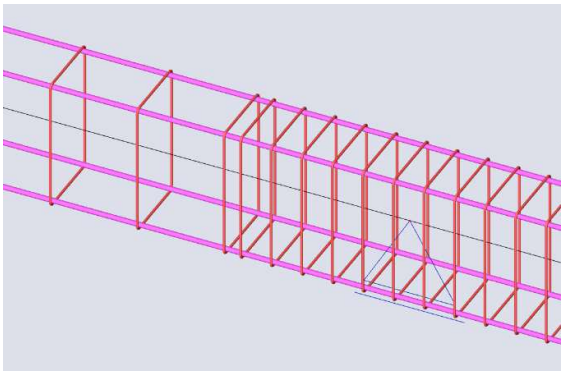
Through view parameter settings a 3D representation of the reinforcement can be obtained:



The total practical reinforcement of the beam is shown below:



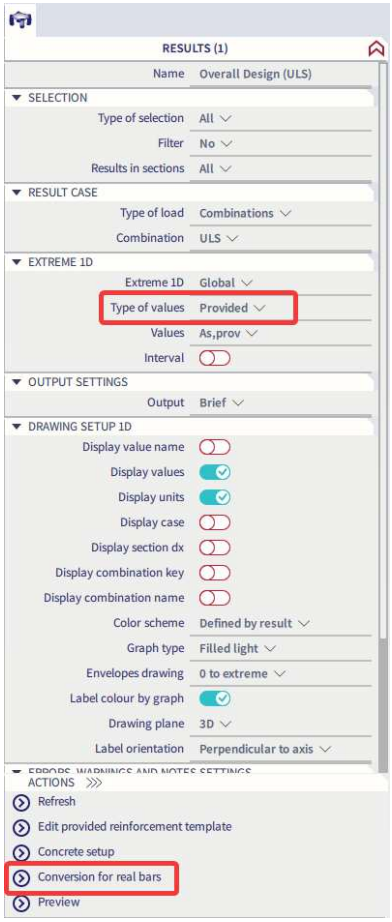
A zoomed view shows the 3D representation:



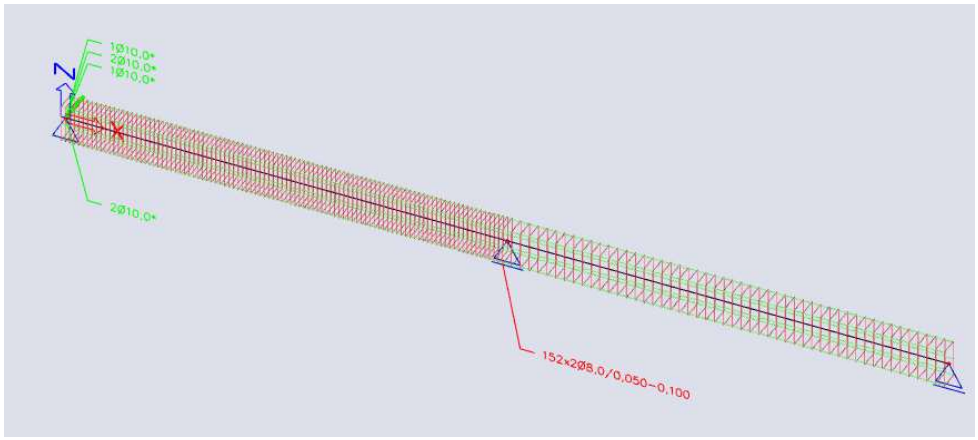
Conversion of theoretical reinforcement into practical reinforcement

It is also possible to convert theoretical reinforcement into practical reinforcement. As already mentioned there are two types of theoretical reinforcmeent: **Required reinfocement** (= mm² necessary in each section) and **Provided reinforcement** (= template of reinforcement with various ammounts of additional reinforcement possible). It is only possible to convert **Provided reinforcement** into practical (=user) reinforcement.

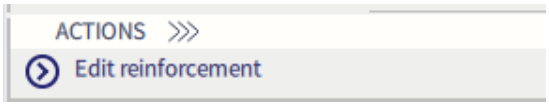
Go to Reinforcement design and look at the value As,prov. This is the provided reinforcement that will be converted into practical reinforcement. Once this is generated, you can convert the provided reinforcement using 'Conversion for real bars' under Actions:



The theoretical provided reinforcement will be converted to practical reinforcement:



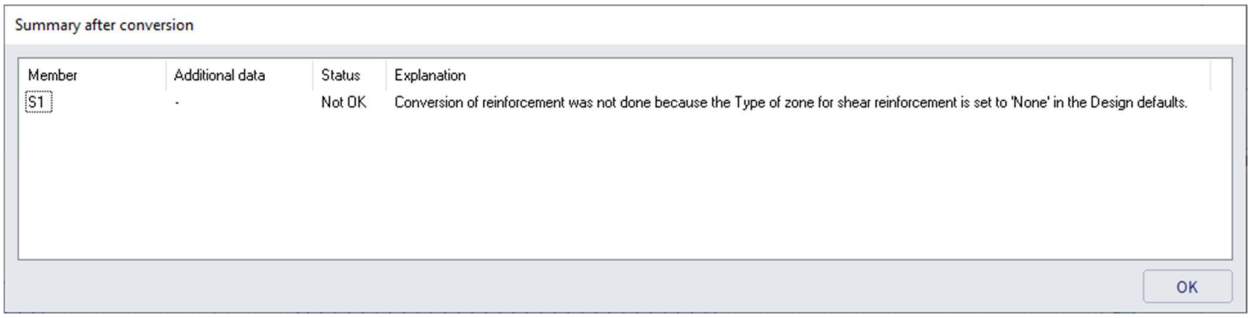
The practical reinforcement is added as reinforcement data. You can edit the reinforcement by selecting it and then click on ‘Edit reinforcement’.



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:

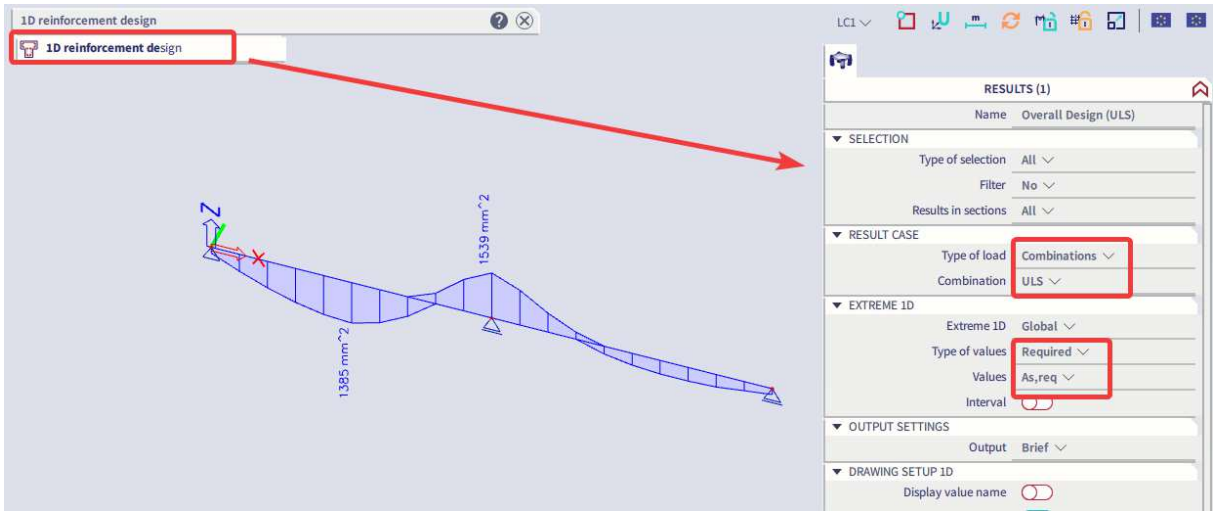
It might occur the error message **‘Conversion of reinforcement was not done because the Type of zone of shear reinforcement is set to ‘None’ in the Design defaults’** appears within the summary after conversion when converting the provided reinforcement into real bars. This behaviour is caused due to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



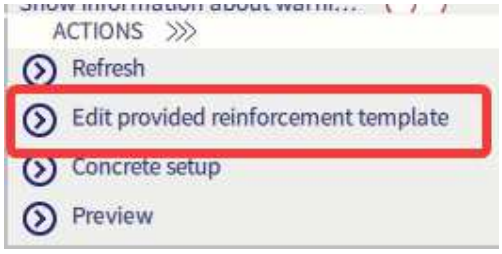
Example

Theoretical reinforcement

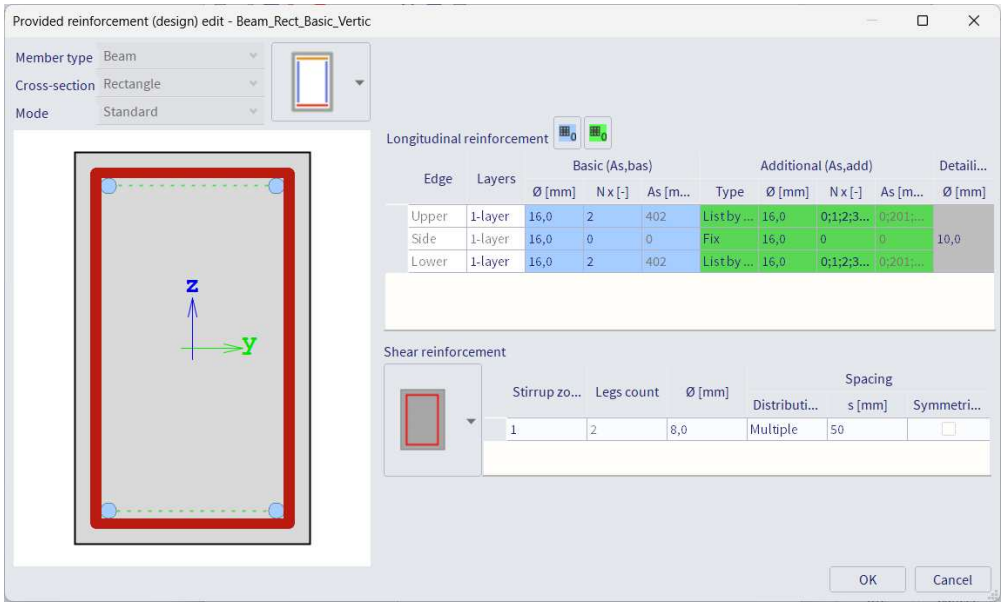
Finally, we are going to explain all of the above once again using a simple example. We start with a simply supported rectangular beam that has some load on it. Looking at the Reinforcement design, we get the following value for the theoretical required reinforcement As,req:



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:

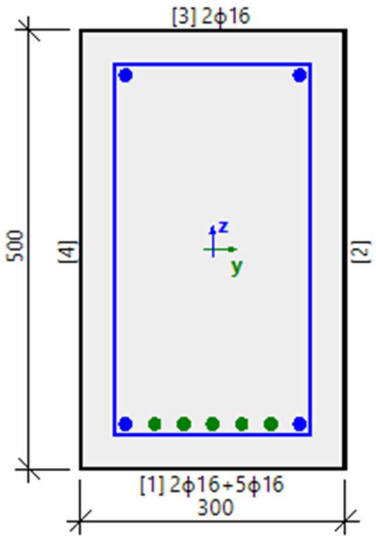


If we take a look at the template of the theoretical provided reinforcement for the beam, we have the following values:



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 1385mm², we get the following in the detailed output:



Member length: L = 10 m
Buckling y-y: L_y = 10 m (sway)
Buckling z-z: L_z = 10 m (sway)

Concrete: C30/37
Bi-linear stress-strain diagram
Exposure class: XC3

Longitudinal reinforcement: B 500A
Bi-linear with an inclined top branch
9ϕ16 mm (A_s = 1810 mm^2)
ρ_l = 1,206 % (14.2 kg/m)

Shear reinforcement: B 500A
Bi-linear with an inclined top branch
ϕ8/300 mm (n_s = 2) (A_{sw} = 101 mm^2)
ρ_w = 0,223 % (2.63 kg/m) (A_{swm} = 335 mm^2/m)

Cover (stirrup)
Top: 35 mm
Bottom: 35 mm
Sides: 35 mm

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.

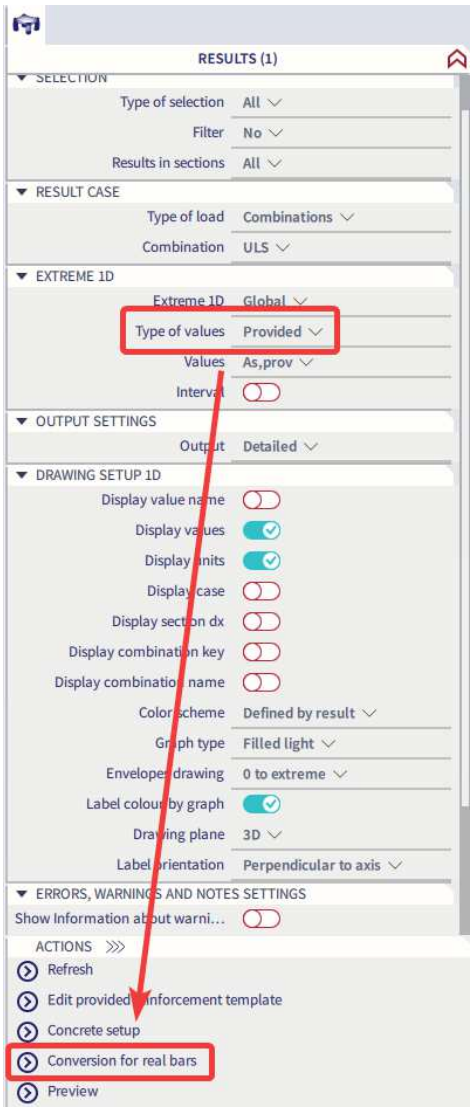
However, the required and provided reinforcement are still theoretical values and thus cannot be used to perform the 1D checks. We will need practical reinforcement.

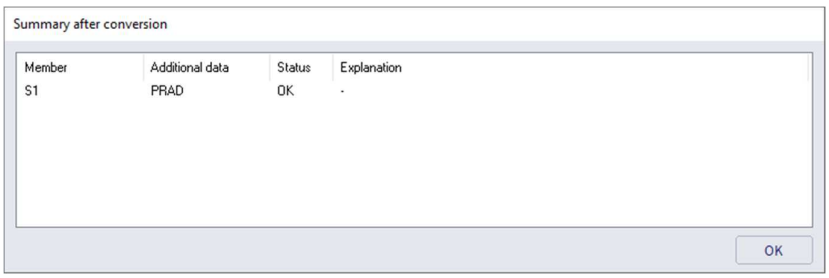
Practical reinforcement

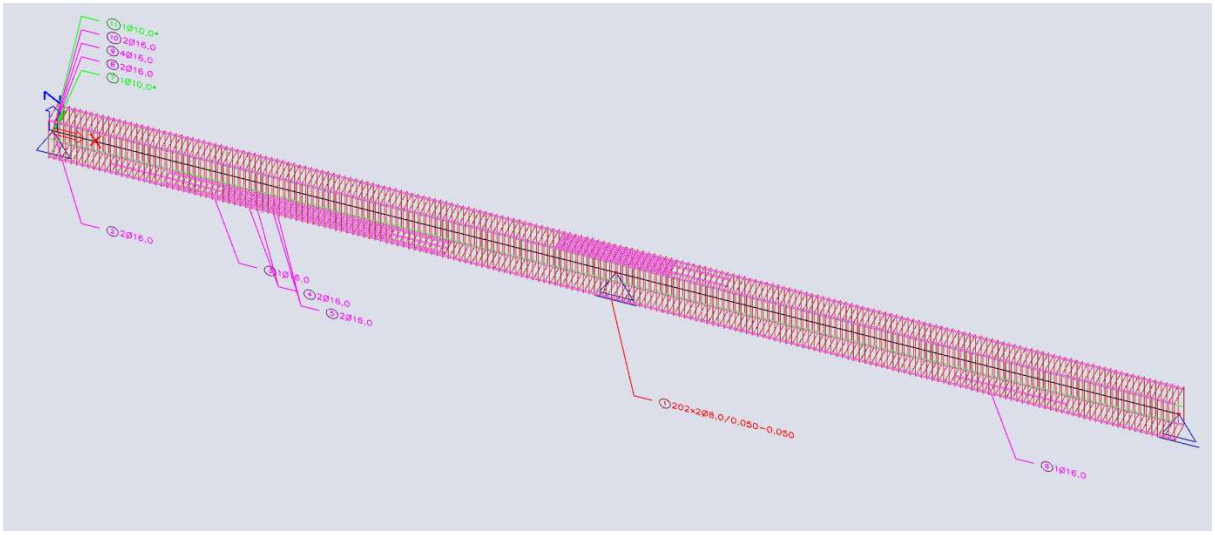
In SCIA Engineer you have two options to input practical reinforcement:

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'.

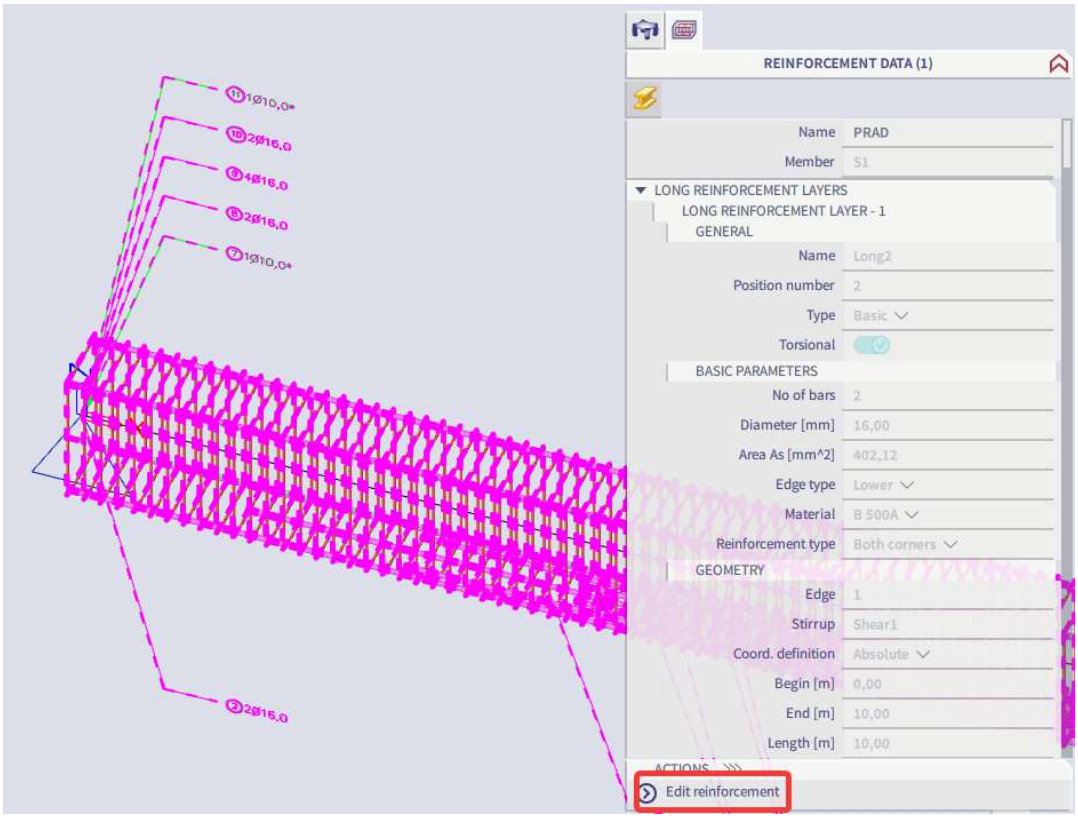


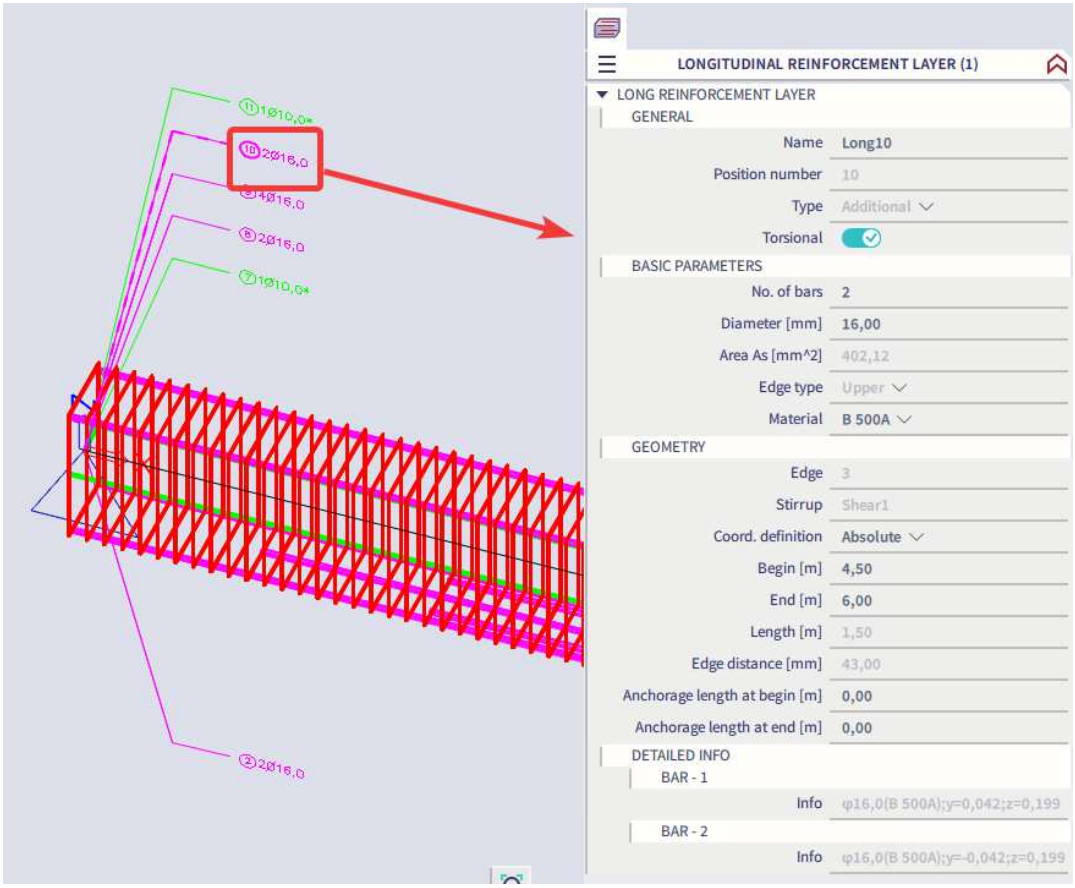




Here we see the basic reinforcement of 2 bars of diameter 16mm along the full length of the beam. On section dx=2.5m we now have the increased reinforcement of 5 bars of diameter 16mm which is of course coming from additional reinforcement inputted in the template of the provided reinforcement. The values 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:



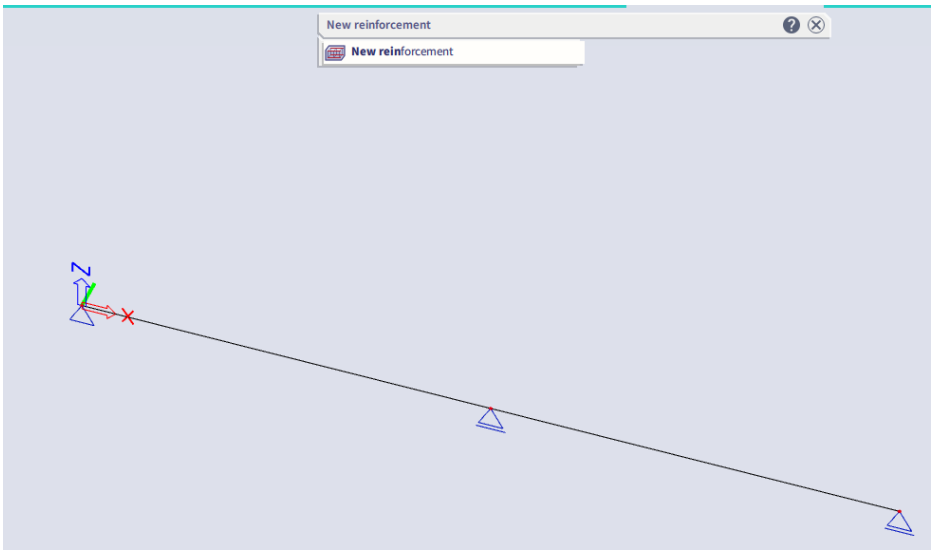


This practical reinforcement will now be used when performing the 1D checks.

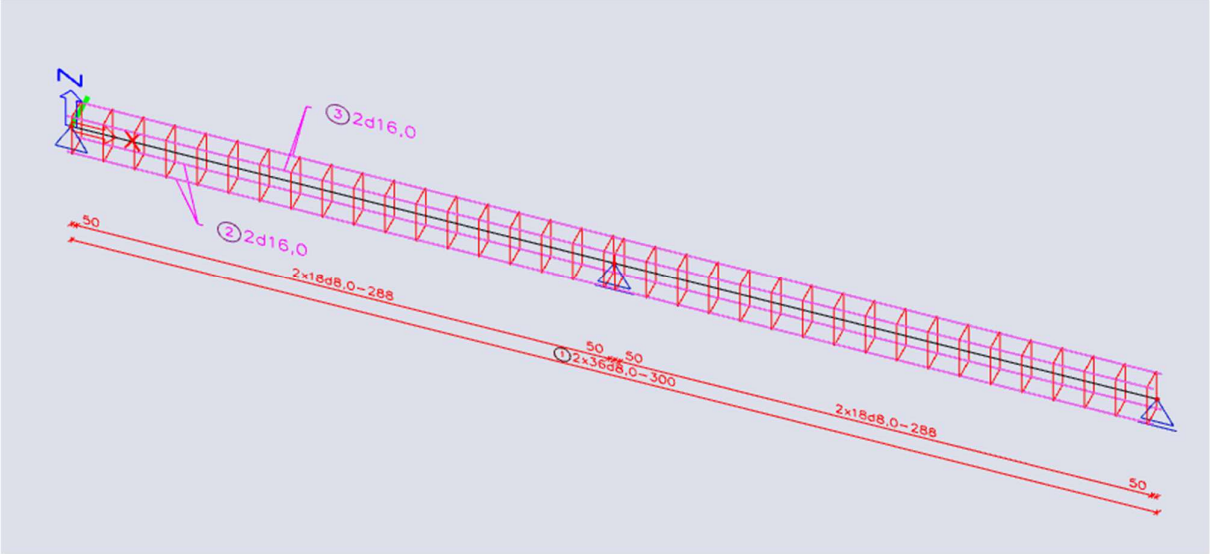
Input practical reinforcement

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.

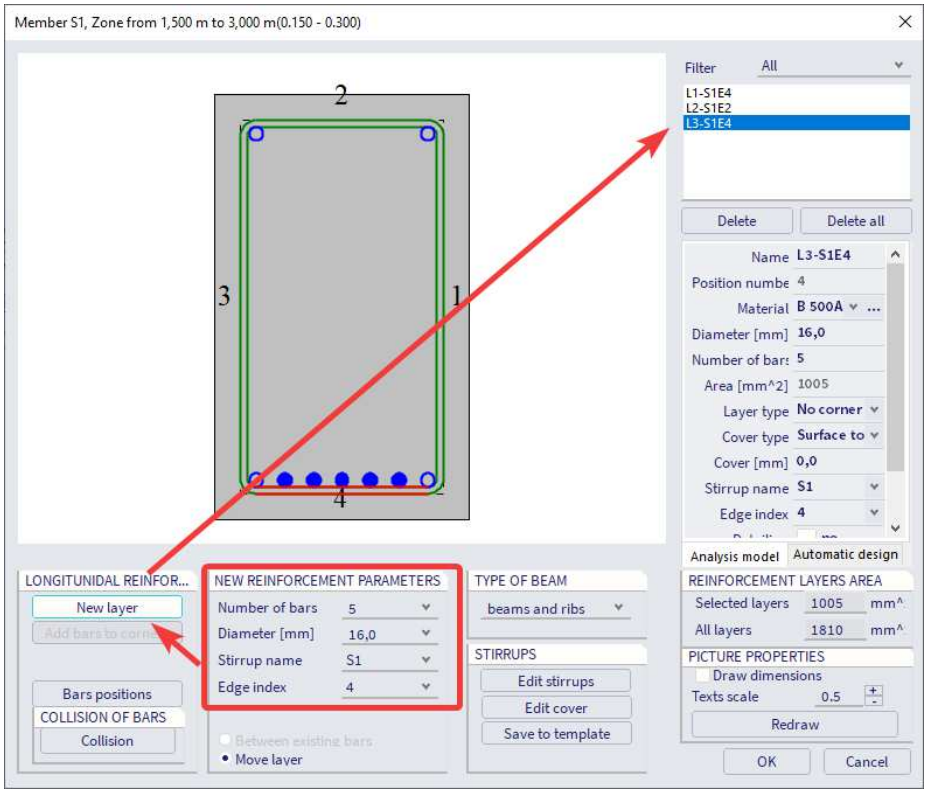
We first choose the option ‘New reinforcement’ and select a start and end point where the reinforcement will be inputted:

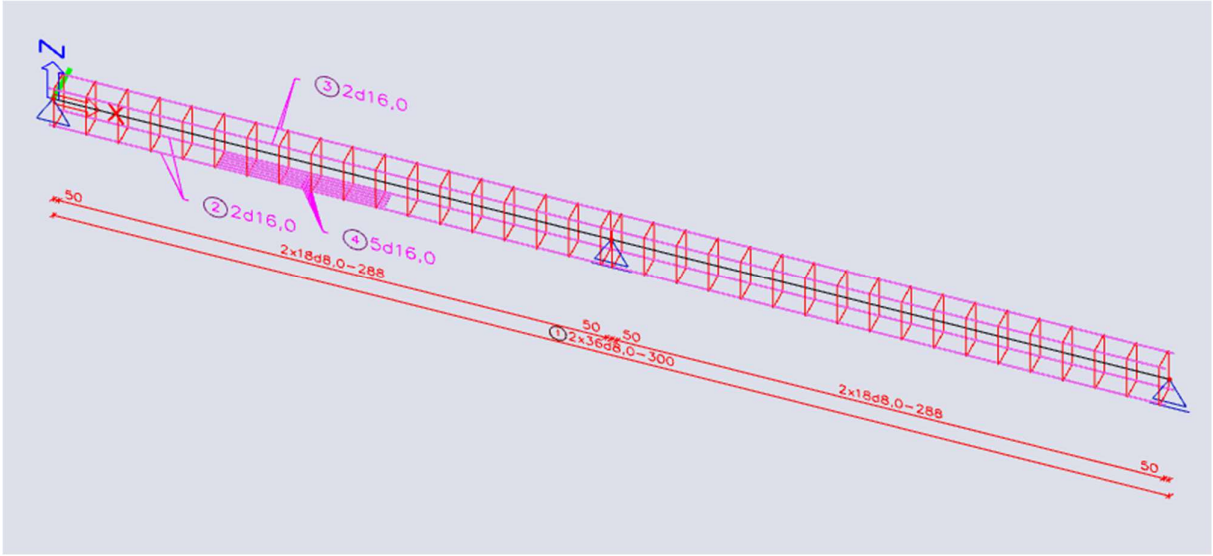


Now we can choose an existing template or make a new one. When making a new one, you first need to select a stirrup or again, make a new one. We will choose the first available template and input this without making any special adjustments:

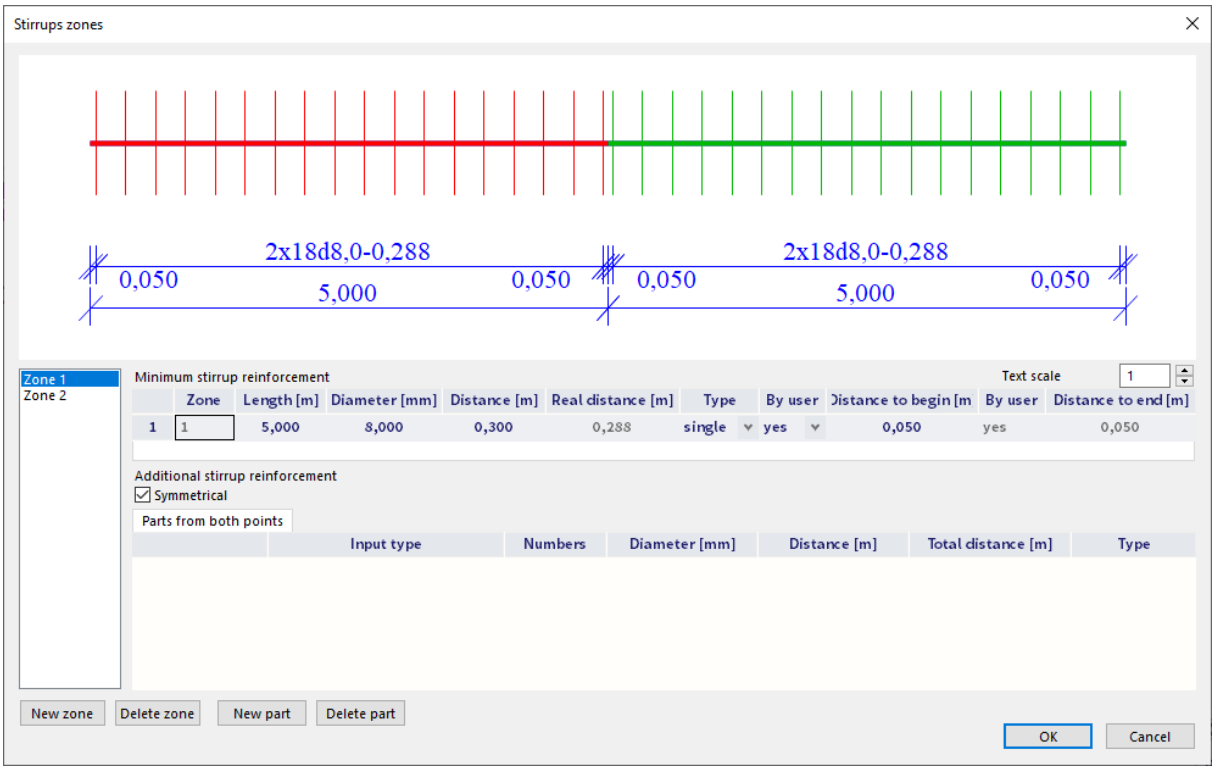


We can also adjust these zones of reinforcement if necessary, by selecting them and changing the parameters in the properties window. However, in this case we want to add the 4 bars of diameter 16 to the middle of the first span. Therefore, we need to choose 'New longitudinal bars' and choose the length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

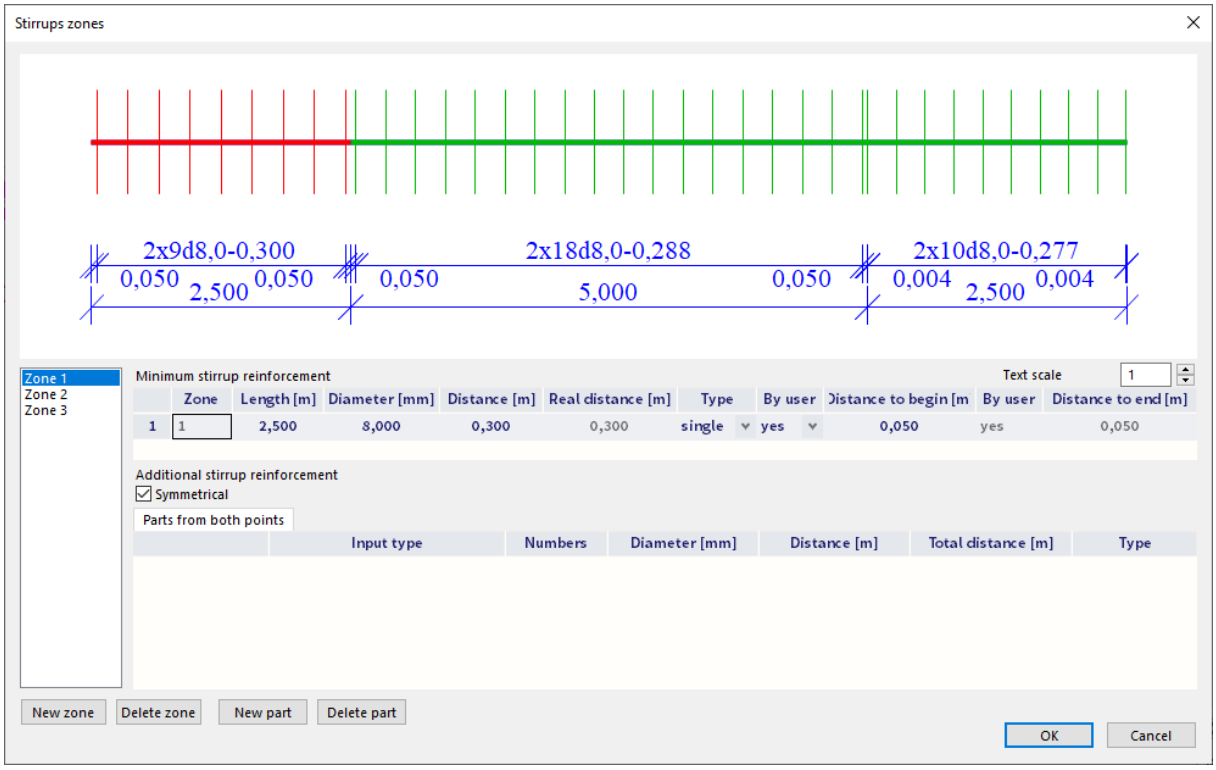




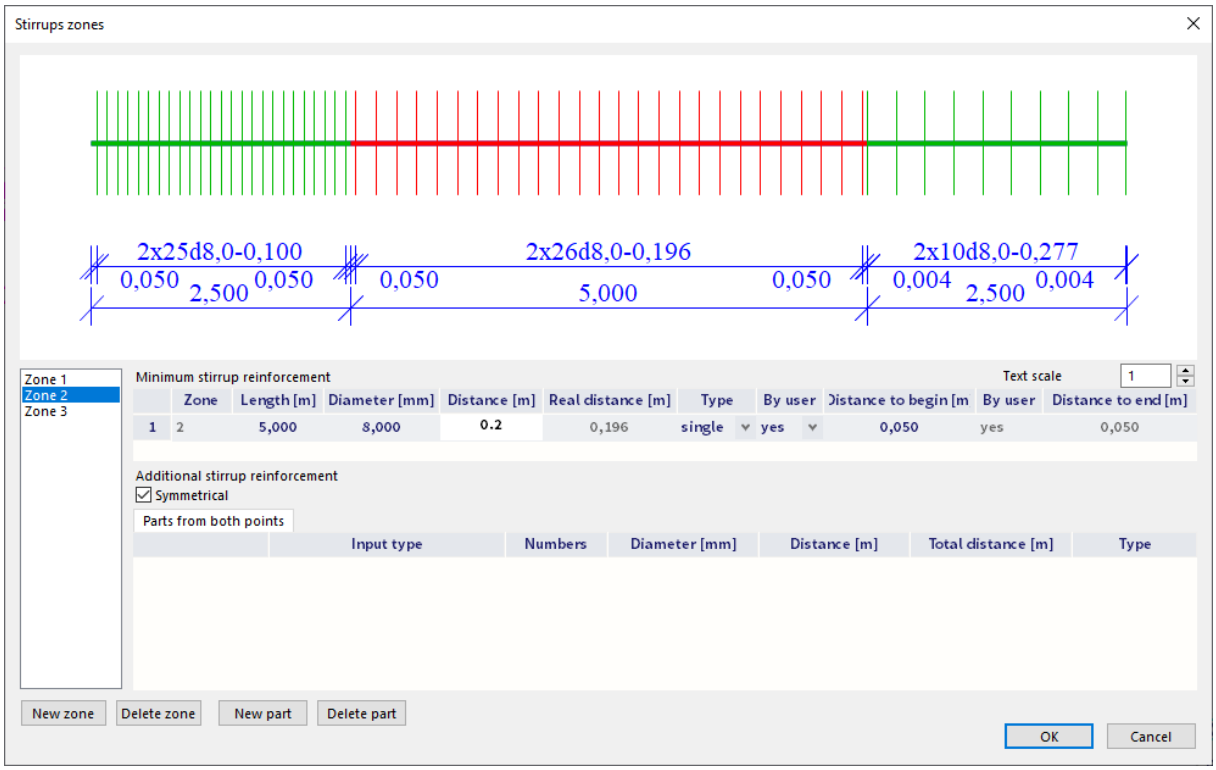
The next step is to change the shear reinforcement. First, select the shear reinforcement. Then, choose ‘Edit stirrups distances’ under Actions and the following window will pop up:

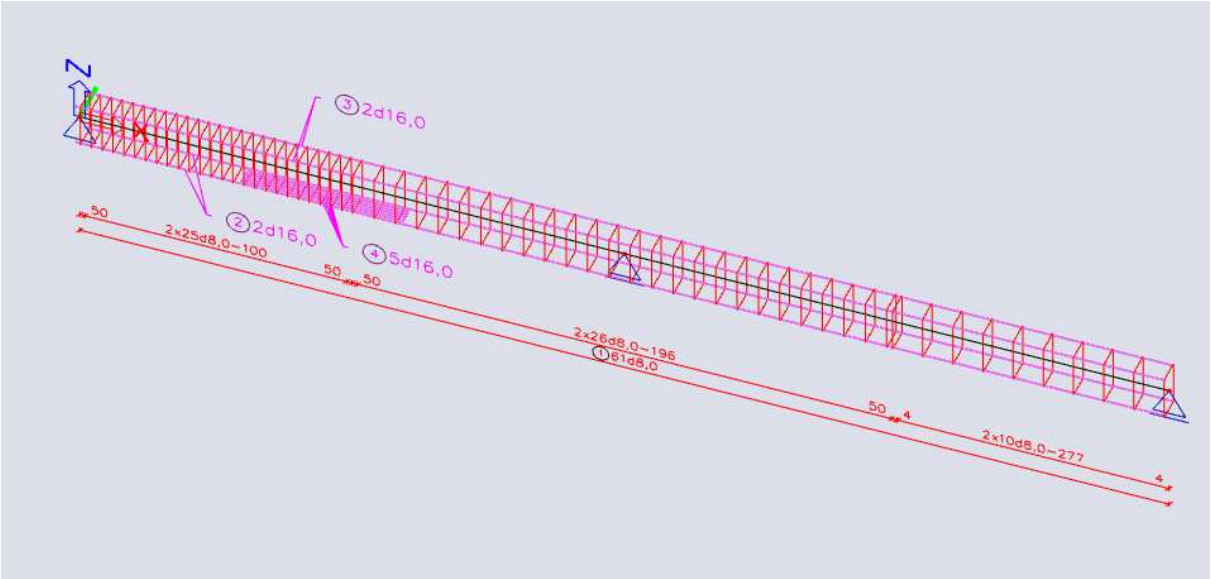


Currently we have two zones over the full length of the beam. We can create a new zone by first making the current zone shorter. Instead of the full length of 10m we will choose 2,5m for this zone. Then we can make new zones of 5m and 2,5m:



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





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