SCIA
BY ALLPLAN



\ SCIA ENGINEER

TUTORIAL

2D Reinforcement

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Introduction

SCIA Engineer allows you to model and check concrete 2D 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

This tutorial will explain the different types of reinforcement and discuss an example on how to input or calculate these types to be able to perform the concrete 2D checks.

Chapter 1: 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 2D 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 much practical reinforcement is going to be needed. There are two types of theoretical reinforcement:

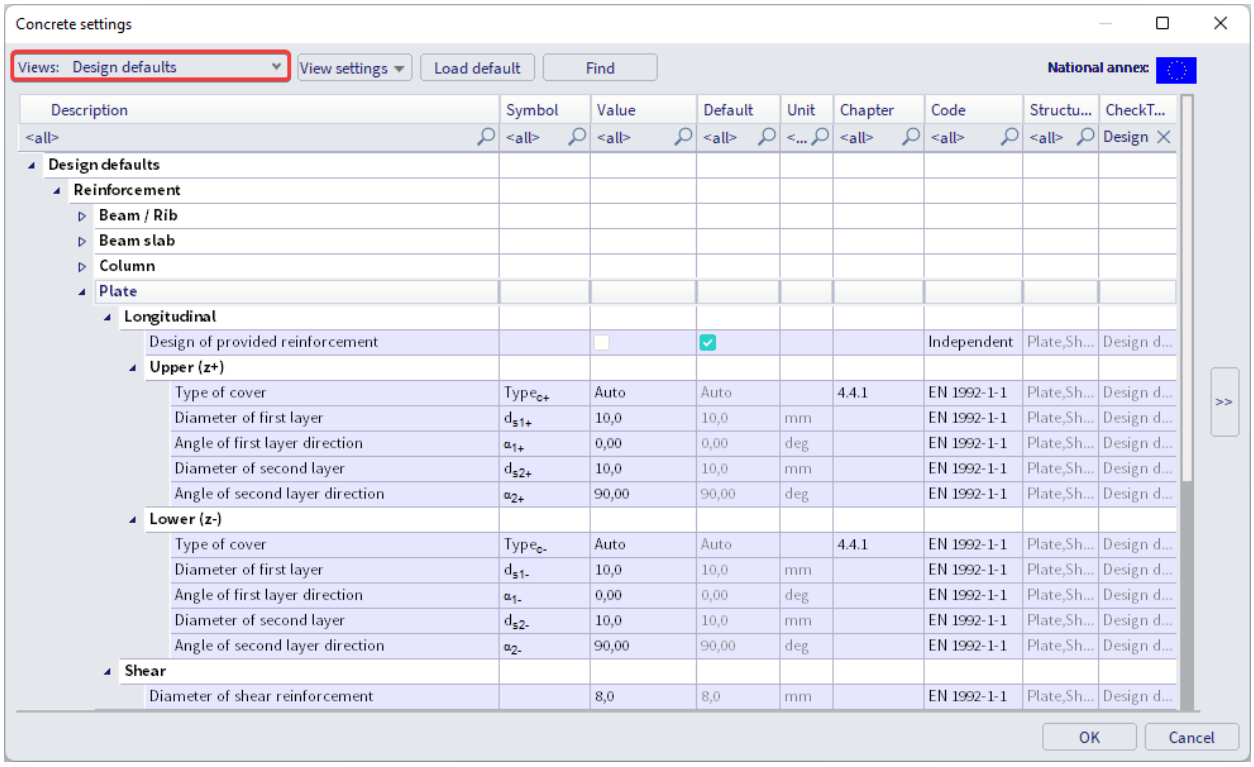
- **Required reinforcement**: The required reinforcement is a value of the reinforcement that is necessary in every mesh element of the 2D element.

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

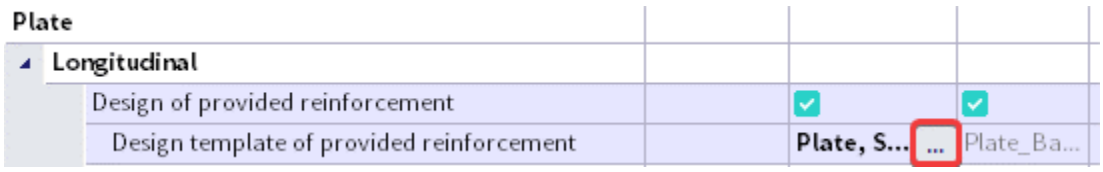
The configuration of theoretical reinforcement can be found in the Concrete settings under Design defaults



For the calculation of the reinforcement an effective depth is needed which is based on diameter and cover. The concrete cover and diameter can be set separately for both the upper and lower face of the slab. For walls there is only one setting available that is applied to both sides.



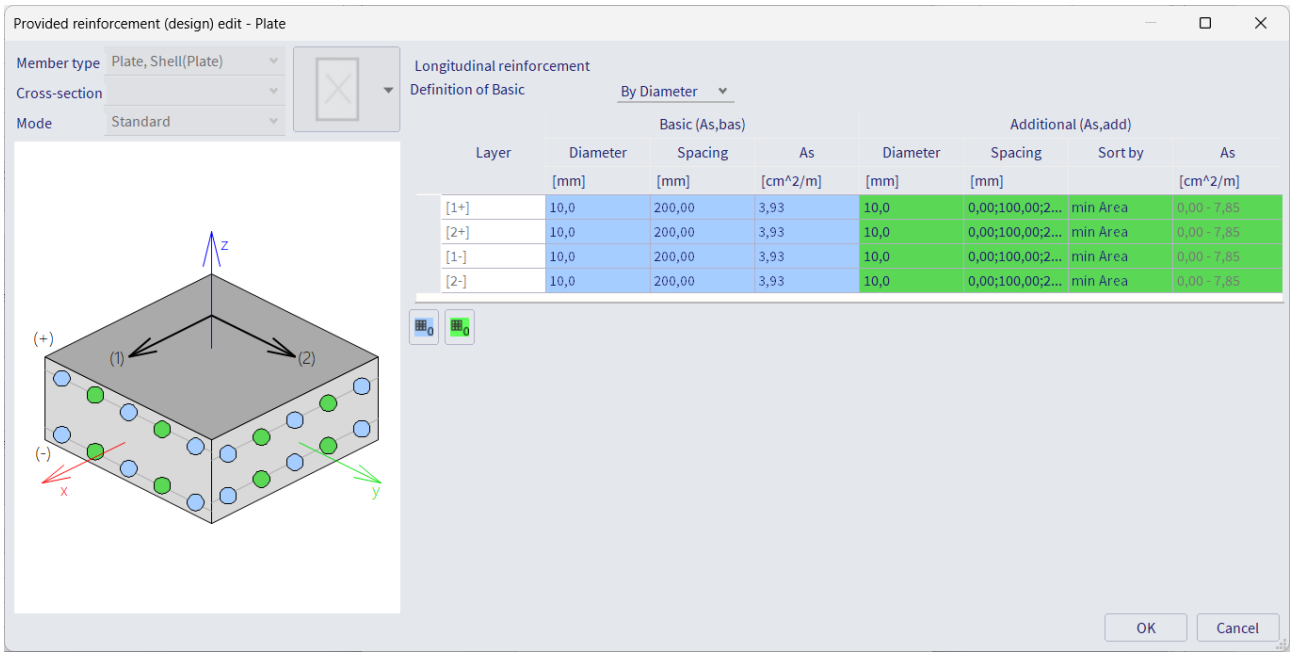
If you enable provided reinforcement you're allowed to create or chose a template of reinforcement. The calculation will still be based on the chosen diameters and covers but Scia is going to compare them with the settings in the template to see if this chosen reinforcement is sufficient.



This template exists of basic and additional reinforcement. For 2D elements no template settings can be made for shear reinforcement so this part will remain 'Required reinforcement'.

Longitudinal reinforcement

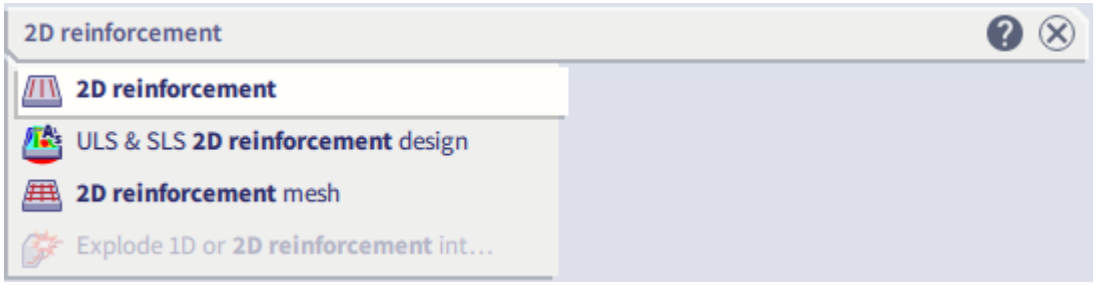
The basic reinforcement is present along the whole area of the slab while the additional reinforcement is added only in zones where basic reinforcement is not sufficient to withstand (recalculated) internal forces. A choice can be made to sort the additional reinforcement by minimal area, minimal diameter or maximal spacing. SCIA Engineer uses the least amount of necessary additional bars or places the maximum setting from the template whenever this template is still not sufficient to resist the (recalculated) internal forces.



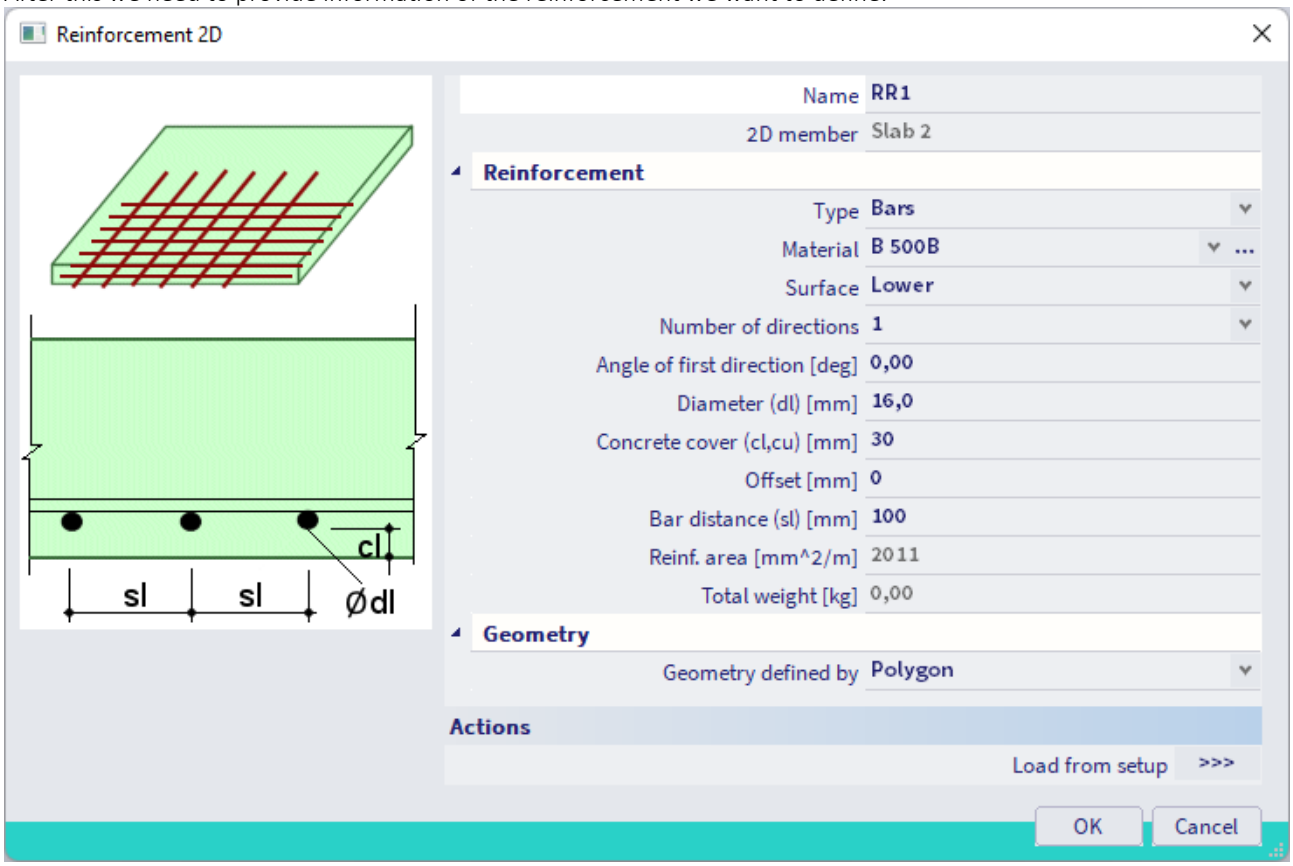
Chapter 2: Practical reinforcement

We will now pass on to the level of practical reinforcement. This will allow us to specify the reinforcement locally over a 2D element.

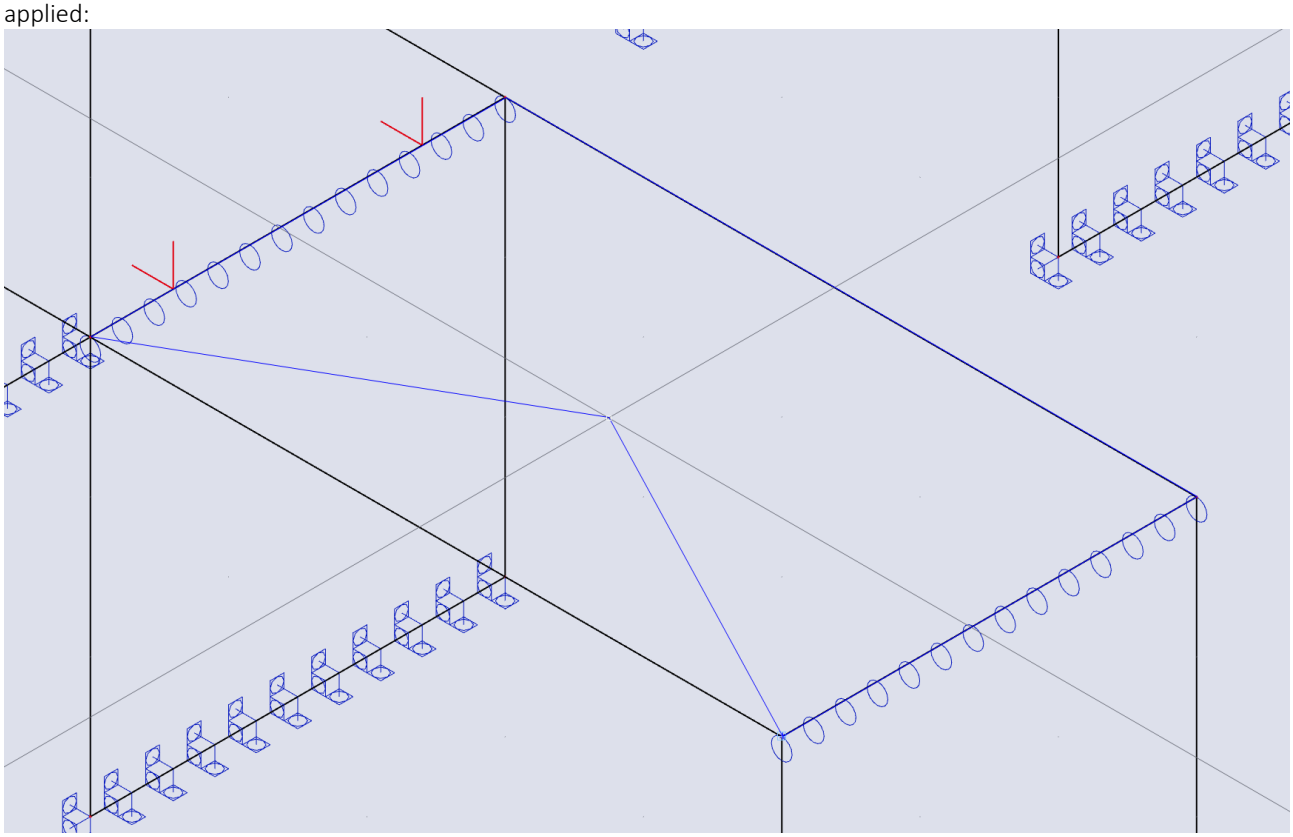
In the theoretical reinforcement design, we have calculated where reinforcement is needed. We can now manually input practical reinforcement in these areas by typing '2D reinforcement' in the SCIA Spotlight and selecting a 2D element:



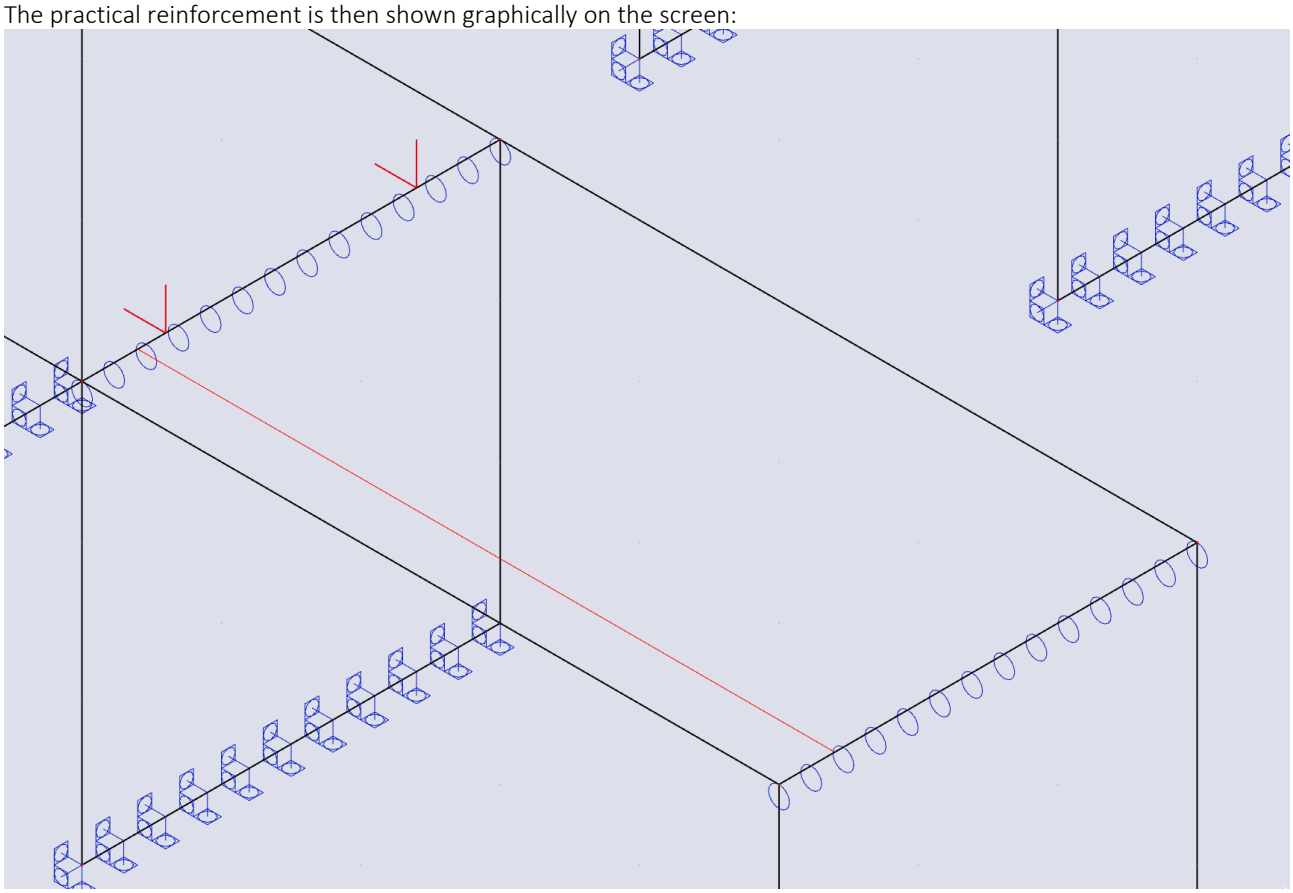
After this we need to provide information of the reinforcement we want to define:



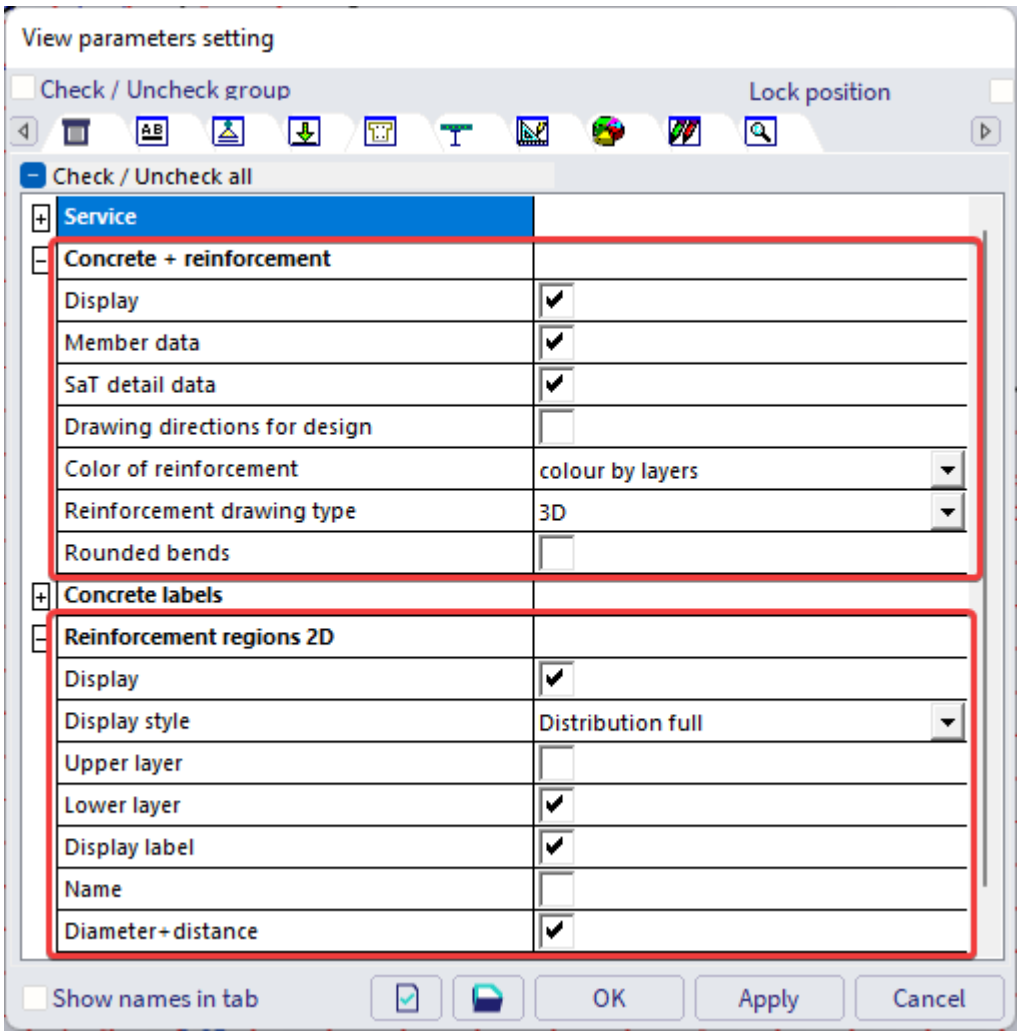
Next, on the 2D element you have chosen, you draw the region in which the defined reinforcement needs to be applied:

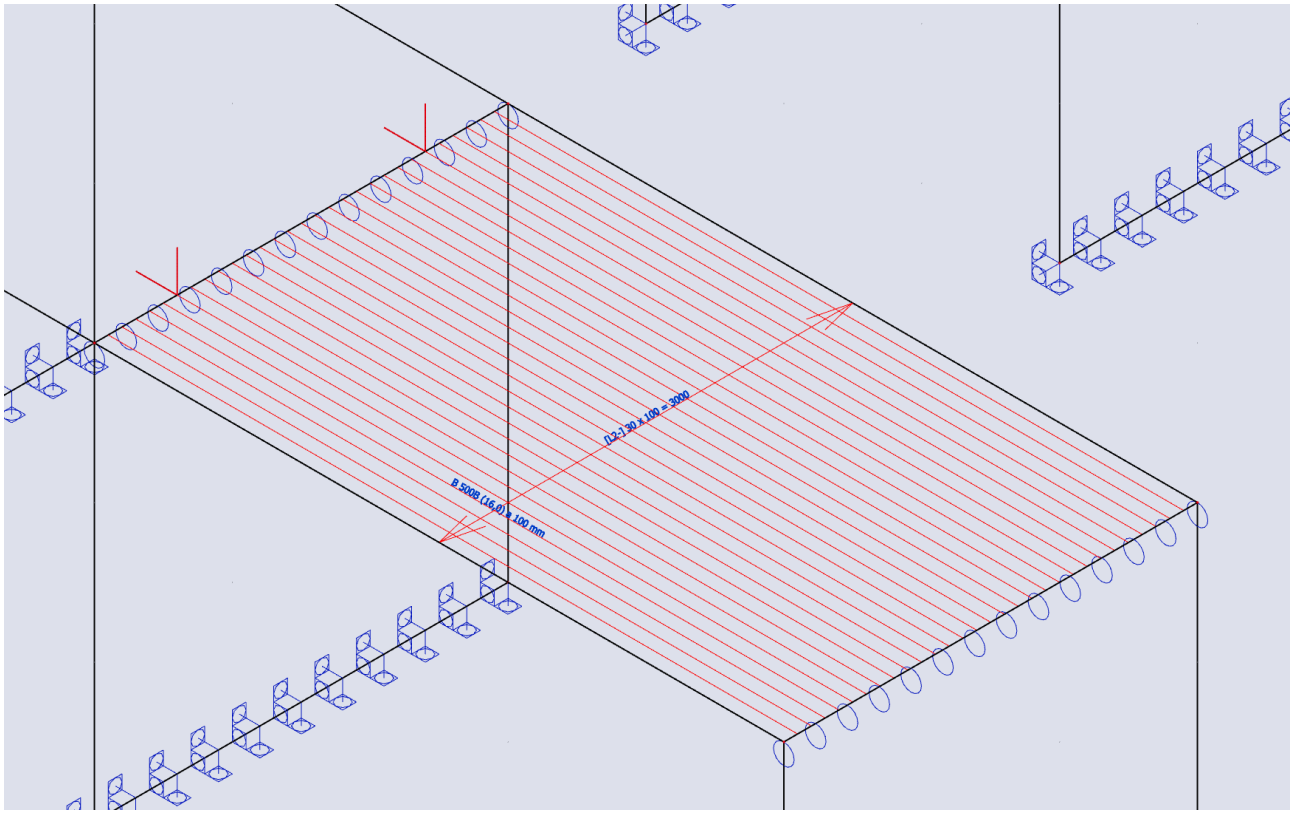


You can draw multiple layers of reinforcement on top of each other.
The practical reinforcement is then shown graphically on the screen:

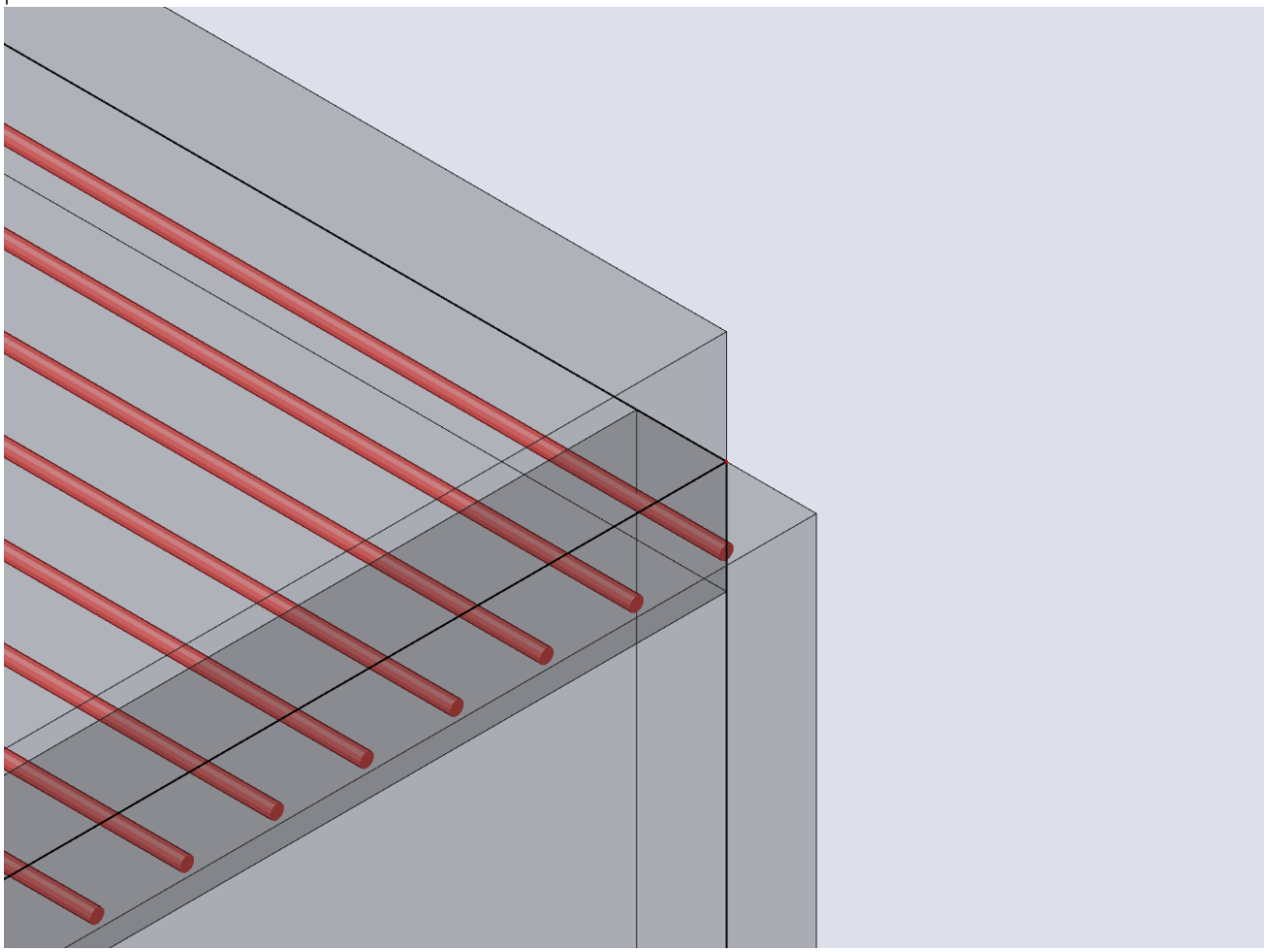


There are a number of view settings to change the visual representation of the reinforcement:





With ‘Reinforcement drawing type’ set to ‘3D’ and ‘Display style’ set to ‘Real positions’ you can show the actual 3D position of the created reinforcement areas:

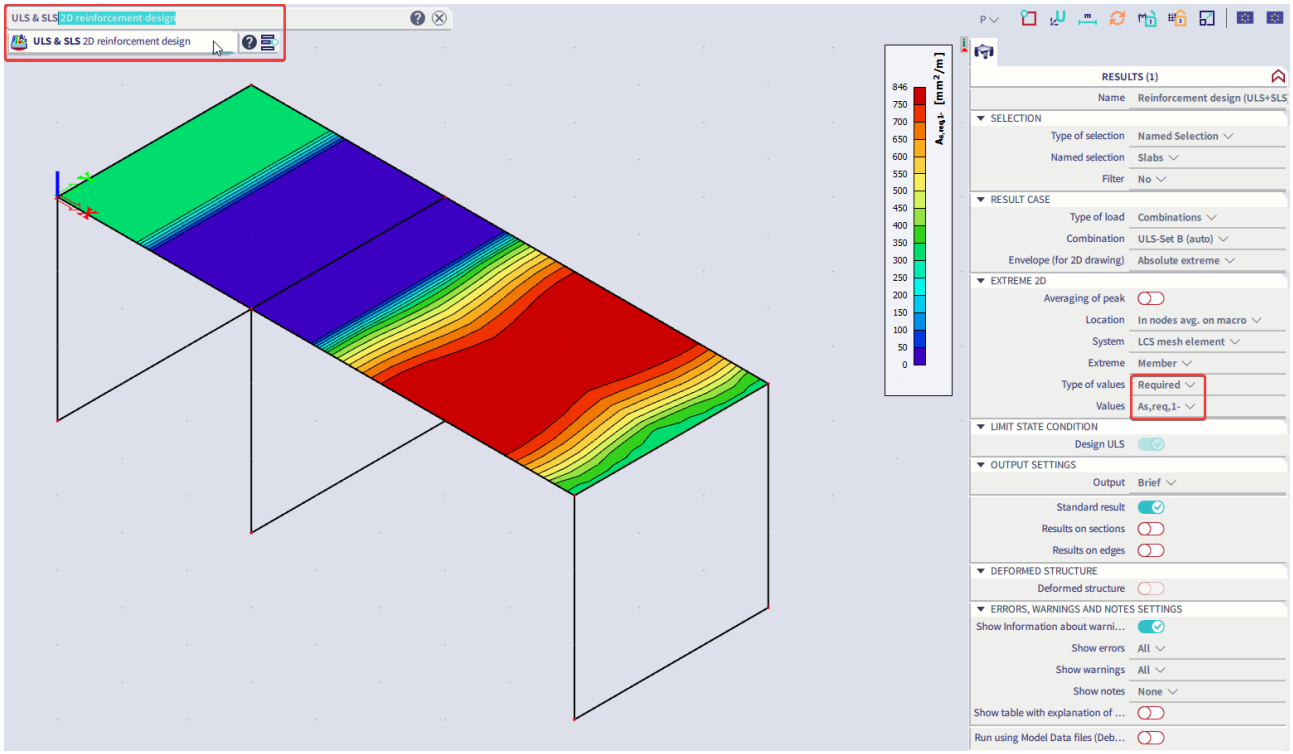


The above is also exportable to a 3D drawing (DWG, IFC etc.).

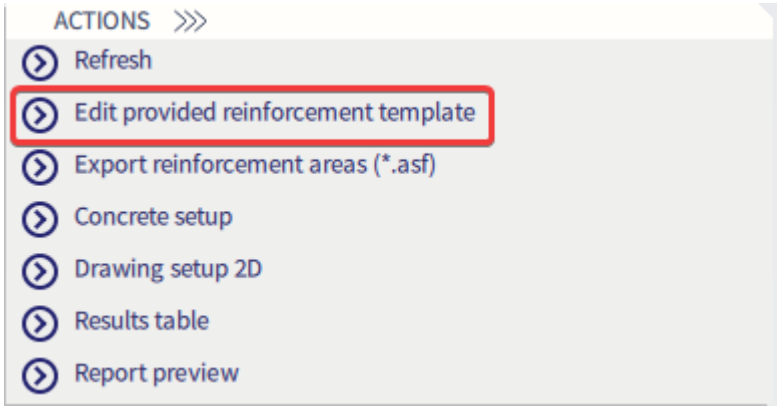
Chapter 3: Example

Theoretical reinforcement

Finally, we are going to explain all of the above once again using a simple example. We start with a slab supported on 3 wall elements that has some surface load on it. Looking at the reinforcement design, we get the following values for the theoretical required reinforcement As,req,1- (reinforcement in the first LCS direction on the bottom of the slab):

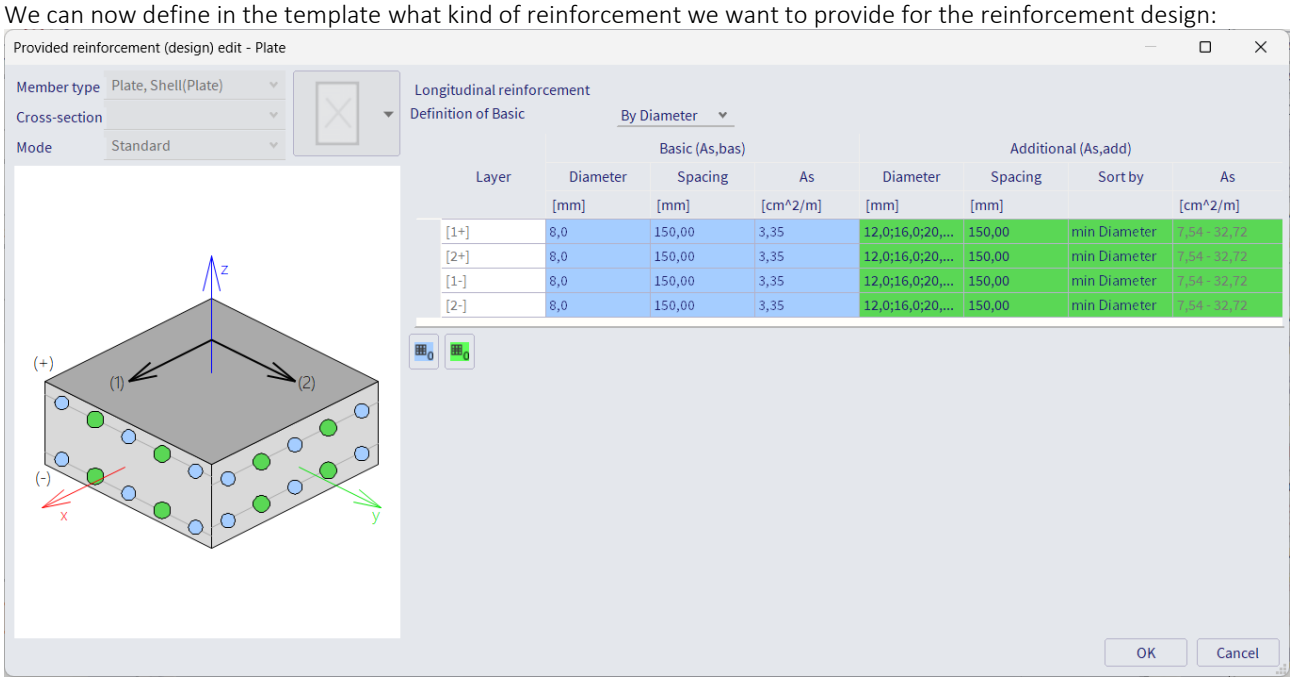


You can access the template of the theoretical provided reinforcement of a member by using the action button 'Edit provided reinforcement template' below the result properties and selecting the member:



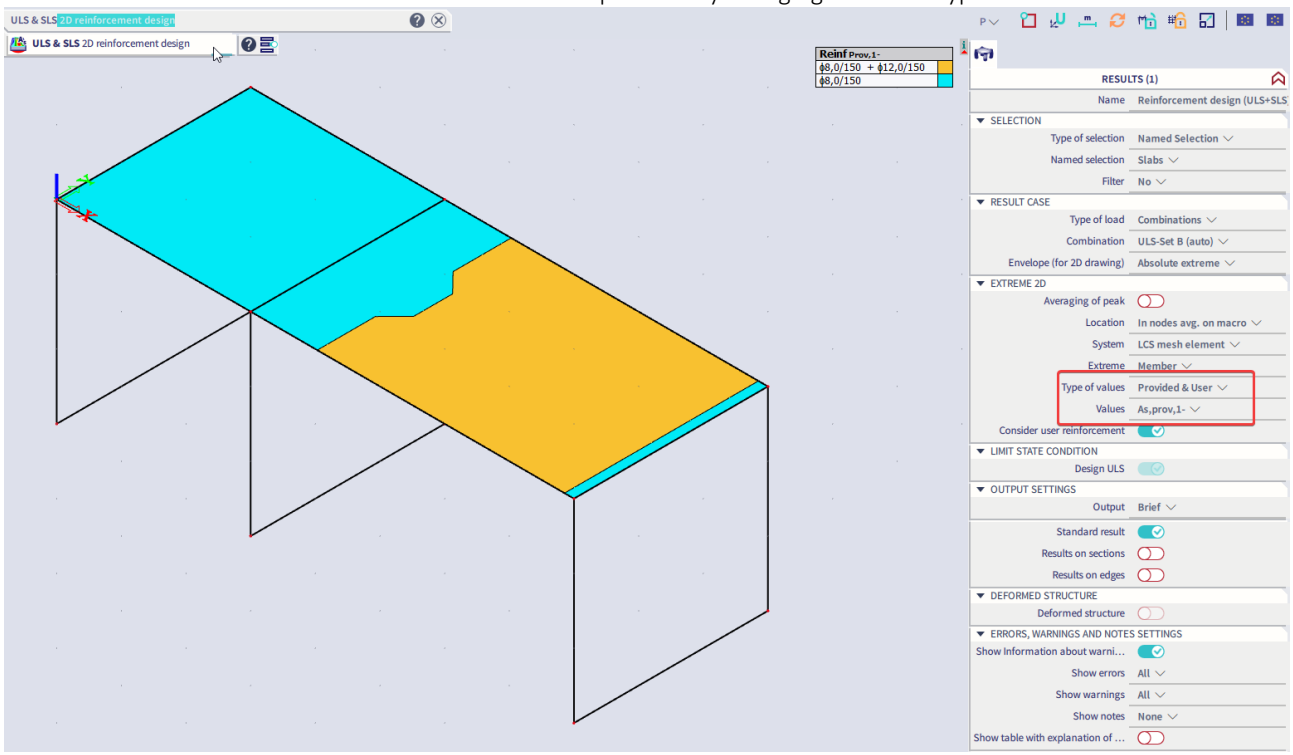
The above is only possible if 'Design of provided reinforcement' is enabled for this type of element in the concrete settings.

We can now define in the template what kind of reinforcement we want to provide for the reinforcement design:

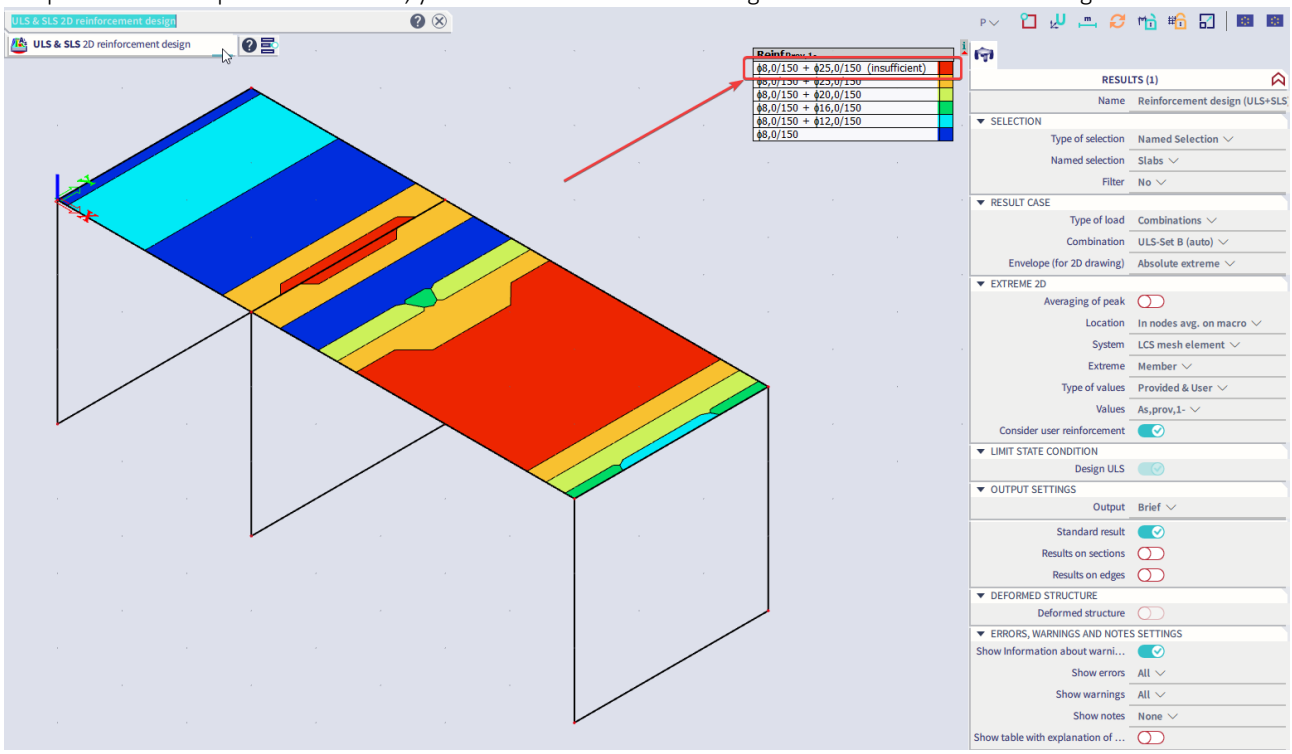


This means that in the provided reinforcement we always have basic reinforcement bars – on the upper and lower edge – of diameter 8mm each 150mm. In practice this would probably be the basic reinforcement net. This can be increased with the values of the additional reinforcement we provided. However, the additional reinforcement will only be added if the provided reinforcement is less than the required reinforcement. This comparison will be done for each mesh element of the 2D element.

Now we can check what was the outcome of these comparisons by changing the result type to 'Provided & User':



If the internal forces would become so large that no reinforcement option (basic plus additional) you provided in the template can take up for these forces, you will see this in the result legend of the reinforcement design:



For the red area in this case a reinforcement of 8mm-150mm plus 25mm-150mm is not sufficient, but Scia will look no further because this was the maximum setting in the template.

If in the result properties you change 'Output' to 'Detailed' and click on 'Report preview' at the bottom of the result properties you can check all the details of the calculation:

Reinforcement design (ULS+SLS)

Linear calculation
Combination: ULS-Set B (auto)
Extreme: Member
Selection: Named selection - Slabs
Location: In nodes avg. on macro. System: LCS mesh element

Plate Slab 1	**h=250 mm**
EC EN 1992-1-1:2004/AC:2008	Node 139/435 [X= 5,647, Y=3,000, Z=0,000 m]

Design assumptions

Reinforcement

Longitudinal: **B500B**

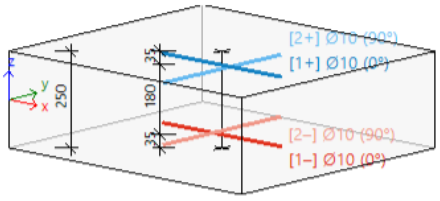
Upper surface

[1+] First layer (0°)	Ø10,0 mm / Principal
[2+] Second layer (90°)	Ø10,0 mm / Principal
Cover:	c_{nom} = 30 mm

Lower surface

[1−] First layer (0°)	Ø10,0 mm / Principal
[2−] Second layer (90°)	Ø10,0 mm / Principal
Cover:	c_{nom} = 30 mm

Shear: **B500B** Ø8 mm



Concrete:

Material: **C30/37**

Structural class:	S3 (design working life of 50 years, no special quality control)	(Table 4.3N)
Environmental conditions:	XC3 (in situ)	(Table 4.1N)

Minimum cover (§4.4.1.2)

$$c_{min} = \max\left(c_{min,b}; c_{min,dur} + \Delta c_{dur,\gamma} - \Delta c_{dur,st} - \Delta c_{dur,add}; 10\right) \quad (4.2)$$
$$= \max\left(10; 20 + 0 - 0 - 0; 10\right) = 20 \text{ mm}$$

Nominal cover (§4.4.1.1)

$$c_{nom} = c_{min} + \Delta c_{dev} = 20 + 10 = 30 \text{ mm} \quad (4.1)$$

Internal forces from structural analysis

Ultimate limit state

Involving the shifting of moment curve : YES (§9.2.1.3(2))

$a_l = h \cdot Coeff_d = 0.25 \cdot 0.9 = 225$ mm (§6.2.2(5))

Case	m_x [kNm/m]	m_y [kNm/m]	m_{xy} [kNm/m]	n_x [kN/m]	n_y [kN/m]	n_{xy} [kN/m]	v_x [kN/m]	v_y [kN/m]
ULS-Set B (auto)/1	73,85	2,23	-2,04	-1,56	0,07	-0,02	24,57	-3,93
ULS-Set B (auto)/2	54,71	1,65	-1,51	-1,15	0,06	-0,01	18,20	-2,91

Case	Combination key
ULS-Set B (auto)/1	1.35*LC1+1.35*P
ULS-Set B (auto)/2	LC1+P

Note that the calculation is always done for one specific mesh node (depending on the 'extreme' setting in the result properties), in this case node 139/435 on global location 5,5647 ; 3,0 ; 0,0.

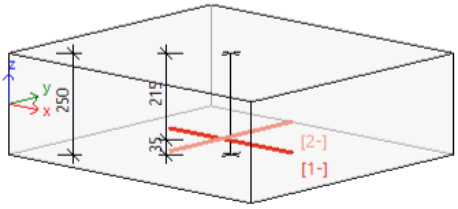
Theoretical calculation of reinforcement uses the diameter that was chosen in the concrete setup, 10mm in this case, so this is not equal to the diameters we chose in the template for provided reinforcement.
Afterwards we are going to compare this theoretical result with the template to decide a diameter and spacing of reinforcement:

Longitudinal reinforcement - Summary

Designed reinforcement layers (in direction from the member local x axis):

	Basic	Additional		α	$A_{s,min}$	$A_{s,ult}$	$\Delta A_{s,serv}$	$A_{s,req}$	$A_{s,prov}$	$A_{s,max}$	$s_{min(cl)}$	s_{max}	Status
		User	Auto	[°]	[mm²]	[mm²]	[mm²]	[mm²]	[mm²]	[mm²]	[mm]	[mm]	
[1-]	ϕ8,0/150	---	ϕ12,0/150	0,0	324	846	---	**846**	**1089**	10000	70	75	OK
								0,34%	0,44%		≥37	≤400	
[2-]	ϕ8,0/150	---	---	90,0	309	50	---	**309**	**335**	10000	142	150	OK
								0,12%	0,13%		≥37	≤400	

$A_{s,req}$ - required reinforcement area as max($A_{s,ult}$; $A_{s,min}$)+$\Delta A_{s,serv}$; $A_{s,prov}$ - provided reinforcement area; $A_{s,min/max}$ - min/max reinforcement area; $s_{max(min)}$ - maximum spacing of bars (minimum clear distance between bars



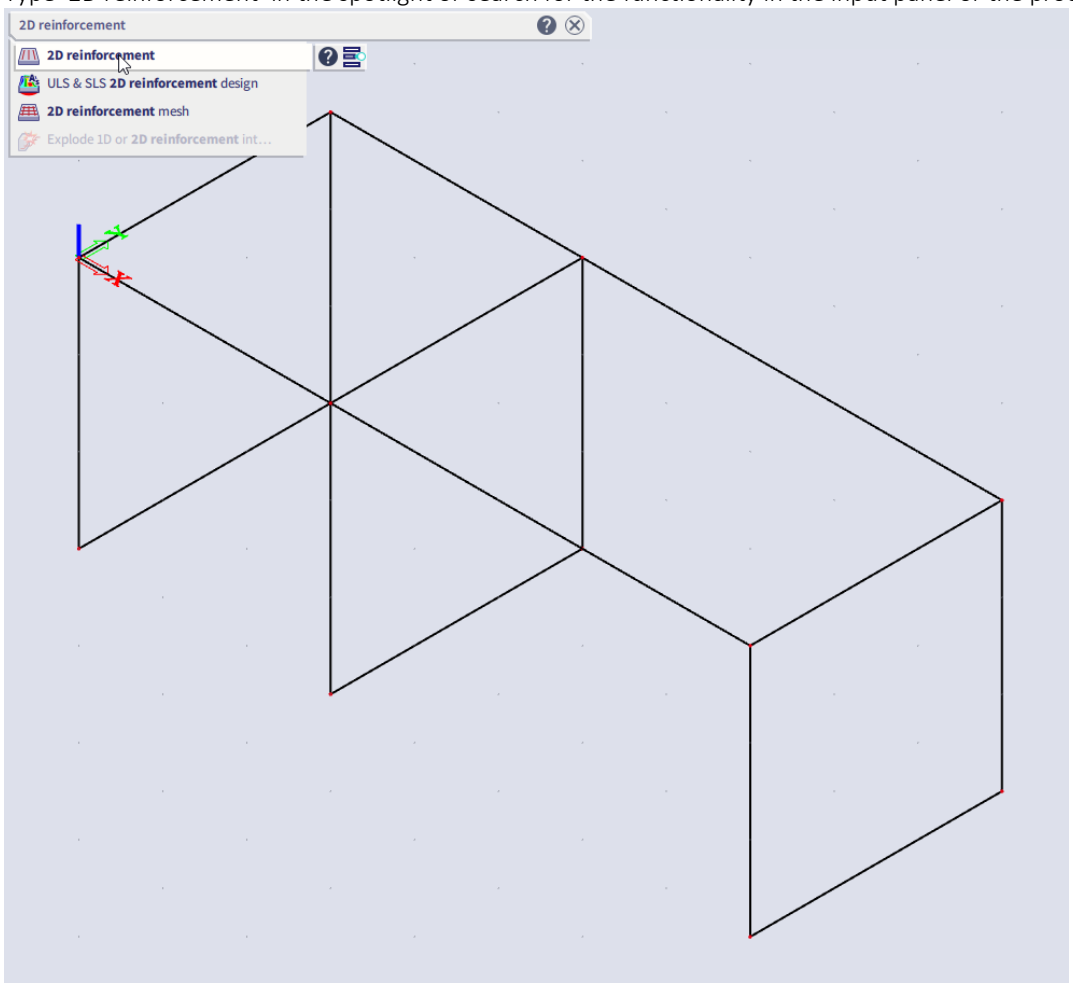
[1-] ϕ8,0/150 + ϕ12,0/150
[2-] ϕ8,0/150

Practical reinforcement

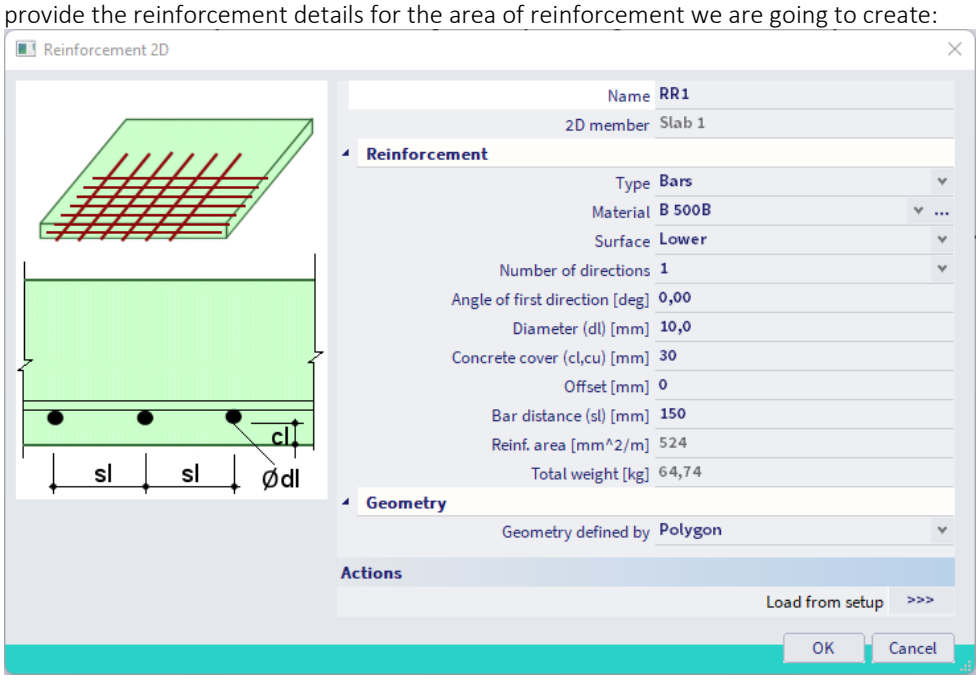
Unlike for 1D members, for 2D elements practical reinforcement always has to be defined manually.

Input practical reinforcement

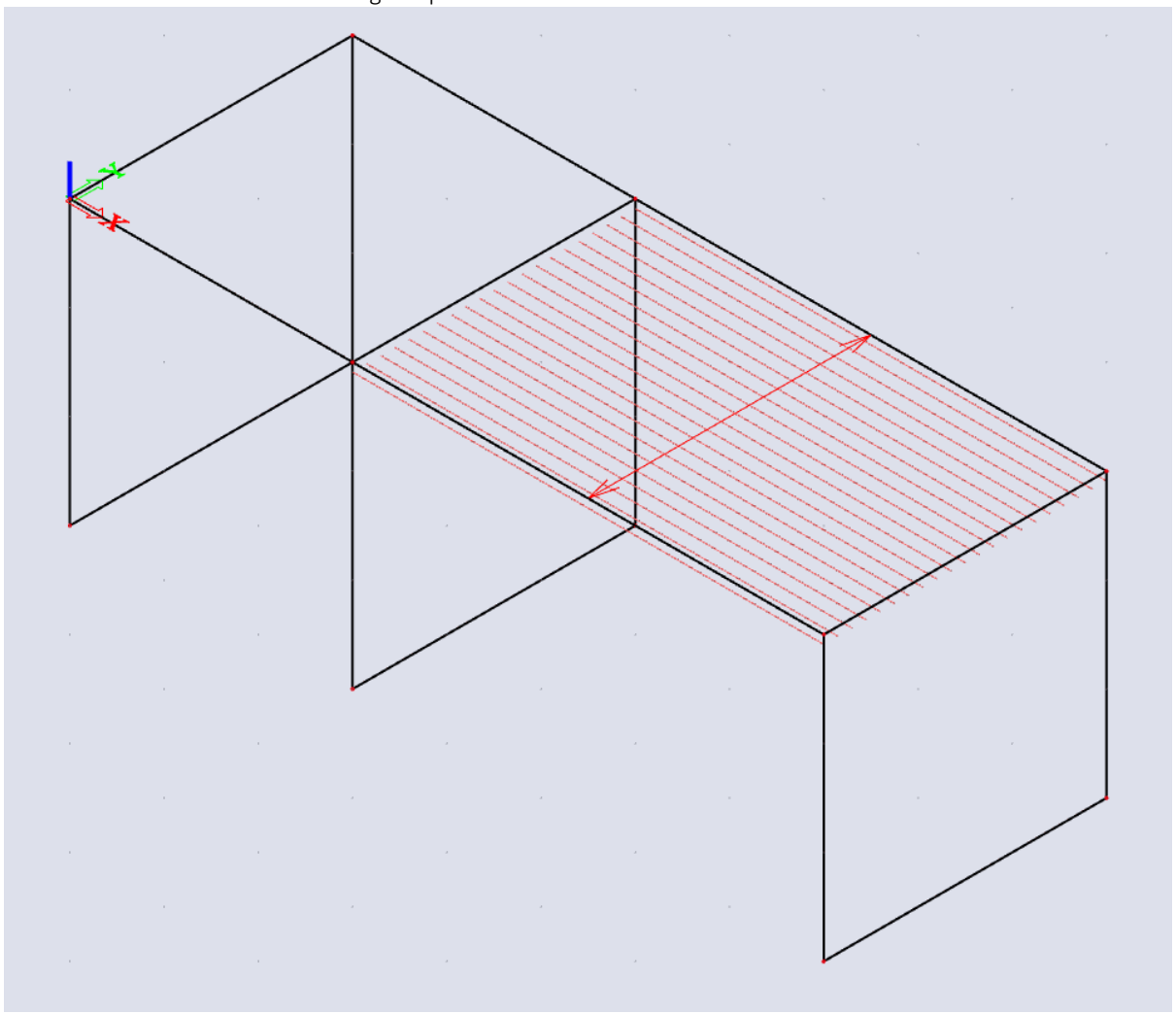
Type '2D reinforcement' in the spotlight or search for the functionality in the input panel or the process toolbar:



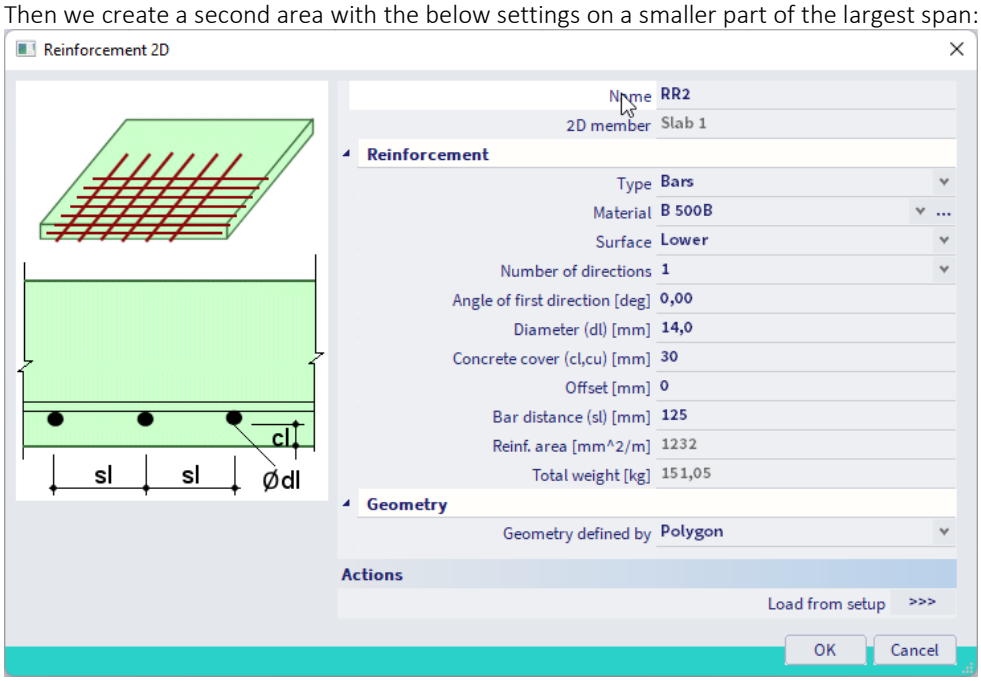
After we selected the 2D member (the slab in our case) on which we want to apply this reinforcement we need to provide the reinforcement details for the area of reinforcement we are going to create:

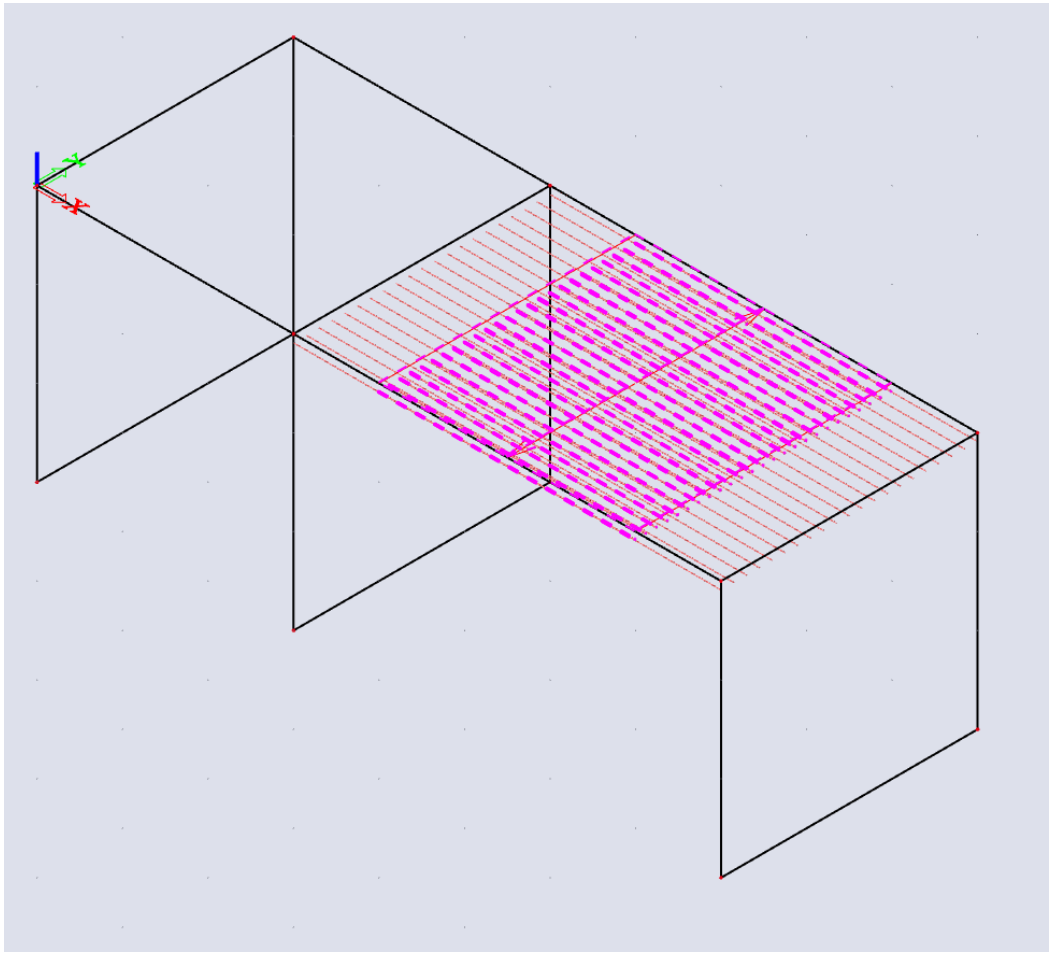


Then you can draw an area in which you want this reinforcement to be taken into account. For this example we define the above reinforcement on the largest span of the slab:

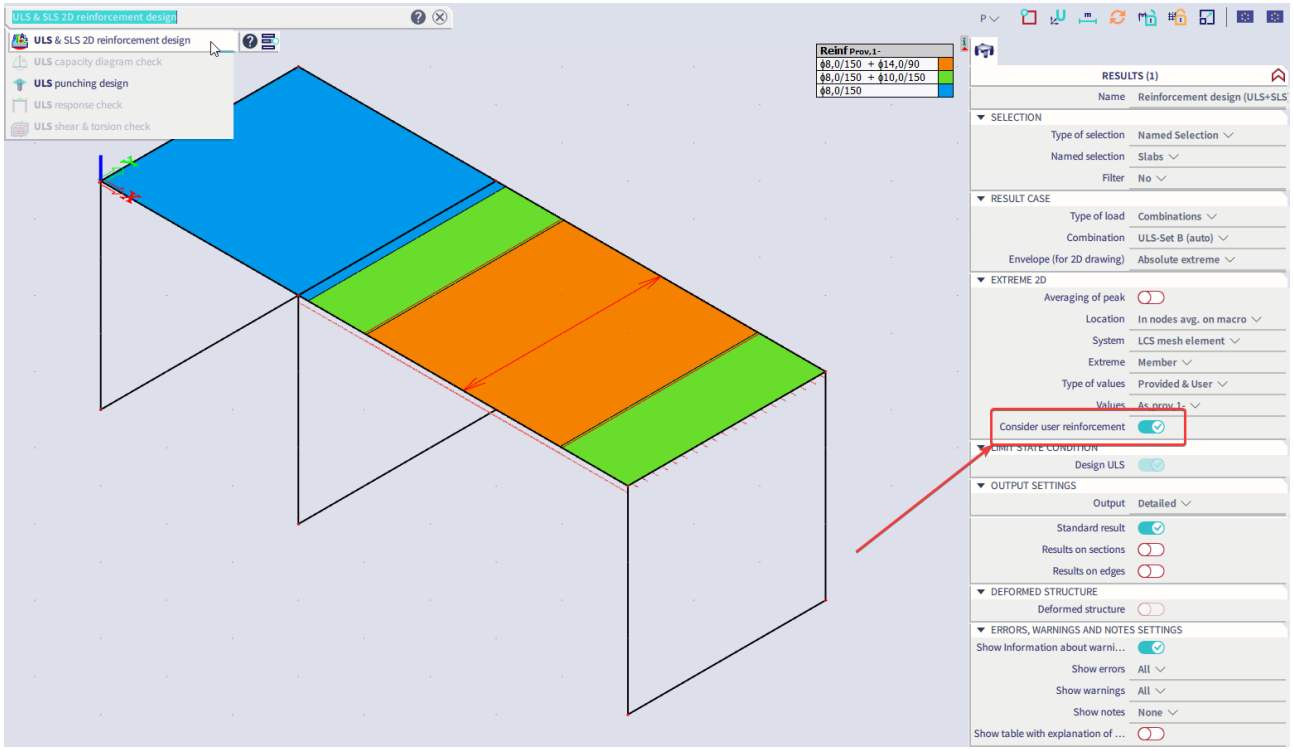


Then we create a second area with the below settings on a smaller part of the largest span:





Let's have a look at the reinforcement design to see what effect this had, to consider user reinforcement don't forget to enable this in the result properties:



As you can see for the largest span the reinforcement we created is taken into account in addition to the basic reinforcement from the template while on the shortest span the basic reinforcement from the provided template is still present because there is no user reinforcement defined here.

Finally we can use the 3 types of reinforcement we discussed in this manual to perform the 2D reinforcement checks (crack width, punching check, code dependant deflections etc.) by choosing one of them in the result properties of a certain check:

