



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
 - o 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 value 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.

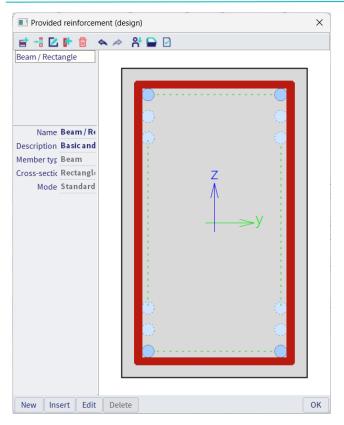
The configuration of theoretical reinforcement can be found in the Concrete settings under Design defaults



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.

s: Design defaults 🛛 👻 View settings 👻 Load o	lefault	Find					Na	tional annex:
Description	Symbol	Value	Default	Unit	Chapter	Code	Structure	CheckType
µ> ∠	<all></all>	<all></all>	<all> 🔎</all>	<a th="" 🔎<=""><th><all> 🔎</all></th><th><all> \wp</all></th><th><all> 🔎</all></th><th>Design defa $imes$</th>	<all> 🔎</all>	<all> \wp</all>	<all> 🔎</all>	Design defa $ imes$
Design defaults								
A Reinforcement								
A Beam / Rib								
Design of provided reinforcement						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
l section		Beam_lsect	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,I}	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	α,5	90,00	90,00	deg		Independent	Beam,Rib	Design defaul
Beam slab								

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 this template 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.

ember type Beam	×		Longitudinal rei	inforcement								
ross-section Rectangle	~	-	Edao	Lavana		Basic (As,bas)		Addition	al (As,add)		Detailing
ode Standard	*		Edge	Layers	Ø [mm]	N x [-]	As [cm^2]	Туре	Ø [mm]	N x [-]	As [cm^2]	Ø [mm]
			Upper	Auto	16,0	2;2	4,02;4,02	List by nu	16,0	0;1;2;3;4;5		
			Side	1-layer	16,0	0	0,00	List by nu	16,0	0		10,0
			Lower	Auto	16,0	2;2	4,02;4,02	List by nu	16,0	0;1;2;3;4;5		
	Z A V		Bo Bo Shear reinforce							Spacin	g	
	с у				p zones	Legs count	Ø [m	im]	Distribution	Spacin s [mm		ymmetrical
	Z ↓>y			Stirru	p zones	-	Ø [m 8,0		Distribution			ymmetric

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.

Provided rein	nforcement (design) edi	it - Beam / F	Rectangle												\times
		~		L	ongitudinal rei	nforcement									
Member type Bea Cross-section Rec	n Rectangle	~		•	Edge	Layers		Basic (As,bas	5)		Addition	al (As,add)		Detail	ling (
Mode	Standard	×			Luge	Layers	Ø [mm]	N x [-]	As [cm^2]	Туре	Ø [mm]	N x [-]	As [cm^2]	Ø [r	mm]
					Upper	Auto	16,0	2;2	4,02;4,02	List by nu	16,0	0;1;2;3;4;5			
					Side	1-layer	16,0	0	0,00	List by nu		0		10,0	
	0				Lower	Auto	16,0	2;2	4,02;4,02	List by nu	16,0	0;1;2;3;4;5	0,00;2,01;		
	2 1 1	ې پې د			Bo Bo		p zones	Legs count	Ø (n 8,0	[Distribution tiple	Spacin s [mn 50,00	-	ymmetri	ical
													ОК	Car	ncel

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

Des	cription	Symbol	Value	Default	Unit	Chapter	Code	Structure	CheckType	
>	Q	<all></all>	Q <all> ♪</all>	⊂all> ∠	<a th="" 🔎<=""><th><all></all></th><th><all></all></th><th><all> \wp</all></th><th><all></all></th><th>)</th>	<all></all>	<all></all>	<all> \wp</all>	<all></all>)
Des	ign defaults									1
⊳	Reinforcement									
⊳	Minimum cover									
Sol	versetting									
⊳	General									
⊳	Internal forces									
⊳	Design As									
	Conversion to rebars									
	Unify upper reinforcement above middle support						Independent	Beam,Bea	Solver setting	
	Minimum length of long.reinforcement		1000	1000	mm		Independent	1D (Beam,	Solver setting	
	Uniformly distributed reinforcement for the column						Independent	Column	Solver setting	
	Number of corrected bars (neighbouring sections)						Independent			
	Type of zone for corrected shear reinforcement		Geometrical	Geometrical			Independent	1D (Beam,	Solver setting	
⊳	Interaction diagram									
	Shear									
⊳	Torsion									
	Punching									
· .	Stress limitations									
	Cracking forces									
· .	Crack width									
· ·	Deflections									
⊳	Detailing provisions									

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.

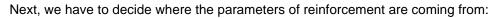
In the theoretical reinforcement design, we have calculated where reinforcement is needed.

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

New reinforcement	⊘ (\$
New reinforcement	

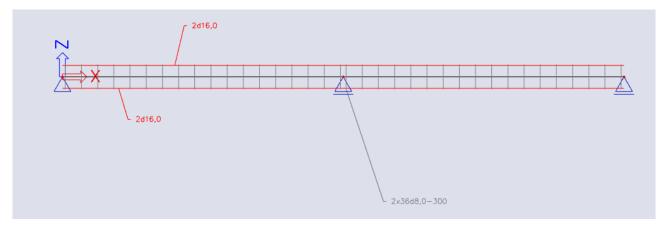
We can first select a template for the longitudinal reinforcement:

E Longitudinal reinforcement	×
LR_B_R1 LR_B_R2 LR_C_R1	
LR_B_R3 LR_B_R4	
Name LR_B_R1	
Description Long. reir	
Stirrup nam StirrupR9	
Number of li 2	
Diameter [m 16	
Area [mm^2 804	
Type of bear beams an	
New Insert Edit Delete	ОК



Reinforcement parameters	×
Do you want to use parameters of reinforcement (diameter of long.reinforcement, stirrup and concrete cover)	
◯ from the Concrete member data	
◯ from the Design defaults	
● from the defined template	
	- I
OK	

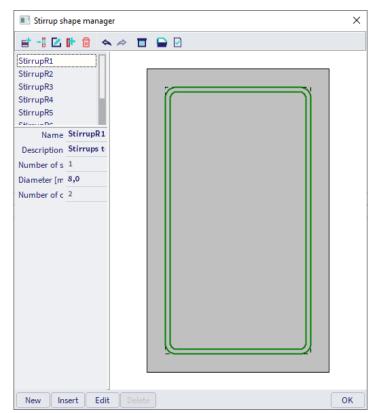
The practical reinforcement is then shown graphically on the screen:



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

New stirrups	Ø 8
New stirrups	_
New logitudinal bars	()
New logitudinal bars	-

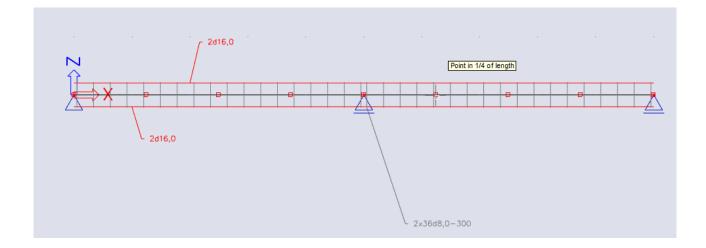
For the stirrups, you can select a certain stirrup shape:

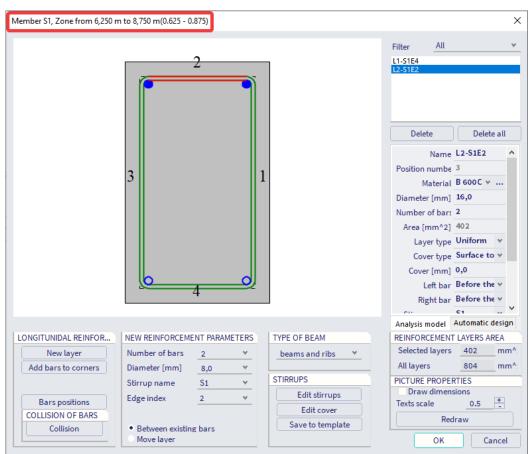


The stirrup shape can be edited or a new one can be made. Therefore, user points may be added.

Stirrup shape		×
	2	51
	3	Delete Delete all Delete Delete all Name \$1 Diameter [mm] \$,0 Color
		Analysis model
STIRRUP New stirrup Automatic Diameter 8,0 V mm	USER DEFINED POINTS	SHEAR CALCULATION Number of cuts 2 Diameter of mandr 2.5 dss PICTURE PROPERTIES Draw intersection points Draw corners points Texts & Points scal 0.5 + Draw dimensions Redraw
		OK Cancel

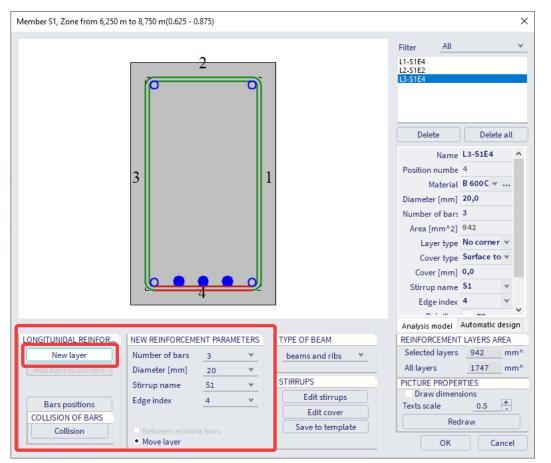
For the longitudinal reinforcement, we can define precisely where the extra practical reinforcement needs to be putted:





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:

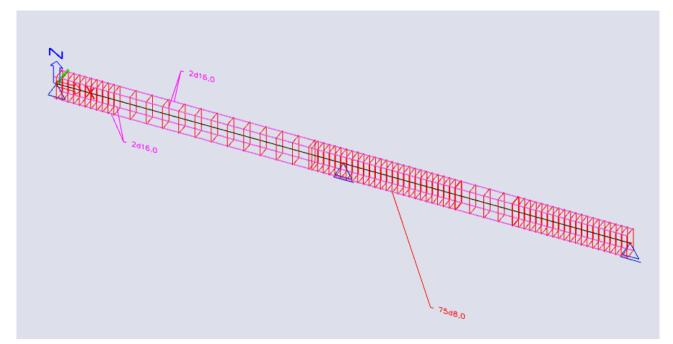
ACTIONS >>>>
S Edit stirrup shape
S Edit covers
Edit stirrups distances
tirrups zones X
$\begin{array}{c c c c c c c c c c c c c c c c c c c $
Zone 1 Zone 2 Zone 2 Zone 3 Zone 4 Zone 4 Zone 5 Additional stirrup reinforcement Symmetrical Parts from both points Text scale 1 Real distance [m] Type By user Distance to begin [m By user Distance to end [m] 0,100 single v yes v 0,004 yes 0,000 0,100 single v yes v 0,004 yes 0,000 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

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:

Vie	w parameters setting								
						Lock pos	ition		
4	🔲 Structure 🛛 🖴 Labels 🛛 📥 Model	➡ Loads/masses	📅 Concrete	Modelling/Drawing	🚰 Attributes	🧭 Misc.	View	₽	
	Check / Uncheck all								
Ξ	Service								
	Display on opening the service	▼							
Ξ	Concrete + reinforcement								
	Display	V							
	Main reinforcement	V							
	Style of main reinforcement	all							
	Stirrups								
	Style of stirrups	all						-	
	Number of stirrups								
	Color of reinforcement	colour by diameter	s					-	
	Scheme of reinforcement								
	Reinforcement drawing type	3D						-	
	Rounded bends								

The total practical reinforcement of the beam is shown below:



A zoomed view shows the 3D representation:

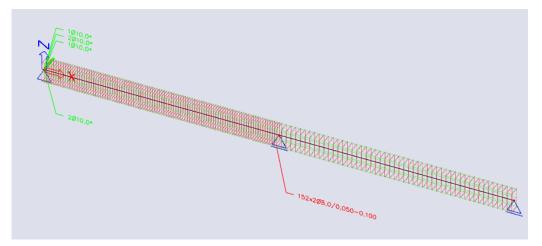
Conversion of theoretical reinforcement into practical reinforcement

It is also possible to convert theoretical reinforcement into practical reinforcement. As already mentioned there are two types of theoretical reinforcement: **Required reinfocement** (= amount 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:

(i)	
RESU	LTS (1)
Name	Overall Design (ULS)
▼ SELECTION	
Type of selection	All 🗸
Filter	No 🗸
Results in sections	All \checkmark
 RESULT CASE 	
Type of load	Combinations V
Combination	ULS 🗸
▼ EXTREME 1D	
Extreme 1D	Global 🗸
Type of values	Provided V
Values	As,prov ∨
Interval	0
 OUTPUT SETTINGS Output 	Brief 🗸
DRAWING SETUP 1D	brier V
Display value name	\cap
Display values	
Display units	
Display case	
Display section dx	
Display combination key	
Display combination name	
Color scheme	Defined by result \checkmark
Graph type	
Envelopes drawing	
Label colour by graph	
Drawing plane	3D 🗸
Label orientation	Perpendicular to axis ∨
Refresh	
Edit provided reinforcement to	emplate
S Concrete setup	
S Conversion for real bars	
> Preview	

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'.

ACTIONS	>>>	
Edit rein	forcement	

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:

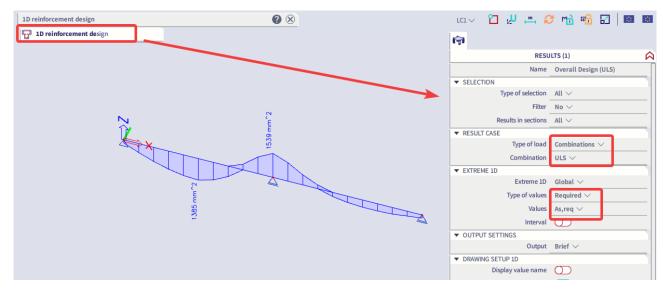
It might occur the error message 'Conversion of reinforcement was not done because the Type of zone of shear reinforcement is set to 'None' in the Design defaults' appears within the summary after conversion when converting the provided reinforcement into real bars. This behaviour is caused due to the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

Summary after conve	ersion		
Member [51]	Additional data -	Status Not OK	Explanation Conversion of reinforcement was not done because the Type of zone for shear reinforcement is set to 'None' in the Design defaults.
			ОК

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:

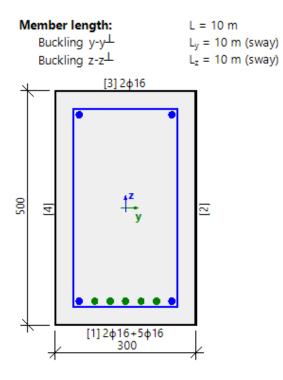


If we take a look at the template of the theoretical provided reinforcement for the beam, we have the following values:

Member type	Beam	~		Longitudinal r	einforcement									
Cross-section	Rectangle	~	· ·	r Edge	Layers		Basic (As,bas))		Addition	al (As,add)		Deta	iling (.
Mode	Standard	~	<u> </u>	Edge	Layers	Ø [mm]	N x [-]	As [cm^2]	Туре	Ø [mm]	N x [-]	As [cm^2]	ø	[mm]
_				Upper	Auto	16,0	2;0	4,02;0,00	List by nu	16,0	0;1;2;3;4;5			
				Side	1-layer	16,0	0	0,00	List by nu	16,0	0		10,0	
	0			Lower	Auto	16,0	2;0	4,02;0,00	List by nu	16,0	0;1;2;3;4;5			
	Z M	<u>->у</u>		Bhear reinford		n 700-95	Less count	Ølm	ml		Spacir	g		
	Z A	→ y				ıp zones	Legs count	Ø [m	im]	Distribution			vmmet	rical
	Z A	> У		Shear reinford	Stirru		-			Distribution	s [mm		ymmet	rical
	Z M	⇒у		Shear reinford	Stirru	ip zones	-	Ø [m 8,0		Distribution tiple			ymmet	rical
	Z A	→ У		Shear reinford	Stirru		-				s [mm			rical
	Z A	⇒У		Shear reinford	Stirru		-				s [mm			rical
	Z A 	. > У		Shear reinford	Stirru		-				s [mm			rical

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:



Concrete: C30/37 Bi-linear stress-strain diagram Exposure class: XC3 Longitudinal reinforcement: B 500A Bi-linear with an inclined top branch $9\varphi16 \text{ mm} (A_s = 1810 \text{ mm}^2)$ $\rho_I = 1,206 \% (14.2 \text{ kg/m})$ Shear reinforcement: B 500A Bi-linear with an inclined top branch $\varphi8/300 \text{ mm} (n_s = 2) (A_{sw} = 101 \text{ mm}^2)$ $\rho_w = 0,223 \% (2.63 \text{ kg/m}) (A_{swm} = 335 \text{ mm}^2/\text{m})$ 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

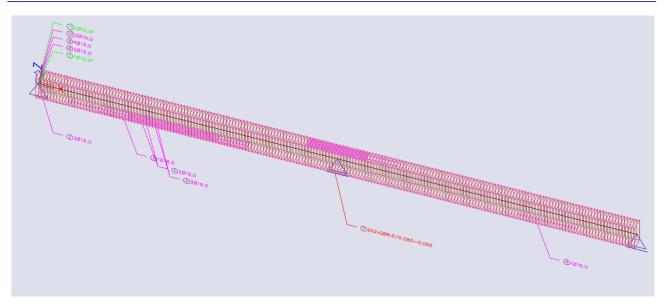
In SCIA Engineer you have two options to input practical reinforcement:

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'.

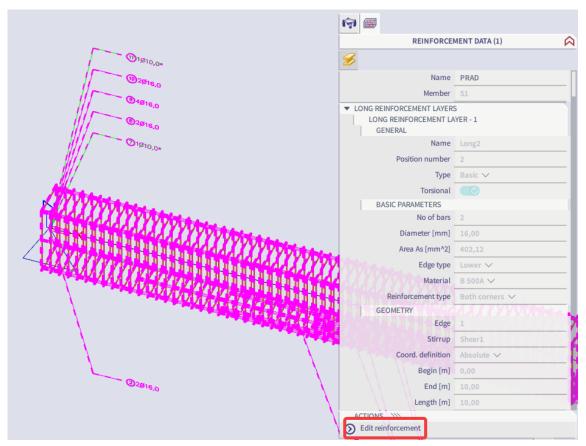
লি		
	LTS (1)	
 SELECTION Type of selection 	All \sim	
Filter		- 1
	No V	-
Results in sections	All V	
 RESULT CASE Type of load 	Combinations \checkmark	
Combination		-
▼ EXTREME 1D	013 0	-
Extreme 1D	Global 🗸	
Type of values	Provided \checkmark	-
Values	As,prov 🗸	-
Interv:	\bigcirc	-
▼ OUTPUT SETTINGS		
Output	Detailed ∨	
▼ DRAWING SETUP 1D		
Display value name	\bigcirc	
Display va ues		
Display inits		
Display case	\bigcirc	
Display section dx	\bigcirc	
Display combination key	\bigcirc	
Display combination name	\overline{O}	
Colorscheme	Defined by result \checkmark	
	Filled light ∨	
Envelope drawing		-
Label colour by graph		-
Dray ing plane		
Label prientation		
▼ ERRORS, WARNINGS AND NOTE		
Show Information about warni	∇	
ACTIONS >>>>		
Refresh		
S Edit provided inforcement t	emplate	
Oncrete setup		
S Conversion for real bars		
> Preview		
<u> </u>		
Summary after conversion		
Member Additional data	Status Explanation	
S1 PRAD	OK -	

ок

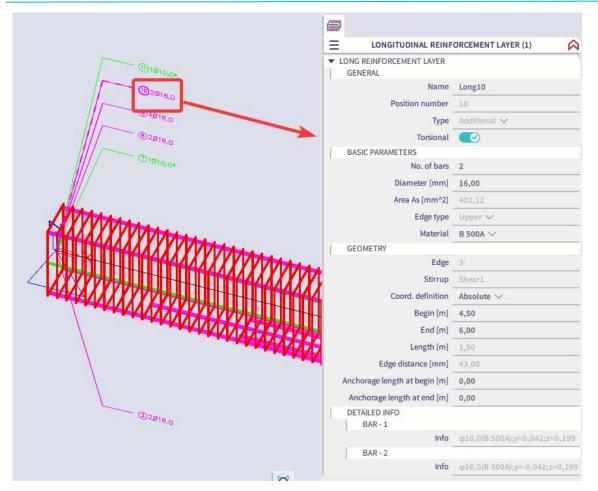


Here we see the basic reinforcement of 2 bars of diameter 16mm along the full length of the beam. On section dx=2.5m we now have the increased reinforcement of 5 bars of diameter 16mm which is of course coming from additional reinforcement inputted in the template of the provided reinforcement. The values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



Tutorial - 1D reinforcement



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

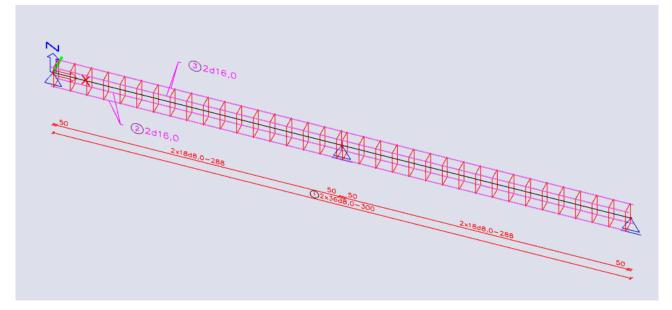
Input practical reinforcement

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.

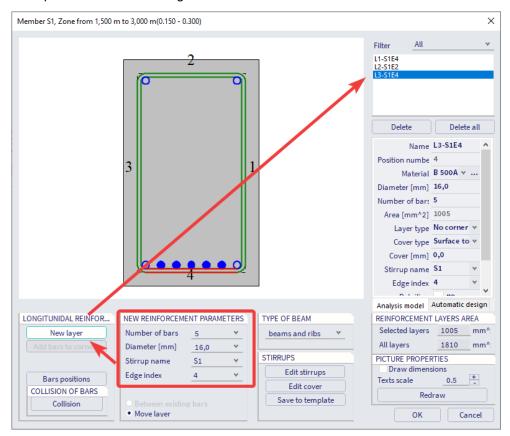
We first choose the option 'New reinforcement' and select a start and end point where the reinforcement will be inputted:

	New reinforcement	⊘ ⊗
	New reinforcement	
X		
	4	
		4

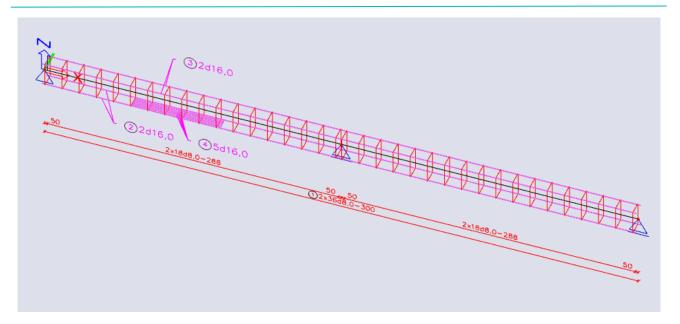
Now we can choose an existing template or make a new one. When making a new one, you first need to select a stirrup or again, make a new one. We will choose the first available template and input this without making any special adjustments:



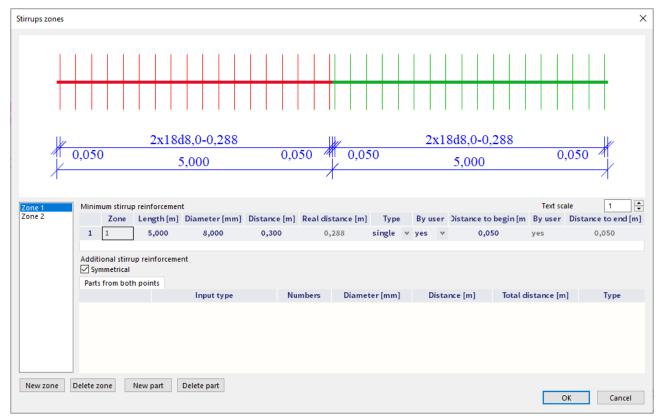
We can also adjust these zones of reinforcement if necessary, by selecting them and changing the parameters in the properties window. However, in this case we want to add the 4 bars of diameter 16 to the middle of the first span. Therefore, we need to choose 'New longitudinal bars' and choose the length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



Tutorial - 1D reinforcement



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:



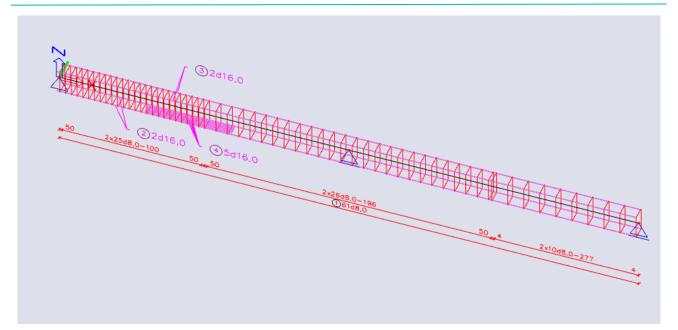
Currently we have two zones over the full length of the beam. We can create a new zone by first making the current zone shorter. Instead of the full length of 10m we will choose 2,5m for this zone. Then we can make new zones of 5m and 2,5m:

Stirrups zones									×
+									$\left \right $
×.	2x9d8,0- 0,050 2,50	-0,300)0 ^{0,050}	0,050	22	x18d8,0-0,2 5,000	38	0,050 0	2x10d8,0-0,27 ,004 2,500 0,0	77
Zone 1 Zone 2 Zone 3	Minimum stirru Zone 1 1 Additional stirru Symmetrical Parts from bot	Length [m] 2,500 up reinforceme	Diameter [mm] 8,000	Distance [m] 0,300	Real distance [m	Type single v		Text scale begin (m By user C 30 yes	
			Input type	Nu	imbers Diam	eter [mm]	Distance [m]	Total distance [m]	Туре
New zone	Delete zone	New part	Delete part					ОК	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 zone	s	×
-		
	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	
Zone 1 Zone 2 Zone 3	Minimum stirrup reinforcement Zone Length [m] Diameter [mm] Distance [m] Real clistance [m] Type By user Distance to begin [m] By user Distance to begin [m] By user Distance to end [m] 1 2 5,000 8,000 0.2 0,196 single v yes v 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	

Tutorial - 1D reinforcement



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