

# Reinforced Concrete Corbel – B9+

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## Basic Documentation – Overview

In addition to the individual program manuals, you will find basic explanations on the operation of the programs on our homepage [www.frilo.com](http://www.frilo.com) ▶ Support ▶ Articles/Information ▶ Basic operating instructions.

## Application options

The B9+ application is suitable for the design of corbels with loads applying directly from above ("corbel with direct load introduction").

### Available direct loading

- Vertical load
- Horizontal load

### Available standards

- DIN EN 1992-1-1: 2012 + 2013 + 2015
- ÖNORM EN 1992-1-1:2011 + 2018
- BS EN 1992-1-1: 2015
- PN EN 1992-1-1:2010
- EN 1992-1-1:2014

### The following entities are determined:

- Framework (if possible) including node dimensions, as well as rod forces (forces in the compression strut and tension band)
- Stability against compressive web fracture (excess of stress in the compression strut at the upper node)
- Compressive strain under load
- Required  $A_s$  of the tensile and web reinforcement
- Anchorage and lap lengths of the reinforcement including intermediate values (for control)
- Output of reinforcement dimensions and layers in the form of tables and as a reinforcement plan

The prerequisite is compliance with the corbel condition  $\frac{a_c}{z_0} \leq 1,0$  and  $\min. \varphi \leq \varphi \leq \max. \varphi$

(see Basis of Calculation)

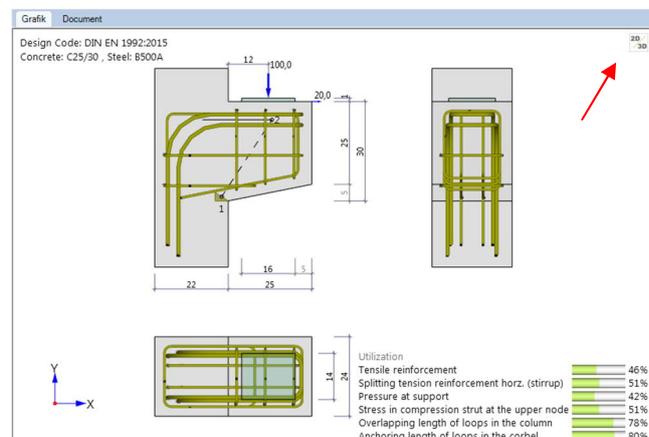
$a_c$  = horizontal distance of the upper node from the edge of the support (DAfStb<sup>1</sup>, Booklet 599, Section 11)

$z_0$  = internal lever arm (vertical length of the compression strut up to the column contact surface)

### 2D/3D-graphical user interface (GUI)

The elements concrete, dimension chains, utilisation, reinforcement etc. can be displayed or hidden via the visibility icons in the menu bar.

The GUI is interactive. See also the context menu (right mouse button) in the document "[Basic Operating Instructions - PLUS](#)".



<sup>1</sup> German Committee for Reinforced Concrete

## Basis of calculation

The calculation is based on the equivalent member method. The regulations of the different National Annexes are taken into account.

## Data entry

The fastest way to enter an item for the first time is to use the [wizard](#).

You can find general information on entering data in the left menu tree or in the interactive GUI and on using the context menu (right mouse button) in the document "[Basic Operating Instructions-PLUS](#)".

## Basic parameters

### Concrete material

Select the desired [standard](#).

Depending on the selected standard, the corresponding material parameters, such as concrete quality or steel grade, are available for selection.

If you check the precast part option, a dialog box for entering parameters/characteristic values specific to precast parts is displayed.

### Concrete cover

Optionally, you can specify whether the concrete cover is the same on all sides of the corbel, or whether it should be possible to enter different values for each side (the corresponding data-entry fields are then displayed).

### Bond conditions

Optionally, you can specify whether the column is to be constructed vertically (e. g. for in-situ concrete columns) with the resulting bond areas or whether the bond areas are to be entered separately (the corresponding data-entry fields are then displayed).

### Column reinforcement

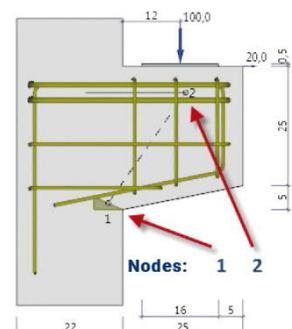
If this option is selected, the data-entry field "Distance column reinforcement  $dr$ " is displayed. Using  $dr$  you can define the centre distance (centre of gravity) of the longitudinal column reinforcement from the right outer edge of the column (for the definition of the lower node (1) - see graphic - on the strut). This ensures that the centre of gravity of the lower node does not lie outside the column reinforcement.

### Anchorage details

**Tensile stirrups** the tensile stirrups in the column area are anchored with consideration of the transverse compression by default – optionally, you can prevent that transverse compression is considered.

**Tensile reinforcement** by default, the tensile reinforcement at the corbel end is only assumed to be lying under transverse compression if the tensile reinforcement lies completely in the transverse compression area (load plate surface including the edge area with a spread angle of the transverse compression of 45 ° up to the center plane of the topmost tensile reinforcement layer). With the option "tensile reinforcement under transverse compression" you can specify that the transverse compression should always be taken into account when determining the anchorage length. If the transverse compression is taken into account, a direct bearing is always assumed ( $\alpha_5 = 0.67$  for NA Germany).

Properties	
Basic parameter	
System	
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Design	
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Concrete material	
Design code	 DIN EN 1992:2015
Concrete quality	C 25/30
Steel quality	B500A
Precast member	<input checked="" type="checkbox"/>
Precast - characteristics	$\gamma_C = 1.50, \gamma_S = 1.15$
Concrete cover	
Covering all over the same	<input checked="" type="checkbox"/>
Concrete cover	cv [cm] 2.5
Bond conditions	
Column upright	<input checked="" type="checkbox"/>
Column reinforcement	
Distance column reinforcement	<input checked="" type="checkbox"/>
Distance of column longitudinal reinforcement $dr$ [cm]	0.0
Anchoring details	
Anchoring links without transversal pressure	<input type="checkbox"/>
Tensile reinforcement by transversal pressure	<input type="checkbox"/>



## System

### Column

Horizontal column dimensions:

- bst perpendicular to the corbel projection
- dst parallel to the corbel projection

### Corbel

Horizontal corbel dimensions:

- bk perpendicular to the projection
- lk parallel to the projection

Vertical corbel dimensions:

- hk total height
- hkr on the right, at the front face of the corbel

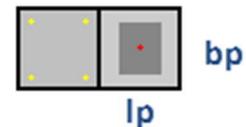
### Load plate

- bp edge length of the load plate perpendicular to the corbel projection
- lp edge length of the load plate parallel to the corbel projection
- dp thickness of the load plate

### Remarks about the system

Optional input of [additional text](#) concerning the system.

Properties			
Basic parameter			
System			
Loading			
Design			
Output			
Column			
Column breath	bst	[cm]	24.0
Column thickness	dst	[cm]	22.0
Corbel			
Corbel breath	bk	[cm]	24.0
Corbel length	lk	[cm]	25.0
Corbel depth	hk	[cm]	30.0
Corbel depth right	hkr	[cm]	25.0
Load slab			
Load slab breath	bp	[cm]	14.0
Load slab length	lp	[cm]	16.0
Load slab thickness	dp	[cm]	1.0
Remarks			
... about the system			



## Loading

### Loading

The dead weight can optionally be taken into account.

Vertical/Horizontal      design value of the load in the respective direction.

### Load impact points

Distance Vertical load      horizontal distance  $a$  of the vertical load from the outer edge of the column.

Distance Horizontal load      vertical distance  $H_{ed}$  of the horizontal load from the top edge of the corbel (positive to the top).

For  $H_{ed}$  at least  $0.2 \cdot F_{ed}$  should be used in accordance with DAfStb, Booklet 600 (at least  $0.1 \cdot F_{ed}$  in accordance with ÖNorm B 1992-1-1)!

This regulation was also adopted for calculations in accordance with the Eurocodes.

### Remarks about the effects

Optional input of [additional text](#) concerning the loading.

Properties			
Basic parameter			
System			
<b>Loading</b>			
Design			
Output			
Loading			
Consider deadweight			<input checked="" type="checkbox"/>
vertical	$F_{ed}$ [kN]		100.0
horizontal	$H_{ed}$ [kN]		20.0
Load impact points			
Distance lateral load	$a$ [cm]		12.0
Distance horizontal load	$h_s$ [cm]		0.0
Remarks			
... about the effects			

## Design / Reinforcement

You can enter the number of layers and the diameters of the respective stirrups/loops.

Further information is shown in the info line below after activation of a data-entry field.

### Option „move the lower node up...“

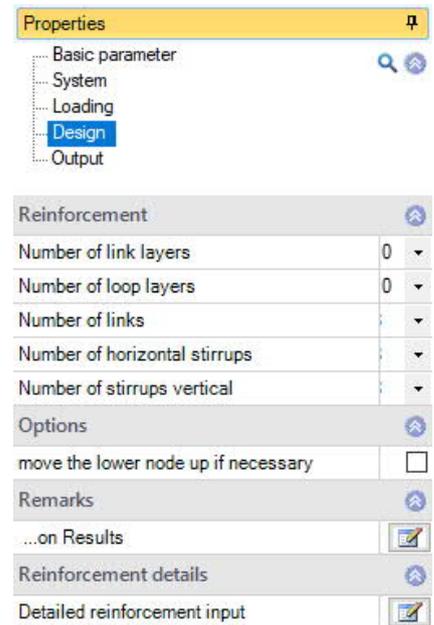
In this way (analogous to the "old" B9), if the maximum permissible strut inclination is exceeded, the lower node can be shifted upwards until the permissible strut inclination is maintained. This option must be set explicitly by the user. Alternatively, as before, there is the option of increasing the upper concrete cover.

### Remarks on Results

Optional input of [additional text](#) concerning the results.

### Reinforcement details

You can make further fine adjustments in the [Reinforcement Details](#) dialog box.

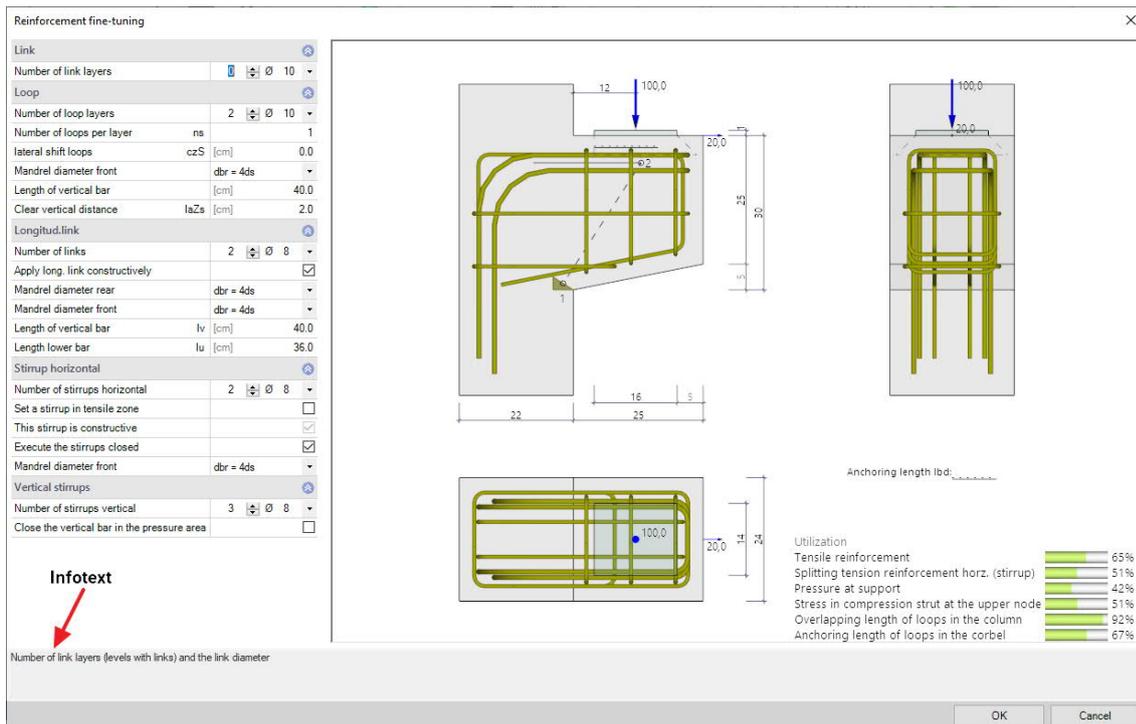


## Reinforcement details

Clicking on the Reinforcement Details icon opens the window for the reinforcement settings.



You can set details of the reinforcement - the explanation of the parameters is displayed as info text after activating the data-entry fields. This allows a detailed adjustment of the reinforcement.



During the data entry, a series of plausibility tests are carried out to ensure that a meaningful structural calculation is possible with the entered values.

A strut-and-tie model is generated from the input values and the design is performed based on these values.

### Tests, error messages and constructive boundary conditions

It is checked

- whether the inclination of the compression strut is within the permissible range and whether  $a_c \leq Z_0$ ;
- whether the user has selected sufficient tensile or splitting tensile reinforcement and whether the permissible stresses under the supporting plate and in the compression strut (at the upper node) are complied with;
- whether the minimum permissible bending roll diameters can be accommodated in the respective steel items and whether the clear distances are complied with, or whether the dimensions of steel items become negative;
- whether, for load-bearing (non-structural) longitudinal stirrups, the load plate end remote from the column does not come closer to the beginning of the curvature of the longitudinal stirrup than the longitudinal stirrup diameter (see BK 2001, P. 2, p. 441);
- whether tensile stirrups or tensile loops are in the area of the lower cant of the corbel or below;

- whether the anchorage and overlap lengths of the tensile reinforcement in the corbel or in the column are adhered to;
- whether, for DIN EN 1992-1-1, the vertical dimension of the lower node meets the requirements of DAfStb, Booklet 599, Section 11.3;
- whether, for ÖNorm B 1992-1-1, the corbel height under the load accounts for at least 60 % of the corbel height at the contact face and whether the length of the diagonal strut of the lower node accounts for maximally 25 % of the structural corbel height.
- Possibly, a message is displayed if the load plate is not enclosed by reinforcement and if the horizontal load is less than recommended by the standard.

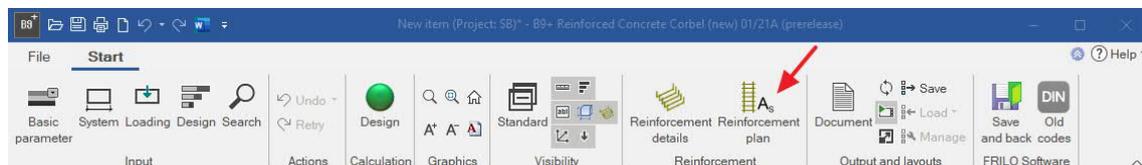
If the test conditions are not complied with, the verification traffic light is coloured red (or yellow for indications) and by clicking on it a window with error messages is displayed.

*Note: The program offers the possibility to arrange several tensile stirrups or loops next to each other (useful for wider corbels). If both, tensile stirrups and loops are positioned, there should be the same number of stirrups and loops per layer, otherwise the clear distance, e. g. for the positioning of longitudinal stirrups, would be too small.*

## Reinforcement plan

Use the reinforcement plan symbol to open the window with the reinforcement drawing and the parts list.

Via the context menu (right mouse button) you can save the graphic separately in different formats (jpg, emf, ...).



# Output

Output of system data, results and graphics.

Call up the output document via the "Document" tab. You can view and print the output data in PDF format.

See also the document ["Output and Printing"](#).

## Output profile

The output profile allows you to define the scope of the output.

System graph      output of the structural system of the corbel

3D system graphics      output of the 3D-system graphic

reinforcement plan      output of the reinforcement drawing

