

# Reinforced Concrete Half Joint B10+

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## Basic Documentation – Overview

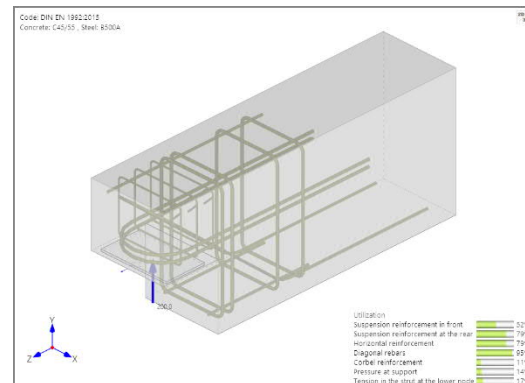
In addition to the individual program manuals, you will find basic explanations on the operation of the programs on our homepage [www.friilo.com](http://www.friilo.com) in the Campus-download-section.

## Application options

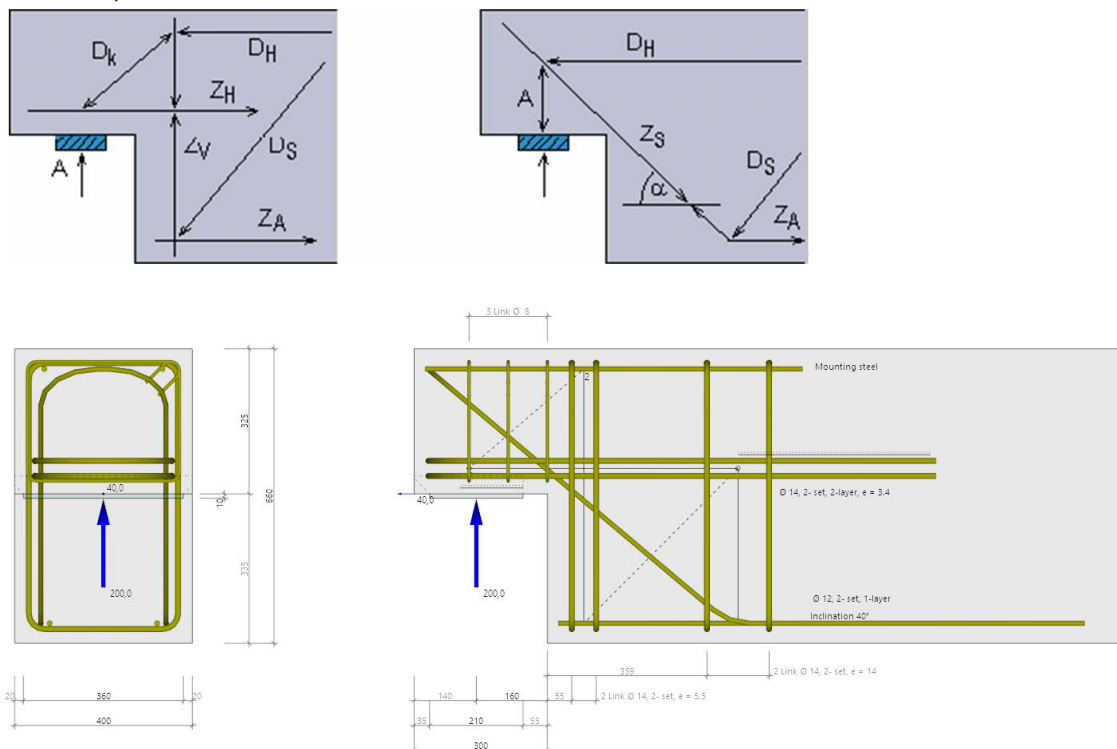
The B10+ software application allows you to calculate dapped beam ends.

### 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
- NTC EN 1992-1-1:2018
- EN 1992-1-1:2014



When using precast beams in reinforced concrete frame structures, dapped beam ends are often required in the bearing area to keep the floor structure as thin as possible. Because anchorage of the diagonal tie  $Z_s$  is difficult due to the geometrical conditions in strut-and-tie models with an inclined reinforcement portion of 100 %, a combined strut-and-tie model comprising perpendicular and inclined suspension reinforcement (see illustration) is selected under normal conditions.



- Calculation optionally in accordance with DAfStb<sup>1</sup> Booklet 599
- Strut-and-tie model combined of perpendicular and diagonal suspension reinforcement
- Percentage of inclined reinforcement can be selected
- Design of an additional load (transfer immediately in the support)
- Calculation of the reinforcement with representation of the reinforcement layout
- Verification of the anchoring of the horizontal reinforcement

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

## Basis of calculation

Calculation in accordance with EN 1992-1-1

The calculation is based on a strut-and-tie model combined of perpendicular and inclined suspension reinforcement in accordance with DAFStb Booklet 599.

The design is performed with the rebar diameters specified by the user. The equilibrium in the strut-and-tie model is determined by iterative addition of the required stirrups and the recalculation of the centres of gravity of the reinforcement.

Strut-and-tie model consisting of inclined suspension reinforcement

The inclined model is always used in combination with the model of perpendicular suspension reinforcement to prevent shearing of the half joint along the inclined bars. This model is more suitable for mapping the actual load-bearing behaviour of higher beam corbels.

The software allows you to define a load-bearing portion of inclined reinforcement of 70 %. It is possible to specify the position of the center of gravity of the front suspension bracket.

**Tensile force in the inclined reinforcement:**

$$F_{ZS} = (F_{ed} - F_{1ed}) \cdot \text{inclined reinforcement portion}$$

Strut-and-tie model consisting of perpendicular suspension reinforcement

While the model of inclined suspension reinforcement results directly from the support geometry, the geometry of the model of perpendicular reinforcement is determined through the dimensioning of the nodes 1 (below) and 2 (above) of the inclined strut (D1), see illustration 3.

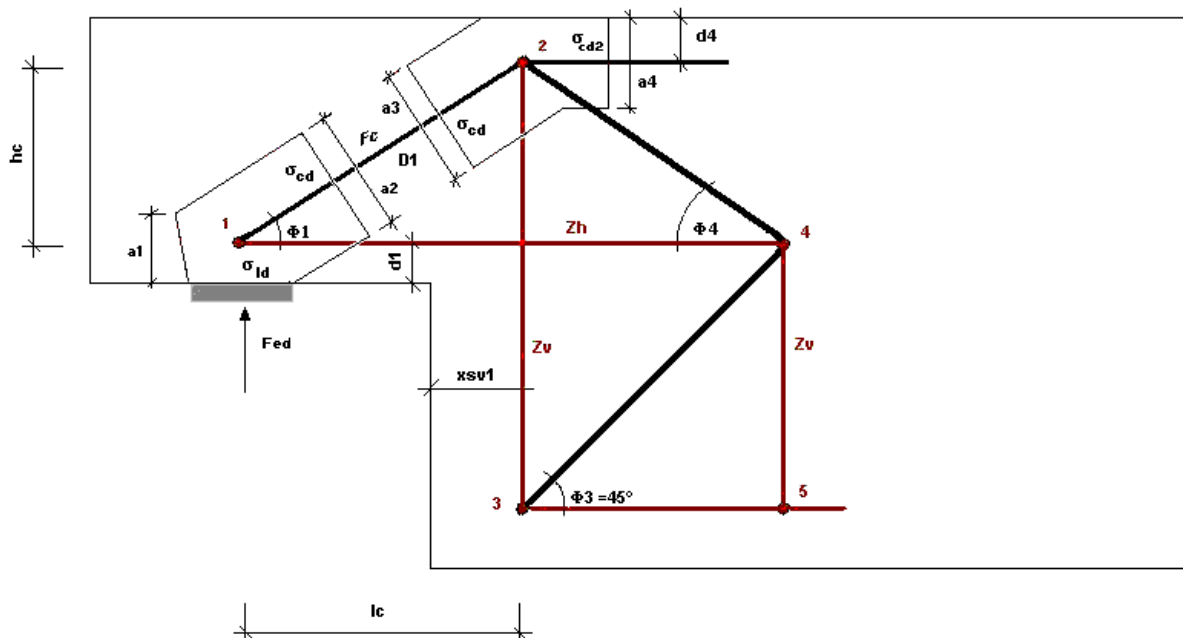


Illustration 3

First, the geometry of the strut-and-tie model is determined in accordance with illustration 3.

It is assumed that the stress limit  $\sigma_{Rdmax} = k_2 \cdot v' \cdot f_{cd}$  in node 2 (stress  $\sigma_{cd2}$  depends on  $a_4$ ) is complied with;  $k_2$  and  $v'$  are assumed in accordance with the selected National Annex (NA).

- for Germany:  $k_2 = 0.75, v' = 1.1 - f_{ck} / 500 \leq 1.0$
- for Austria:  $k_2 = 0.9, v' = 1.0 - f_{ck} / 250 \leq 1.0$

The exact compression strut position with the dimensions of the nodes below and above is determined in the above expressions and the given border conditions such as the concrete cover and the centre of gravity of the suspension reinforcement and the horizontal reinforcement.

By defining unfavourable half joint dimensions and/or if a high number of reinforcement layers is required, an inclination of the compression strut below  $30^\circ$  can result. The software aborts the calculation in this case because a design based on such a strut-and-tie model is not permitted.

Compression strut inclination:

$$\Phi_1 = \arctan\left(\frac{hc}{lc}\right)$$

$$\sigma_{cd2} = \frac{F_{ZH}}{(b_k \cdot a_4)} \quad b_k = \text{half - joint width}; F_{ZH} = F_{ZV} \cdot \frac{l_c}{h_c}$$

Compressive strut force:

$$F_C = F_{ZV} / \sin(\Phi_1)$$

Horizontal forces due to the compressive strut geometry that are to be anchored:

$$F_{ZH} = (F_{ZV} + F_{1ed}) \cdot (lc / hc) + H_{ed}$$

Verification of the load-bearing capacity of the compressive concrete strut:

The load-bearing capacity of the compression strut is verified by compliance with the permissible stress on the (inclined) surface of the lower node.

Verification of bearing pressure:

The verification of the compressive stress underneath the load plate is based on EN 1992-1-1:

With the following conditions underneath the load plate:

$$\sigma_{ld} = \frac{F_{ed}}{l_p \cdot b_p} \leq \sigma_{rd} = k_2 \cdot v' \cdot f_{cd} \quad k_2 \text{ and } v' \text{ in accordance with the applicable National Annex (NA)}$$

- for Germany:  $k_2 = 0.75, v' = 1.1 - f_{ck} / 500 \leq 1.0$
- for Austria:  $k_2 = 0.9, v' = 1.0 - f_{ck} / 250$

and in the node below:

$$a1(1) = 2 \cdot d_1$$

$$a2(1) = \left( a1(1) \cdot \left( \frac{I_C}{hc} \right) + I_P \right) \cdot \sin(\Phi_1)$$

$$\sigma_{cd} = \frac{F_C}{a2(1) \cdot b_P} \leq \sigma_{rd} = k_2 \cdot v' \cdot f_{cd} \quad k_2 \text{ and } v' \text{ as with node 1 for bearing stress}$$

Model for the back anchorage of the horizontal force:

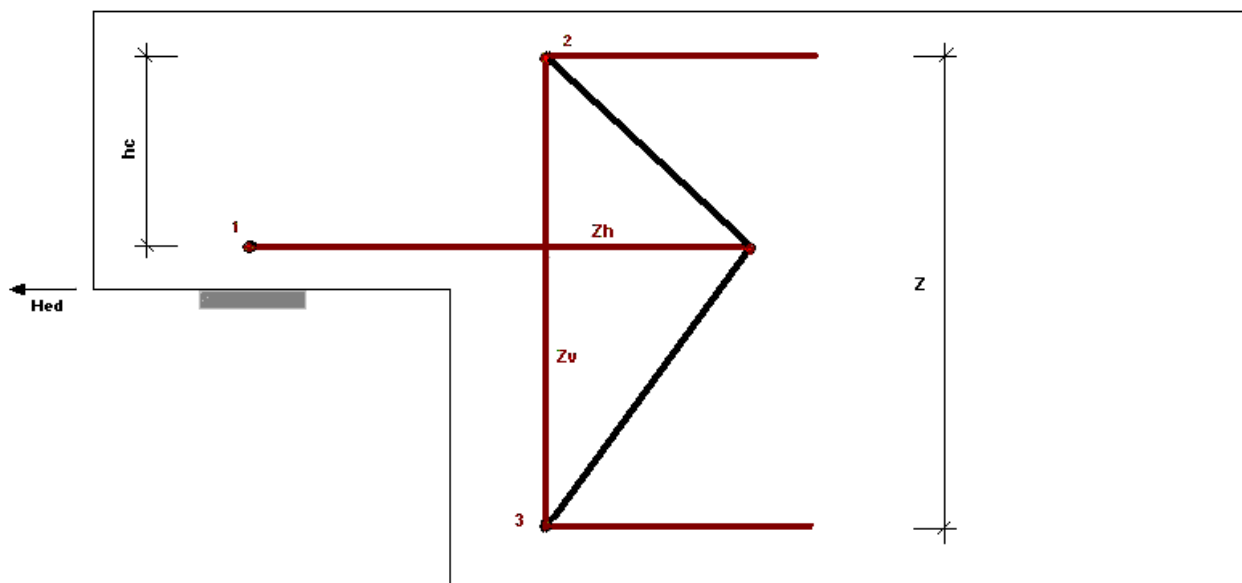


Illustration 4

Optionally, the back anchorage of a horizontal support reaction in the vertical suspension stirrups can be approached as shown in illustration 4 in accordance with /10/, Concrete Yearbook (Betonkalender) 2007, Part 2.

The following results for the tensile force of the vertical (front) suspension reinforcement:

$$F_{ZV} = (F_{ed} - F_{1ed}) \cdot (1 - \text{inclined reinforcement portion}) + H_{ed} \cdot \frac{hc}{Z}$$

#### Reinforcement

The software applies a tensile splitting reinforcement in the form of vertical corbel stirrups, which is sufficient to bear the tensile splitting force  $F_{td}$  determined in accordance with /8/ 3.5.4.

If additional tensile splitting reinforcement should be required, it is to be applied with constructive measures.

## Wizard

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

Only the most important, basic item/system data is queried in compact form.

With such a basic system, the user immediately has a completely calculable system that can then be further developed/refined. The wizard is called by default when a new item is entered - this behavior can optionally be switched off.

## Basic parameters

### Concrete material

First, select the applicable [standard](#).

Depending on the selected standard, the corresponding material parameters - concrete and steel quality - are listed for selection.

For a precast member, mark the option, then you can also call up a dialog for entering precast-specific parameters / characteristic values.

### Concrete cover

Optional können Sie hier festlegen, ob die Betondeckung an allen Seiten der Konsole gleich ist, oder ob sie differenziert eingebbar sein soll (die entsprechenden Eingabefelder werden dann eingeblendet).


### Bond conditions

It can be selected whether the beam is produced (concreted) in the installation position (and the bond conditions result from this) or the bond conditions can be specified for the horizontal and the inclined reinforcement.

### Options

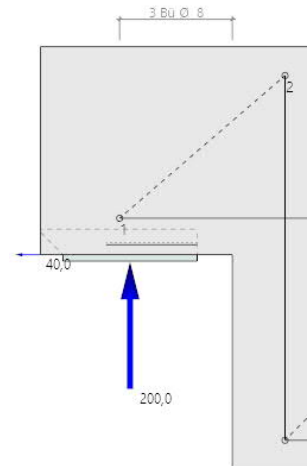
#### Suspension rod is also a tie member

Select this option if the vertical suspension reinforcement is also to be used as a tie member (suspension of the horizontal force).

Properties	
Basic parameter	
System	
Loading	
Design	
Output	
Concrete material	
Design code	 DIN EN 1992:2015
Concrete quality	C 45/55
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	
The beam is manufactured in situ	<input type="checkbox"/>
Connection area horizontal reinforcement at the end of the console	good bond conditions
Connection area horizontal reinforcement in the beam	moderate bond conditions
Options	
Suspension rod is also a tie member	<input type="checkbox"/>
Horizontal reinforcement supposed to cross pressure	<input type="checkbox"/>

### Horizontal reinforcement under transverse pressure

Select this option if the anchorage check of the horizontal reinforcement in the corbel should always be based on the assumption that the horizontal reinforcement in the corbel is under the influence of transverse pressure (transverse pressure is then applied). If this option is not selected, the transverse pressure is only applied if the horizontal reinforcement in the corbel is completely within the area of influence of the transverse pressure. The area of influence results from the load plate area including an edge area, which results from the load spread (under 45 °) up to the center plane of the lowest layer of the horizontal reinforcement (indicated in the graphic by a thin dashed line). If the transverse pressure is applied, a direct support is assumed (reduction of the required anchoring length to 2/3 of the original value according to NA Germany)



## System

### Beam

Enter the beam dimensions.

b0	Web width
h0	Height of beam
bm	Slab width (optional)
hp	Slab height

### Corbel

Eingabe der Konsolenmaße.


hk	Corbel depth
lk	Corbel length

### Load slab

bp	Edge length of the load plate perpendicular to the console overhang
lp	Edge length of the load plate parallel to the console overhang
dp	Thickness of the load plate

### Remarks on system

Call up the [comment editor](#). The comments are listed in the output under the system data.

Properties			
Basic parameter			
System			
Loading			
Design			
Output			
Beam			
Web width	b0	[mm]	400
Height of beam	h0	[mm]	660
Slab width	bm	[mm]	0
Slab height	hp	[mm]	0
Corbel			
Corbel depth	hk	[mm]	325
Corbel length	lk	[mm]	300
Load slab			
Load slab breath	bp	[mm]	360
Load slab length	lp	[mm]	210
Load slab thickness	dp	[mm]	10
Remarks			
...on system			



## Loading

Fed	Vertical support reaction (design value)
Hed	Horizontal support reaction (design value)
F1ed	Close-to-support load that is not up anchored (design value)

### Load application point

e1	Horizontal distance of the vertical load from the notch edge.
Hed	at the height of the horizontal reinforcement Choice of whether the horizontal force <i>Hed</i> should be set at the level of the center of gravity of the horizontal reinforcement or at the level of the lower edge of the corbel. <i>Note: In order to take into account any possible constraining forces in the horizontal direction it is recommended: <math>H, ed \geq 20\%</math> (ONorm-EN 10%) of <math>F, ed</math>.</i>

### Remarks about the effects

Call up the [comment editor](#). The comments are listed in the output under "Loads".

Properties			
Basic parameter			
System			
Loading			
Design			
Output			
Load			
Vertical load	Fed	[kN]	200.0
Lateral load	Hed	[kN]	40.0
Vertical load close to the support	F1ed	[kN]	0.0
Load application point			
Distance vertical load	e1	[cm]	16.0
Hed at the height of the horizontal reinforcement			<input type="checkbox"/>
Remarks			
...about the effects			

## Design

### Diagonal rebars

Load share (in%) that the inclined reinforcement should take up.

If a load share > 0% (up to a maximum of 70%) is entered, the angle of the inclined reinforcement to the horizontal (25 ° - 75 °) must then be specified.

### Longitudinal beam reinforcement

Distance of the center of gravity of the upper / lower longitudinal beam reinforcement from the upper / lower edge of the beam to define the position of the pressure node in the compression strut.

### Suspension link

Option for specifying the position of the center of gravity of the front suspension link in relation to the notch edge of the beam. Defines the truss model with regard to anchoring area of the lower longitudinal beam reinforcement.

Selection of the diameter and input of the number of shear faces of a layer of the suspension link.

### Horizontal reinforcement

Selection of the diameter and input of the number of shear faces of a layer of the horizontal reinforcement.

#### Determination minimum mandrel diameter

You can choose whether the minimum mandrel diameter  $D_{min}$  is to be determined according to the table 8.1 DE or according to equation (8.1) or whether the mandrel diameters should be used for stirrups. When calculating according to equation (8.1), sometimes a smaller permissible mandrel diameter  $D_{min}$  can be determined than according to the table.

#### Minimum layer number of horizontal reinforcement

A minimum number of layers can be defined for the horizontal reinforcement. This makes it possible to favourably influence the verification of the anchorage length.

### Diagonal rebars

Selection of the diameter and input of the number of shear faces of the inclined reinforcement (if available).


The options table, calculate or  $d_{br} = 4$  or 7 (for 20mm reinforcement) are available for the selection to determine the minimum mandrel diameter for the upper as well as for the lower curvature.

### Corbel link

Selection of the diameter. You can choose whether the corbel links should be closed with hooks in the pressure area or not.

### Remarks about the results

Call up the [comment editor](#). The comments are listed in the output under "Results".

Properties			
Basic parameter			
System			
Loading			
Design			
Output			
<b>Diagonal rebars</b>			
Load portion of inclined reinforcement in %			30.00
Inclination diagonal rebars	Alpha [°]		40.0
<b>Longitudinal beam reinforcement</b>			
Spacing upper beam reinforcement	do [cm]		4.5
Spacing lower beam reinforcement	du [cm]		4.5
<b>Suspension link</b>			
Specify the position of the suspension link			<input type="checkbox"/>
Diameter suspension link	mm	14	
Cutting ability of suspension links			2
<b>Horizontal reinforcement</b>			
Diameter horizontal reinforcement	mm	14	
Cutting ability of horizontal reinforcement			2
Determination min. mandrel diameter		acc.to table	
Minimum layer number of horizontal reinf.			1
<b>Diagonal rebars</b>			
Diameter of diagonal reinforcement	mm	12	
Cutting ability of inclined reinforcement			2
Determination of the minimum mandrel diameter above		acc.to table	
Determination of the minimum mandrel diameter below		acc.to table	
<b>Corbel link</b>			
Diameter corbel link	mm	8	
Close the corbel link in the compression area			<input type="checkbox"/>
<b>Remarks</b>			
... about the results			

## Results

The utilisation is displayed in the graphic.

If verifications or geometric requirements are not complied with, the [verification traffic light](#) is colored red and a corresponding note is given. The non-complied requirements / verifications are marked accordingly in the printout.

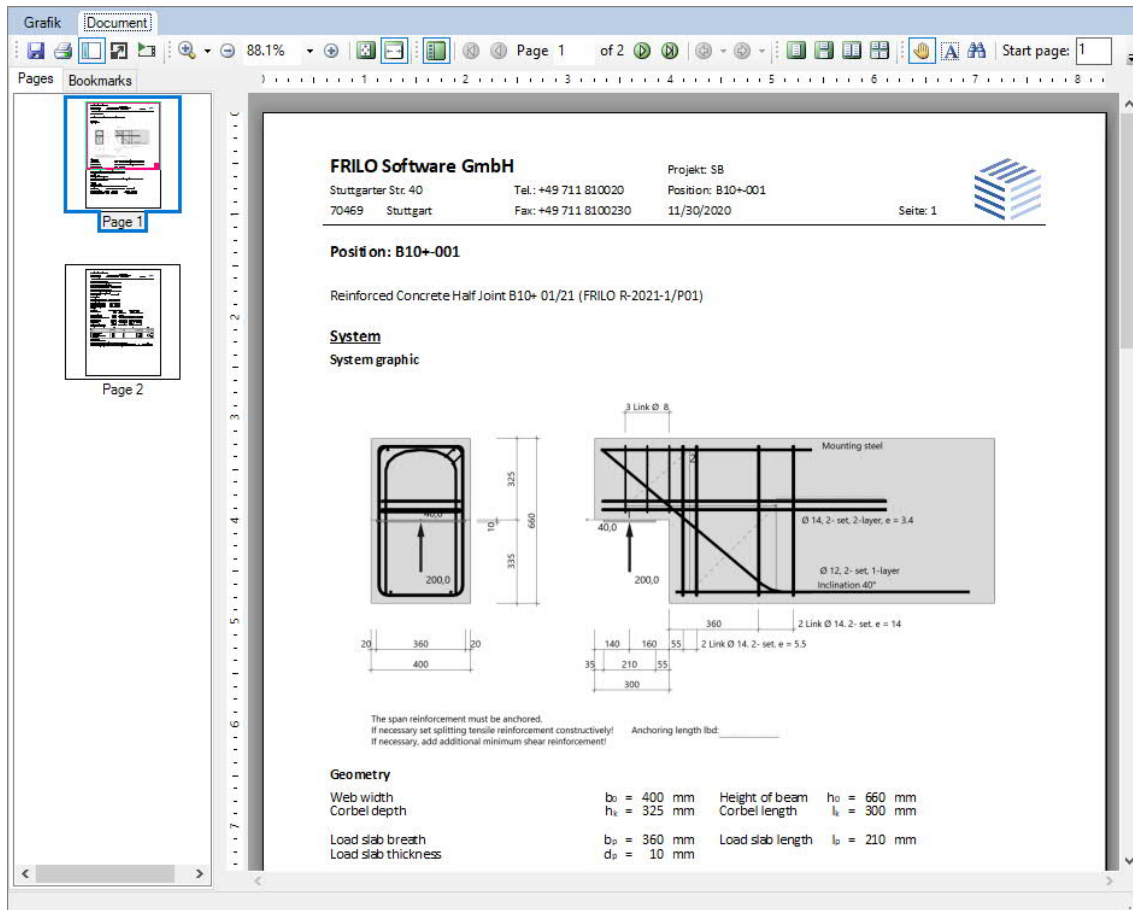
The following results are determined:

- The node dimensions of the lower and upper nodes.
- The dimensions (horizontal and vertical length) of the strut and the angle of the strut to the horizontal.
- The geometrical dimensions of the determined framework as well as the forces occurring therein.
- It is checked whether a reasonable framework results and whether the boundary condition (min. inclination of the strut = 30 ° is observed).
- Determination of the existing stress under the load plate and on the (inclined) node surface of the lower node (verification of the load-bearing capacity of the compression strut) and comparison with the permissible values.
- Determination of the anchorage length of the horizontal reinforcement.
- Determination of the necessary anchorage length of the horizontal reinforcement (in the corbel area and in the beam) including output of intermediate values for better traceability of the results.
- Determination of the required number of reinforcement layers and the center distances for the suspension reinforcement at the front and rear, for the horizontal reinforcement, for the inclined reinforcement (if selected) and for the corbel reinforcement (Splitting tensile reinforcement)
- It is checked whether the geometric requirements for the reinforcement (permissible min. clear distance and min. mandrel diameter/mandrel diameter) are met.
- Graphic representation of the determined reinforcement as well as the anchorage length  $l_{bd}$ .

## Output

You call up the output document by clicking on the Document tab (above the graphic).

See also [Output and printing](#).



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 11/30/2020 Seite: 1

**Position: B10+-001**  
 Reinforced Concrete Half Joint B10+ 01/21 (FRILO R-2021-1/P01)

**System**  
 System graphic

The span reinforcement must be anchored.  
 If necessary set splitting tensile reinforcement constructively!  
 If necessary, add additional minimum shear reinforcement! Anchoring length l<sub>bd</sub>: \_\_\_\_\_

**Geometry**

Web width	$b_w = 400$ mm	Height of beam	$h_o = 660$ mm
Corbel depth	$h_k = 325$ mm	Corbel length	$l_k = 300$ mm
Load slab breadth	$b_p = 360$ mm	Load slab length	$l_p = 210$ mm
Load slab thickness	$d_p = 10$ mm		

Reinforcement details:  
 3 Link Ø 8  
 Mounting steel  
 Ø 14, 2-set, 2-layer, e = 3.4  
 Ø 12, 2-set, 1-layer, Inclination 40°  
 2 Link Ø 14, 2-set, e = 14  
 2 Link Ø 14, 2-set, e = 5.5