B10 – Reinforced Concrete Half Joint

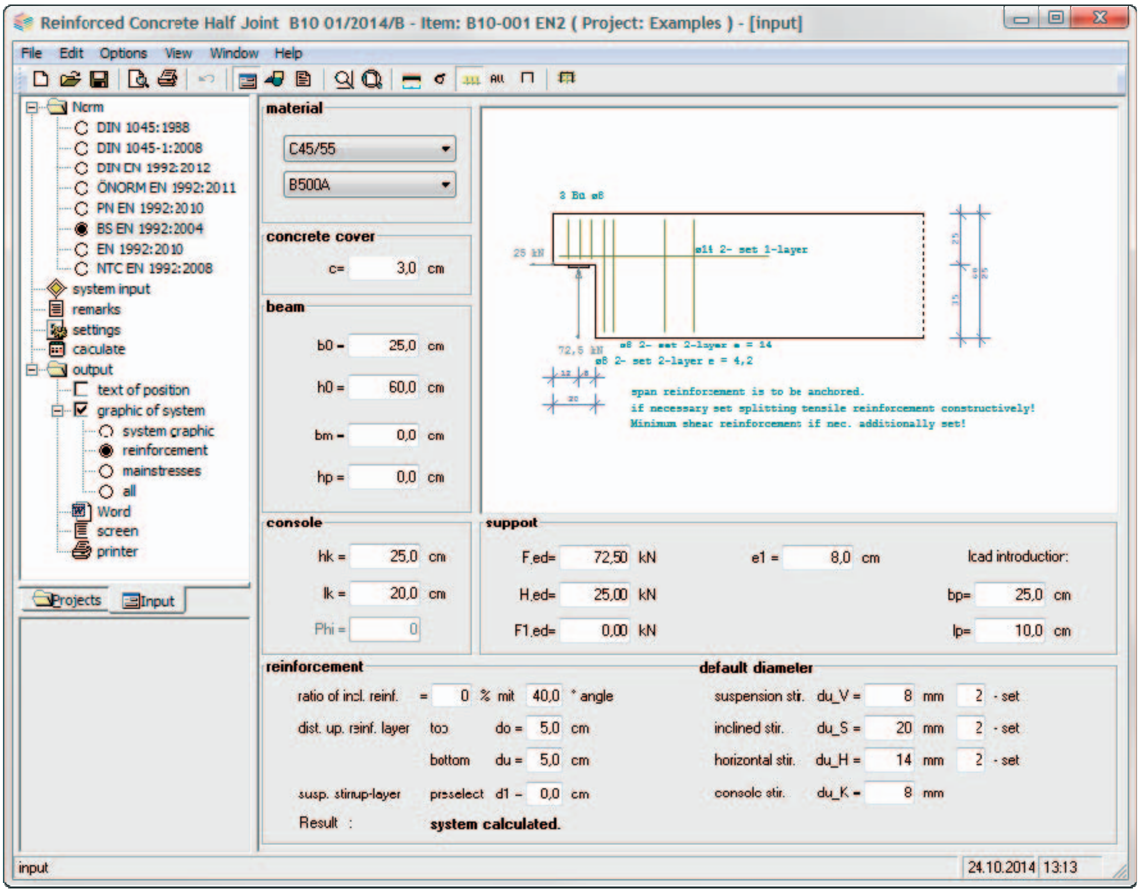
FRILO Software GmbH

www.frilo.com

info@frilo.com

Version: 1/2015

As of 30/01/2015



B10 – Reinforced Concrete Half Joint

Contents

Further information and descriptions are available in the relevant documentations:

Durability - Creep Coefficient and Shrinkage Strain.pdf"

FDC – Basic Operating Instructions	General instructions for the manipulation of the user interface
FDC – Menu items	General description of the typical menu items of Frilo software applications
FDC – Output and printing	Output and printing
FDC - Import and export	Interfaces to other applications (ASCII, RTF, DXF …)
FCC	Frilo.Control.Center - the easy-to-use administration module for projects and items
FDD	Frilo.Document.Designer - document management based on PDF
Frilo.System.Next	Installation, configuration, network, database

Application options

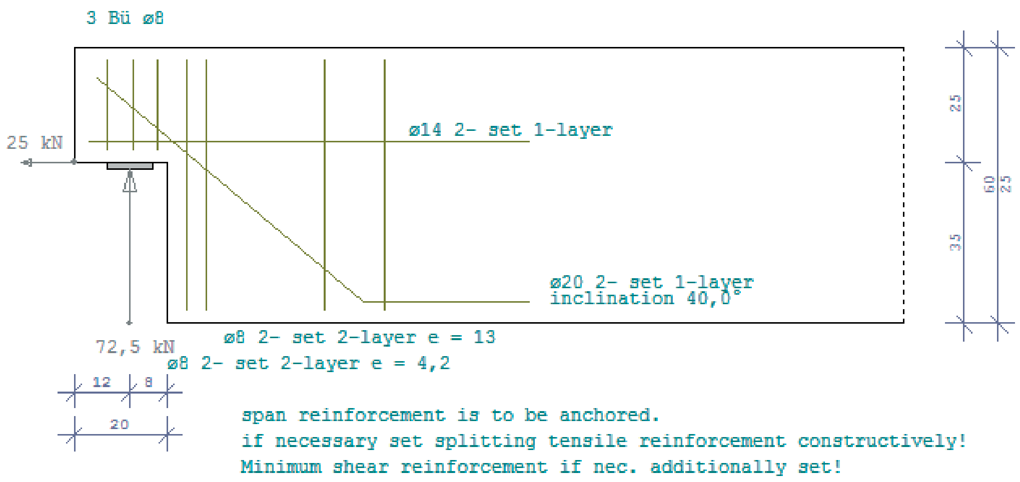
The B10 software application allows you to calculate dapped beam ends.

Available standards:

- DIN EN 1992-1-1:2012 + 2013
- ÖNORM EN 1992-1-1:2011
- BS EN 1992-1-1:2004 + 2009
- EN 1992-1-1
- NTC EN 1992-1-1:2008

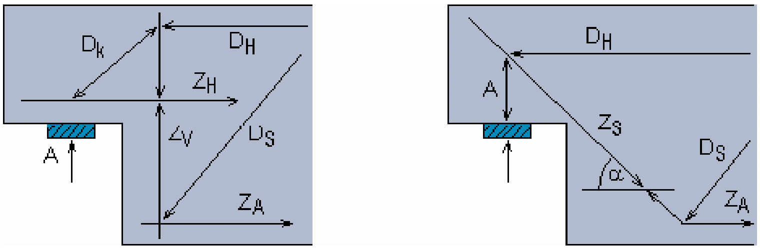
DIN 1045 and DIN 1045-1 are still optionally available.

When using precast beams in reinforced concrete frame structures, dapped beams ends are often required in the bearing area to keep the floor structure as thin as possible. Because anchorage of the diagonal tie *Zs* 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.



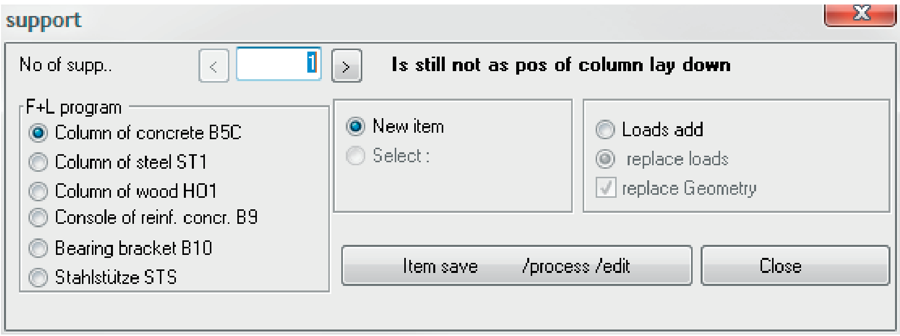
- Calculation optionally in accordance with DAfStb[1] Booklet 399
- Strut-and-tie model combined of perpendicular and diagonal suspension reinforcement
- Freely selectable portion of inclined reinforcement
- Design of an additional load (transfer immediately in the support)
- FE-modelling to check the load-bearing behaviour
- Representation of the main stress determined in the FE modelling
- Calculation of the reinforcement with representation of the reinforcement layout

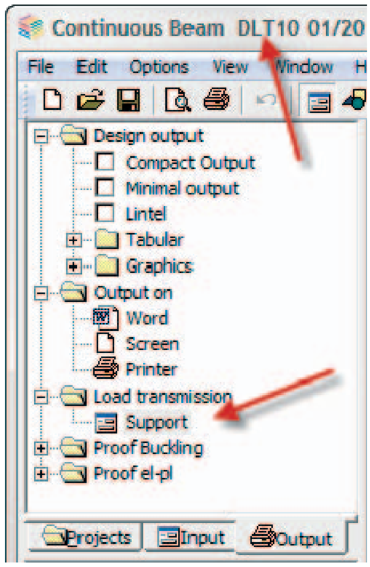
[1] German Committee for Reinforced Concrete



Load transfer from DLT to B10

The load transfer interface allows you to transfer loads from the Continuous Beam application DLT to B10.





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 399.

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 %.

Tensile force in the inclined reinforcement:

$F_{ZS} = (F_{ed} - F1_{ed}) \cdot$ 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 and 2 of the inclined strut (D1), see illustration 3.

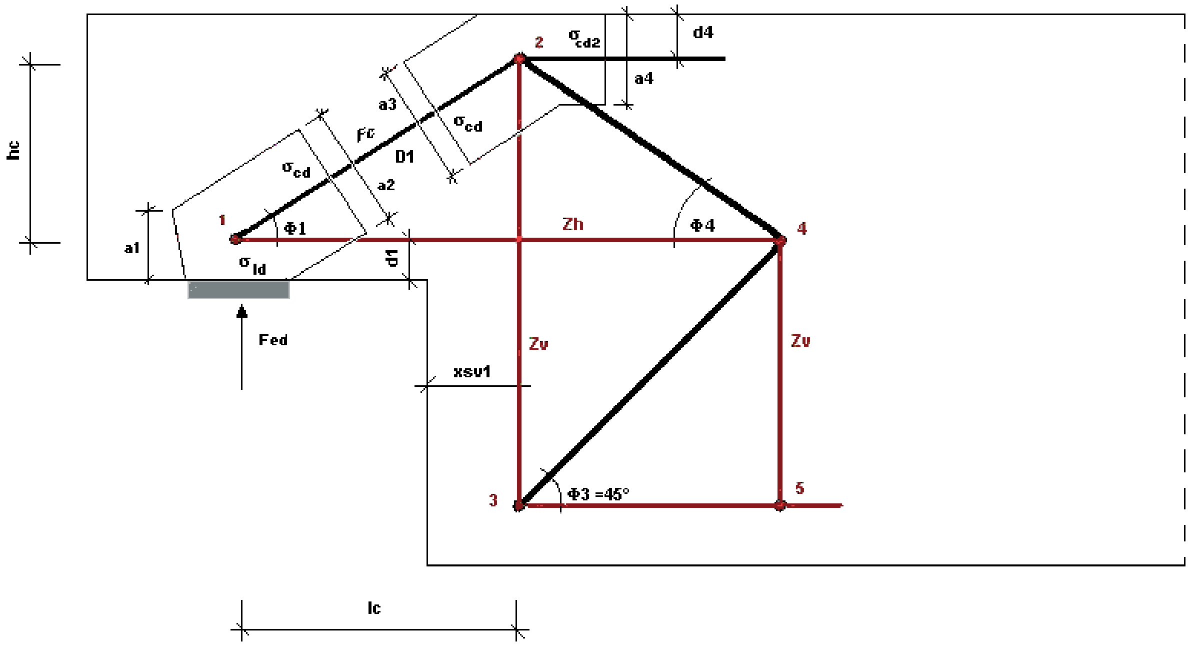


Illustration 3

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

It is assumed that the stress limit $\sigma_{Rdmax} = k_2 \cdot \nu' \cdot f_{cd}$ in node 2 (stress σ_{cd2} depends on a4) is complied with; k_2 and v' are assumed in accordance with the selected National Annex (NA).

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

The exact compression strut position with the dimensions of the nodes 1 and 2 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° can result. The software aborts the calculation in this case because a design based on such a strut-and-tie model is not permitted.

Tensile force in the vertical suspension reinforcement:

$F_{ZV} = (F_{ed} - F1_{ed}) \cdot$ (1 - inclined reinforcement portion)

Compression strut inclination:

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

$$\sigma_{cd2} = \frac{F_{ZH}}{(b_K \cdot a4)} \qquad b_k = \text{half}-\text{joint width;}\ F_{ZH} = F_{ZV} \cdot \frac{l_c}{h_c}$$

Compressive strut force:

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

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

$F_{ZH} = (F_{ZV} + F1_{ed}) \cdot (lc / hc) + H_{ed}$

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

Compliance with the following condition must be verified

$F_{ed} \le V_{rd\_max}$

with $VR_{d,max}$ as per EN 1992-1-1 eq. (6.9) and consideration of the applicable NA.

Verification of node 1 (bearing stress):

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:

$$\sigma_{ld} = \frac{F_{ed}}{l_p \cdot b_p} \le \sigma_{rd} = k_2 \cdot \nu' \cdot f_{cd}$$

k_2 and v' in accordance with the applicable National Annex (NA)

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

and in node 1:

$a1(1) = 2 \cdot d_1$

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

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

Optionally, σ_{ld} and σ_{cd} can be limited to $0.85 \cdot f_{cd1}$ in accordance with Schlaich/Schäfer.

Model for the back anchorage of the horizontal force:

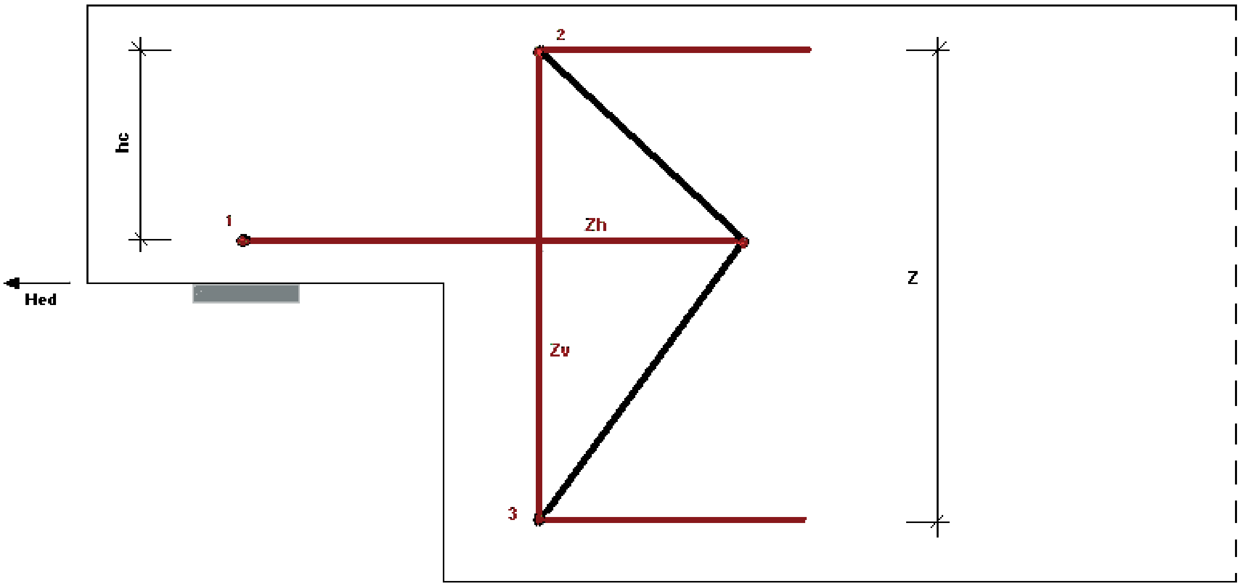


Illustration 4

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 suspension reinforcement:

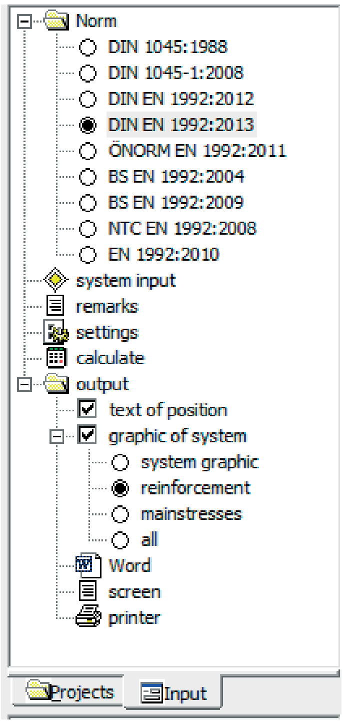
$$F_{ZV} = (F_{ed} - F1_{ed}) \cdot (1 - \text{inclined reinforcement portion}) + H_{ed} \cdot \frac{hc}{z}$$

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.

Definition of the structural system



First, select the applicable standard in the main menu.

Material selection

The available materials depend on the selected standard.

Concrete cover

Define the concrete cover nom.c in this data-entry field.

Beams

Specification of the beam dimensions.

b0 web width

h0 beam height

bm plate width

hp plate thickness

Half joint

Specification of the half joint dimensions.

hk height of the half joint

lk length of the half joint

Supports

F,ed resulting design value of the total vertical support reaction

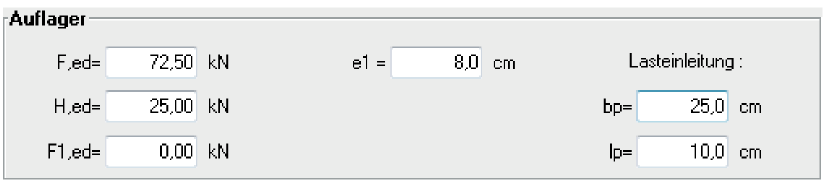
H,ed resulting design value of the horizontal support reaction
Note: In order to take into account any possible constraining forces in the horizontal direction it is recommended: H, ed >= 20% of F,ed.

e1 distance from support axis to front edge of beam

F1,ed resulting design value of close-to-support load that is not up anchored

bp width of the load-transferring plate (direction as with b0)

lp length of the load-transferring plate



Reinforcement

Inclined reinforcem. portion of inclined bars in the suspension reinforcement (70 % maximum)

Preferable diameter

du_V suspension stirrups, diameter of the vertical suspension reinforcement

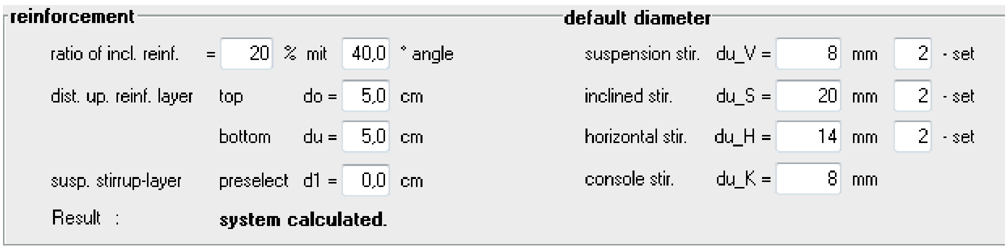
du_S diameter of the inclined suspension reinforcement, requires the specification of the number of shear faces of a stirrup layer (see du_H)

du_S diameter of the horizontal tensile stirrups, requires the specification of the number of shear faces of a stirrup layer.

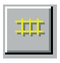
The maximum number of shear faces of a layer with stirrups laid next to each other is verified under the assumption of a bending roll diameter of 7 · du (or 4 · du when du < 20) in accordance with DAfStb Booklet 400 and is displayed in the status line.

The maximum number of shear faces that can be specified in the data-entry field is determined by the minimum rebar spacing defined in the code ($a_{min} \geq$ ds and $a_{min} \geq$ 20 mm).

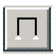
du_K stirrup diameter in the half joint



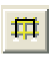
Functions of the buttons in the graphical user interface



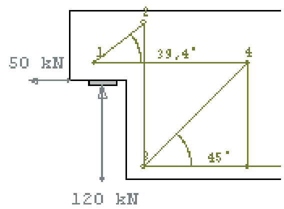
Pressing this button displays the reinforcement in the GUI.



Pressing this button displays the inner strut-and-tie model in addition to the reinforcement in the GUI.

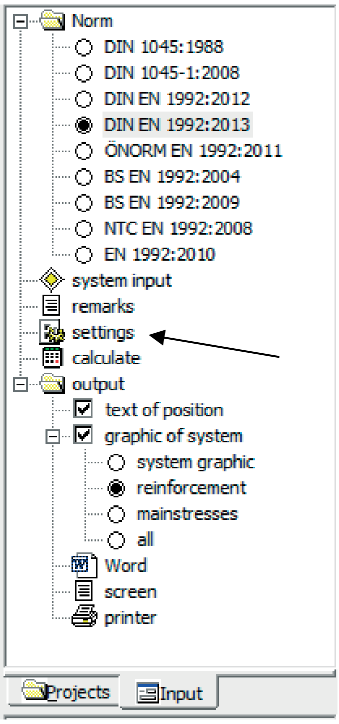


Pressing this button <u>hides</u> or <u>displays</u> the reinforcement in the inner strut-and-tie model.

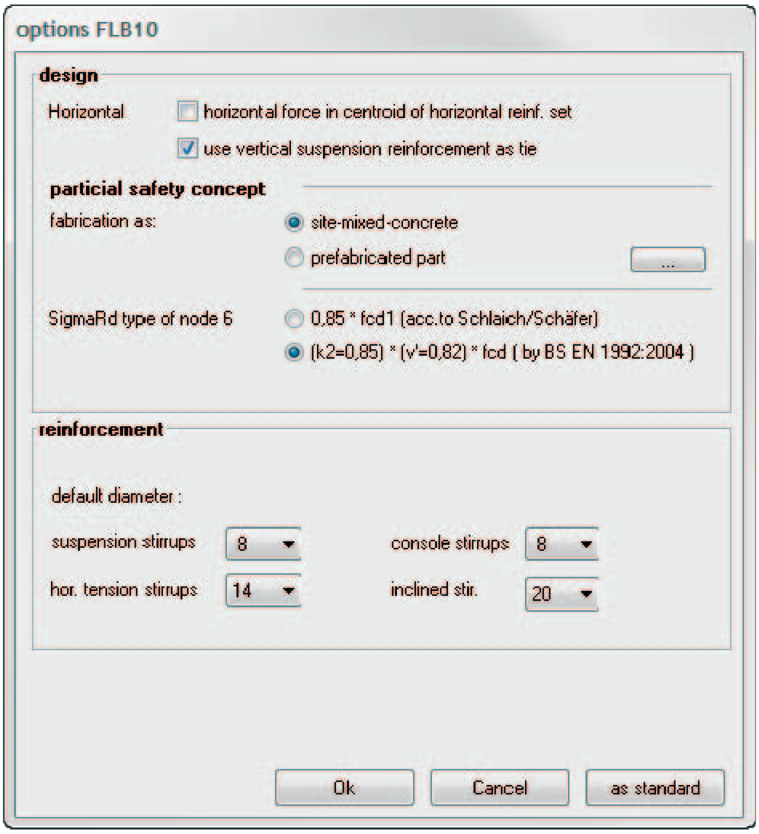


Verification options

▸ Main menu ▸ Settings.



Any changes of the settings in this dialog have an immediate effect on the defined half joint and the values set in the system definition section. When you set up a new item, the software goes back to the default settings, however. The button "By default" allows you to save your settings as defaults.



Horizontal force The horizontal force acts normally on the support (bottom edge of half joint). You can optionally transfer it directly to the horizontal stirrups.

According to the enhanced strut-and-tie model described in the Concrete Yearbook 2007 (Betonkalender 2007, Teil 2, Seite 342, Modell C), the horizontal force is borne by the triangle formed by the ideal strut inclination and the vertical stirrups
(see the paragraph "Model for the back anchorage of the horizontal force" in the Basis of calculation section).

Fabricated as Available options are "Cast-in-place concrete" or "Precast component". The selection has an influence on the determination of the material coefficients γc and γs.

SigmaRd... The limit stress for the design of the compression strut underneath the load plate in the node type 6 of the strut-and-tie model can optionally be assumed with 0.85 · fcd1 in accordance with Schlaich/Schäfer or $k_2 \cdot \nu' \cdot f_{cd}$ as per EN 1992-1 and the values specified in the applicable NA (see above).

Preferable diameter Specification of default values for the preferable diameters of the different stirrup types.

Output

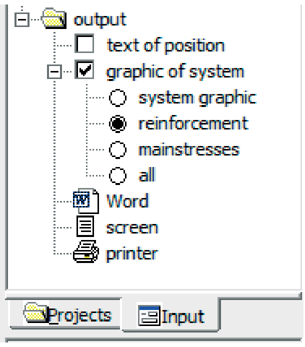
Output of the system data, results and graphics on the screen or printer.

The Output item in the Main menu allows you to start the output on a printer or the screen.

Word	output to MS-Word, if this software is installed on your computer.
Screen	displays the values in a text window on the screen
Printer	starts the output on the printer

▸ File ▸ Print preview displays a print preview.

Output profile



The individual output options allow you to customise the scope and contents of the data to be put out. Only the activated options are considered in the output scope.

Item text	texts that you entered in the "Comments" section are put out at the beginning of the output document.

Graphic of system

Main stress	representation of the structural system with the main stresses
Reinforcement	representation of the structural system with the reinforcement
All	representation of the structural system with the main stresses and the reinforcement

Application-specific icons

The buttons allow you to select the output on the screen

- system graph
- main stress chart
- reinforcement
- combination of main stresses and reinforcement
- internal strut-and-tie model
- internal strut-and-tie model with or without reinforcement

Reference literature

/1/ EN 1992-1-1 including the relevant National Annexes

/2/ Booklet 599 of the German Committee for Reinforced Concrete DAfStb

/3/ Booklet 600 of the German Committee for Reinforced Concrete DAfStb

/4/ Stahlbetonbau aktuell 2013, Stabwerksmodelle

/5/ Booklet 399 of the German Committee for Reinforced Concrete DAfStb

/6/ Booklet 425 of the German Committee for Reinforced Concrete DAfStb

/7/ LEONHARDT, Vorlesungen über den Massivbau Teil 3

/8/ Concrete Yearbook: Betonkalender 2001, Part 2, Konstruieren im Stahlbetonbau (SCHLAICH, SCHÄFER)

/9/ Concrete Yearbook: Betonkalender 2002, Part 1, Grundlagen der Bemessung nach DIN 1045-1 in Beispielen (LITZNER)

/10/ Concrete Yearbook: Betonkalender 2007 Teil 2, Konstruktion und Bemessung von Details nach DIN 1045 (FINGERLOOS / STENZEL)