Reinforced Concrete Column B5+

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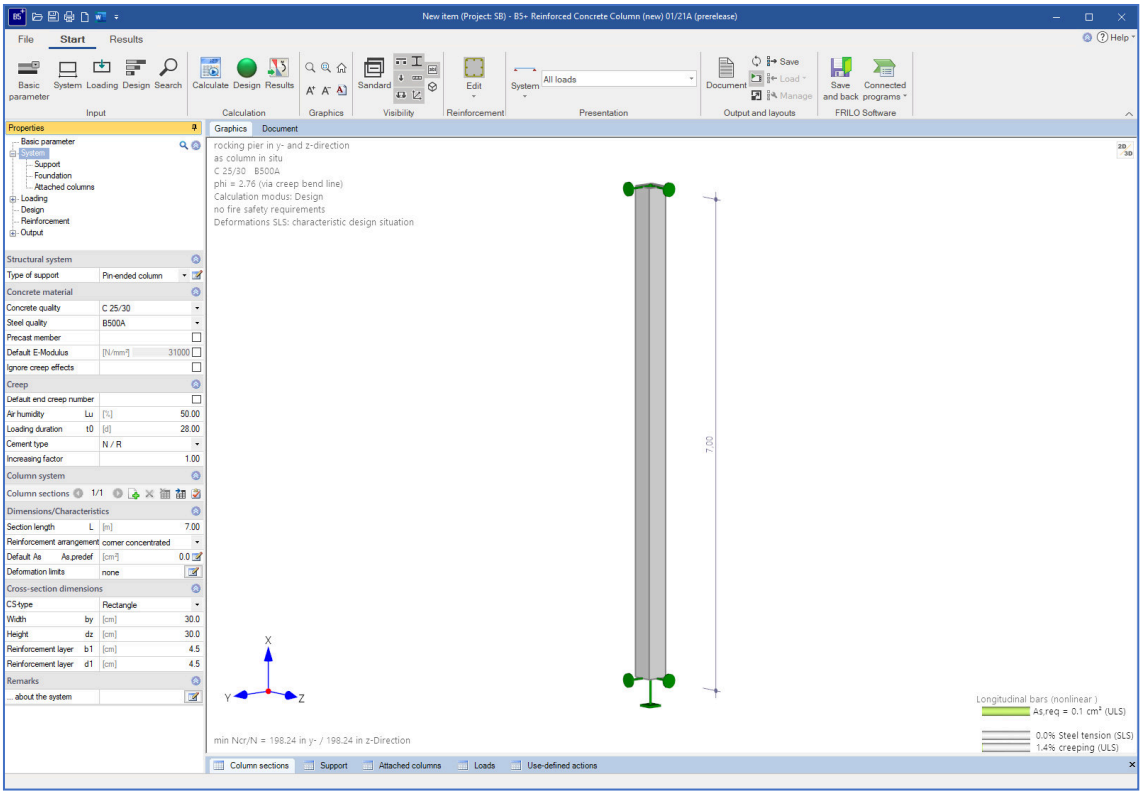


Reinforced Concrete Column B5+

Contents

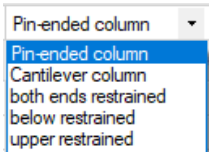
Basic documentation - overview

In addition to the individual program manuals, you can find basic explanations on how to operate the programs on our homepage www.frilo.eu (▸ Service ▸ Articles Information ▸ Basic Operating Instructions).

Application options

B5 is intended for the calculation of reinforced concrete columns and walls under uniaxial and biaxial loading.
Note: Items of former versions of B5 can be opened directly via the context menu.

Data entry



- General columns with any number of storey segments
- Fast definition of simple standard systems via a wizard
- Interactive graphical user interface for data entry and editing
- Data entry via characteristic loads and their actions. Automatic combinatorial analyses for all relevant design situations in the ULS and the SLS
- Grouping of loads into alternative and concurrency groups
- Automatic inclusion of standard snow loads as accidental actions
- User-defined actions
- Selection options concerning the durability requirements

Available standards

- DIN EN 1992
- ÖNORM EN 1992
- EN 1992

Calculation

- Non-linear stiffness can be calculated in accordance with the actual stress strain ratio (A_s or the actual reinforcement pattern can be specified!)
- Foundation restraints can optionally be considered
- Verification of all border conditions (minimum reinforcement, necessity of a buckling safety analysis, regular design etc.)
- Calculation modes: design, verification, limit load factor
- Creep influence via explicit calculation of the creep bending line
- Shear force design
- Serviceability analyses (stress analyses, deformations)
- Fire-safety verification or design according to EN 1992-1-2, method A (eq. 5.7)
- General hot design for hinged and cantilever columns (add-on, *see next page*)

Output

- Detailed output control.
- Graphical representation of the system, loads and internal forces charts.
- Extensive graphical preparation of the calculation results (state lines for internal forces, stiffnesses, etc. for all relevant design situations and stages)

Load transfer

Interfaces to the foundation FD+ and block foundation FDB+ programs.

Hot design add-on

EN 1992-1-2/NA:2010, 4.1 specifies that general methods may be applied in the calculation of the component temperatures and its load-bearing capacity under fire exposure in the hot design. Therefore, we have implemented a corresponding calculation method for exposure on four sides in the software.

The temperature is assessed with the help of the TA program - Temperature Analysis in the Cross-Section, which calculates temperature distribution in rectangular and circular cross-sections of any dimensions based on the FEM.

Basis of calculation

In combination with the B5-HSB add-on, the software performs fire-safety analyses of cantilever columns based on the general method (temperature determination) using the TA program. In this calculation, thermal expansion is considered in addition.

In order to calculate the internal forces acting on the concrete, the concrete cross-section is divided into elements with an edge length of 1 cm each.

The internal forces resulting for the reinforcing steel depend on the temperatures in the reinforcement points.

Method of calculation

The "cold" design is performed for the persistent, transient, accidental, and seismic design situations, if available. The column is divided into subsegments in this calculation. Subsequently, the stiffnesses in state II are calculated in a second-order analysis. Idealised reinforcement layers or explicitly specified reinforcement patterns are used as a basis.

The internal forces for the hot design have to be calculated for the accidental design situation “fire”. The accidental actions from the cold design are not considered in this analysis. The calculation process corresponds to a great extent to that of the "cold" design. The distribution of the reinforcement, i. e. the precise description of the location of the existing longitudinal reinforcement, has a decisive effect on the result, however, because the reinforcement is located in the hot border zone. The steel strengths are reduced by 10 % to 80 % according to Table 3.2 of EN 1992-1-2; the stiffnesses in the individual member segments decrease accordingly.

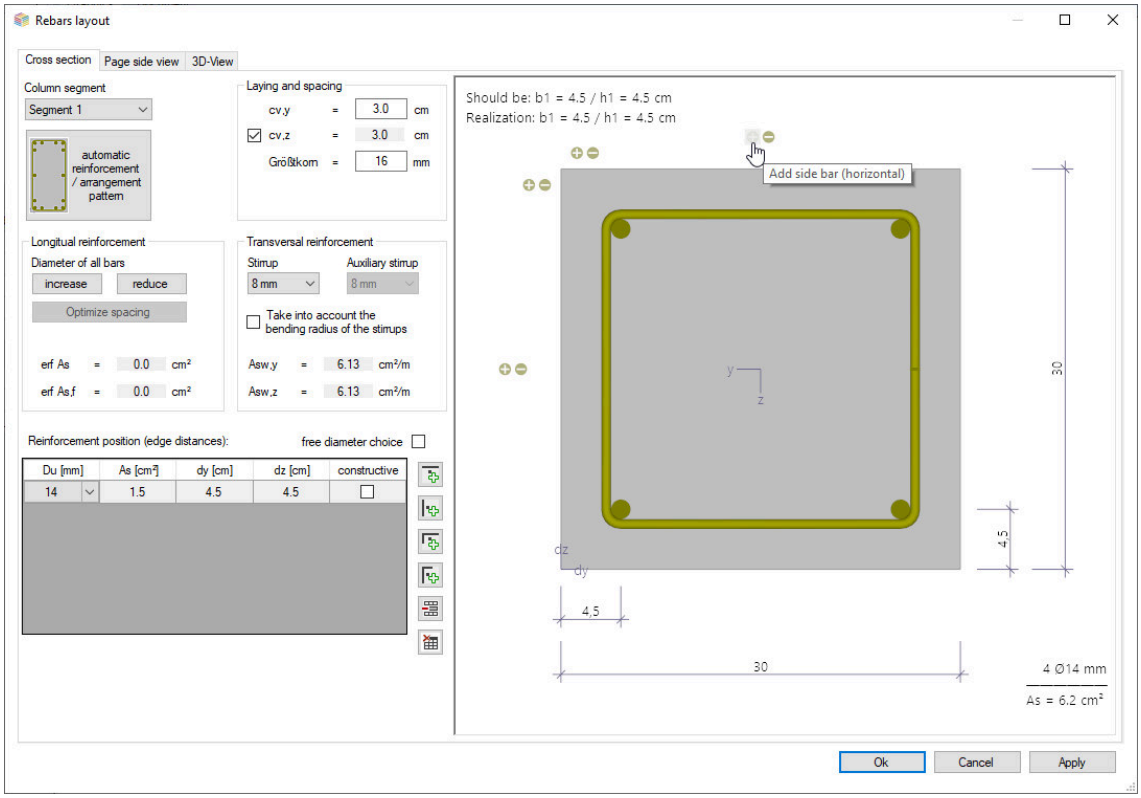
You can optionally select whether the calculation should be for the purpose of a design, a verification or determining the realised fire-resistance period.

Validation

DIN EN 1992-1-2 / NA:2010, 4.1 requires a validation if the general calculation method is used. Therefore, the validation example CC 4.10 was examined with the help of the described method (see Validierung B5 (in German)).

Reinforcement layout

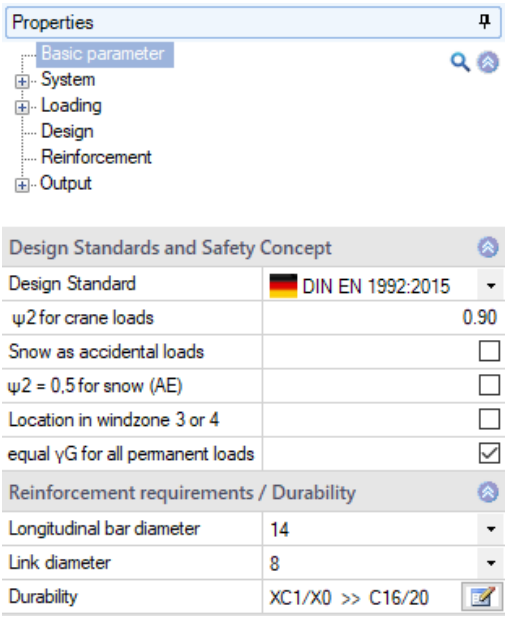
The reinforcement layout gains particular importance due to the introduction of the hot design in accordance with DIN EN 1992-1-2 because the defined reinforcement is included in the calculation with its precise location and temperature.



The reinforcement dialog automatically suggests a standard-compliant reinforcement arrangement in the cross-section (incl. necessary structural bars and intermediate stirrups or S-hooks) as well as over the column segment height (with optional consideration of compaction areas).

The user can customise these suggestions subsequently using the controls and the interactive GUI (adding/removing/moving individual rebars, diameter changes, etc.)

Basic parameters



Design standard — select the desired standard.

ψ2 for crane loads — determine the combination coefficient ψ2 for crane loads (= ratio of permanent portion to total crane load)

Snow accidental — when you check this option, snow loads are included automatically as accidental action in addition to the typical design situations. You can either specify a load factor for the accidental snow loads or have it determined automatically by the software.

Load factor for snow — toggles between automatic and user-defined determination of the load factor that should be used to include snow load as an accidental action relative to its characteristic value.

ψ2 = 0.5 for snow — check this option to increase the value of the combination coefficient ψ2 to 0.5 for snow action in the seismic design situation (AE). (See introductory decrees of the German federal states, e. g. Baden-Württemberg).

Location in wind zone... — specify whether the building is located in wind zone 3 or 4. In this case, you need not consider snow as an accompanying action to wind, which is the leading action.

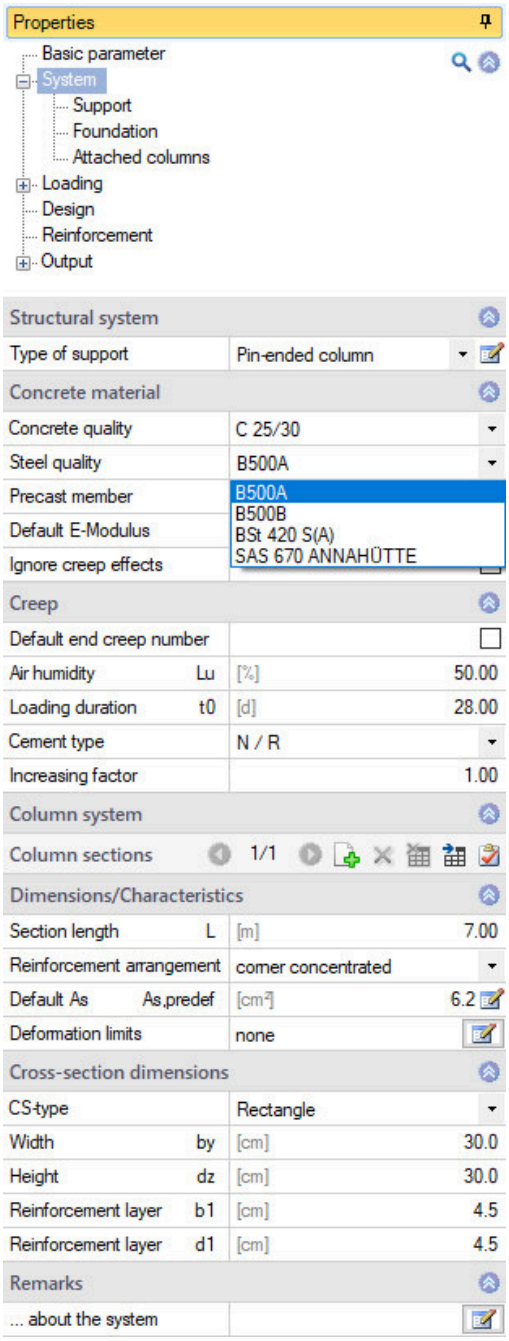
same γG for... — when you check this option, all permanent loads and/or load cases are included with the same partial safety factor (γG,sup or γG,inf). Otherwise, all permanent loads and/or load cases are combined with each other using γG,sup and γG,inf.

Longitudinal bar/stirrup diameter — specify the diameter of the reinforcement bars. The calculations on the cross-section (exposure classes, reinforcement layer) are first based on this value. The final diameter is determined during the processing of the reinforcement layout that follows the calculation.

Durability — a dialog is displayed, in which the design parameters to be observed with regard to ensuring durability can be determined based on the preselected reinforcement diameters and the environmental conditions.
For further explanations concerning durability requirements, exposure classes, creep factor and shrinkage strain, please refer to the document "Durability - Creep and Shrinkage Strain.pdf".

Structural system

Basic system data



Structural system

Select the column type from the selection list. Alternatively, you can also display a well-structured graphical selection screen via the button.

- hinged column (Pin-ended)
- cantilever column
- restrained on both sides
- restrained on bottom
- restrained on top

Concrete material

The concrete quality and reinforcing steel options in this section depend on the selected standard. High-strength reinforcing steel SAS 670 from Stahlwerk Annahütte Max Aicher GmbH & Co. KG can be selected (general method).

Precast component	check this option if the column is to be designed as a precast component. The data-entry field for the precast component parameters is displayed.
Default e-modulus	check this option to enter the e-modulus manually. This way, you can take a known deviation resulting from the aggregates used into account.
Ignore creep effects	this option disables the inclusion of any creep effects. The data-entry section for creep is hidden.

Creep

Default final creep factor	check this option to enter the final creep factor manually; otherwise, it will be calculated automatically from the ambient parameters to be entered below: air humidity, load age and cement type.
Increase factor	this factor is applied to the final creep factor to account for non-linear creep. *Background information: The final creep factor as a material parameter is determined for a permanent load level of approx. 45 % of the compressive concrete strength. If the permanent load level is higher, an increased creep factor must be used in the calculation in accordance with EN 1992-1-1, 3.1.4. If the verification whether the inclusion of linear creep is permissible fails in a first calculation run, you can specify the necessary increase factor as per EN 1992-1-1, 3.1.4 (4), Eq. 3.7.*

Column system

You can define several column segments - see Data entry via tables (Basic Operating Instructions). Alternatively, you can display the entire data-entry table via the "Column segments" tab below the graphic screen.

To define an additional segment, insert a new row first by activating the button.

Dimensions / Properties

Enter the parameters for each column segment. Use the left/right buttons below “Column System” ( ) to toggle between the individual segments.

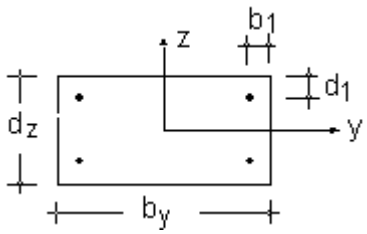
Segment length L	length of the respective column segment.
Offset	offset of the column segment relative to the segment underneath in the direction of the y-axis.
Reinforcement arrangement	you can choose between corner-concentrated, circumferential, or side-distributed arrangement of the longitudinal reinforcement for the calculations on the cross-section. Corner-concentrated: all cross-section calculations assume a concentration of longitudinal reinforcement in the corners (1/4 As per corner). *Attention: At least in the case of assumed corner-concentrated reinforcement, it should be checked again after the reinforcement has been laid, whether the calculation assumption for the realised arrangement is still correct, if necessary. Compared to corner-concentrated reinforcement, distributed longitudinal reinforcement leads to lower load-bearing capacities with the same reinforcement ratio!*
Default As	You can define a default value for the longitudinal reinforcement (distributed in the cross-section according to the selected reinforcement arrangement), which is considered as a minimum value in the design. In the calculation mode ‘Load Factor’ or ‘Verification’ (chapter Design), the load-bearing capacity of the system is analysed with regard to this longitudinal reinforcement. Via the edit button , you can open the “Reinforcement layout” dialog where you can define a reinforcement arrangement. The area of the longitudinal reinforcement is assumed as default reinforcement in this case.
Limit deformations	use the edit button to open a dialog where you can specify limit values for the displacements within the column segment in both axial directions. In the design mode (chapter Design), the reinforcement is then set in such a way that these deformations are not exceeded in the serviceability limit state. In the load factor or verification calculation mode, the structural system’s load-bearing capacity is analysed taking these limit values into account.

Cross-sectional dimensions

Select the type of cross-section, rectangular, circular, or annular.
After this, specify the width, height or diameter for the selected cross-section type, as well as the reinforcement layer.

Reinforcement layer:

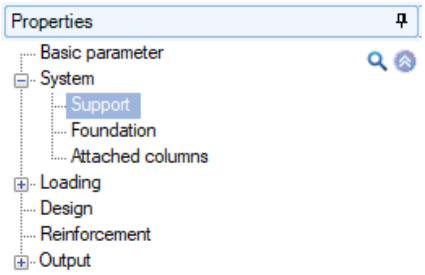
For rectangular cross-sections, use b_1 and d_1 to define the reinforcement layer in the width direction of the cross-section (y-direction) via the distance of the nearest outer face to the centre of gravity of the longitudinal reinforcement bars.

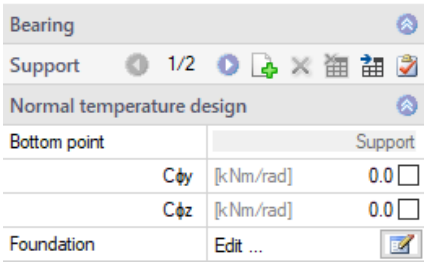


Supports

You can define several supports - see Data entry via tables (Basic Operating Instructions).
Alternatively, you can display the entire data-entry table via the "Support" tab below the graphic screen.

To define an additional segment, insert a new row first by activating the button.





Base point indicates the origin of the support conditions of the column's base point. Support conditions resulting from elastic foundation restraint, if a foundation was defined, can only be edited via the foundation properties.

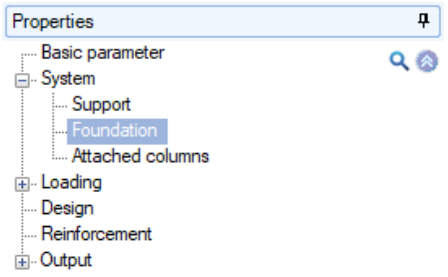
Torsion springs Cφy/z

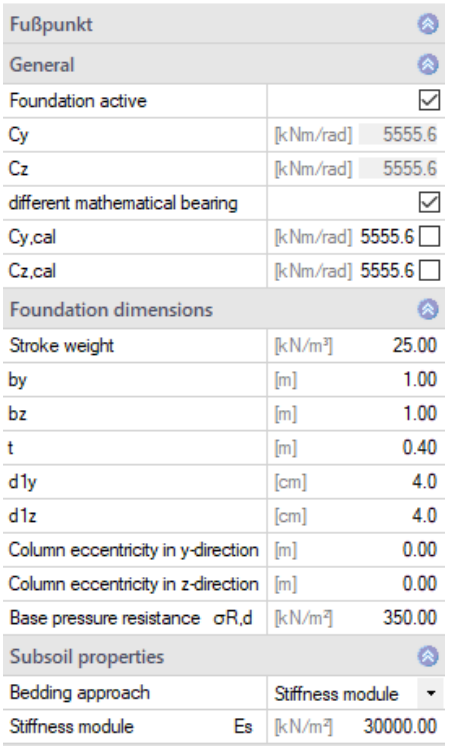
Enter the support condition or spring stiffness for rotation about the y- or z-axis.

For rigid support, tick the box.

Foundation

The application calculates the spring stiffnesses from the entered dimensions and the modulus of elasticity of the subsoil.





General

Foundation active check this option to display the data-entry fields for the foundation.

deviating calculated support enables the specification of calculated support conditions for the column that deviate from support stiffnesses based on the foundation and subsoil properties. When you tick the checkbox, the calculated elastic restraints are automatically adopted and can subsequently be adjusted.

Foundation dimensions

You can enter the weight of the foundation material, the dimensions, reinforcement layer, column eccentricity and the base pressure resistance.

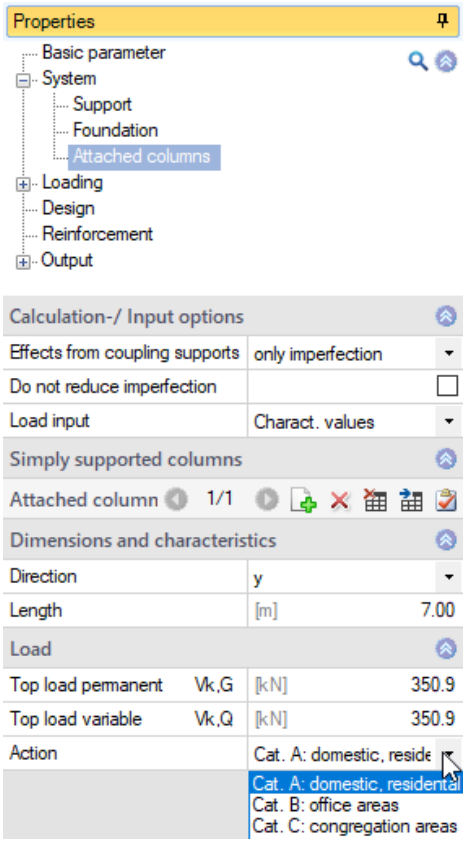
Subsoil properties

Consider subgrade reaction (Bedding approach) defines the method (and thus the specific input parameters) used to convert the elastic restraint effect of the soil compliance into discrete spring stiffnesses for the base point of the column.

Stiffness modulus Es stiffness modulus of the soil (from compression test with impeded transverse strain), which is used as a basis for determining the elastic foundation restraint.

Appended hinged column

Calculation/data-entry options



Effects from coupled columns:

Determines which effects caused by coupled hinged columns should be taken into account.

Only imperfection:
No structural influences (buckling length or sagging forces) are taken into account.

Only buckling length:
Only the influences of the coupled columns on the buckling lengths of the column are considered. Additional sagging forces must be included in the defined horizontal loads.

Buckling length and sagging forces:
The sagging forces from the inclined position of the coupled columns as well as effects on the buckling length of the column are taken into account.

Do not reduce imperfections:

Disables the possible reduction of the unwanted eccentricity to be applied due to the number of components to be braced in a storey.

Load input

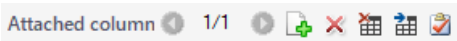
Allows you to set how the loading for the appended hinged column should be determined.

Charact. values
The loads acting on the appended hinged columns are defined in terms of characteristic values of the permanent and variable portions of the vertical loads and the (dominant) action for the variable portion. During the calculation, the design values are then automatically derived for each limit state or design situation.

Design values:
The loads of the appended hinged column are defined in terms of design values of the vertical loads for the ULS in the persistent/transient design situation and in terms of reduction factors for all other limit states or design situations.

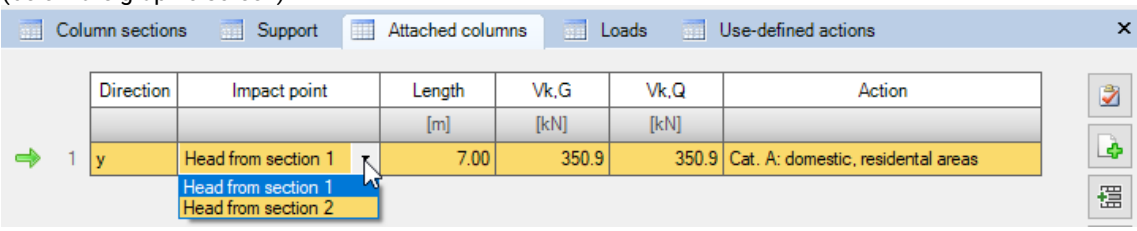
Hinged columns

For each hinged column, insert a new row first by activating the button (an empty data-entry mask is displayed each time).



- see Data entry via tables (Basic Operating Instructions)

Alternatively, you can also enter the data in a table - to do this, click on the "Appended hinged column" tab (below the graphic screen)



Dimensions and properties

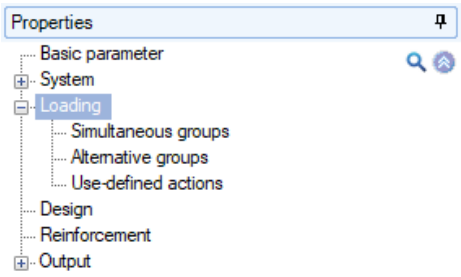
Direction	define the (global) axis direction in which the hinged column should be appended.
Point of application	column segment to whose head the hinged column is to be coupled.
Length	length of the appended hinged column.

Loads

Head load	depends on how the loads are defined - characteristic: permanent / variable, action - design values: design value, reduction factors for the situations accidental, seismic, characteristic, frequent, quasi-permanent

Loading

Self-weight



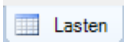
Consider automatically	check this option to take self-weight automatically into account.
Apply self-weight as	the self-weight of the column can be considered as a concentrated load applying at the head or as a UDL distributed load over the segment.

Loads

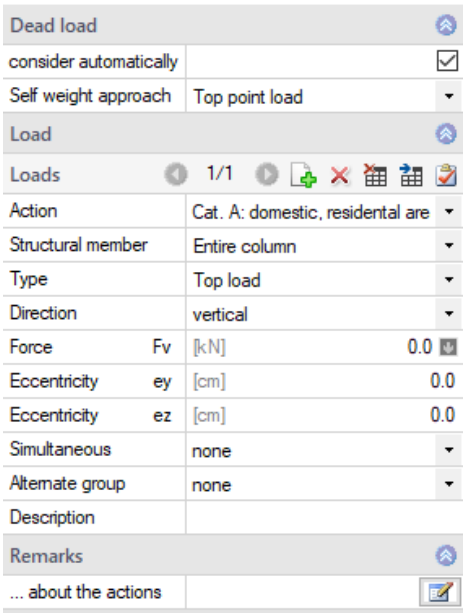
Add additional loads with the help of the load toolbar:

- see Data entry via tables (Basic Operating Instructions)

To add loads, always set up a new row first by activating the  button (an empty data-entry mask is displayed each time).

Alternatively, you can enter loads also in a well-structured load table - click on the 

tab (below the graphic screen) to access the table.



Action	select the action that is assigned to this load from a list
Component	defines the component (entire column/column segment) on which the load acts and to which all distances to be defined relate.
Type	select the load type: head load, base load, UDL, UDL (limited), trapezoidal load, trapezoidal load (limited), concentrated load.
Direction	define the direction of action of the load.
Force	enter the load value directly or call up the load value compilation via the "arrow icon"  - see description in the Load program.
Eccentricity	eccentricity of the load application point for vertical loads (distance to the cross-sectional centre of gravity in the direction of the y- or z-axis).
Simultaneous group	you can assign loads to groups that always act simultaneously. You can create new groups. Names are assigned automatically. The loads of a group must be assigned to an action. ▸ See the chapter Load groups.
Alternative group	the loads of an alternative group are always assumed to act individually, i. e. only one load of the alternative group applies at a time. You can create new groups. Names are assigned automatically. ▸ See the chapter Load groups.

Load groups

The load grouping has only an effect on the p-loads.

g-loads are always considered.

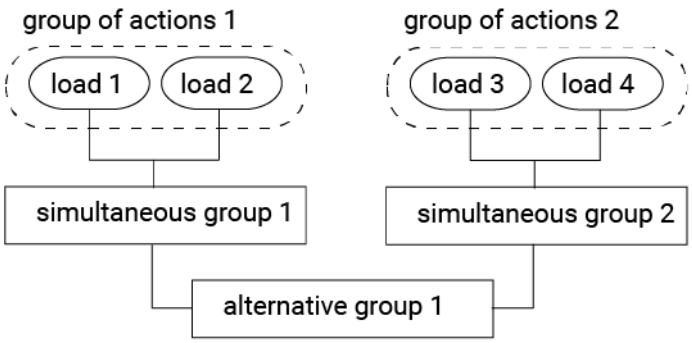
Loads that belong to the same group of actions can be defined as "always acting simultaneously".

In addition, loads or load groups can be set as mutually exclusive (alternative).

This method corresponds to the typical superposition load case.

Note: *In the event of conflicting inputs in the data-entry fields “Concurrency group” and “Alternative group”, the entries in the concurrency group fields have priority.*

Example of groups of actions and load groups within an item



The loads 1 and 2 are assigned to the group of actions 1.

Correspondingly, the loads 3 and 4 are assigned to the group of actions 2.

Load 1 and 2 are assumed to be wind loads in the same direction that always apply together.

The loads 3 and 4 are wind loads in the opposite direction.

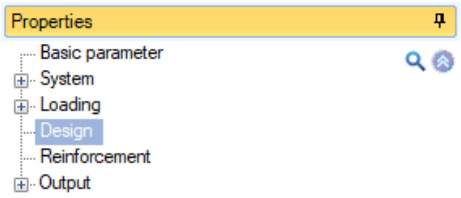
As wind can only blow in one or the other direction, the concurrency groups 1 and 2 are assigned to the alternative group 1.

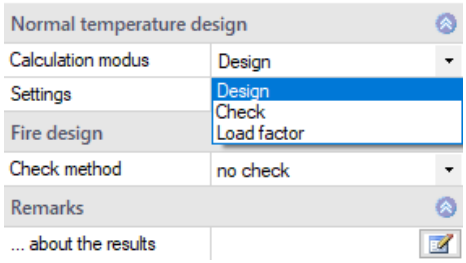
The effect is that either the concurrency group 1 or 2 or none of both is considered depending on whether the loads become decisive for the design or not.

Design

Cold design

Set the basic calculation mode. The method with nominal curvatures is only available in the “Design” calculation mode.





Design

The required longitudinal and transverse reinforcement is determined. The serviceability is assessed via verifications.
To ensure serviceability, the selected reinforcement must possibly be increased and the design or verification must be repeated.

Verification

For the pre-set longitudinal reinforcement, it is checked whether a stable state of equilibrium establishes under the given load. If it does, a shear force design and all serviceability verifications are performed.

Load factor

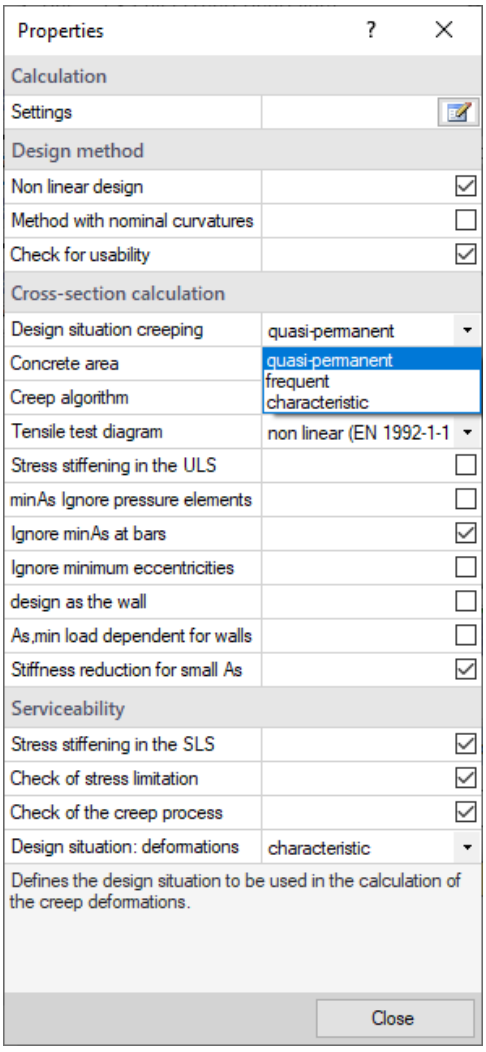
The smallest load factor is determined at which, when applied to the design values of the external loads and the specified longitudinal reinforcement, a stable state of equilibrium still establishes.
The serviceability verification as well as the shear force design are carried out for the load modified with the smallest load factor.

Settings

Displays a dialog with all setting options for the cold design.

See figure on the right.

When clicking on the individual data-entry options, a corresponding explanatory text is displayed at the bottom of the window.



Hot design

Specifies the method according to which the selected fire-resistance period is to be verified.

No check

No verification of the fire-resistance period is performed.

Eq. 5.7 (EN 1992-1-2, method A)

The fire-resistance period is calculated using the simplified method EN 1992-1-1, Clause 5.3.2, eq. (5.7).

FEM

The verification of the load-bearing capacity under fire exposure is performed on the basis of a second-order non-linear structural component calculation and non-linear temperature-dependent material behaviour, whereby the temperature distribution within the cross-sections is determined as a function of the fire duration by means of thermal FEM analysis.

Fire-resistance class	fire-resistance class for which the load-bearing capacity is to be verified.
Calculation mode	calculation mode for hot design.

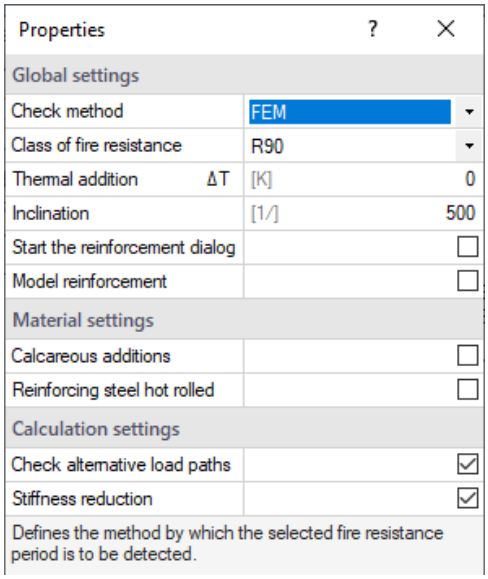
Design:
The required longitudinal and transverse reinforcement is determined. The serviceability is assessed via verifications. To ensure serviceability, the selected reinforcement must possibly be increased and the design or verification must be repeated.

Verification:
For the pre-set longitudinal reinforcement, it is checked whether a stable state of equilibrium establishes under the given load. If it does, a shear force design and all serviceability verifications are performed.

Fire-resistance period:
The fire-resistance period is determined at which, when applied to the design values of the external loads and the specified longitudinal reinforcement, a stable state of equilibrium still establishes.

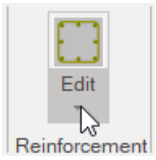
Settings

Displays a dialog with all setting options for the hot design.



Reinforcement layout

The reinforcement layout can be either created automatically or specified manually.



Generate reinforcement patterns

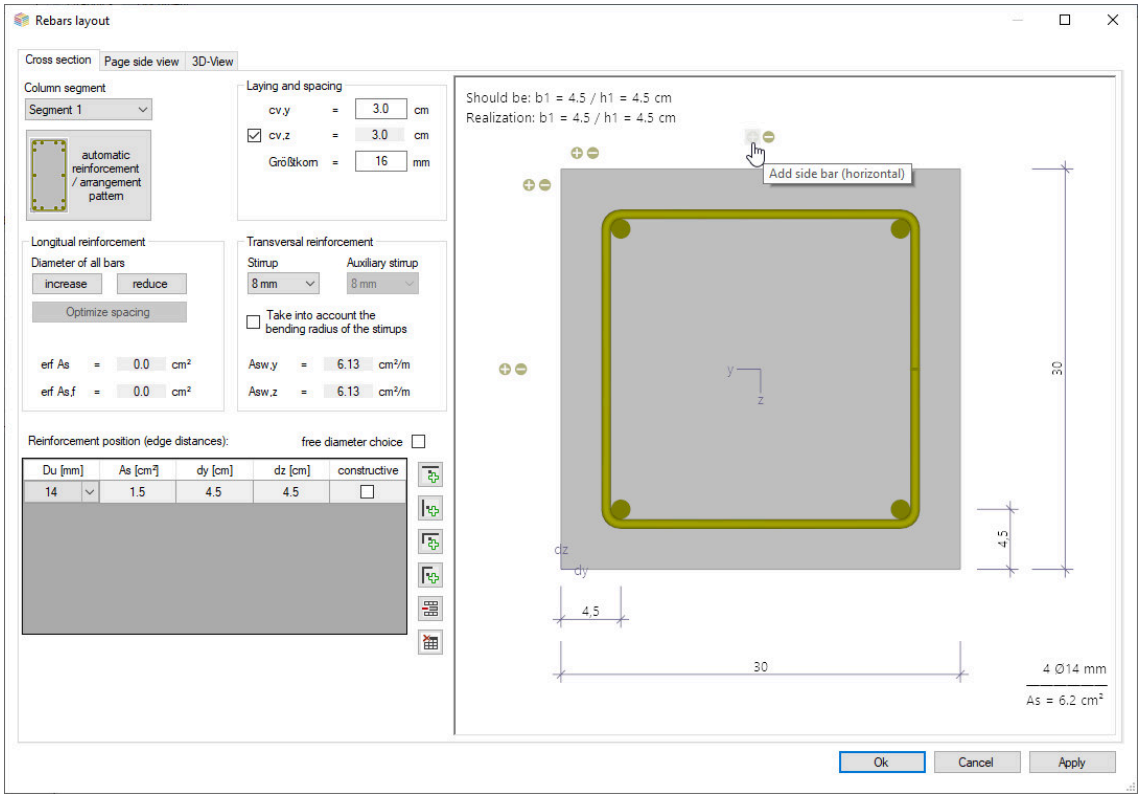
Automatically generates a reinforcement arrangement for each column segment based on the default settings (without explicitly calling up "Manual reinforcement layout").

Remove reinforcement patterns

Removes all existing reinforcement patterns.

Reinforcement layout manual

Opens the reinforcement layout dialog for creating or editing the reinforcement patterns for each column segment.



Cross-section

Graphical view of the cross-section. Setting of reinforcement parameters such as longitudinal and transverse reinforcement, spacing/layer etc.

Column segment

For multi-part columns, select the column segment for which the reinforcement layout is to be created.

Automatic reinforcement laying/arrangement

Opens the dialog for selecting the reinforcement arrangement - the options available for selection are self-explanatory.

In the right dialog area, select the spacing, the diameters of the longitudinal bars and stirrups as well as the maximum grain.
As and req. As are shown.

Reinforcement layer

Add or remove side/corner bars using the corresponding icons.

Interactive reinforcement GUI

The graphical user interface is interactive, i. e. you can add/ remove bars or increase/reduce diameters using the +/- icons or the context menu (right mouse button).

Side view

Side view of the column.

Check the option "Reinforce as wall" if you want to make sure that the cross-section is treated like a wall.

Floor thickness	thickness of the floor slab at the column segment head
Connecting length	lap length of the longitudinal reinforcement above the column head or the top edge of the floor slab
Compaction areas:	
As per standard	controls the automatic determination of the compaction areas of the transverse reinforcement
lv,top/bottom	length of the compaction areas of the transverse reinforcement at the top/bottom segment end
Quantity of steel pre-set Asw	default value for the referenced cross-sectional area of the transverse reinforcement

The option "Consider bending radius of stirrups" controls the stirrups when positioning the corner bars.
The round steel list shows the steel items with their masses and the total for the selected column segment.

3-D view

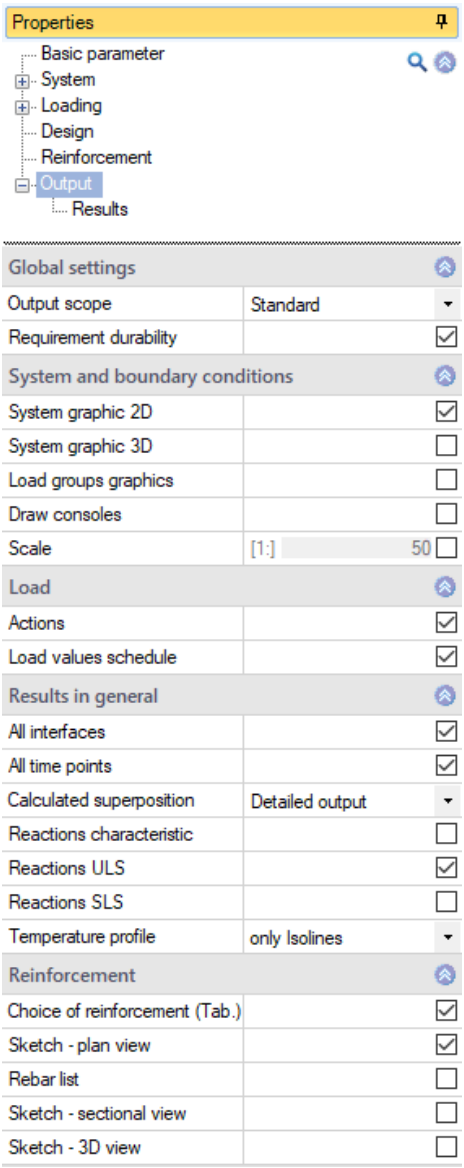
The right mouse button can be used to rotate and tilt the view.

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.



You can customise the output scope via the displayed options.

Load transfer

Call up the desired program via the icon "Connected programs" (FD+, FDB+) and the data is transferred.