Reinforced concrete design – B2

Contents

Further information and descriptions are available in the relevant documentations:

Analyses on Reinforced Concrete Cross Sections.pdf

Durability - Creep Coefficient and Shrinkage Strain.pdf

B2-Schöck-combar Reinforcement made of glass fiber reinforced plastic

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 in the Campus-download-section.

Application options

With the program B2, the design of reinforced concrete cross-sections can be performed. Cross-sections can be designed for bending with longitudinal force and for shear force and torsion. Moreover, the user can verify the crack width and the stress resistance or determine the effective stiffness. Via an add-on (B2-poly), a fire safety verification can be performed and polygonal cross-sections can be designed for biaxial bending with longitudinal force.

Standards/Eurocode

- Originaleurocode and national annexes of Austria, Czech, Germany, Great Britain, Netherlands, Belgium and Poland. See also actual overview of the implemented national annexes on www.frilo.com

Note: *You can select the desired standard as a start option via the function "Standard" in the dialog "Design configuration".*

Additional option Polygonal design and temperature analysis with B2-Poly :
Dimensioning of polygonal cross-sections. For polygonal cross-sections with up to 100 straight sections, a design for biaxial bending with longitudinal force can be carried out or the effective stiffness can be determined. If the additional option B2-Poly is licensed, verification in the exceptional fire design situation according to EN 1992-1-2 (with national appendix) is possible for rectangular and circular cross-sections with general point reinforcement.

The following table gives an overview of the optional scope of calculation for each type of cross section:

Cross section	Effect of actions	ULS bending + longitud. force	ULS/SLS effective rigidity	ULS shear force + torsion	Stress analysis reinf./concrete	Crack width proof	Comments
T-beams *(Plate beams)*	Uniaxial	X	X	X	X	X	optional with cast-in-place complement
Rectangle 1	Uniaxial	X	X	X	X	X	optional with cast-in-place complement (*1) n/m diagrams
Rectangle 2, hollow box	Uniaxial and biaxial	X	X	X	X	-	
Circle, annulus	Uniaxial and biaxial	X	X	X	X	X	n/m diagrams
Layers cross section	Uniaxial	X	X	X	X	X	optional with cast-in-place complement
Universal cross section	Uniaxial and biaxial	X	X	-	X	-	(Additional module B2-Poly!) Design and rigidity for the design situation "fire": (*2)

ULS Ultimate limit state
SLS Serviceability limit state
*1 For floor slabs and NA Germany joint reinforcement also with lattice girders according to general building approval [67], [68], [69], [70], [71]
*2 For rectangle and circle cross sections with general point reinforcement.
See also Fire protection parameters

Standards and terms

EN 1992 1-1

If the national annexes are not mentioned explicitly, the statements apply to all national annexes in the same way.

NDP

The abbreviation refers to definable parameters in the national annex (NA).

Implemented national annexes (NA) and abbreviations used

EN: recommended values EN 1992 1-1
EN 1992-1-1:2004 /A1:2014 und EN 1992-1-2:2004 /AC:2008

Implemented national annexes (NA)

NA-D: Germany
DIN 1992-1-1/ NA:2015-09 and DIN EN 1992-1-2/NA:2015-09

NA-A: Austria
ÖNORM B 1992-1-1:2018 and ÖNORM B 1992-1-2:2011
This NA replaces the previously valid NA of 2007 and 2011

NA-GB: UK
NA to BS EN 1992-1-1 A2:2015-07, BS8500-1:2015 and NA to BS EN 1992-1-2:2004

NA-I Italy
UNI EN 1992-1-1/NTC:2008 and EN 1992-1-2:2004 /AC:2008
NTC 2018 replaces the previous version of 2008
NTC: the application of Eurocode in Italy ist described in the document „Norme tecniche per le costruzioni" (/73/) and the complementary newsletter "Circolare finissima 2.2.2009" (/74/).

NA-NL Netherlands
NEN EN 1992-1-1 + C2:2011/NB:2011 and NEN-EN 1992-1-2+C1:2011/NB:2011
This NA NA replaces the previously valid NA of 2007

NA-B Belgium
NBN EN 1992-1-1 ANB:2010 and NBN EN 1992-1-2 ANB:2010

NA-CZ Czech Republic
CSN EN 1992-1-1/NA:2011 and CSN EN 1992-1-2/NA:2007
The former NA replaces the previously valid NA of 2007

NA-PL Poland
PN EN 1992-1-1:2008/NA:2010 and PN-EN 1992-1-2:2008/NA:2010

See also actual overview of the implemented national annexes on www.frilo.com

Basis of calculation

The topics

- Design for bending and longitudinal force
- Calculation of the effective rigidity
- Shear design
- Proofs of serviceability
- Accidental design situation

are dealt with in the document "Analyses on Reinforced Concrete Cross Sections.pdf".

The durability requirements calculated by the program can be found here:

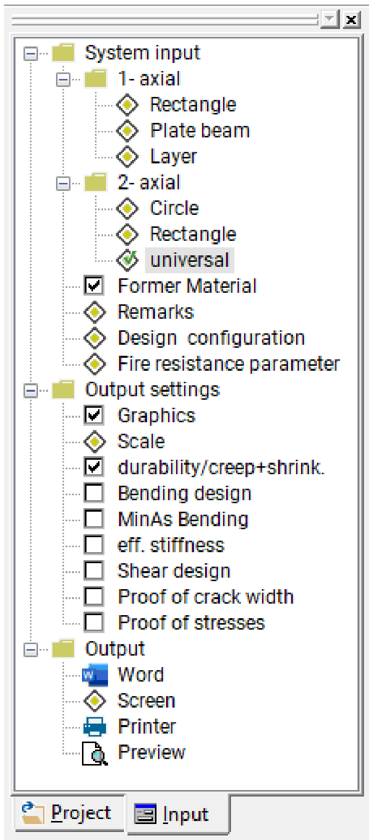
Durability - Creep Coefficient and Shrinkage Strain.pdf

System input

The items of the main tree reveal the input options of the application.

When you set up a new item, a window for the selection of the type of cross section and the standard is displayed.

Type of cross section:



Uniaxial

- Rectangle
- T-beam
- Layers

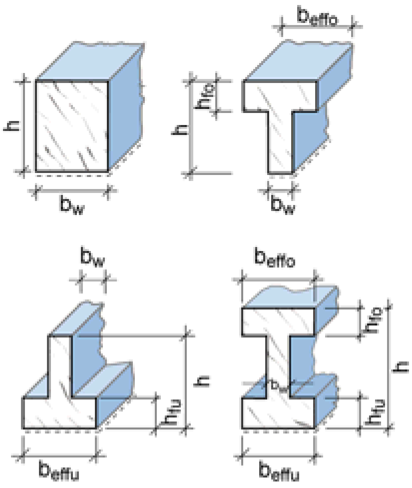
Biaxial

- Circle
- Rectangle
- Polygon   *Note: The processing of polygonal cross sections requires the additional module B2-Poly.*

Direct chapter links:

- Material input
- Design options EN 1992 1-1
- Cast-in-place complement
- Environmental conditions / requirement classes
- Input of action effects
- Design - results

T-beam / rectangle uniaxial



Cross section — See illustration

Cast-in-place compl.: — See dialog Cast-in-place complement

Reinforcement

dob — distance of the upper layer (from the top edge or the cast-in-place complement, if applicable)

dun — distance of the lower layer (from the bottom edge)

You must specify the distance of the center of gravity for multilayer reinforcements.
See also
Durability - Creep Coefficient and Shrinkage Strain

Reinforcement distribution:

- → See Design according to the Kh (Kd) method
- → See Design for a given reinforcement relation
Asu/Aso= 1, 3, 5, 7

Layers cross section input

Cross section — You can enter any simple symmetrical cross sections. Each layer has a distance from the top and a width. The distance of the first layer is equal to 0.

Cast-in-place compl.: — → See dialog Cast-in-place complement

Thickness	hE <= thickness of the first layer
Joint width	bj <= width of the first layer,
	additional BFug <= width of second layer, when HErg = thickness of first layer

Reinforcement

dob — distance of the upper layer (from the top level or the cast-in-place complement, if applicable)

dun — distance of the lower layer (from the bottom edge)

You must specify the distance of the center of gravity for multilayer reinforcements.

See also Durability - Creep Coefficient and Shrinkage Strain

- → See Design according to the Kh (Kd) method
- → See Design for a given reinforcement proportion Asu/Aso= 1, 3, 5, 7

Circle / annulus

Cross section	da	outer diameter > 0
	di	inner diameter (full circle: Di=O, otherwise > 0)
Reinforcement	d1	distance from the circumference > 0

See also Durability - Creep Coefficient and Shrinkage Strain
The reinforcement is distributed over the circumference.

Rectangle biaxial

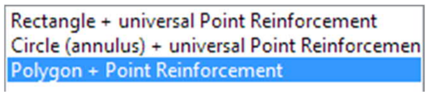
Cross section	bw	width > 0
	h	height > 0
	bi	box width (full cross section = 0, otherwise > 0)
	di	box thickness (full cross section = 0, otherwise > 0)
Reinforcement	b1	distance of the upper layer (from the top edge)
	d1	distance of the lower layer (from the bottom edge)

You must specify the distance of the center of gravity for multilayer reinforcements.
See also Durability - Creep Coefficient and Shrinkage Strain
Reinforcement distribution:

- Distributed over the corners: 4 · 1/4, 3 · 1/6+3/6, 3 · 1/8+ 5/8, 3 · 1/10+ 7/10
- Distributed over the sides: Asli= Asre, Asu= Aso
- Distributed over the circumference

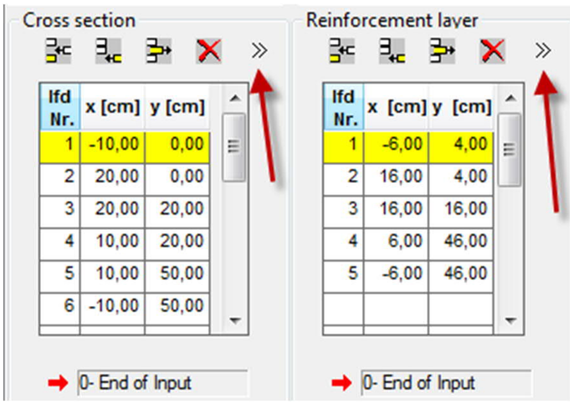
General cross section biaxial

The following cross section types are available for the fire protection proofs:



- rectangle and universal point reinforcement
- circle (anulus) and universal point reinforcement
- polygon and point reinforcement

Polygonal cross section



Outline	The input of the polygon is done by entering polygon points in a x/y system of coordinates into a table. You can enter up to 100 polygon points.
Block-out	The polygon is entered via a table in the same way. This table can be accessed via the >> button on top of the table for the outline.

Note: *Standard cross sections of B2 (rectangle, T-beam, layers cross section) can most efficiently be entered in the sections of the corresponding cross section types and converted into a polygonal cross section subsequently.*

Note concerning the input in the table: All entered coordinates are shown in the graphic window. The recalculation is only performed after you exit the table. You can terminate the input of data and exit the table by specifying zero in the column "current no." (lfd Nr.)

Layer of reinforcement / universal point reinforcement

The reinforcement can comprise up to 100 reinforcement points. The x/y coordinates are entered via a table.

You can optionally define a reinforcement point as a constant point, i. e. the area assigned to it once is not changed during the iteration.

The definition of constant points is done via an enhanced table that is accessible by clicking on the button >> . In this section, you also define the selected reinforcement that is required for the calculation of the effective rigidity.

Design see Design for polygonal cross sections

Fire resistance

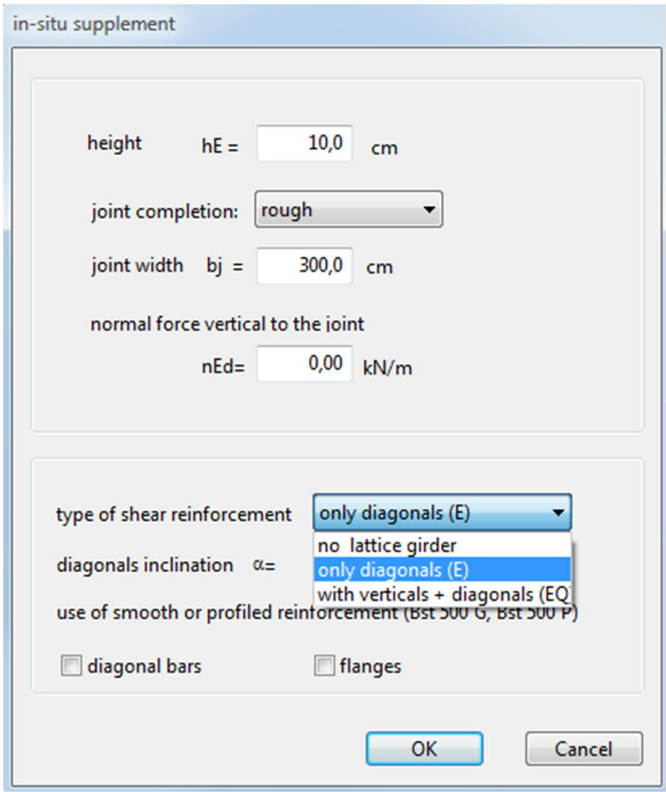
Fire resistance analysis can be used for the two universal 2-axial cross-sectional types

- Rectangle and universal point reinforcement
- Circle (anulus) and universal point reinforcement

See also chapter Fire protection parameters.

Cast-in-place complement

You can enter cast-in-place complements for the cross section types rectangle uniaxial, T-beam uniaxial and layers cross section uniaxial – click the button “in situ concrete”.



Cross section

Height: height of the cast-in-place complement

hE <= hfo - 5 cm, if hfo = 0, then HErg <= h - 5 cm

Joint finishing

Very smooth Cast against steel or smooth timber formwork.

Smooth Screed surface or finished with slide or extruder process or untreated.

Rough Exposure of aggregate skeleton >= 3 mm (40 mm distance approx.)

NA_D: or sand surface method, average peak-to-valley depth > 1.5 mm

Interlocked Interlocking according to figure 6.9 NA_D: or when dg>=16 mm and exposure of aggregate skeleton > 6 mm or sand surface process average peak-to-valley depth > 3 mm

bj Accountable joint width, reduced in regard to the total width due to prefabricated formwork, if applicable.

BFug <= beffo

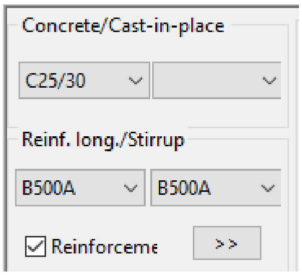
nEd Lower design value of the normal force perpendicular to the joint per length unit, negative pressure.
The default value is 0, the friction part of the joint support capacity is not taken into account in this case. In the case of a beam (plate cross-section with plate at the bottom) and nEd = 0, it is assumed on the safe side that the joint is perpendicular under tension and thus the adhesive bond portion of the joint carrying capacity must not be considered.

Shear reinforcement (only NA-D)

This input section is only shown for floor slabs (i.e. b/h ≥ 5 or optionally defined as slab - see Configuration - Design).

Then lattice girders according to general building approval ([67], [68], [69], [70], [71], [72]) can also be used as joint reinforcement to be selected.

Material input



The materials concrete/reinforcing steel are entered via standard-specific selection lists. Alternatively, you can freely define the material values via the menu item "Free". You can select different materials for the longitudinal reinforcement and the stirrups.

Reinforcement with carbon concrete

For rectangular cross-sections subject to uniaxial bending stress, reinforcement with carbon concrete - CARBOrefit® can be designed according to approval. A bending and shear force design in the GZT taking into account the component pre-expansions as well as a bearing capacity determination for the shear joint between reinforcement and existing structure are possible.

Material input EN 1992-1-1

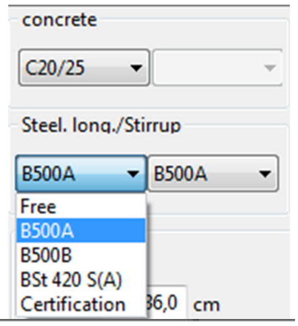
C12/15....C100/115 standard concrete acc. to 3.1.3 an NA

LC12/13...LC80/88 lightweight concrete acc. to 11.3.1 an NA
additional input for cast-in-place complement, if applicable

If high-strength concrete (> C50/60) is used, the design option "Ac net" (net concrete surface) should be selected (cf. /14/ p.161).

When entering a cast-in-place complement, you can select the material of the cast-in-place concrete in the top right selection list.

The selected concrete class should comply with requirements due to durability. When you select a lower concrete class, a corresponding note is displayed in the information window.

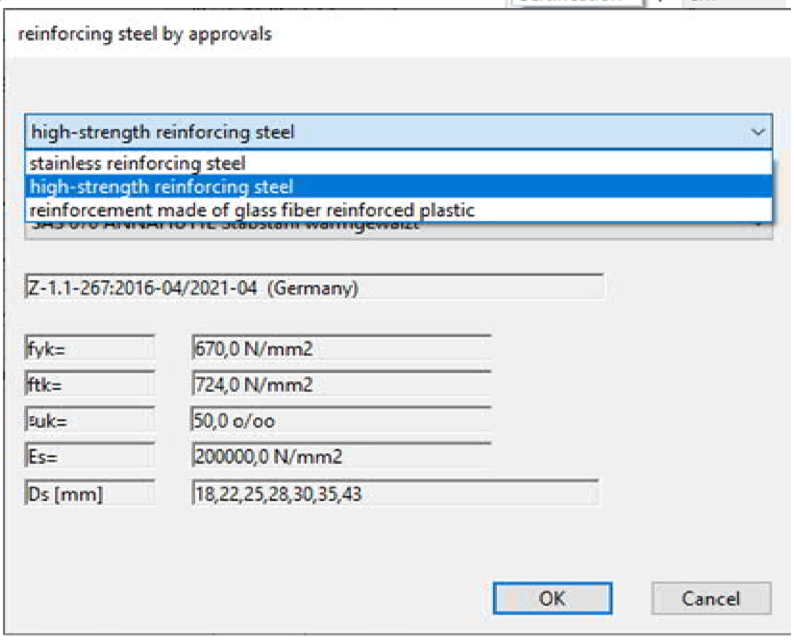


Steel in accordance with Annex C and national regulations

usually:	B 500 A, B 500 B, B 500 C
NA_D:	B500A und B500B nach DIN 488 (2009)
NA_I:	B450A, B450C
NA_A:	B500A, B550A, B600A, B550B
Ductility class:	A (standard), B (high), C (very high)

Reinforcing steel by certifications (AbZ) and NA_D:

- Stainless reinforcing steel SCHEIBINOX [75], [76], [77], [78]
- Stainless reinforcing steel SWISS STEEL [79], [80]
- High strength reinforcing steel SAS 670 for flexing members [81]
- Reinforcement made of glass fibre reinforced plastic: Schöck Combar reinforcement (Z-1.6-238:2019-01/2024-01). Parameters: statically indeterminate/determinate bearing, straight/bent bar, without/with calculated shear reinforcement, long-term (100)/short-term (5 years).



Concrete - user-defined

Call up the dialoge by selecting "Free" in the concrete selection list.

To get more info about the parameters, read the tooltips.

Input of lightweight concrete

- Tick the option "Lightweight concrete"
- Enter the concrete density
- Tick the option “with light shot” (lightweight sand) if applicable

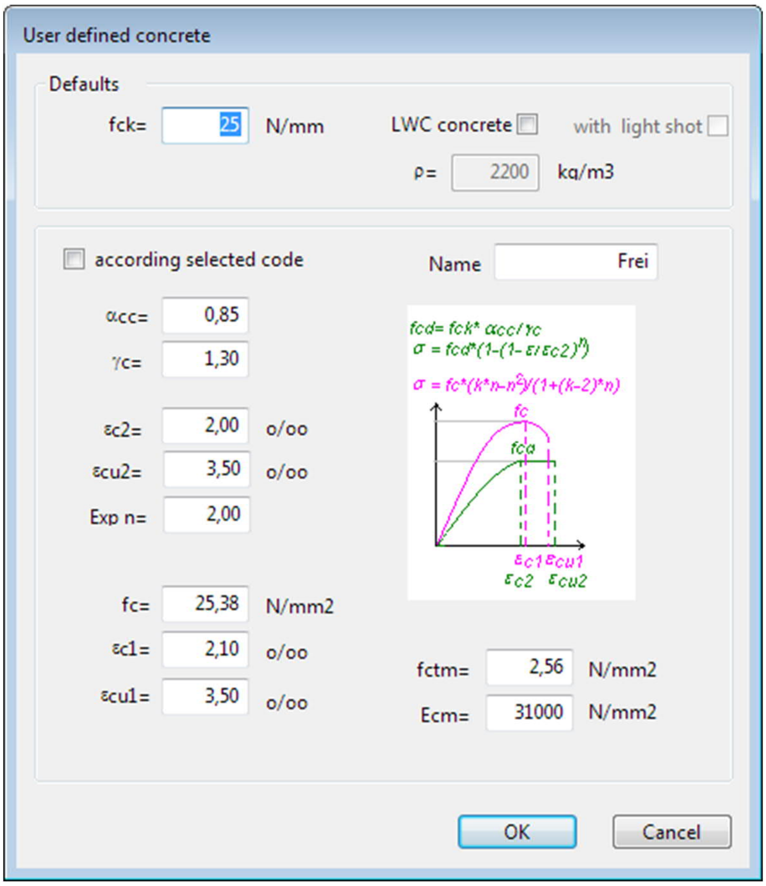
Free input

You can only enter the following values manually if the option "according to selected code" is unticked. Otherwise, these values are set by default.

αcc	factor for long-term effect
γc	partial safety coefficient

Parabolic rectangular stress-strain diagram

$\varepsilon c2$	strain when attaining full strength
$\varepsilon c2u$	strain under maximum load
Exp n	exponent
fctm	average tensile strength
Ecm	average module of elasticity



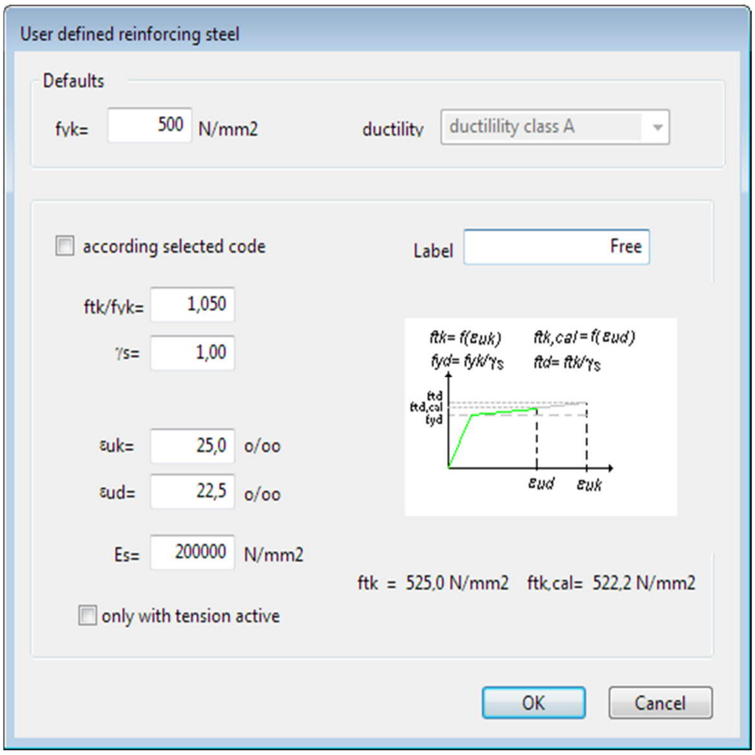
Reinforcing steel - user-defined

fyk	yield point
Ductility	ductility classes

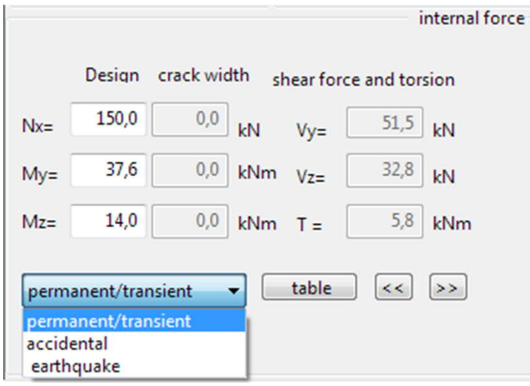
Free input

You can only enter the following values manually if the option "According to selected code" is unticked. Otherwise, the steel properties are set by default.

ftk/fyk	- standard ductility: 1.05, - high ductility: 1.08, - earthquake-resistant steel: 1.15 (see also /5/ p.176)
γs	corresponding partial safety factor
εuk	strain under maximum load
εsu	limit strain during design



Input of action-effects



Depending on the scope of calculation of the individual cross-section types (→ see Application options) particular action-effect options are enabled or disabled.

Alternatively, you can enter multiple action-effects also via the → action-effect table.

If several action-effects occur you can toggle between these combinations via the buttons << >>.

Nx longitudinal force, point of application in accordance with the Configuration, positive tension, negative compression

My bending moment in y-direction, positive in accordance with the configuration

Mz bending moment in z-direction, positive in accordance with the configuration

Vy design shear force in y-direction, positive in accordance with the configuration

Vz design shear force in z-direction, positive in accordance with the configuration

T torsional moment

Flexural design / shear force and torsion

Ultimate limit state (ULS) according to the selected design situation.

Crack width proof

Quasi-permanent combination, special cases acc. to table 7.1 (NDP)

Stress calculation (only via table)

Nx longitudinal force, point of application in accordance with the configuration, positive tension, negative compression

My bending moment, positive according to the configuration

Mz bending moment, only with the cross section types rectangle biaxial and circle, positive according to the configuration

Infrequent and quasi-permanent load combination

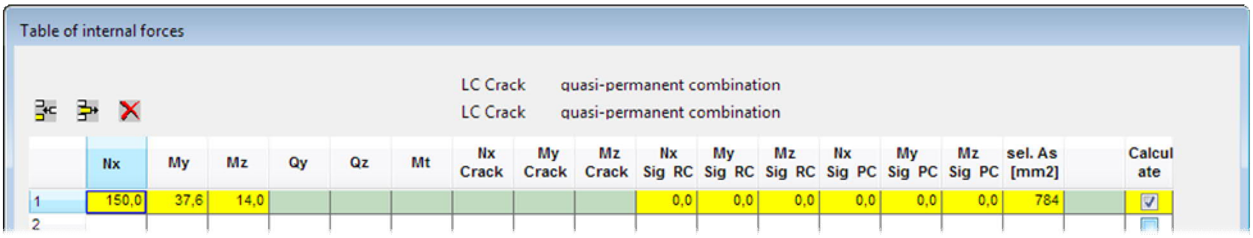
Definition of the design situation

- permanent/transient
- accidental
- earthquake

After having selected the situation(s) from this list, the entered action-effects of the ultimate limit state are assigned to the corresponding design situation(s).

Action-effect table

If a cross section should be designed for more than one action-effect combination, you can use the action-effect table, which is available with all cross section types. Each action-effect combination holds a separate line in the table and you can enable it for subsequent calculation.



Depending on the scope of calculation of the individual cross-section types (→ see Application options), particular action-effect options are enabled or disabled.

You can also enter the actions-effects required for the stress analysis in this section.

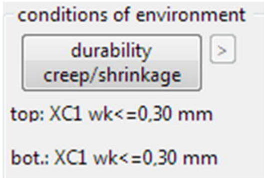
If the load combination for the crack width proof corresponds to the quasi-permanent load combination (standard with reinforced concrete), the values in the corresponding columns are set automatically.

In addition, you can enter the reinforcement selected for the rigidity calculation, the crack width proof and the stress analysis. If the value of the selected reinforcement is equal to zero, the result from the bending design is assumed.

Environmental conditions / requirement classes

You can access the dialogs for the durability and the calculation of the creep coefficient and the shrinkage strain via the buttons durability/creep/shrinkage.

(→ See also the document Durability, creep coefficient and shrinkage strain)

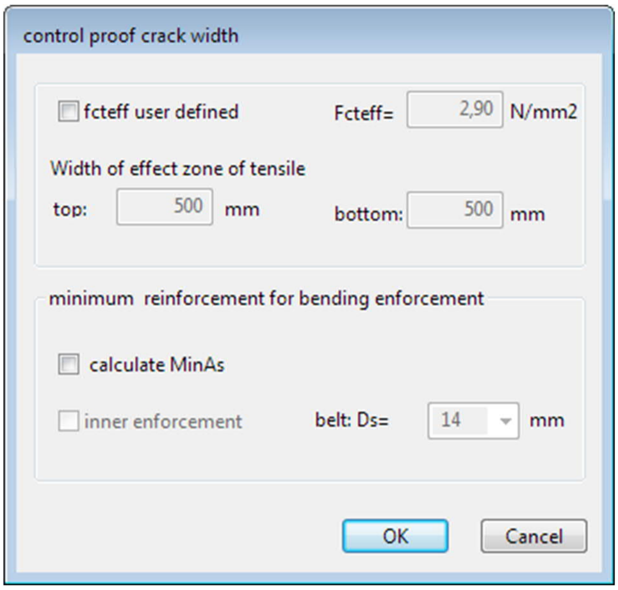


Control of the crack width proof

The button >> allows you to access the dialog for the control of the crack width proof.

fcteff

The option allows to modify the concrete tensile strength. Full strength after 28 days is set by default.



Width of the effective zone of the tensile reinforcement

Correspondingly, the width of the effective zone of the tensile reinforcement decisive for the crack width proof is limited in the slabs of T-beams according to /13/ p.145: beff(ZII) = 0,5 · beff(ZI) + 2 · cl with cl = nomc,l).

Minimum reinforcement for bending enforcement

Option for the calculation of the minimum reinforcement for imposed bending. In case of internal imposed bending, a reduction (k<1.0) can be taken into consideration.

You can specify a different bar diameter for the flange.

→See also the Crack width proof.

Design

Design - results

In the design section of the application interface, the decisive design results are displayed. The available input fields depend on the selected cross section.

In case of erroneous inputs or calculation errors, a corresponding message is displayed. If all inputs are valid, the following design results are displayed:

You can subsequently modify the result by editing the default values:

- Selected Asb / Ast and/or As (shear design, eff. rigidity, crack width):

  The results of the bending design are set by default.

- kz and/or z/d user-defined (relative lever arm for the shear design):

  The direct result of the bending design is set by default,
  if no bending design was performed, 0.9 · d
  NA-D: limitation z < max(d-2 · nomc, d-3-nomc)

Uniaxial rectangle, T-beam, layers cross section

- Asb, Ast — required flexural reinforcement (→ Design for bending with longitudinal force)
- Mrd — resisting moment, Nxd and reinforcement are given (please expand the list)
- EIeff/EIb — effective rigidity referenced to state I for the selected reinforcement and the considered effect of actions (→ Calculation of the effective rigidity)
- Ds — limit diameter for the selected reinforcement (→ Crack width proof)
- asw, Asl — required stirrup reinforcement and torsion additions (→ Shear design)

Circle/annulus

- tot. As — required flexural reinforcement (→ Design for bending with longitudinal force)
- MRdy — resisting moment in y-direction, Mzd, Nxd and tot.As are given
- EIeff/EI — effective rigidity referenced to state I for the selected reinforcement and the considered effect of actions (→ Calculation of the effective rigidity)
- Ds — limit diameter (→ Crack width proof)
- asst — required stirrup reinforcement

Biaxial rectangle

- tot. As — required flexural reinforcement (→ Design for bending with longitudinal force)
- MRdy — resisting moment in y-direction, Mzd, Nxd and tot.As are given
- MRdz — resisting moment in y-direction, Mxd, Nxd and tot.As are given
- EIeff/EI,y — effective rigidity in y-direction referenced to state I for the selected reinforcement and the considered effect of actions (→ Calculation of the effective rigidity)
- EIeff/EI,z — effective rigidity in z-direction referenced to state I for the selected reinforcement and the considered effect of actions (→ Calculation of the effective rigidity)
- asst — required stirrup reinforcement

General cross section biaxial

tot. As — Required flexural reinforcement,
→ see Design for polygonal cross sections.

Note: *Whether the iteration is successful or not depends on the reasonable definition of the reinforcement points, preferably for each polygon corner.*

Please note that all reinforcement points with the same weighting i.e. the same area are considered in the first place for the design result. By defining reinforcement points exposed to less effect of actions (e.g. in the compression zone) as points with constant areas, you can optimize the result.

Areas known as difficult in iteration are the transitions from pure longitudinal action to bending with longitudinal force (e.g. white areas in the design diagrams).

For this reason, moments under a related limit moment m < 0.0023 are not considered (my = My/(Ac · fcd · Dz) mz = Mz/Ac · fcd · Dy); Dy and Dz are the dimensions of the rectangle enclosing the polygon). Because Dy and Dz do not vary with the compactness of the polygon, you should prefer a design with increased moments.

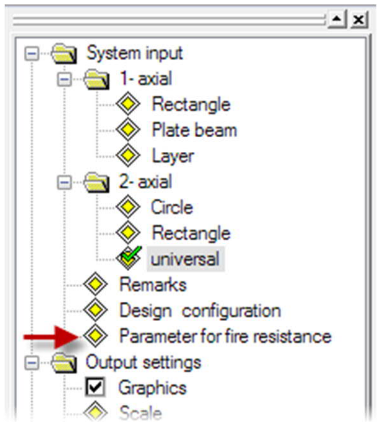
- MRdy	resisting moment in y-direction, Mzd, Nxd and tot.As are given
- MRdz	resisting moment in y-direction, Mxd, Nxd and tot.As are given
- EIeff/EI,y	effective rigidity referenced to state I in y-direction
- EIeff/EI,z	effective rigidity referenced to state I in z-direction

Note: *You can select a reinforcement for each cross section. If the reinforcement area is the same for each reinforcement point, you only need to define selected As (default). You can define different reinforcement areas via the enhanced reinforcement table (button >> on top of the reinforcement table)*

With general cross sections, uniaxial effect of actions can also produce curvatures in the direction where the moment is equal to zero.

Therefore, you should consider the curvatures instead of the effective rigidities in the deformation calculation approach.

Fire protection parameters



Only with licensed additional module B2-Poly!

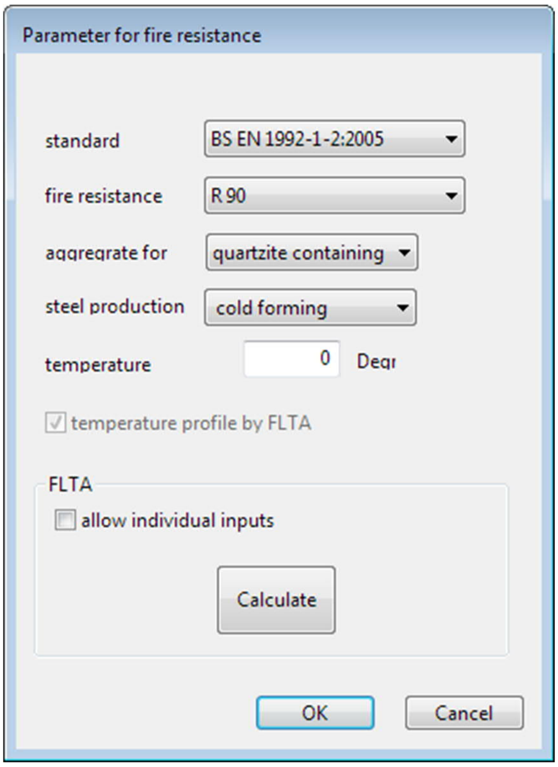
In this section, you can define the parameters required for the hot design and the rigidity calculation in the accidental design situation fire

As the exact position of the steels is of decisive importance for the result, the additional module "Polygonal design and temperature analysis with B2-Poly" must be available.

This dialog is only enabled for the relevant cross section types "universal":

- Rectangle + universal point reinforcement as well as

- Circle (annulus) + universal point reinforcement.



Fire resistance: Select a fire-resistance class among R30, R60, R90, R120, R180 according to the target fire-resistance period.

Concrete aggregate: has an effect on the thermal strains /42/ fig. 3.1 and the stress-strain curve of the concrete /42/ fig. 3.5.

Quarzitic aggregates are set by default, if less typical calcerous aggregates should be considered, the user must select them explicitly.

Steel production: has an effect on the stress-strain curve of the steel /42/ fig. 3.3.

Cold-worked steel is set by default.

The more favourable hot-rolled steel must be selected explicitly by the user.

Temperature addition: Not required for temperature analysis with the FEM program TA.
In order to minimize errors occurring when the temperature profiles calculated on cross sections with h = 30 cm are transferred to greater or smaller cross sections, a positive (h < 30 cm) or negative (h > 30 cm) temperature addition should be entered.

FLTA: Temperature profile calculated with the program TA - Temperature Analysis Cross-Section:
If the Frilo program TA is installed, an FEM-based temperature analysis is performed according to the parameters defined in the national annexes.
If the option "allow individual inputs" is activated, conditions other than the NA can also be considered.

Design for polygonal cross sections

In the design, the state of strain in the ultimate limit state, in which the internal action-effects on the concrete and the reinforcing steel and the external action effects are in a balance, is calculated for the cross section failure with the given forces N, My, Mz.

The result are three non-linear equations. Their iterative solution with the help of the Newton method delivers the unknown border strain, the zero-line inclination and the required reinforcement.

The internal action-effects on the concrete are calculated by splitting the concrete compression zone into thin strips.

The internal action-effects on the steel include portions for the reinforcement points with constant areas as well as for the points with areas varying during iteration that result subsequently from the balance conditions.

Note: *Whether the iteration is successful or not depends on the reasonable definition of the reinforcement points, preferably for each polygon corner.*

Please note that all reinforcement points with the same weighting i.e. the same area are considered in the first place for the design result. By defining reinforcement points exposed to less effect of actions (e.g. in the compression zone) as points with constant areas, you can optimize the result.

Areas known as difficult in iteration are the transitions from pure longitudinal action to bending with longitudinal force (e.g. white areas in the design diagrams).

Therefore, moments under a relative limit moment $m < 0.0023$ are not considered
$my = My / (Ac \cdot fcd \cdot Dz)$ $mz = Mz / (Ac \cdot fcd \cdot Dy)$.

Dy and Dz are the dimensions of the rectangle enclosing the polygon.

Because Dy and Dz do not vary with the compactness of the polygon, you should prefer a design with increased moments.

Minimum reinforcement

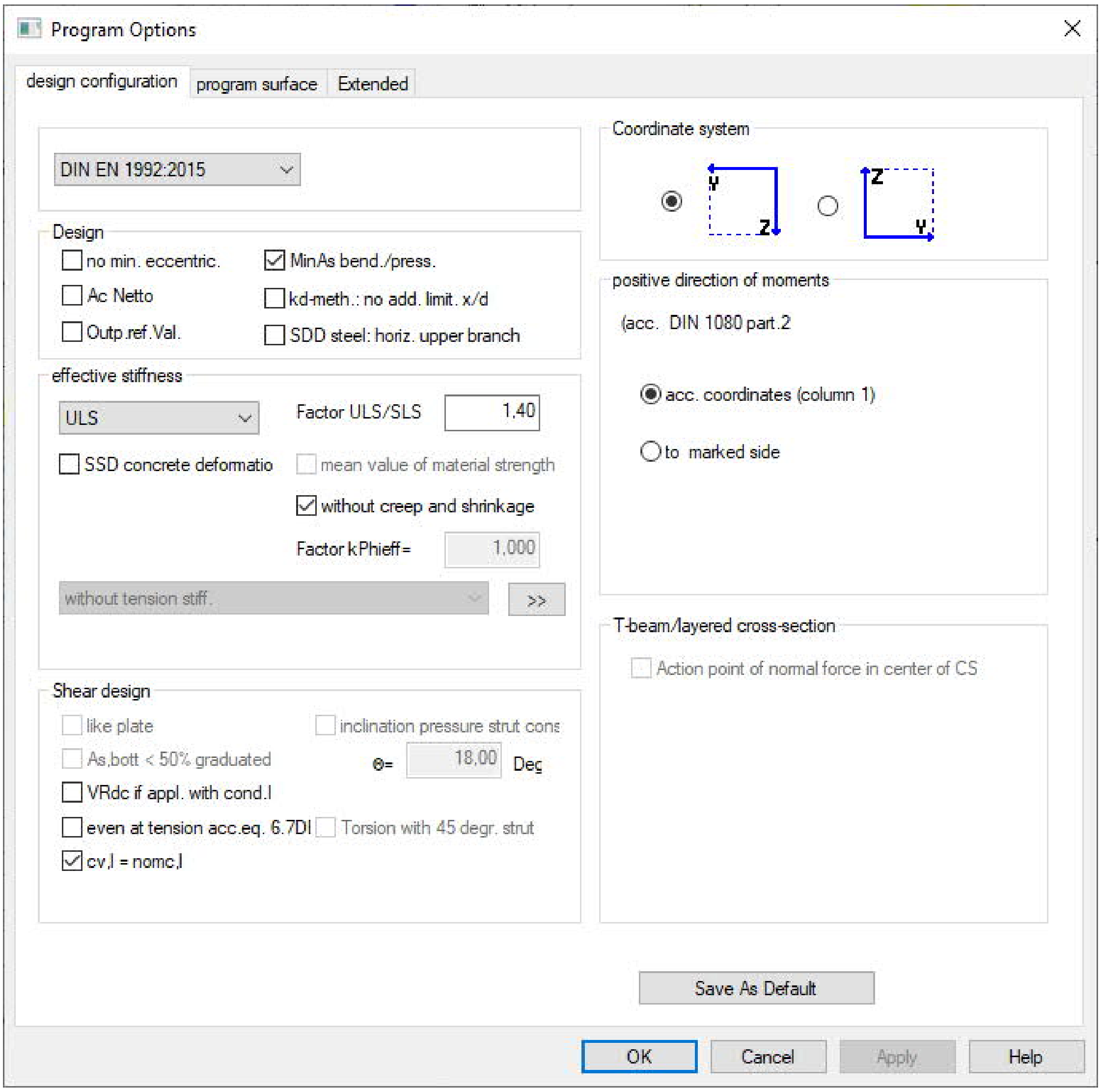
Where compression members (ed/h < 3.5) are concerned, the system checks automatically whether a design of the minimum reinforcement is decisive.

The required minimum reinforcement for components exposed to bending stress is currently not considered.

You can disable the consideration of the minimum reinforcement in the section
→ Design configuration.

Design configuration

Access via the menu item ▸ Design configuration in the main tree.



Standard

Standard selection → see also System input - standard selection.

When you edit the standard, the concrete and steel classes are matched to the new standard.

System of coordinates

Selection of a system of coordinates:

- My left, Mz bottom (*DIN 1080 P. 1, standard*)
- My right, Mz top (bar rotated by 180 degrees)

Positive direction of moments

Definition of the positive direction of moments:

- corresponding to the coordinate axes *(DIN 1080 P.2 tab. 1 col. 1)*
- tension sides in positive coordinate direction *(DIN 1080 P.2 tab. 1 col. 2)*

Design

No min. eccentricity

Minimum eccentricity according to EN 1992-1-1 6.1 (4) is not taken into account.

Ac net

The concrete area displaced by the reinforcing steel is deducted in the calculation of the internal action-effects on the concrete (recommended when high-strength concrete is used).

MinAs flex./comp. member

Enables the minimum reinforcement for flexural and/or compression members.

No additional limitation x/d: → See [Design acc. to the Kd-method]

No default, as a limitation is required even without action-effects redistribution.

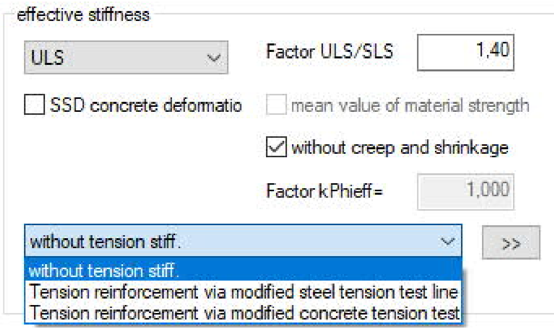
SDD steel with upper horizontal branch

The inclination of the upper horizontal branch of the stress-strain diagram of the reinforcing steel is neglected in order to obtain results comparable to design charts, for instance.

Effective rigidity

Effect of actions

ULS	action-effects in the ultimate limit state
SLS=ULS/factor	action-effects in the serviceability limit state action-effect SLS = action effect ULS / factor
SLS=lc q.-perm.	action-effects in the serviceability limit state quasi-permanent load combination
Factor ULS/SLS	factor for the conversion of the action-effects



Tension stiffening

without tension stiff. Default → see [Calculation of the effective rigidity].

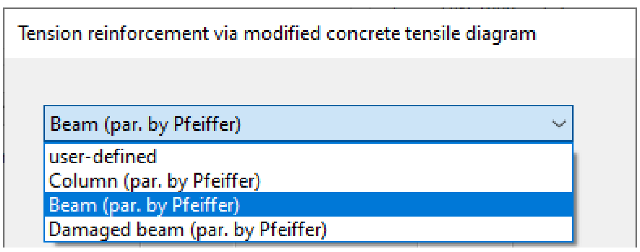
Tension reinforcement via modified steel tension test line:

Click on the button >> to open the advanced dialogue.

Sectional stiffness	Method for determining the tension reinforcement at the respective section.
Component rigidity	Method for estimating the average tension reinforcement of a component at the most stressed section.

Tension reinforcement via modified concrete tension test line:

Click on the button >> to open the advanced dialogue.



W/o creep and shrinkage

If you enable this option, the influence of creep and shrinkage is not considered for the calculation of the effective rigidity.

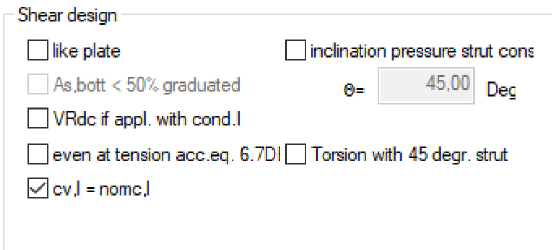
Default w/o creep and shrinkage

SDD (stress-strain diagram) for the calculation of action-effects

Border conditions in compliance with 5.8.6, if the option "Mean values for material strength" is checked. Border conditions shall be in compliance with 5.7.

→ See Calculation of the effective rigidity.

Shear design



Like plate

The shear design is based on the assumption that the cross section is a plate (plate strip) independent of the relation of width to height.

VRdct / VRdc in state I, if appl.

Calculation of the shear resistance of the concrete according to equation 72 or 6.4 when the border and main tensile stresses are smaller than fctk 0.05/1.8 and/or fctd.

even at tension acc. to Eq. 6.7DE

You can optionally select a calculation of the strut inclination acc. to Equation 6.7aDE for cross sections under longitudinal tension. In most cases, the design results are more favourable as in a calculation with cot Θ = 1.00.

Strut inclination

The ticking of this option allows you to define a strut inclination independent of the state of the effect of actions for sections that shall be calculated with the inclination angle at the relevant section but are not decisive for the shear resistance analysis, for instance. You should ensure compliance with the limitation of the strut angle in the relevant standard → see Shear design.

Torsion with 45 degrees strut

Torsion design with simplified methods.

For concrete types > C50 characteristic compressive strength (fck) without reduction (*NA_GB*)

If the shear resistance of the concrete is verified via a test, you may take the characteristic compressive strength (fck) for concretes > C50/60 as per NA to BS EN 1992-1-1 also without deduction into account.

Increased design compressive strength of concrete (fcd) in accordance with PD 6687:2006 *(NA_GB)*

According to PD 6687:2006 you may take an increased design compressive strength of the concrete (fcd) calculated with αcc=1.0 into account in the verification of the shear resistance.

T-beam / layers cross section

Point of application of the normal force in the centre of the cross section

You can optionally define a central application of loads with T-beams and layers cross sections (standard: load application in the centre of gravity).

Save as default

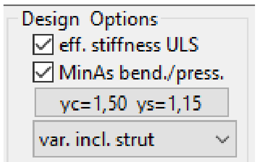
The button 

allows you to save configuration settings as default, i.e. when defining a new item these values are set automatically.

Tab program surface

- The display of the cross-section selection dialog at the program start can be switched off by the option "New position without cross-section selection".
- All reinforcing steels selectable: apart from the country-specific steels, all known types of reinforcing steel are offered.

Design options EN 1992 1-1



Effective rigidity

See Design configuration.

Partial safety coefficients γc, γs

In accordance with Annex A, reduced partial safety coefficients (NDP) could be used for pre-cast components that are subject to special quality control.

Shear resistance

Variable strut inclination: assumption of the flattest possible inclination.
(NDP, with NA-A acc. to 4.6 (1))

Default strut inclination: an inclination of 45° is assumed if you have not made any other selection in the Configuration design.

Variable strut inclination according to Sigsd (NA-A)

When σsd < fyd: flatter limit angle acc. to 4.6 (2)

Variable strut inclination with constant Asz (NA-A):

A flatter limit angle acc. to 4.6 (2) is assumed due to a constant flexural tension reinforcement between bearings.

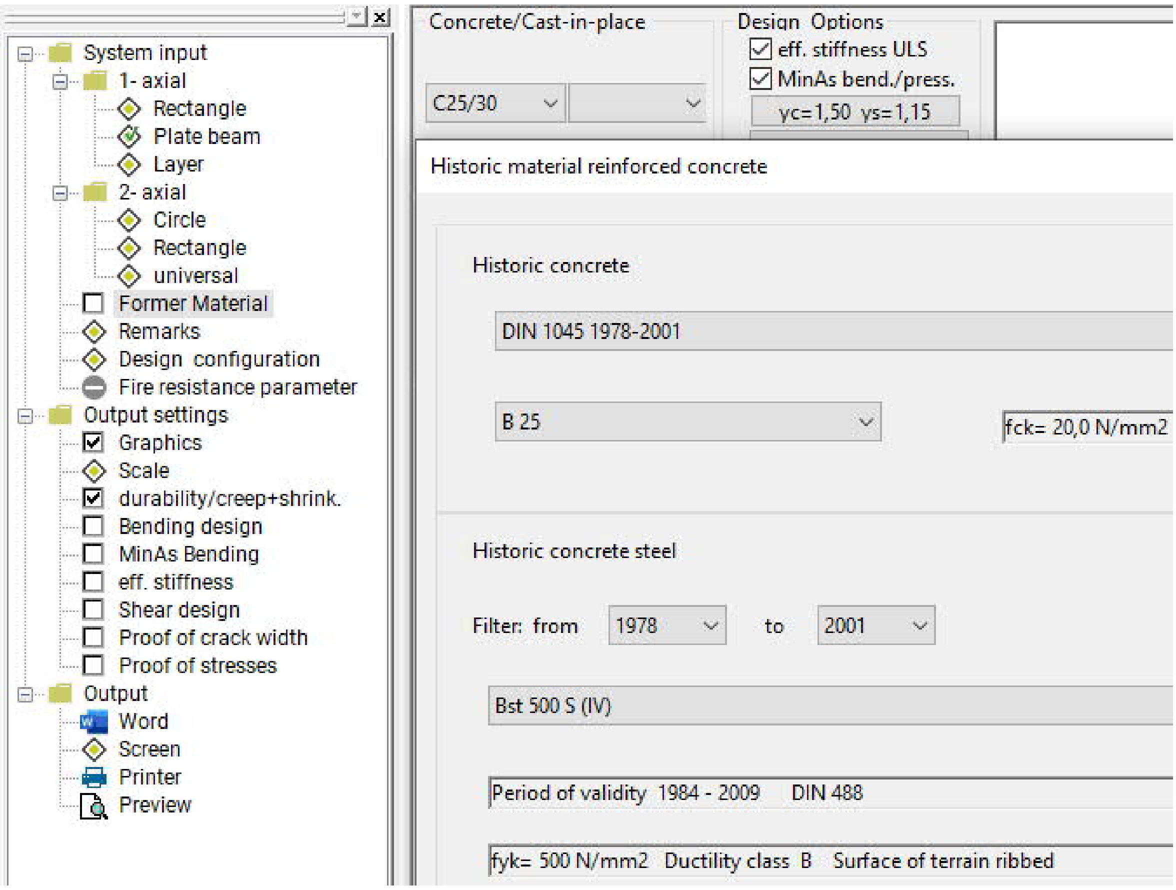
MinAs flexural/compression members

With longitudinal compression forces: compliance with the minimum reinforcement for compression members is checked.

With bending stress: compliance with the minimum reinforcement for flexural members is checked with the cross section types T-beam, rectangle or layers (uniaxial).

Former Material

Selection of historical materials according to DAfStb Heft 616.



If the option "Former Material" is activated, the standard selection for concrete and reinforcing steel is modified.

When activated for the first time, a selection dialogue for historical material is displayed directly.

Output

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

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

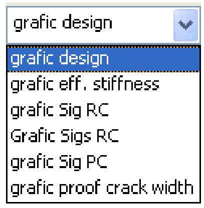
Output profile — allows you to define/limit the scope of data to be put out (output profile);
- Graphic
- Scale: The scale can be a user-defined.
- Durability/creepage + shrinkage
- Bending design
- Minimum flexural reinforcement
- Effective rigidity
- Shear design
- Crack width proof
- Stress analysis

Screen — displays the values in a text window
Input and result values are displayed in a text window. The output is detailed with intermediate values, in case of several internal force combinations in tabular form.

Printer — starts the output on the printer

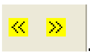
Word — allows the output in the form of an RTF file. The application MS Word is launched (if installed). You can format the output individually in Word.

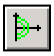
Graphic view



The cross section, reinforcement and strain condition of the selected analysis are shown in the form of a graphic including dimensions.

The total output of an analysis with one action-effect (print icon) covers half a standard page.

In case of several action-effect combinations, you can select the desired combination via the arrow keys .

The icon  in the toolbar allows you to put out general n/m diagrams for the uniaxial symmetric design of rectangle and circle cross sections.

Click again on the icon to return to the standard application mode.

Literature

See document "Analyses at the reinforced concrete section", chapter Literature.