Strip foundation FDS+

Contents

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

The FDS application allows you to calculate the required dimensions of strip foundations under centric and uniaxial eccentric loading. The required bending and shear reinforcement is calculated for the defined dimensions. The software also checks whether shear and bending reinforcement can be dispensed with in the lower layer. Moreover, the permissible bearing pressure, the gaping joint as well as the safety against sliding, displacement and ground failure are verified. Settlements can also be calculated.

The following loads are available:

- Wall loads G and Q
- Moments in the x- and y-directions
- Horizontal loads in the x- and y-directions
- Loading on the foundation area left and/or right to the wall
- Any number of load cases with definable actions, possibly in simultaneous and alternative groups.
- Foundation self-weight is automatically taken into account

As a result, utilization of the foundation analyses is displayed on bottom right of the graphical user interface.

Conditions:

- the corresponding verifications have utilizations greater than 0 %

- the verifications have been selected in the output profile

The bending moment and the required bending reinforcement are indicated per linear metre of the foundation, if applicable. For rising masonry walls, the design is performed for the smoothed moment underneath the wall axis and for rising concrete walls for the face moment.

Optionally, you can design the connecting reinforcement for rising concrete walls.

!! *Attention:* *The FDS+ application is intended for the calculation of strip foundations in the classical sense. If the defined loads and dimension of the structural system produce a deviating load-bearing behaviour like that of an angular retaining wall for instance, another calculation method is required and you should use the appropriate application program.*

Additional option FDPro

With the additional option FDPro, the foundation programmes FD+/FDB+/FDS+ and GBR+ can be extended to include

- an earth pressure approach
- an inclined foundation base
- a seismic ground failure verification
- a ground failure - punching shear verification
- a bearing capacity calculation of the foundation soil with a table of design values of the base pressure resistance.
- a graphical output of the internal forces along the main axes

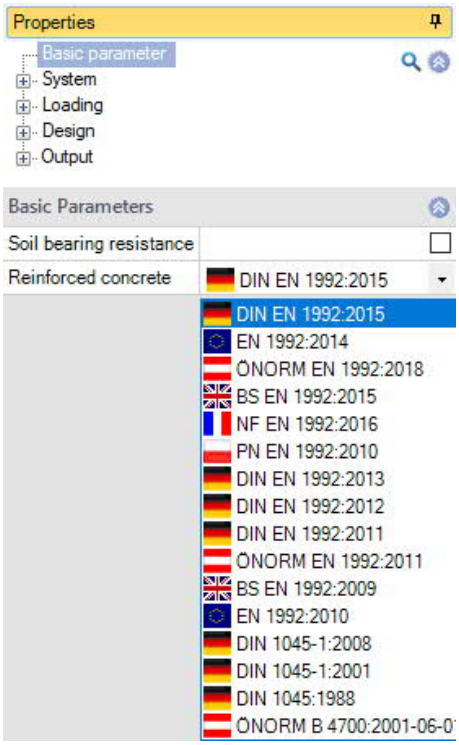
See calculation basis for foundation engineering in the FD+ manual.

See also ▸ Video

Basis of calculation

Available standards

- EN 1992
- DIN EN 1992
- ÖNORM EN 1992
- BS EN 1992
- NF EN 1992
- PN EN 1992
- DAfStb[1] Booklet 240
- Foundation standard:
  DIN EN 1997-1 in combination with DIN 1054
  The software selects the foundation standard automatically (DIN 1054:1976/2005/2021) in accordance with the selected reinforced concrete standard.



FDS+ offers support for all 3 verification methods according to Eurocode 7, adjustable for all national annexes.

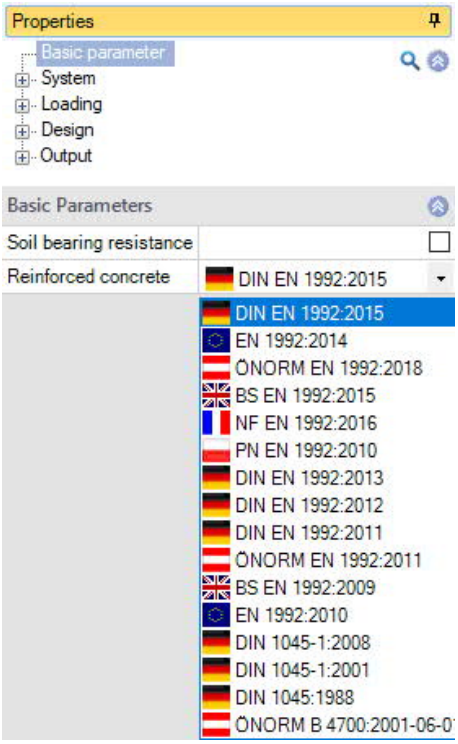
The partial safety factors and combination equations for the geotechnical verifications are editable. See Design - Parameters.

You can find further information about the basis of calculation in the document FL_FD_eng.pdf.

[1] German Committee for Reinforced Concrete

Data entry

The definition of properties and control parameters is done in the menu on the left side of the screen. You can check the effect of the entered values in the graphical representation on the right side of the screen. Before entering any data, you can change the dimensional units (cm, m ...) via the options File ▸ Program options.



Wizard

The Wizard appears by default / automatically at startup, but can be switched off (File ▸ Program options).

Input Options in the GUI

The input options in the GUI window are described in the document Basic operating instructions-PLUS.pdf.

Basic parameters

Reinforced Concrete

Select the desired reinforced concrete standard:

see also Basis of calculation

Soil bearing resistance — If the option is selected, only the bearing capacity of the soil is output in the form of a table with the design values for the bearing pressure resistance.

Soil Engineering and Bearing failure

According to the selected reinforced concrete standard, the software selects the corresponding standards for soil engineering and bearing failure automatically.

System

Foundation material

Selection of normal or lightweight concrete as well as the concrete quality and reinforcement steel grade for the foundation.

Material wall

Selection of material for the wall (concrete / masonry).
For concrete you can select the wall connection

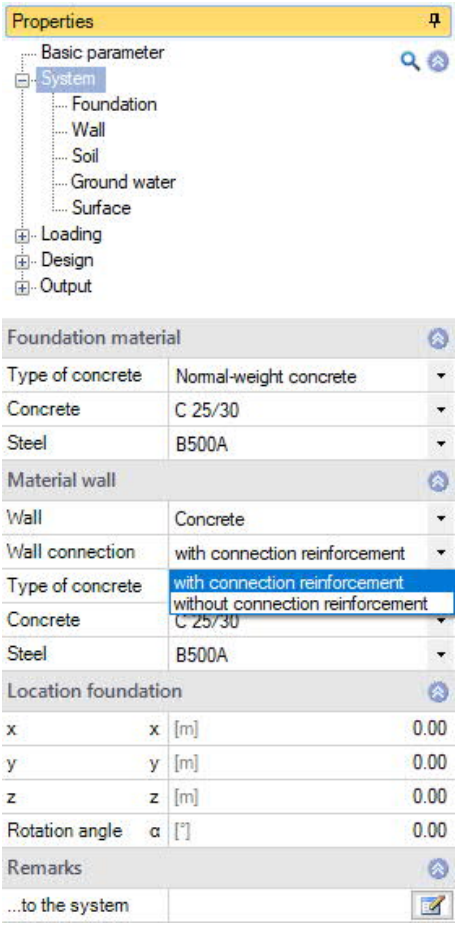
- with connection reinforcement
- without connection reinforcement as well as
- selection of the concrete type as well asconcrete and reinforcing steel grades.

Location foundation

The global position related to the foundation axis is only required for communication with other programs such as GEO and SBR+.

Remarks

Click on the  button, to enter your own comments to the system.

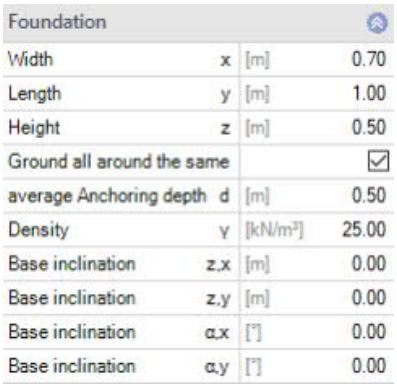


Foundation

In the foundation ground plan, the x-axis (positive) runs from the left to the right and the y-axis (positive) from the bottom to the top.

Width	x	foundation dimension in the x-direction
Length	y	foundation dimension in the y-direction
Height	z	foundation height
Anchoring depth d		lowest foundation depth below the ground level or the top edge of the basement floor. The programme does not automatically generate a resulting earth fill. Define area loads for this if necessary.
Density	γ	weight density of the foundation concrete

Base inclination and a 4-sided different surface definition are possible with the additional option FL+ PRO.



Wall

Wall

Thickness x	thickness of the wall
Length y	length of the wall
Layer of reinf.	reinforcement position in the wall for concrete

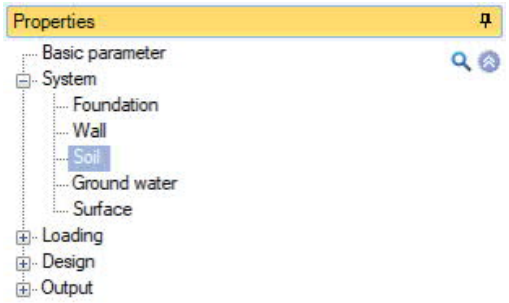
Eccentricity

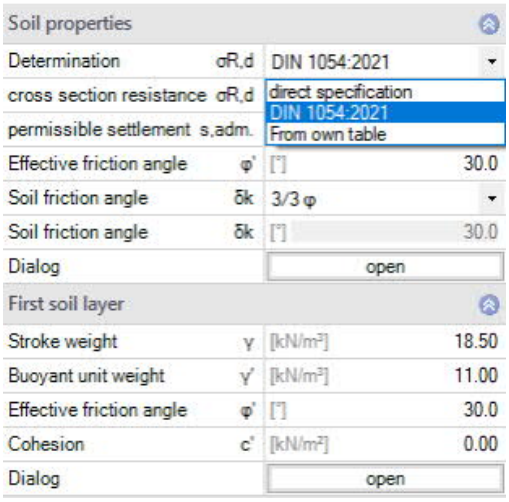
Eccentricity across	eccentricity in the x-direction (transverse)
Eccentricity lengthwise	eccentricity in the y-direction

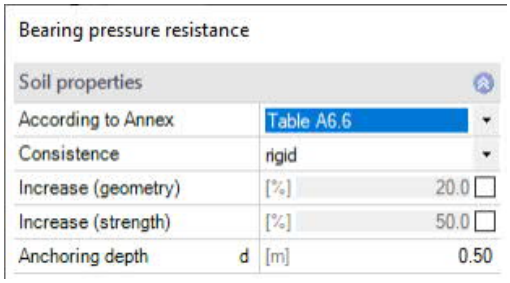
Soil

Soil Properties

Determination σR,d	Select whether the design value of the bearing resistance should be entered directly, or to come from a standard table or from a user defined table - see section below.
cross section resistance	Specification of the permissible bearing pressure $\sigma_{R,d}$
Permissible settlement	Permissible settlement for comparison with the calculated settlement and presentation of the utilisation of the settlement verification.
Effective friction angle φ´	Angle of the inner friction underneath the foundation base.
Soil friction angle	The soil friction angle is relevant for the sliding safety check. If the angle of friction δ is not determined separately, the characteristic angle of friction ϕ'k may be used instead of the critical angle of friction for in-situ concrete foundations. A value of 35° must not be exceeded. The same applies to prefabricated foundations if the precast elements are laid in the mortar bed. If the prefabricated foundations are smooth and without a mortar bed, the characteristic soil friction angle $\delta k = 2/3\ \phi' k$ shall be used.
Load tilt	Enter the maximum tilt of the characteristic or representative bearing pressure-resultant H/V, which should be checked in the case of simplified verification.
Dialog/Table	If the determination σR,d is not specified directly, the design value of the bearing pressure resistance is taken from a table (standard or user defined) Click the “open”/”edit” Button to open the tabledialog.







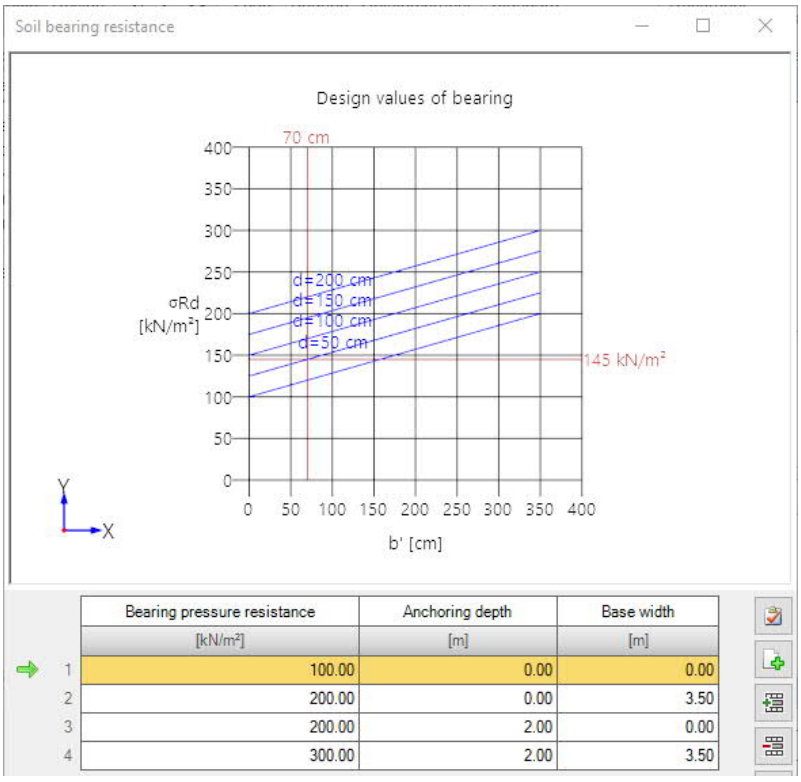
Parameters by standard table:

According to Annex	The soil pressure is taken from the corresponding table in the soil engineering standard or its National Annex.
Consistence	consistency of soil: rigid, half-solid, solid – only with tables A6.6. to A6.8.
Increase (geometry)	When the option "Bearing pressure: from table" is activated, the permissible bearing pressure is increased by 20 % if the relevant border conditions (b/d) specified by the applicable standard are satisfied.
Increase (strength)	When the option "Bearing pressure from table" is activated, the permissible bearing pressure is increased by 50 %, if the soil is sufficiently solid. *Note: The values are added up under particular conditions (70 %).*
Anchoring depth d	Lowest foundation depth below the ground level or the top edge of the basement floor.

From own table:

Create:	Generates a table with design values of the bearing pressure resistance from several parameters.
Edit:	Open the dialog to enter the design value of the bearing pressure resistance σRd. The value σRd should come from a geotechnical report and should have sufficient guarantees against ground failure and a sufficient limitation of settlements. Furthermore, the corresponding foundation width and anchoring depth must be specified.

The meaning of the other buttons can be seen from the Tooltips.



	Bearing pressure resistance [kN/m²]	Anchoring depth [m]	Base width [m]
1	100.00	0.00	0.00
2	200.00	0.00	3.50
3	200.00	2.00	0.00
4	300.00	2.00	3.50

First soil layer

In this section you can enter the values of the first soil layer.
For additional soil layers click the Button “Dialog – open”.

Stroke weight	γ	Specific weight of the soil.
Buoyant unit weight	γ´	Specific weight of the soil layer under buoyancy. This value is only used if groundwater was defined (▸ System ▸ Soil)
Friction angle	φ´	Friction angle of the soil in this layer.
Cohesion	c'	Soil cohesion.

Further soil layers / additional values (▸ Dialog „open“)

Library	Cat.	Name	Icon	γ	γ'	φ'	c'	xU'	ν	Em	Pl	α	qc	E'	Procedure	E*	Es	x	ks	both sides drained	Cα'
				[kN/m³]	[kN/m³]	[°]	[kN/m²]	[m]		[kN/m²]	[kN/m²]		[kN/m²]	[kN/m²]		[kN/m²]	[kN/m²]		[m/s]		
Table	-	-	-	18.50	11.00	30.0	0.00	1.50	0.20	6000.00	700.00	0.50	1000.00	3500.00	direct specification	4946.00	2473.00	0.50	1E-09	☐	0.003

direct specification
from constrained modulus

Table	Defined layers/values can be selected via a soil layer library.
Category	Soil category according to Annex A of standard NF P94-261. It is important for the bearing capacity calculation from values of the pressiometer test according to Annex D of NF-P94-261.
Name	A name for the soil layer can be assigned here.
Symbol	An abbreviation for the soil layer can be assigned here.
xU	Thickness of the soil layer. Soil layers below 0.10 m cannot be defined.
v	The Poisson's ratio defines the ratio of a change in thickness to a change in length as soon as a stress is applied. The Poisson's ratio or transverse contraction coefficient has the formula υ or μ. It is one of the elastic material constants and bears the name of the physicist Siméon Denis Poisson.
Em	Define the pressiometric modulus according to Ménard here. It is needed for the settlement calculation from data of a pressiometer test.
Pl	The representative value of the limit pressure according to Ménard in the foundation base of the shallow foundation.
α	Rheological factor for settlement calculation from results of a pressiometer test.
qc	The peak pressure resistance comes from the pressure test and derives modulus of elasticity and friction angle for base failure and settlement calculation.

Settlement analysis

Procedure	Direct specification or from constrained modulus: To define the compressibility of the soil (*Em*-module) select - directly in E* or - from the constrained modulus - *Em* will be calculated from stiffness/constrained modulus *Es* and correction factor *x* (from DIN 4019 T1).
E*	Compression modulus. The compressibility of the soil can be specified by a pressure settlement line or calculated from the constrained modulus in connection with a correction factor.
Es	Constrained modulus.
x	Correction factor.

Settlement analysis: Consolidation

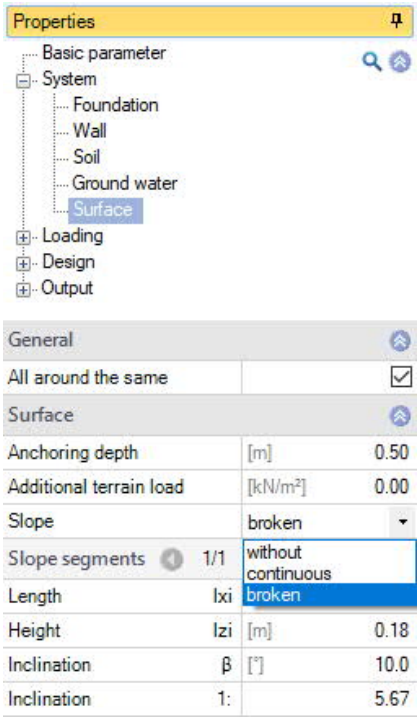
ks	Permeability coefficient of the rate of consolidation. The value can be extracted from the soil report.
Both sides drained	For the calculation of the time to approximate decay of consolidation settlement in unilateral drainage the full layer thickness is set, in bilateral drainage only half the layer thickness.
Cα'	The creep coefficient Cα can be determined from a time-settlement test according to DIN 18135. Usual value range 0.001 to 0.00001.

Ground water

Ground water existing	This option allows you to define whether groundwater exists (displays the entry “Ground water”).
Ground water	Only if ticked option “Ground water existing”. Absolute depth of the groundwater below the bottom edge of the foundation body. Negative values can be used to define a groundwater level below the base of the foundation.

Surface

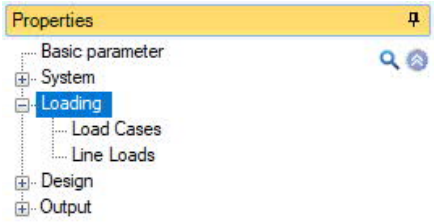
Anchoring depth	Anchoring depth of the foundation body.
Additional Terrain load	Additional characteristic permanent area load on the bearing failure figure, which increases the characteristic punching shear resistance.
Slope	The ground level can be modeled as horizontal, with a continuous slope, or with a broken embankment. Continuous: Here you can define a berm and the slope - see advanced foundation dialog. Broken: Input of the embankment sections. The "+" symbol creates a new table row for a further section. Parameters are length, height or inclination or rise (the height adjusts automatically to the incline).

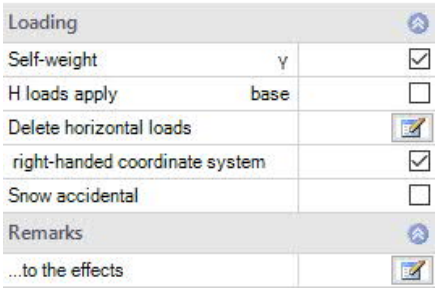


Four-sided different terrain definition with the additional option FDPro

With an existing FDPro license, the terrain can be defined differently for each of the four foundation faces. To do this, remove the tick from the “All around the same” option – the entry will be extended accordingly.

Loads





Self-weight γ
: automatic consideration of the self-weight.

H loads apply
: ☐ Option not ticked:
The horizontal loads apply at the top edge of the base and generate a moment with a particular lever arm
☑ Option ticked:
The horizontal loads apply directly in the base joint without generating a moment

Delete horizontal loads
: delete all horizontal loads with one click!
This ist useful if a lot of loadcases from other applications (GEO, B5...) has been imported.
Note: The horizontal loads of the individual load cases can be found/entered under the following item "Load Cases".

coordinate system
: Coordinate system, which is also referred to as a right-handed coordinate system or right-hand rule. It corresponds to the definition of technical mechanics. Positive moments rotating around the X-axis generate pressure below or in the negative Y-range of the foundation. Positive moments rotating about the Y axis generate pressure on the right or in the positive X range of the foundation. If this option is deactivated (previous definition in the program), positive moments generate pressure on the upper right or in the positive X / Y range of the foundation. In the graph, the numbers are represented with their absolute values for both variants, the arrows serve to represent the actual direction of action. The numbers in the input fields and in the output are signed. If the sign definition is changed, the sign of the moments around the X axis changes.

Snow accidental
: Defines whether, in addition to the usual design situations, the snow loads should automatically be considered as accidental effects. The load factor for the accidental snow loads can be user defined. The default value is 2,3.

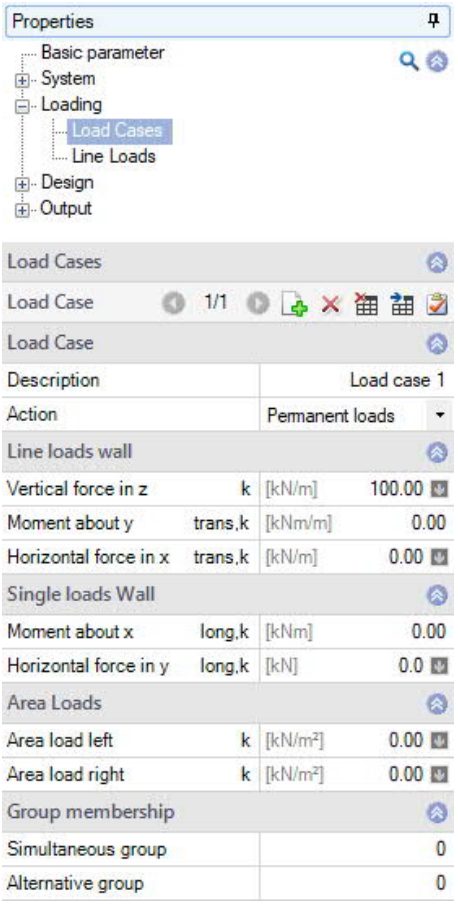
Load Cases

Enter the data of the first load case via the input mask or directly in the load case table, which can be displayed by activating the Load case tab (beneath the grafic).

Load case toolbar: Load case 1/2
- see Data entry via tables

To add additional load cases, click on the button once more (a new empty input mask is displayed each time).

Tip: *A description is displayed in the status line each time you click into an input field.*



Description	optionally, a comment to the selected action can be entered. This text is included in the output.
Action	the appropriate actions can be selected from a list: Permanent loads ... seismic loads. (calculation method"characteristic").

Load value compilation

By clicking on the arrow icon you can access a load value compilation.

Line loads / single loads Wall

Vertical force in z	vertical force in the centre of the wall
Moment about x/y	positive moments generate pressure on top right or in the positive x/y section of the foundation.
Horizontal force in x/y	horizontal loads act on the top edge of the foundation. They generate moments on their way down to the foundation base, which are taken into account automatically by the software.

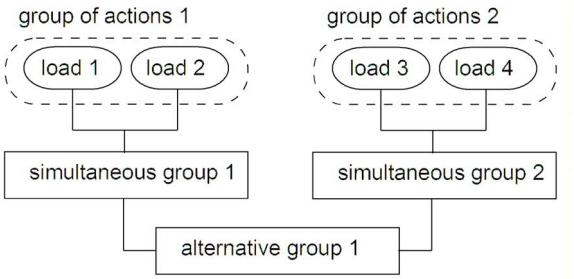
Area Loads

Area load left/right	you can define area loads on the left or the right of the wall.

Group membership

Simultaneous (concurrent) group

Loads of a particular action group can be defined as "always acting simultaneously"
by assigning them to simultaneous (concurrent) groups.



Ill.: Example for the functioning of alternative and simultaneous groups

Alternative group

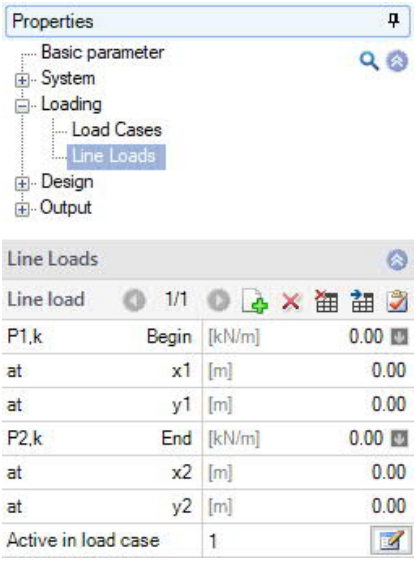
Different variable load cases with similar actions can be assigned to an alternative load case group via the allocation of an alternative group number. Only the decisive load case of this alternative load case group is invoked in the superposition.

Line Loads

Here, line loads can be defined on the foundation.

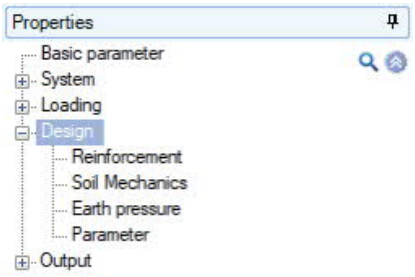
The symbol  can be used to define a new line load.

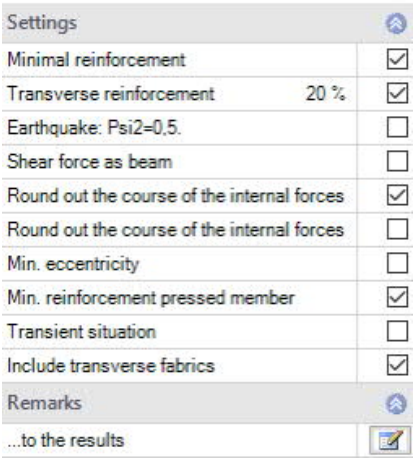
P1,k	Initial value of the line load
x1	x-value of the starting coordinate of the line load
y1	y-value of the starting coordinate of the line load
P2,k	End value of the line load
x2	x-value of the end coordinate of the line load
y2	y-value of the end coordinate of the line load
Aktive in load case	Enter the load case number(s) in which the line load is active



Design

Settings - Program settings





Minimum reinforcement	ductility reinforcement in accordance with the selected reinforced concrete standard
Earthquake: Psi_2=0.5	in accordance with the introductory decree of DIN 4149 for Baden-Württemberg, the combination coefficient Psi2 = 0.5 for snow loads should be used in the superpositions with earthquake loads.
Shear force as beam	specification whether the shear resistance should be verified on a slab or a beam.
Round out the course	only affects the graphical representation. Function: see tool tip or info text.
Min. eccentricity	when you tick this option, minimum eccentricities for compression members are taken into account as per EN 1992-1-1 6.1 (4).
Minimum reinforcement pressed member	this option allows you to take a minimum reinforcement for compression members into account.
Transient situation	Here you can decide whether the permanent or transient design situation should be used. The design situations 'earthquake' and 'accidental' are considered automatically, when appropriate actions are available.
include transverse fabrics	The selected mats increase the calculatied predefined reinforcement also in the transverse direction.

Reinforcement

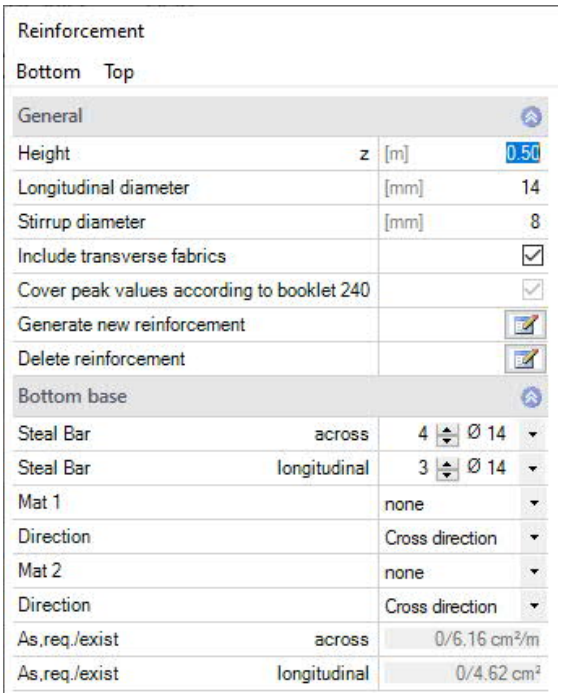
Cv, u/s/o	Laying dimensions of the specified reinforcement on the bottom (u)/sides (s)/top (o) of the foundation. The specified reinforcement is designed into the foundation body according to this laying dimension. Based on this, 2D and 3D graphics are created.
Layer of reinf. x/y	Center of gravity of the reinforcement at the bottom in the x or y direction. This value is used for the reinforced concrete checks. After calling up the durability dialog, this value is adjusted if necessary.
Longitudinal diameter	Select the longitudinal diameter for the reinforcement. The software starts with this diameter to calculate a reinforcement that covers the requirements. If the minimum and maximum spacing cannot be realised with the initially defined diameters, higher diameters are used.
Durability:	Activating the  button displays the Durability dialog. When you confirm your settings in this dialog with OK, the concrete cover, reinforcement layers and their diameter are checked and adjusted accordingly.

Distribution	Extended reinforcement dialog ( ).
Delete reinforcement	Deletes the defined reinforcement
Practical construction spacing	By default, the bar spacing is defined "exactly", that is, the resulting bar distances are determined on 1 mm accuracy. When this option is ticked, the bar spacings are adapted to 5, 6, 7, 7.5, 8, 9, 10, 12.5, 15, 17.5, 20, 22.5, 25, 27.5 or 30 cm.

Distribution / Extended reinforcement dialog

Click this symbol 

for the extended reinforcement dialog.



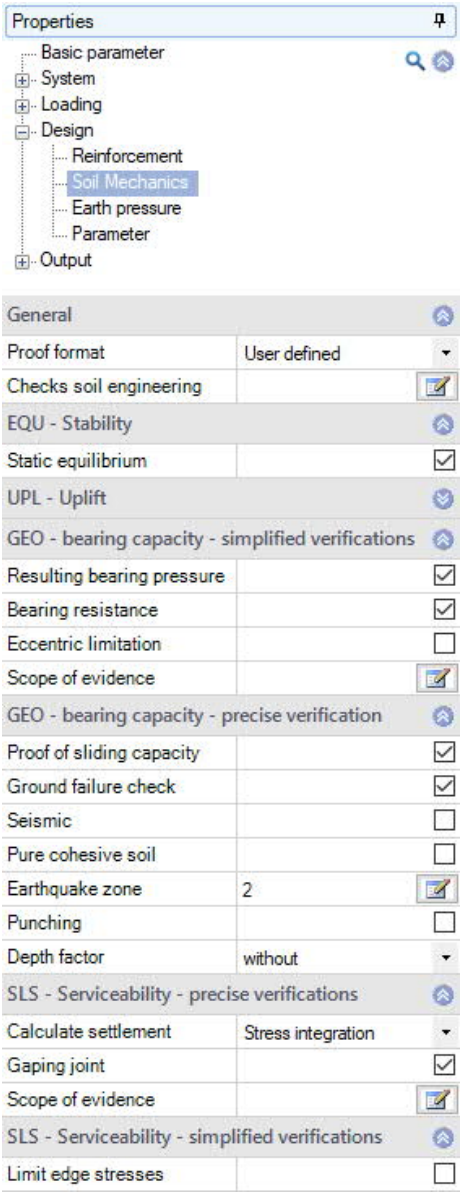
General

Height	Height of the foundation in z-direction
Longitudinal diameter:	see chapter “Reinforcement”.
Generate new reinforcement	The program calculates a reinforcement that covers at least the required reinforcement. If the minimum and maximum bar spacing cannot be achieved with this longitudinal diameter, larger diameters are used. If the pre-set reinforcement is deleted or modified, the automatic generation of reinforcement is deactivated and the pre-set reinforcement remains as it is. If this is not sufficient, the program issues a warning. If no reinforcement is specified, no warning is given. When the reinforcement is generated automatically, the program begins with the specified longitudinal diameter.
Delete reinforcement	Deletes the defined reinforcement. Only the required reinforcement will be taken into account.

Bottom / Top base

Steel Bar across/longitudinal	definition of number (1. column) and diameter (2. column) of steel bars
Mat 1/2	Selection of rebar mats.
As,req/exist ...	Display of required / existing reinforcement.

Soil Mechanics



Proof format

Define here whether a
- simplified proof, a
- exact proof or a
- userdefined proof

should be performed.
The simplified verification includes compliance with the design value of the base pressure resistance with limitation of the inclination of the load resultant.
The exact verification format includes a bearing failure verification, a sliding safety verification and a settlement calculation.

Checks soil engineering

Click this symbol to open the extended dialog with graphical illustrations to bearing failure, bearing pressure and settlements.
You can find this function also in the toolbar with the “Bearing Pressure” symbol (*note: if only the simplified verification is carried out, only the "Bearing Pressure" tab is displayed*).

User-defined proof format

All verification options are offered here for individual selection.

Resulting bearing pressure

Requirement for the simplified verification: the inclination of the characteristic or representative bearing pressure resultant complies with the condition HV <0.2.

Bearing resistance

The verifications for the border conditions ground failure, sliding and suitability for use (verification of settlements) are replaced by the use of practical data for the design value of the bearing resistance.

Eccentricity limitation

Proof according to NF P 94-261 13.3 of the eccentricity of the load.

Scope of verification

In a separate dialogue, you define whether the limit states and design situations according to the selected standard are to be used for this verification or whether they are to be adapted individually (user-defined).

Proof of sliding capacity

Verifies the foundations against failure by sliding in the base plane, if the loadfactor isn´t vertical on the base plane.

Ground failure check

In the case of ground failure verification the shear resistance of the soil below the foundation level are considered.
The soil layers above the foundation level are considered in the case of a horizontally soil plane and a horizontal terrain only as top load.

Seismic

With the additional option FDPro: if the option is selected, a seismic bearing failure analysis according to DIN EN1998-5:2010 Appendix F is performed. A dialog with the appropriate selection/input parameters is displayed.

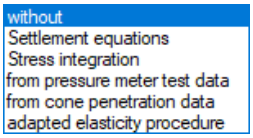
Depth factor

The depth coefficients take into account the favorable influence of the shear strength in the fracture joint above the base of the foundation in the

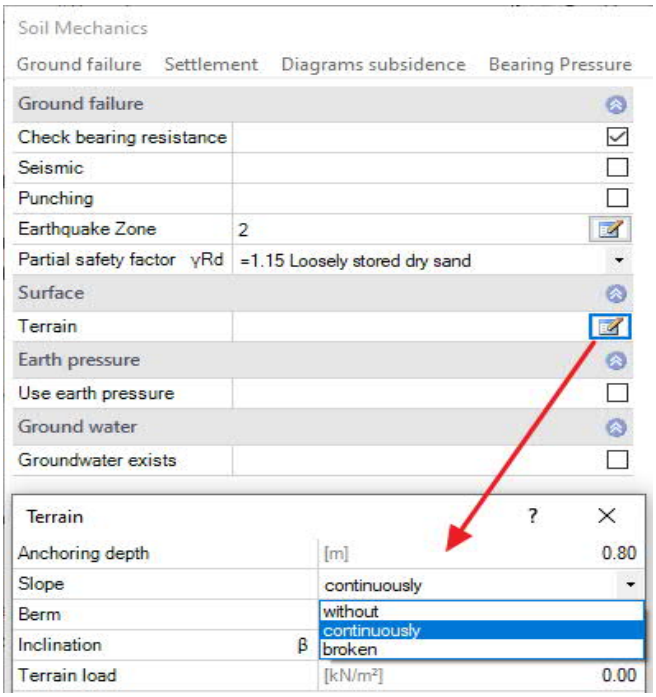
bearing failure analysis. In some European countries, this effect can be taken into account with coefficients > 1.

Calculate settlement

For the settlement analysis, the compression of the soil should be taken into account down to the settlement influence depth ts. Ts may be assumed in the depth at which the vertical additional stress generated by the mean settlement effective load has an amount of 20% of the effective vertical output stress of the soil.
One of 5 calculation methods can be selected.



Extended Soil Mechanics dialog



Calling up the dialogue on “checks soil engineering  ” (exact/simplified verification).

Ground failure

Seismic/Earthquake zone: call up the earthquake dialog.

Selection of the partial safety factor γRd.

Surface

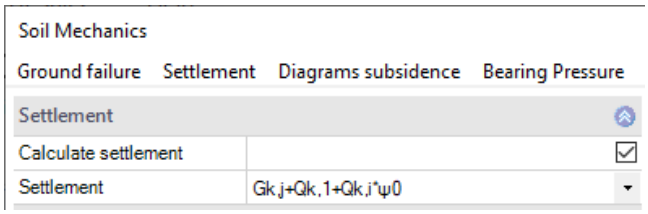
The following input parameters are displayed via the "Surface" button:

Anchoring depth	Lowest anchoring depth below terrain/ top of basement sole.
Slope	The ground level can be horizontal, with a continuous slope, or with a broken embankment.
Berm	The width of berm is the distance between the outer edge of the foundation and the beginning of the slope.
Inclination β	The terrain inclination indicates the angle of inclination of a slope from the defined berm. The inclination affects the ground failure verification and defines exclusively downsloping terrain.
Additional terrain load	An additional characteristic permanent area load on the bearing resistance figure can be entered here, which increases the characteristic punching shear resistance.

Ground water

Groundwater exists	See System ▸ Groundwater.
Groundwater Depth	See System ▸ Groundwater.

Settlement



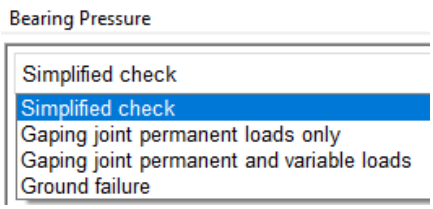
Representation of the course of settlement and stress over the depth as well as graphic representation (diagrams of settlement) of the course of settlement over time, the settlement and influence coefficients per selection list.

Calculate settlement	For the settlement calculation, the compression of the soil up to the settlement influence depth *ts* must be taken into account. This may be assumed at the depth at which the vertical additional stress from the average settlement-effective load is 20% of the effective vertical initial stress of the soil.
Settlement Gk,j...	Tick this option when settlement should be determined with permanent loads only, or permanent and variable loads together.

Bearing pressure

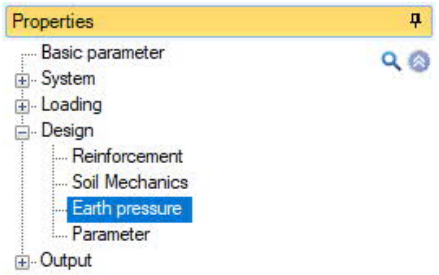
Display of the bearing pressure pattern in 2D/3D. Selection via the top selection line.

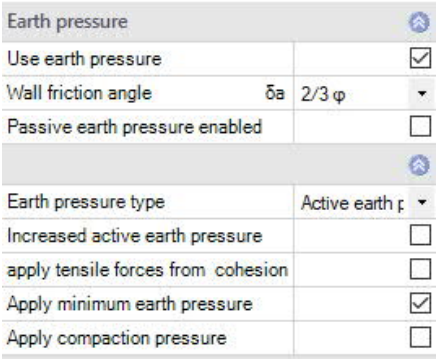
For entries/changes, see the chapter System ▸ Soil.



Earth pressure (with additional option FDPro)

Allows the approach of Erddruck with existing licensing of FDPro.





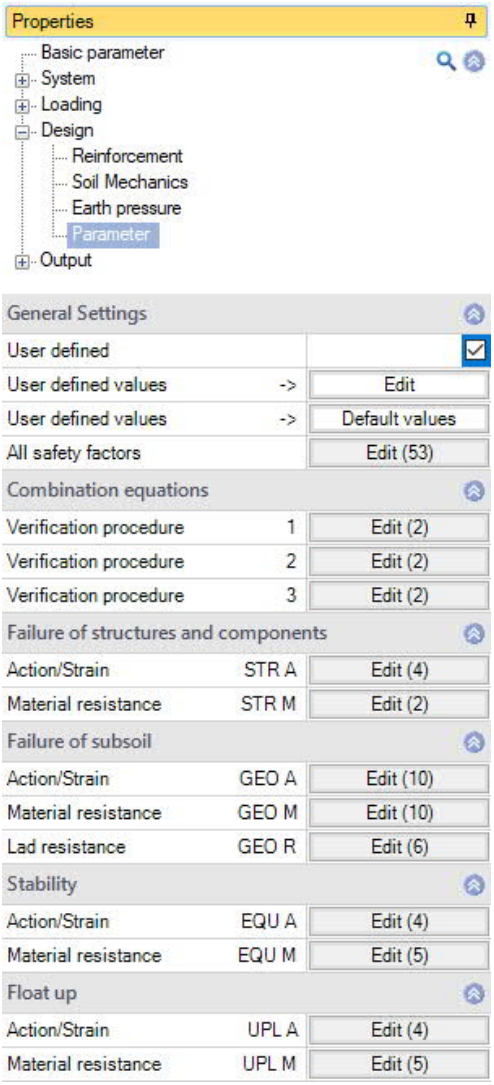
Parameter

User defined

Mark this option if you want to change the safety factors and design rules that deviate from the set standards.

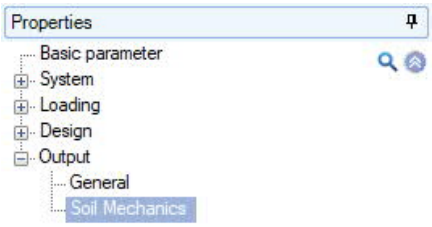
The corresponding input fields/editing buttons are then displayed.

Use the "Edit" button to open the respective tables for changing the values - the information texts for the individual parameters are displayed in the lower window area when you click in an input field.



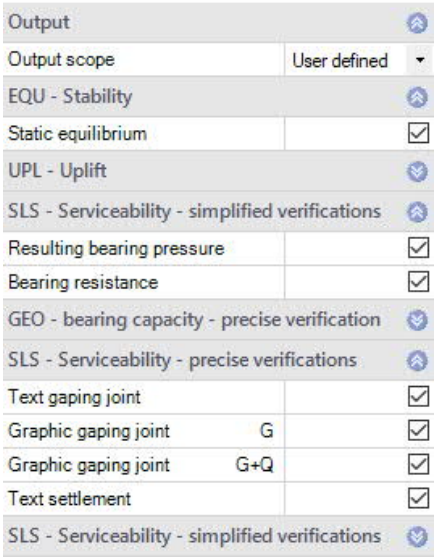
- Support of all 3 verification methods according to Eurocode 7, adjustable for all national annexes.
- The partial safety factors and combination equations for the geotechnical verifications can be edited.
- Since all table values can be changed, the standard setting for a specific country (e.g. India, Sweden, etc.) can be easily defined.

Output



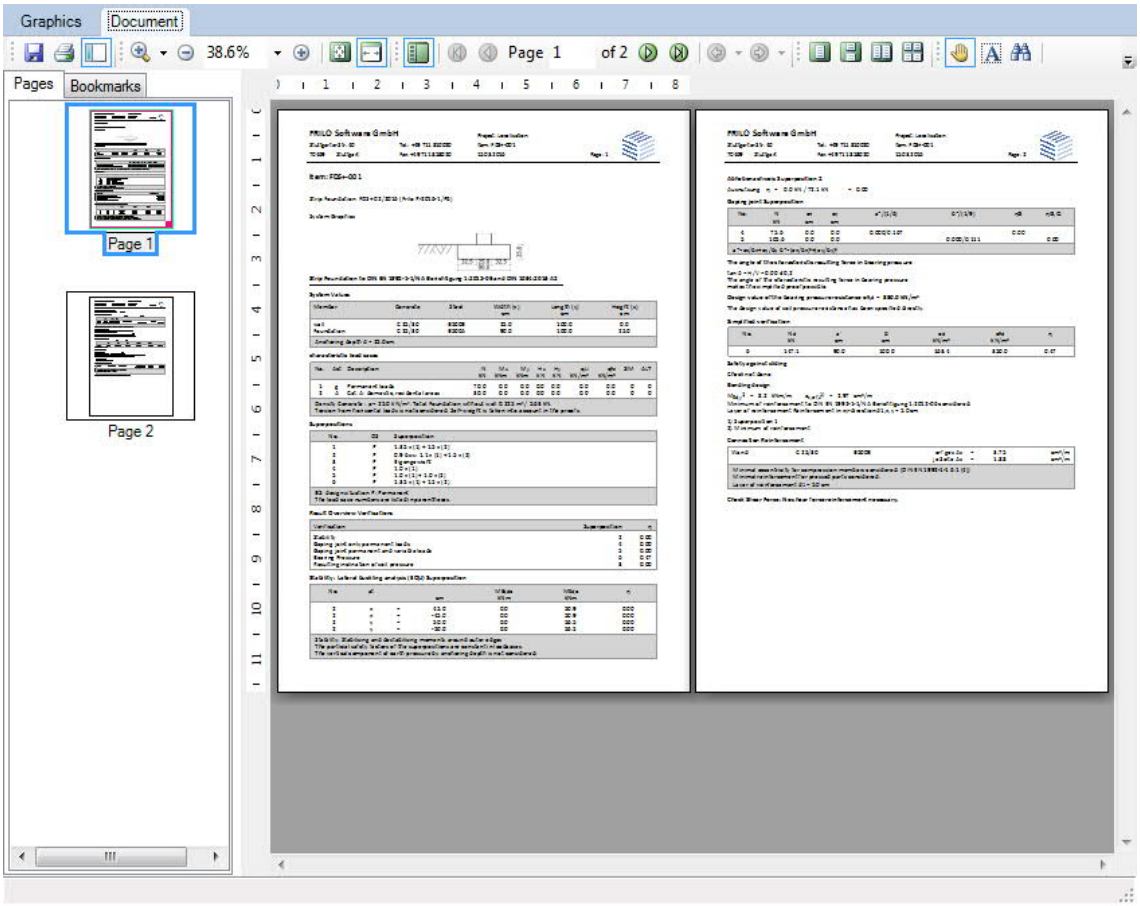
Output scope / Options

By checking the desired options, you can determine the scope of text to be put out. Font size and scale can be adjusted for the graphic.



Output as PDF

The Document tab displays the document in PDF.



See also: Output and printing_eng.pdf