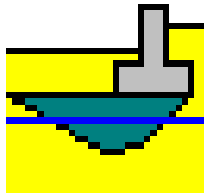


Analysis of footings to DIN 4017, DIN 4019,
DIN 1054 and EC 7

GGU-FOOTING

VERSION 8



Last revision: January 2017
Copyright: Prof. Dr. Johann Buß
Technical implementation and sales: Civilserve GmbH, Steinfeld

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1 Preface

The **GGU-FOOTING** program allows the analysis of bearing capacity according to DIN 4017 and of settlement according to DIN 4019. Both the *global safety factors* according to DIN 1054 (old) and the *partial safety factors* according to DIN 1054:2005 or EC 7 may be taken into consideration. In addition to the standard DIN 4017 methods, the methods after Terzaghi, Meyerhoff, Hansen and Vesic that are well known from many literature references may also be adopted.

The program provides two different types of analysis:

- **Mode 1: "Multiple footings"**
Multiple footings of a single type (pad or strip footing), which only vary in their width, are analysed. In this mode it is possible to generate footing analysis diagrams from which the bearing pressure (EC7), the acceptable bearing pressure (DIN 1054:2005) or the allowable footing pressure (DIN 1054 old) can be read off as a function of the footing width, together with the corresponding settlement.
- **Mode 2: "Pad footing"**
A pad footing is analysed. It is possible to select between either a *rectangular*, or a *circular or annular footing*. Analysis of the torsional stiffness, which can be determined using this mode for circular or annular footings, is often required for wind energy converters.

The program system allows comfortable data input. Reading of the manual can mostly be dispensed with, because

"?" buttons  and "Info" buttons 

dealing with almost all geotechnical and program-specific problems are available in the dialog boxes. You are presented with the necessary information by clicking the "?" or "Info" buttons (see also Section 8.1).

Graphic output supports the true-type fonts supplied with WINDOWS, so that excellent layout is guaranteed. Colour output and any graphics (e.g. files in formats BMP, JPG, PSP, TIF, etc.) are supported. DXF files can also be imported by means of the integrated Mini-CAD module (see the **Mini-CAD** manual).

The program is used almost daily in the course of GGU engineering work. Further to this, the program has been thoroughly tested on numerous examples from the literature and in engineering practice. No faults have been found. Nevertheless, liability for completeness and correctness of the program and the manual, and for any damage resulting from incompleteness or incorrectness, cannot be accepted.

2 Licence protection and installation

In order to guarantee a high degree of quality, a hardware-based copy protection system is used for the **GGU-FOOTING** program.

The GGU software protected by the *CodeMeter* copy protection system is only available in conjunction with the *CodeMeter stick* copy protection component (hardware for connection to the PC, "*CM stick*"). Because of the way the system is configured, the protected software can only be operated with the corresponding CM stick. This creates a fixed link between the software licence and the CM stick copy protection hardware; the licence as such is thus represented by the CM stick. The correct Runtime Kit for the CodeMeter stick must be installed on your PC.

Upon start-up and during running, the **GGU-FOOTING** program checks that a CM stick is connected. If it has been removed, the program can no longer be executed.

For installation of GGU software and the CodeMeter software please refer to the information in the *Installation notes for GGU Software International*, which are supplied with the program.

3 Language selection

GGU-FOOTING is a multilingual program. The program always starts with the language setting applicable when it was last ended.

The language preferences can be changed at any time in the "**Info**" menu, using the menu item "**Language preferences**" (in German: "**Spracheinstellung**", in Spanish: "**Configuración de idioma**").

4 Starting the program

After starting the program, you will see two menus at the top of the window:

- File
- Info

By going to the "**File**" menu, a previously analysed system can be loaded by means of the "**Load**" menu item, or a new one created using "**New**". After clicking the "**New**" menu item a dialog box opens for specifying general preferences for your new system (see Section 7.1.1). After leaving the box you then see six menus in the menu bar:

- File
- Edit
- System
- Output preferences
- Graphics preferences
- Info

After clicking one of these menus, the menu items roll down, allowing you access to all program functions.

The program works on the principle of *What you see is what you get*. This means that the screen presentation represents, overall, what you will see on your printer. In the last consequence, this would mean that the screen presentation would have to be refreshed after every alteration you make. For reasons of efficiency and as this can take several seconds for complex screen contents, the **GGU-FOOTING** screen is not refreshed after every alteration.

If you would like to refresh the screen contents, press either [F2] or [Esc]. The [Esc] key additionally sets the screen presentation back to your current zoom, which has the default value 1.0, corresponding to an A3 format sheet.

5 Short description and worked examples

5.1 Output sheet design

5.1.1 Generate result graphics

After starting the program the logo is at first displayed. Select the menu item "File/New". Then, the following dialog box is shown.

The dialog box is titled "New" and contains the following settings:

- Equation after: **DIN 4017:2006**
- Bearing cap. failure with English designations
- Standard:
 - Partial safety factor concept (EC 7) **Info EC 7**
 - Partial safety factor concept (DIN 1054:2005)
 - Global safety factor concept (DIN 1054 old)
- Type of analysis:
 - Multiple footings **Info**
 - Rectangular footing
 - Circular/annular footing
- Do not investigate overturning
- Ref. parameter (bearing cap.):
 - Load
 - Shear coefficients
- Use absolute heights
- Designation for abs. height.: **mNHN**
- Use kappa correction coefficients (DIN 4019)
- Punching analysis to DIN 4017:2006 (recommended)
- Project identification: **My first attempt**

Buttons: **OK** **Cancel**

Keep the default settings. You may enter a project identification (e.g. "My first attempt"). After confirming with "OK" you will see a dialog box, in which you can select the load case to be analysed. The safety factors corresponding to the selected load case are automatically used in the system data.

Leave the dialog box clicking on the "DS-P" button and then select the "System/Analyse" menu item. First, an info box concerning the punching verification appears. Then the analysis results with all graphics for the values given by the program are shown on the screen.

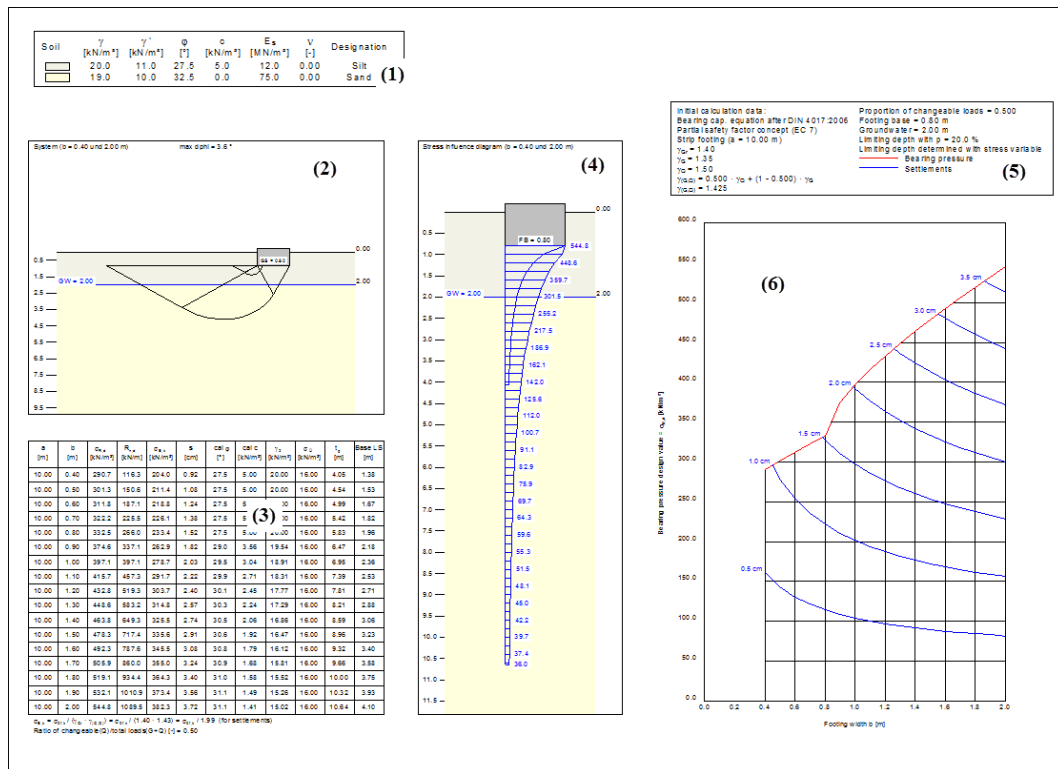


Figure 1 Result screen

The graphic consists of a total of seven elements (also see "Output preferences" menu).

- Legend with **soil properties** (1);
- Legend with **line loads** (if present);
- Graphical representation of the **system** (2) (soil structure, footing and associated logarithmic spiral);
- **Output table** (3) with analysis results for the selected footing types;
- **Stress influence diagram** (4) with the soil structure, footing and associated stress distribution;
- Legend with **analysis fundamentals** (5) such as bearing capacity safety factor, groundwater level, etc.;
- **Footing analysis diagram** (6) with analysis results for bearing pressure or allowable soil pressure and settlements.

5.1.2 Move graphic elements

All seven elements can be arranged at will. Select the "**Move objects**" menu item from the "**Output preferences**" menu. Confirm the info box with "**OK**". Move the mouse over the object to be moved, press the left mouse button and keep it pressed whilst moving the object. After releasing the mouse button the object is shown at its new position.

The size of some objects can also be altered. To alter the size of an object, move the mouse to the top or right-hand edge of the object in question and move the edge with the left mouse button pressed. If you are within the boundaries of a graphic element, the mouse pointer changes to a cross with double arrows pointing *left-right* and *up-down*. If the mouse pointer is at the top or right-hand edge of a resizable element, the mouse pointer changes to a simple double-arrow, pointing either *left-right* or *up-down*. To carry out further alterations, the menu item must be reactivated after each movement.

You can activate this program function without the info box by pressing the [F11] function key.

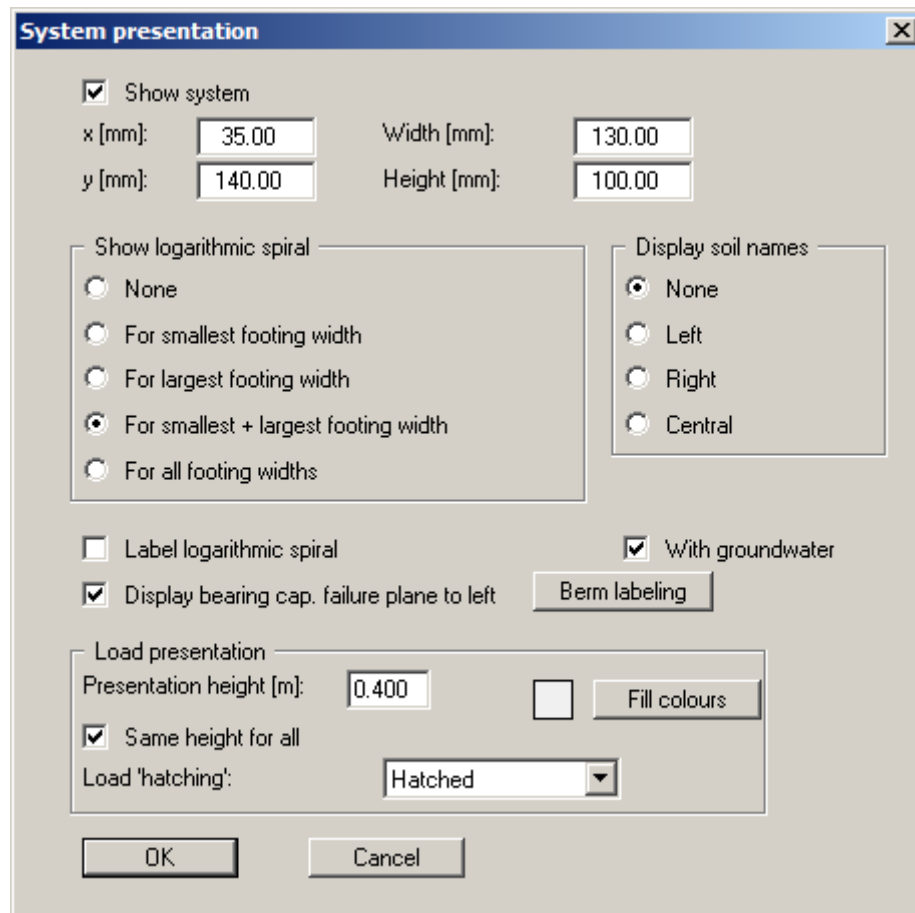
5.1.3 Edit and turn off graphic elements

You can completely remove graphic elements or alter their size and position. Select one of the following menu items from the "**Output preferences**" menu:

- "**Footing analysis diagram**"/"**Footing plan**";
- "**Soil properties**";
- "**System presentation**";
- "**General legend**";
- "**Output table**"/"**Pad footing**";
- "**Stress influence diagram**";
- "**Line loads**".

This can be achieved even more easily by double-clicking in the appropriate element.

For example, you will see the following dialog box by selecting the "Output preferences/System presentation" menu item:



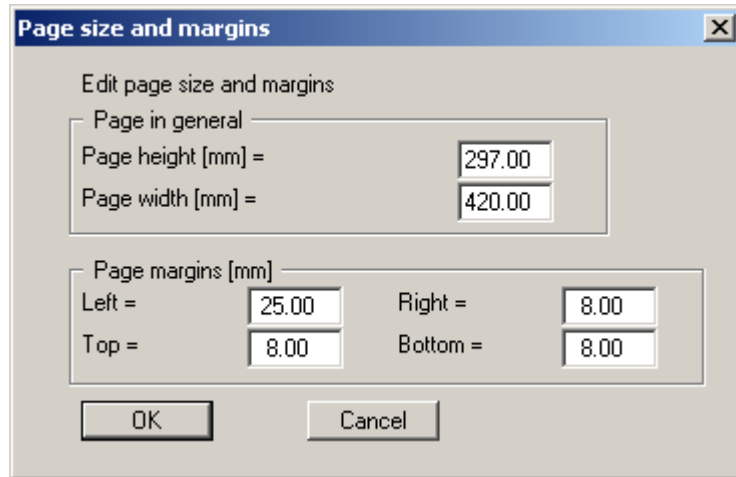
You can switch off the representation of the system using the "Show system" check box. Just deactivate the check box. If you leave the dialog box by means of "OK", the system presentation will no longer be displayed.

The size and position of the system presentation can be defined in the dialog box. You can also decide whether certain elements and labelling should be displayed in the diagram.

The dialog boxes for other graphic elements are similarly structured.

5.1.4 Edit page size and margins

The program uses A3 format as the default drawing size. However, the size can be edited to suit your needs. Go to the "**Output preferences/Page size and margins**" menu item and enter your personal page format.



Page margins defines the position of a frame as a distance to the cutting border. This frame encloses the subsequent diagram.

5.2 Example 1: Multiple footings

5.2.1 Enter analysis options (Example 1)

Select the menu item "**File/New**". When the program is started the check boxes "**Partial safety factor concept (EC 7)**" and "**Multiple footings**" are already activated. Alternatively, the standard and the analysis mode can be selected by going to the menu item "**Edit/Analysis options**".

The screenshot shows the "New" dialog box with the following settings:

- Equation after: DIN 4017:2006
- Bearing cap. failure with English designations
- Standard:
 - Partial safety factor concept (EC 7) (Info EC 7)
 - Partial safety factor concept (DIN 1054:2005)
 - Global safety factor concept (DIN 1054 old)
- Type of analysis:
 - Multiple footings (Analysis and output with: sigma(R,d) (Info))
 - Rectangular footing
 - Circular/annular footing
 - Do not investigate overturning
- Ref. parameter (bearing cap.):
 - Load
 - Shear coefficients
- Use absolute heights (Designation for abs. height: mNHN)
- Use kappa correction coefficients (DIN 4019)
- Punching analysis to DIN 4017:2006 (recommended)
- Project identification: 'Multiple footings' worked example

After confirming with "**OK**" you can select the load case. Choose "**DS-P**". The partial safety factors are used in the system data.

You can enter a project identification for the current problem, which is subsequently shown in the *General legend*. A project identification is entered when selecting the type of system in the above dialog box or via the "**Edit/Project identification**" menu item.

5.2.2 Enter system parameters (Example 1)

The appropriate partial safety factors have already been entered into the "Edit/System parameters" menu item. The quantities described below can be entered or edited. Use the default values for the example.

System parameters

Partial FOS (bearing capacity): 1.40

Partial FOS (permanent actions): 1.35

Partial FOS (changeable actions): 1.50

Groundwater table [m]: 2.00

Footing base [m]: 0.80

Slope inclination [°]: 0.00

Berm width [m]: 0.00

Slope to DIN 4017:2006

Base inclination [°]: 0.00

Preloading [kN/m²]: 0.00 ?

Surcharge (bearing cap.) [kN/m²]: 0.00 ?

Surcharge (limiting depth) [kN/m²]: 0.00 ?

H/V [-]: 0.00000

Depth coefficients

Calculate using depth coefficients ?

Depth coeff. after: IEG7 (SE) ?

Friction angle for bearing capacity failure ?

Depth coefficients for slopes too ?

Verify bearing capacity for short side only

Limit soil pressure

Limit to max. $\sigma(R,d)$ [kN/m²] = 200.00 Apply

5° condition

Check and correct Info

Decrement [°]: 0.10

Ratio changeable/total loads [-]

Ratio [-]: 0.500 Info

Punching analysis

Carry out punching analysis Info

Flexible footing

Done Cancel

- **"Partial FOS (bearing capacity/permanent actions/changeable actions):"/>"Bearing capacity FOS [-]:"**
safety factor η according to DIN 4017
- **"Groundwater table [m]:"**
measured from ground level in m
- **"Footing base [m]:"**
measured from ground level in m
- **"Slope inclination [°]:"**
positive values only (= falling slope)

The older version of DIN 4017 did not envisage taking slope inclination into consideration. If you are not investigating slopes in accordance with DIN 4017:2006 (the appropriate check box is deactivated, see below), you should therefore examine the approach for your problem used in "Theoretical principles" as a matter of urgency. Input of slope inclination here does not represent a substitute for slope stability analysis according to DIN 4084 !!!!!. The program assumes that the slope is stable.

- **"Berm width [m]:"**
measured in m beside the footing

The current issue of DIN 4017 does not envisage consideration of berms. You should therefore examine the **"Theoretical principles"** for an approach to your problem.

- **"Slope to DIN 4017:2006"**
Previous versions of DIN 4017 did not provide for consideration of slopes. We therefore installed our own model for taking slopes into consideration.
- **"Base inclination [°]:"**
inclination of the footing base in [°]
- **"Preloading [kN/m²]:"**
For settlement analyses, a preloading in kN/m² can be subtracted from the current footing pressure. Settlement analysis will then be performed with the reduced values. The overburden stress is also reduced by this amount when calculating the limiting depth.
- **"Surcharge (bearing capacity) [kN/m²]:"**
The bearing capacity surcharge defines a stress on the ground, which generates a stress on the failure body in addition to the embedment depth.
- **"Surcharge (limiting depth) [kN/m²]:"**
According to DIN 4019, settlement analysis can be terminated at a depth (limiting depth) in which the stress from soil self-weight and ground surcharges is greater than 20 % of the stresses caused by the footing. You can enter the ground surcharge for this limiting depth calculation, here. Input is only of importance if you calculate the limiting depth as a function of the surcharge stress (see also Section 5.2.5).
- **"H/V [-]:"**
Ratio of the horizontal force H to the vertical force V
In the bearing capacity equation in DIN 4017, a horizontal force can be taken into consideration. In **GGU-FOOTING** this force can be defined as a ratio to the vertical force.
- **"Calculate using depth coefficients"**
In the bearing capacity equations in DIN 4017, the effects of the shear strength of the soil above the footing base are neglected. According to Section 6.1 (**"Theoretical principles/Analysis of bearing capacity failure"**), this influence can be considered by applying the depth coefficients d_c and d_d . Four different procedures are available, which can be selected via the dropdown menu. The depth coefficient equations can be found in the above mentioned Section 6.1 of this manual.
- **"Friction angle for bearing capacity failure"**
Three of the four depth coefficient equations use a friction angle:
Check box deactivated ==> mean friction angle at footing base will be adopted.
Check box activated ==> friction angle for bearing capacity analysis will be adopted.
- **"Depth coefficients for slopes too"**
If the slope inclination $\neq 0$, the parameters d_c and d_d are set to **"1.0"** if the check box is deactivated. If the check box is activated, the influence of the shear strength of the soil above the footing base is also taken into consideration in a slope.
- **"Verify bearing capacity for short side only"**
The program verifies the bearing capacity safety for the short and the long sides of the footing. In rare, exceptional cases (see the included file **"DIN 4017 new Example 6 a flexible.gdg"**) it may be expedient to verify the short side only. You should then activate this check box.

- **"Limit soil pressure"** group box
For predefined footing types, the program calculates the allowable soil pressure as a function of the footing width. If footing pressures are determined, which are too high for your taste, in particular for large footing widths, possibly due to excessively high settlement or for simple safety reasons (the structural engineer always computes with the allowable values provided by you), you can limit the allowable footing pressure to a defined level. Activate the **"Apply"** check box and enter the required maximum value.
- **"5° condition"** group box
According to DIN 4017 the soil properties can be averaged out for stratified ground. The condition for this is that the averaged friction angle demonstrates a maximum deviation of 5° to the true friction angles. The program checks this condition. If it is not adhered to, a warning signal is given after the analysis. Alternatively, you can have the program reduce all friction angles in stages, which lie above the average value. The size of the reduction is specified with **"Decrement [°]"**. Small decrement values mean long computation times with high precision. A reduction only takes place if the **"Check and correct"** check box is activated.
- **"Ratio changeable/total loads [-]:"** group box
The failure stress is first divided by the bearing capacity partial safety factor. This gives the bearing capacity stress. A further reduction by the partial safety factors for actions is necessary for calculation of an allowable footing pressure or acceptable bearing pressure. In load case 1, e.g., a partial safety factor of $\gamma(G) = 1.35$ for permanent loads and one of $\gamma(Q) = 1.50$ for changeable loads is demanded. From a ratio of 0.40, for example, a **total partial factor** results from:

$$\text{Ratio} \cdot 1.50 + (1.0 - \text{ratio}) \cdot 1.35 = 1.410$$

- **"Punching analysis"** group box
Punching analysis can be activated here. DIN 4017:2006 describes a new punching analysis method. To use this new analysis method the **"Punching analysis using new method (recommended)"** check box in the 'File/New' dialog box is activated by default when the program starts. The punching analysis equations given in DIN 4017:2006 differentiate between flexible and rigid footings. Accordingly you will activate or deactivate the **Flexible footing** check box.

5.2.3 Define footings (Example 1)

In the "Edit/Footing details" menu item you define the size and shape of the footing.

The screenshot shows a dialog box titled "Footing shape". It is divided into two main sections. The first section, "Define footing width b", contains three input fields: "Start width [m]:" with the value 0.400, "End width [m]:" with the value 2.000, and "Width increment [m]:" with the value 0.100. The second section, "Type of footing (a = footing length)", contains three radio button options. The first option, "Strip footing with a [m] =", is selected and has a value of 10.000. The second option, "Pad footing with a/b =", has a value of 1.000. The third option, "Pad footing with a [m] =", has a value of 2.500. At the bottom of the dialog are "OK" and "Cancel" buttons.

The "Start width", the "End width" and the "Delta width" are entered in this box. You thus define the width range to be investigated. Thus, using the example given above, the widths 0.4, 0.5, 0.6, ... to 2.0 m will be investigated.

You must also enter whether a strip or a pad footing is to be analysed. The example above would analyse a strip footing. When analysing a strip footing, enter the strip length applicable to all widths. This strip length is required for the subsequent settlement analysis.

To analyse a pad footing you define whether a constant length/width ratio (a/b) or a constant footing length (a) is analysed. If you have activated a pad footing with constant length a, you may find, for an appropriate start width, that $a < b$. In this case a warning message is issued to inform you that $a = b$.

5.2.4 Define soils (Example 1)

In the "**Edit/Soils**" menu item, enter the values for the soils present as shown in the following dialog box.

| | Designation | Base | gam | gam' | phi | c | Es | nu |
|---|-------------|------|----------------------|----------------------|------|----------------------|----------------------|------|
| | | [m] | [kN/m ³] | [kN/m ³] | [°] | [kN/m ²] | [MN/m ²] | [-] |
| 1 | Silt | 2.00 | 20.0 | 11.0 | 27.5 | 5.0 | 12.0 | 0.00 |
| 2 | Sand | 7.00 | 19.0 | 10.0 | 32.5 | 0.0 | 80.0 | 0.00 |

The layer depths (base) are with reference to ground level and are positive downwards, as are all other inputs. But if you have activated the "**Use absolute heights**" check box in the dialog box in the "**File/New**" menu item, layer depths are positive upwards. In addition, you must enter a value in the "**Edit/Ground level**" dialog box. In this case you can enter the layer depths and other height-referenced values e.g. in m AD.

Furthermore:

- gam = unit weight of soil above groundwater
- gam' = buoyant unit weight
- phi = soil friction angle
- c = cohesion of soil
- E_s = soil constrained modulus
- nu = Poisson's ratio of soil

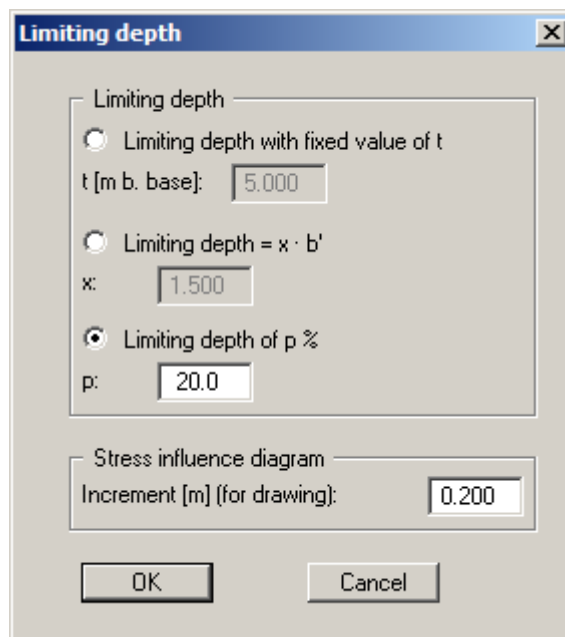
If the constrained modulus is used for analysis, nu equals 0.0 for all soils. The value of nu displayed in the soil properties legend can then be switched off (see Section 7.4.3).

If you would like to edit the number of soils, select the "**Edit number of soils**" button and then enter the new number of soils. Using the "**Sort**" button, you can have the soils sorted according to depth. This sorting will be carried out automatically when leaving the dialog box, without the function being explicitly called-up. Erroneous input is thus impossible from the outset.

If several soils have been entered, and you would like to delete a soil which is not at the end of the list, you can assign this soil a **large** depth (e.g. 99.0). Then select the "Sort" button. The soil will now be at the end of the table. With the "Edit number of soils" button you can reduce the number by 1. The soil has now been deleted from the list, without a lot of typing.

5.2.5 Select the limiting depth (Example 1)

In the "Edit/Limiting depth" menu item, the type of limiting depth calculation can be defined in three different ways.



If the limiting depth lies below the depth of the lowest soil layer, the values of this layer are used in the settlement analysis.

For settlement analyses, a preloading in kN/m² can be subtracted from the current footing pressure. Settlement analysis will then be performed with the reduced values. The overburden stress is also reduced by the preloading value when calculating the limiting depth.

5.2.6 Analyse system (Example 1)

After editing one of the previous dialog boxes, the system is first represented without the analysis results. If you want to have the footing reanalysed with the new values go to the "System" menu and select "Analyse". Alternatively, press the [F5] function key or click on the *calculator* in the tool bar.

First, an info box concerning the punching verification appears. Then, the analysis results are presented to you in the various drawing elements (table and graphics). The current screen contents can be sent to the printer at any stage of project processing. Select the "Print and export" menu item from the "File" menu (see Section 7.1.7).

5.3 Example 2: Single rectangular footing

5.3.1 Enter analysis options (Example 2)

Select the menu item "**File/New**". Activate the "**Rectangular footing**" switch. Alternatively you can alter standard and analysis mode in the "**Edit/Analysis options**" dialog box.

The screenshot shows a dialog box titled "New" with the following settings:

- Equation after: (dropdown menu)
- Bearing cap. failure with English designations
- Standard:
 - Partial safety factor concept (EC 7)
 - Partial safety factor concept (DIN 1054:2005)
 - Global safety factor concept (DIN 1054 old)
- Type of analysis:
 - Multiple footings (dropdown menu)
 - Rectangular footing Circular/annular footing
 - Do not investigate overturning
- Ref. parameter (bearing cap.):
 - Load Shear coefficients
- Use absolute heights
Designation for abs. height:
- Use kappa correction coefficients (DIN 4019)
- Punching analysis to DIN 4017:2006 (recommended)
- Project identification:
-

Confirm with "**OK**". After this you can select the load case. Choose "**DS-P**". The partial safety factors given are used in the system data.

You can enter a project identification for the current problem, which is subsequently shown in the **General legend**. The project identification is entered when selecting the type of system in the above dialog box or via the "**Edit/Project identification**" menu item.

5.3.2 Enter system parameters (Example 2)

The appropriate partial safety factors have already been entered into the "Edit/System parameters" menu item. Enter '1.00' in the "Footing base" input box.

System parameters

Partial FOS (bearing capacity): 1.40
 Partial FOS (permanent actions): 1.35
 Partial FOS (changeable actions): 1.50
 Groundwater table [m]: 2.00
 Footing base [m]: 1.00
 Slope inclination [°]: 0.00
 Berm width [m]: 0.00
 Slope to DIN 4017:2006
 Base inclination [°]: 0.00
 Preloading [kN/m²]: 0.00 ?
 Surcharge (bearing cap.) [kN/m²]: 0.00 ?
 Surcharge (limiting depth) [kN/m²]: 0.00 ?

Depth coefficients

Calculate using depth coefficients ?
 Depth coeff. after: IEG7 (SE) ?
 Friction angle for bearing capacity failure ?
 Depth coefficients for slopes too ?

Additional bearing cap. analysis with V(permanent), M(total) and H(total)
 Calculate settlements below permanent loads
 Verify bearing capacity for short side only

5° condition

Check and correct Info
 Decrement [°]: 0.10

Punching analysis

Carry out punching analysis Info
 Flexible footing

EQU analysis

Verify gamma(G,dst): 1.10
 gamma(G,stb): 0.90 gamma(Q,dst): 1.50

Done Cancel

The dialog box largely corresponds to that of the "Multiple footings" mode. The input values are described in Section 5.2.2. In addition, when analysing pad footing (*rectangle* or *circle/annulus*) with the *partial safety factor concept*, the following two check boxes can be activated:

- **"Additional bearing cap. analysis with V(permanent), M(total) and H(total)"**
 Bearing capacity is analysed with the total loads = permanent + changeable loads. However, if the load combination V(permanent), M(total) and H(total) is possible because the loads can occur independently, this load combination may provide unfavourable results. It is therefore possible to investigate this load combination separately.
- **"Calculate settlements below permanent loads"**
 If this check box is activated, only the settlements below permanent loads will be calculated. Otherwise, settlements below total loads will be calculated (= permanent + changeable loads).

5.3.3 Define footing (Example 2)

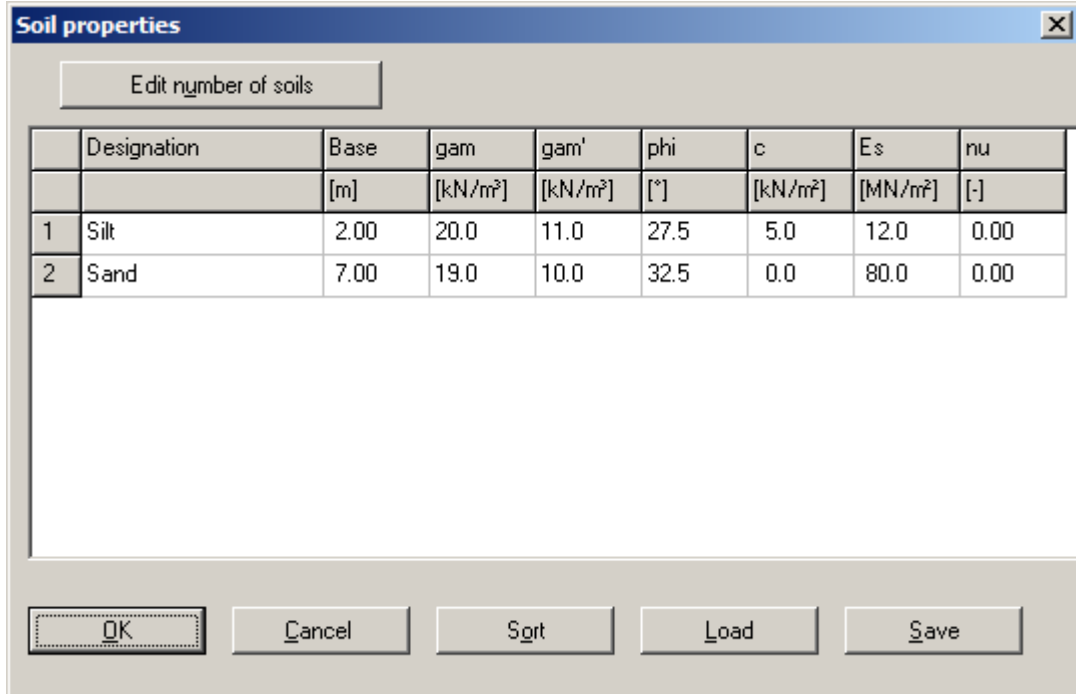
Select the menu item "Edit/Footing details".

| | Permanent | Changeable |
|----------------------------|-----------|------------|
| Vertical force [kN]: | 1250.00 | 0.00 |
| Horizontal force (x) [kN]: | 125.00 | 0.00 |
| Horizontal force (y) [kN]: | 0.00 | 0.00 |
| Moment (x) [kN·m]: | 500.00 | 0.00 |
| Moment (y) [kN·m]: | 500.00 | 0.00 |

According to the new *partial safety factor concept*, you can define differing stresses for permanent and changeable loads.

5.3.4 Define soils (Example 2)

If you have previously analysed the "**Multiple footings**" worked example, you can leave the soil properties unchanged. Otherwise, enter the values for the soils present in the menu item "**Edit/Soils**", as shown in the following dialog box.



The dialog box titled "Soil properties" contains a button "Edit number of soils" at the top. Below it is a table with 9 columns: Designation, Base, gam, gam', phi, c, Es, and nu. The units for each column are: [m], [kN/m²], [kN/m²], [°], [kN/m²], [MN/m²], and [-]. There are two rows of data: Row 1: Silt, 2.00, 20.0, 11.0, 27.5, 5.0, 12.0, 0.00; Row 2: Sand, 7.00, 19.0, 10.0, 32.5, 0.0, 80.0, 0.00. At the bottom of the dialog are buttons for "OK", "Cancel", "Sort", "Load", and "Save".

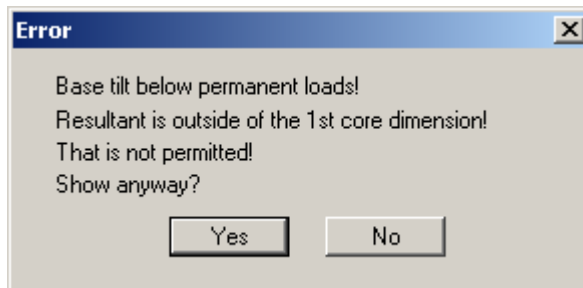
| | Designation | Base | gam | gam' | phi | c | Es | nu |
|---|-------------|------|---------|---------|------|---------|---------|------|
| | | [m] | [kN/m²] | [kN/m²] | [°] | [kN/m²] | [MN/m²] | [-] |
| 1 | Silt | 2.00 | 20.0 | 11.0 | 27.5 | 5.0 | 12.0 | 0.00 |
| 2 | Sand | 7.00 | 19.0 | 10.0 | 32.5 | 0.0 | 80.0 | 0.00 |

The input values are more closely described in Section 5.2.4.

5.3.5 Analyse system (Example 2)

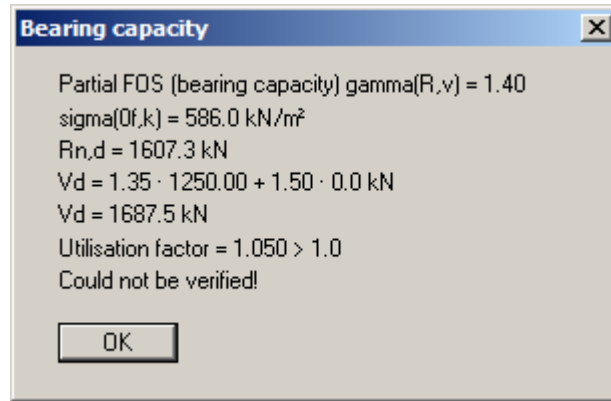
After editing one of the previous dialog boxes, the system is first represented without the analysis results. If you want to have the footing reanalysed with the new values go to the "**System**" menu and select "**Analyse**". Alternatively, press the [F5] function key or click on the *calculator* in the tool bar.

After a short time the following message appears.



The error dialog box contains the following text: "Base tilt below permanent loads! Resultant is outside of the 1st core dimension! That is not permitted! Show anyway?". At the bottom are "Yes" and "No" buttons.

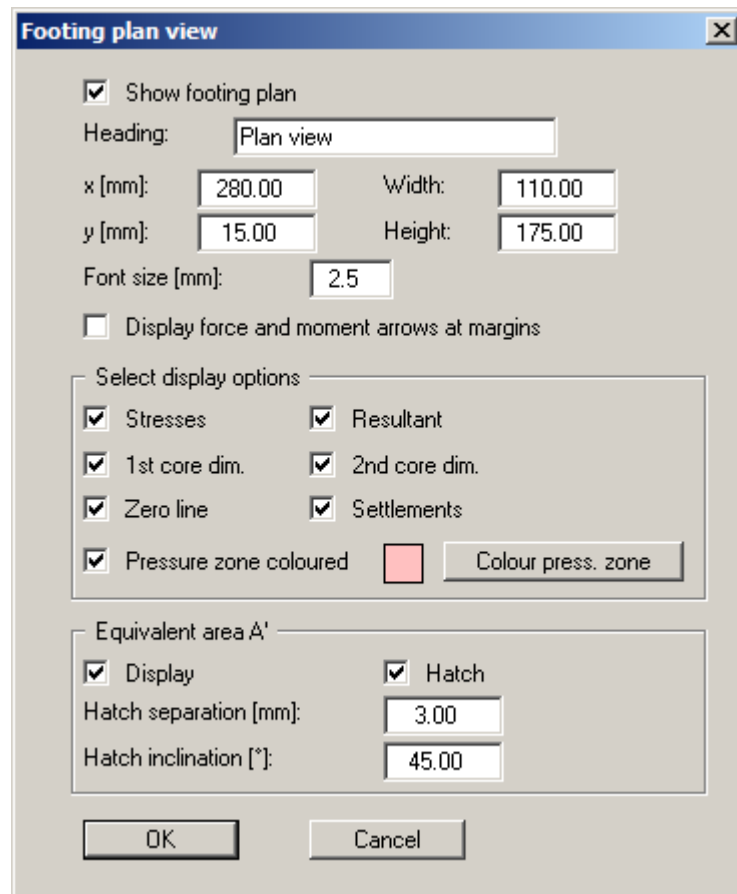
If you confirm with "**Yes**" you will see an info box concerning the punching verification. Then a further window with information on the safety and utilisation factors is displayed.



If you close the window with "OK" the diagram and all analysis results are presented on the screen. If the results are too small to read, you can use the zoom. To do this, hold the [Ctrl]-key and the left mouse button and mark the region to be enlarged on the diagram. Press the [Esc] key to return to the full screen representation.

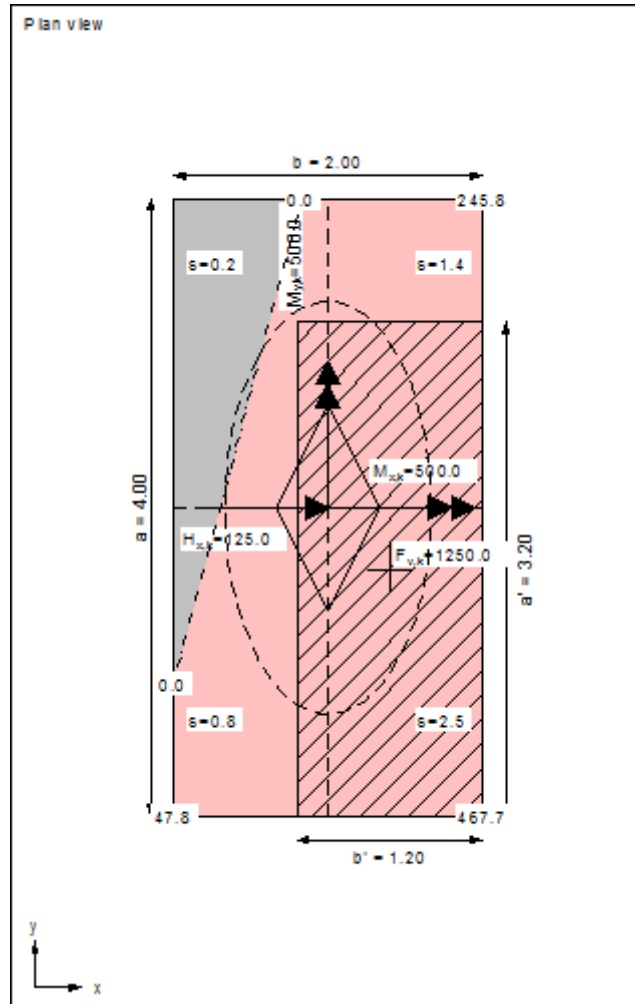
5.3.6 Represent results in the plan view of footing (Example 2)

Select the "Output preferences/Footing plan" menu item or click in the "Plan view" drawing element at the right side of the diagram. (Note: The footing analysis diagram is here when analysing in "Multiple footings" mode).



Activate the "**Pressure zone coloured**" check box. Press the "**Colour press. zone**" button and select a quiet red from the box (or perhaps not). Confirm with "**OK**".

In the plan view at the right the pressure zone is now coloured.



The graphic also contains:

- the characteristic forces $M_{x,k}$, $M_{y,k}$, $H_{x,k}$ and the vertical force $F_{v,k}$ (= resultant, marked by a cross).
- the 1st core dimension.
If the resultant is within this rhombic area, the complete footing is under pressure.
- the 2nd core dimension.
If the resultant is within this elliptical area, a base tilt will occur.
- the equivalent area A' .
This region is additionally labelled at the edge with a' and b' .
- the four corner stresses or, in our case (with base tilt), the stresses at the five corners of the pressure zone.
- the settlements at the four characteristic points.

The resulting torsion can be read from the pad footing legend at the lower left of the screen.

```

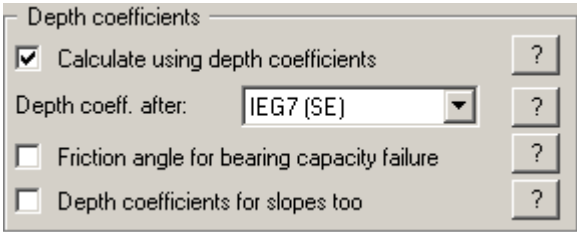
Settlement from total loads:
Limiting depth  $t_p = 6.14$  m b. GL
Settlement (mean of all CPs) = 1.21 cm
Settlement of CPs:
Top left = 0.17 cm
Top right = 1.42 cm
Bottom left = 0.77 cm
Bottom right = 2.47 cm
Torsion (x) (CP) = 1 : 356.4
Torsion (y) (CP) = 1 : 100.4

```

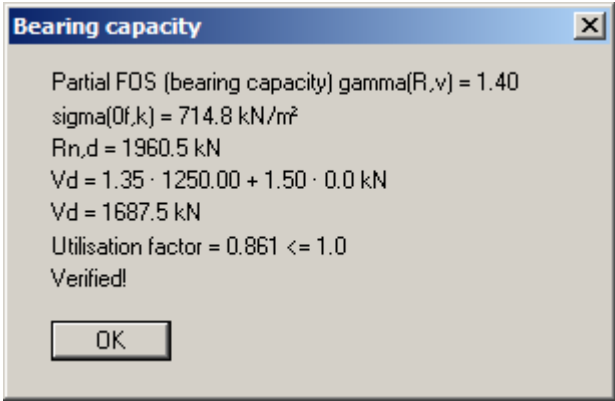
5.3.7 Consider depth coefficients (Example 2)

In the bearing capacity equations in DIN 4017, the effects of the shear strength of the soil above the footing base are neglected. According to Section 6.1 ("**Theoretical principles/Analysis of bearing capacity failure**"), this influence can be considered by applying the depth coefficients d_c and d_d .

An example will demonstrate the influence of taking depth coefficients into consideration. First activate the following check box in the "**Edit/System parameters**" menu item:



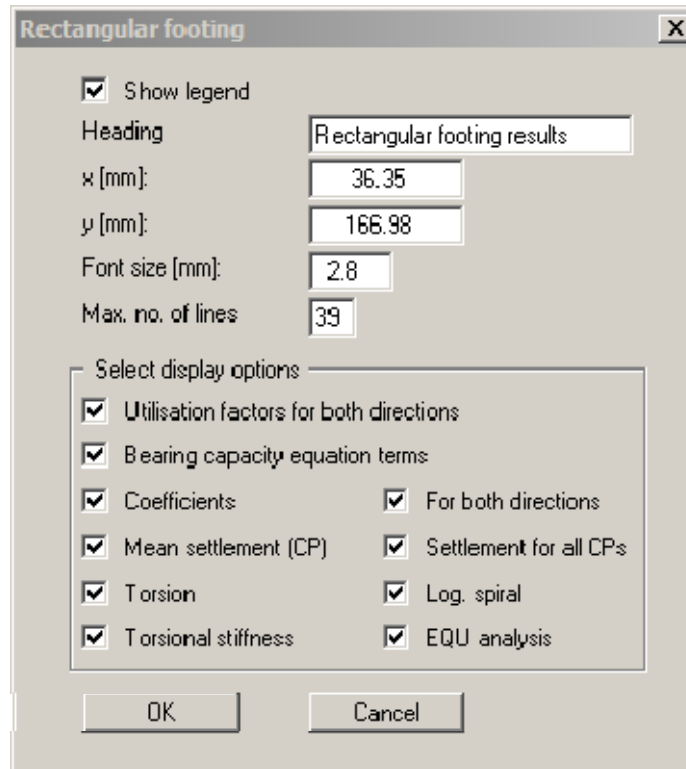
Analyse the system once again. Pressing [F5] is the fastest way to do it. After a short wait the base tilt message appears again, and after confirmation with "**Yes**", the following information:



The utilisation factor was improved from **1.050** to **0.861** by considering the shear strength of the soil above the footing base and is thus below the maximum allowable value of **1.0**. Naturally, the base tilt is still there.

5.3.8 Represent results in the pad footing legend (Example 2)

Select the "Output preferences/Pad footing" menu item or click in the "Pad footing" drawing element at the left side of the diagram. (Note: An output table with the result data for all footings is here when analysing in "Multiple footings" mode).



Activate all the check boxes in the "Select display options" group box. Confirm with "OK" and then zoom in on the tabulated data in the bottom left corner of the screen. You can now view all principal analysis results. The maximum utilisation factor of **0.861** is parallel to the side x of the footing. Parallel to y the utilisation factor is **0.687**.

| | | |
|--|---|--|
| Rectangular footing results | $G_{or,x} / G_{or,d} = 714.8 / 510.55 \text{ kN/m}^2$ | $N_{ed} = 34.94; N_{ed} = 22.68; N_{ed} = 13.45$ |
| Loads = Permanent / Changeable | $R_{n,k} = 2744.74 \text{ kN}$ | Shape coeff. (y): |
| Vertical load $F_{v,k} = 1250.00 / 0.00 \text{ kN}$ | $R_{n,d} = 1960.53 \text{ kN}$ | $V_x = 1.207; V_x = 1.198; V_x = 0.888$ |
| Horizontal force $F_{h,x,k} = 125.00 / 0.00 \text{ kN}$ | $V_d = 1.35 \cdot 1250.00 + 1.50 \cdot 0.00 \text{ kN}$ | Gradient coeff. (y): |
| Horizontal force $F_{h,y,k} = 0.00 / 0.00 \text{ kN}$ | $V_d = 1687.50 \text{ kN}$ | $I_x = 0.826; I_x = 0.834; I_x = 0.750$ |
| Moment $M_{x,k} = 500.00 / 0.00 \text{ kN}\cdot\text{m}$ | μ (parallel to x) = 0.861 | Depth coefficients (y): |
| Moment $M_{y,k} = 500.00 / 0.00 \text{ kN}\cdot\text{m}$ | μ (parallel to y) = 0.687 | $d_c = 1.109; d_c = 1.109; d_c = 1.000$ |
| Length a = 4.000 m | Cohesion term = 372.88 kN (k) | Settlement from total loads: |
| Width b = 2.000 m | Width term = 554.78 kN (k) | Limiting depth $t_d = 6.14 \text{ m b. GL}$ |
| Below permanent loads: | Depth term = 1817.07 kN (k) | Settlement (mean of all CPs) = 1.21 cm |
| Eccentricity $e_x = 0.400 \text{ m}$ | $\alpha \text{I} \phi = 30.0^\circ$ | Settlement of CPs: |
| Eccentricity $e_y = -0.400 \text{ m}$ | Cal c = 2.52 kN/m ² | Top left = 0.17 cm |
| Resultant in 2nd core | Cal $\gamma_2 = 17.86 \text{ kN/m}^2$ | Top right = 1.42 cm |
| Length a' = 3.200 m | Cal $G_d = 20.00 \text{ kN/m}^2$ | Bottom left = 0.77 cm |
| Width b' = 1.200 m | Base of log. spiral = 2.58 m b. GL | Bottom right = 2.47 cm |
| Below total loads: | Length log. spiral = 6.52 m | Torsion (x) (CP) = 1 : 356.4 |
| Eccentricity $e_x = 0.400 \text{ m}$ | Area of log. spiral = 5.35 m ² | Torsion (y) (CP) = 1 : 100.4 |
| Eccentricity $e_y = -0.400 \text{ m}$ | Bearing capacity coeff. (x): | Torsional stiffness: |
| Resultant in 2nd core | $N_{ed} = 30.25; N_{ed} = 18.50; N_{ed} = 10.12$ | $k_{q,x} = 178.2 \text{ MN}\cdot\text{m/rad}$ |
| Length a' = 3.200 m | Shape coeff. (x): | $k_{q,y} = 50.2 \text{ MN}\cdot\text{m/rad}$ |
| Width b' = 1.200 m | $V_x = 1.198; V_x = 1.188; V_x = 0.888$ | EQU analysis: |
| Bearing capacity: | Gradient coeff. (x): | Governing factor: footing width |
| Punching investigated, | $I_x = 0.824; I_x = 0.834; I_x = 0.750$ | $M_{ed} = 1250.0 \cdot 2.00 \cdot 0.5 \cdot 0.90 = 1125.0$ |
| but not governing. | Depth coefficients (x): | $M_{ed} = 500.0 \cdot 1.10 = 550.0$ |
| Partial FOS (bearing capacity) $\gamma_{R,v} = 1.40$ | $d_c = 1.292; d_c = 1.292; d_c = 1.000$ | $\mu_{ed} = 550.0 / 1125.0 = 0.489$ |
| | Bearing capacity coeff. (y): | |

5.4 Example 3: Single circular footing (EC 7)

5.4.1 Enter analysis options (Example 3)

Select the menu item "**File/New**". Activate the "**Circular/annular footing**" switch. Alternatively you can alter standard and analysis mode in the "**Edit/Analysis options**" dialog box.

The screenshot shows a dialog box titled "New" with the following settings:

- Equation after: (dropdown menu)
- Bearing cap. failure with English designations
- Standard:
 - Partial safety factor concept (EC 7)
 - Partial safety factor concept (DIN 1054:2005)
 - Global safety factor concept (DIN 1054 old)
- Type of analysis:
 - Multiple footings (dropdown menu)
 - Rectangular footing
 - Circular/annular footing
 - Do not investigate overturning
- Ref. parameter (bearing cap.):
 - Load
 - Shear coefficients
- Use absolute heights
Designation for abs. height.:
- Use kappa correction coefficients (DIN 4019)
- Punching analysis to DIN 4017:2006 (recommended)
- Project identification:
-

Confirm with "**OK**". After this you can select the load case. Choose "**DS-P**". The partial safety factors given are used in the system data.

You can enter a project identification for the current problem, which is subsequently shown in the **General legend**. The project identification is entered when selecting the type of system in the above dialog box or via the "**Edit/Project identification**" menu item.

5.4.2 Enter system parameters (Example 3)

The appropriate partial safety factors have already been entered into the "Edit/System parameters" menu item.

The dialog box largely corresponds to that of the "Multiple footings" mode. The input values are described in Section 5.2.2. In addition, when analysing pad footing (*rectangle* or *circle/annulus*) with the *partial safety factor concept*, the following two check boxes can be activated:

- **"Additional bearing cap. analysis with V(permanent), M(total) and H(total)"**
 Bearing capacity is analysed with the total loads = permanent + changeable loads. However, if the load combination V(permanent), M(total) and H(total) is possible because the loads can occur independently, this load combination may provide unfavourable results. It is therefore possible to investigate this load combination separately.
- **"Calculate settlements below permanent loads"**
 If this check box is activated, only the settlements below permanent loads will be calculated. Otherwise, settlements below total loads will be calculated (= permanent + changeable loads).

5.4.3 Define footing (Example 3)

Select the menu item "Edit/Footing details".

The screenshot shows a dialog box titled "Circular/annular footing" with the following fields and options:

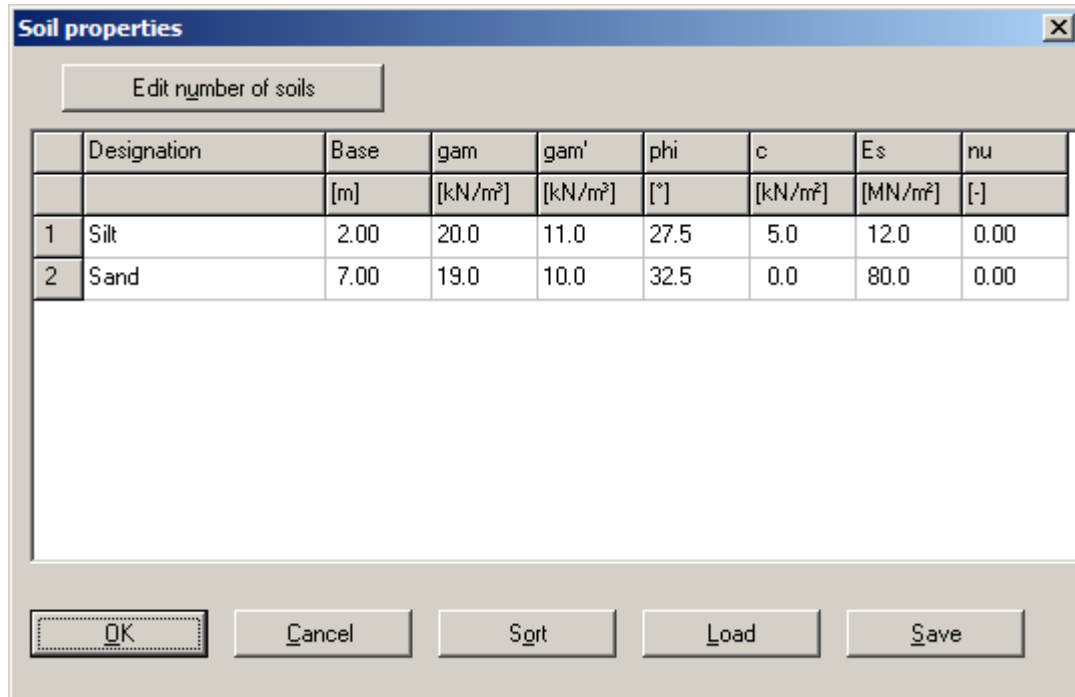
- Dimensions:**
 - Diameter D [m]: 3.500
 - Diameter (internal) d [m]: 0.000
 - Equivalent area bei Circlering über: Moment of inertia (dropdown)
- Stress:**
 - Forces act at the footing base level
 - Vertical force [kN]: Permanent (1250.00), Changeable (0.00)
 - Horizontal force (x) [kN]: Permanent (125.00), Changeable (0.00)
 - Horizontal force (y) [kN]: Permanent (0.00), Changeable (0.00)
 - Moment (x) [kN·m]: Permanent (500.00), Changeable (0.00)
- Self weight:**
 - Automatic self weight
 - Gamma concrete [kN/m³]: 25.00
- Slip resistance:**
 - Verify slip resistance
 - Partial FOS gamma(R,h) [-]: 1.00
 - Sliding resistance with user-defined angle
 - User-defined angle [°]: 30.00

Buttons: OK, Cancel

Enter the diameter shown for the circular footing. The analysis is performed on an equivalent area for an annular footing (see "**Theoretical principles circle/annulus**", Section 6.2). According to the new *partial safety factor concept*, you can define differing stresses for permanent and changeable loads.

5.4.4 Define soils (Example 3)

If you have previously analysed the "Multiple footings" worked example, you can leave the soil properties unchanged. Otherwise, enter the values for the soils present in the menu item "Edit/Soils", as shown in the following dialog box.



The dialog box titled "Soil properties" contains a button "Edit number of soils" and a table with the following data:

| | Designation | Base | gam | gam' | phi | c | Es | nu |
|---|-------------|------|----------------------|----------------------|------|----------------------|----------------------|------|
| | | [m] | [kN/m ²] | [kN/m ²] | [°] | [kN/m ²] | [MN/m ²] | [-] |
| 1 | Silt | 2.00 | 20.0 | 11.0 | 27.5 | 5.0 | 12.0 | 0.00 |
| 2 | Sand | 7.00 | 19.0 | 10.0 | 32.5 | 0.0 | 80.0 | 0.00 |

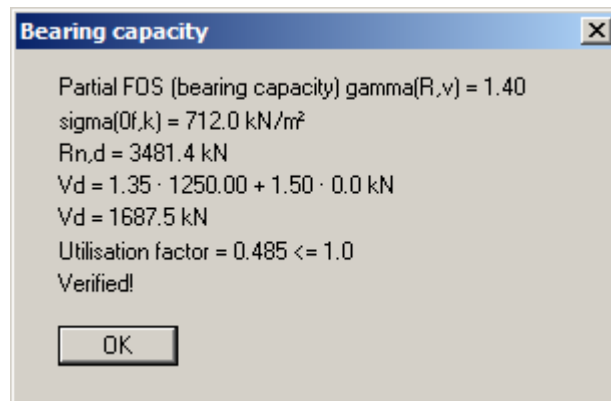
At the bottom of the dialog box are buttons for "OK", "Cancel", "Sort", "Load", and "Save".

The input values are more closely described in Section 5.2.4.

5.4.5 Analyse system (Example 3)

After editing one of the previous dialog boxes, the system is first represented without the analysis results. If you want to have the footing reanalysed with the new values go to the "**System**" menu and select "**Analyse**". Alternatively, press the [F5] function key or click on the *calculator* in the tool bar.

First, an info box concerning the punching verification appears. Then a further window with information on the safety and utilisation factors is displayed.



If you close the window with "**OK**" the diagram and all analysis results are presented on the screen. If the results are too small to read, you can use the zoom. To do this, hold the [Ctrl]-key and the left mouse button and mark the region to be enlarged on the diagram. Press the [Esc] key to return to the full screen representation.

5.4.6 Represent results in the plan view of footing (Example 2)

Select the "Output preferences/Footing plan" menu item or click in the "Plan view" drawing element at the right side of the diagram. (Note: The footing analysis diagram is here when analysing in "Multiple footings" mode).

Footing plan view

Show footing plan

Heading:

x [mm]: Width:

y [mm]: Height:

Font size [mm]:

Display force and moment arrows at margins

Select display options

Stresses Resultant

1st core dim. 2nd core dim.

Zero line Settlements

Pressure zone coloured Colour press. zone

Equivalent area A'

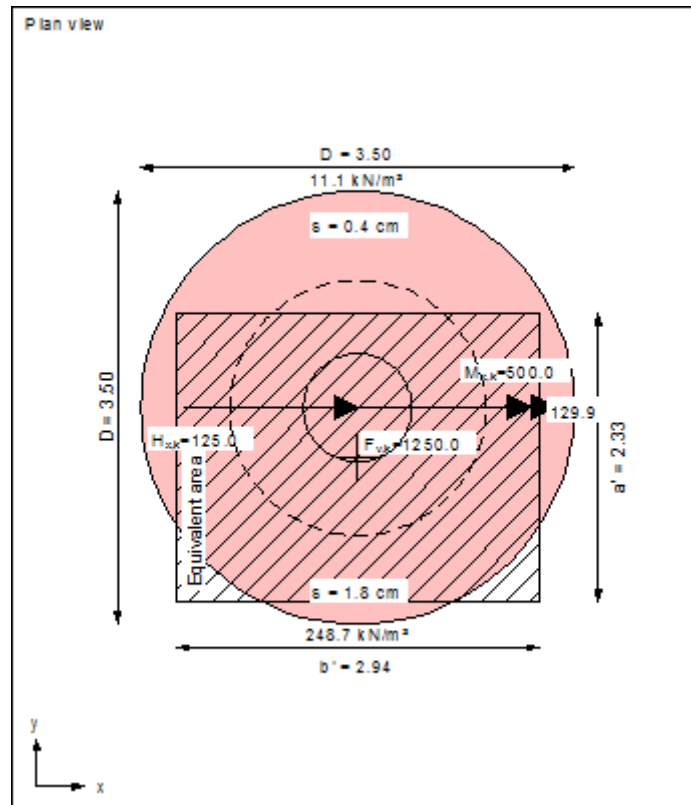
Display Hatch

Hatch separation [mm]:

Hatch inclination [°]:

Activate the "Pressure zone coloured" check box. Press the "Colour press. zone" button and select a quiet red from the box (or perhaps not). Confirm with "OK".

In the plan view at the right the pressure zone is now coloured.



The graphic also contains:

- the characteristic forces $M_{x,k}$, $H_{x,k}$ and the vertical force $F_{v,k}$ (=resultant, marked by a cross).
- the 1st core dimension.
If the resultant is within this rhombic area, the complete footing is under pressure.
- the 2nd core dimension.
If the resultant is within this elliptical area, a base tilt will occur.
- the equivalent area A' .
This region is additionally labelled at the edge with a' and b' .
- the edge stresses.
- the settlements at the two characteristic points..

The resulting torsion can be read from the pad footing legend at the lower left of the screen.

```

Settlement from total loads :
Limiting depth  $t_p = 5.99$  m b. GL
Settlement (mean of all CPs) = 1.13 cm
Settlement of CPs:
  Top = 0.44 cm
  Bottom = 1.81 cm
Torsion (x) (CP) = 1 : 175.4

```

6 Theoretical principles

6.1 Analysis of bearing capacity safety

The bearing capacity analysis will be carried out according to DIN 4017:2006. The following relationship applies:

$$\sigma_{0f,k} = c \cdot N_c + \gamma_1 \cdot d \cdot N_d + \gamma_2 \cdot b' \cdot N_b$$

where:

- $\sigma_{0f,k}$ = characteristic bearing stress
- c = cohesion [kN/m²]
- N_c = bearing capacity coefficient cohesion
- γ_1 = unit weight of soil above footing base
- d = embedment depth of footing
- N_d = bearing capacity coefficient footing depth
- γ_2 = unit weight of soil below footing base
- b' = calculated depth of footing
- N_b = bearing capacity coefficient footing width

Bearing capacity coefficients N_c N_d and N_b

- $N_c = N_{c0} \cdot v_c \cdot i_c \cdot \lambda_c \cdot \xi_c (\cdot d_c)$
- $N_d = N_{d0} \cdot v_d \cdot i_d \cdot \lambda_d \cdot \xi_d (\cdot d_d)$
- $N_b = N_{b0} \cdot v_b \cdot i_b \cdot \lambda_b \cdot \xi_b (\cdot d_b)$

The following values are adopted:

- N_{c0} N_{d0} N_{b0} according to DIN 4017
- v_c v_d v_b according to DIN 4017 (shape coefficients)

For settlement analysis, the length information is also needed for strip footings. The program consistently uses the values for a and b , including for calculation of the shape coefficients v_d and v_b for strip footings, as this delivers somewhat more favourable values.

$v_d = 1 + 0.2 \cdot b/a$ (instead of 1.0 for strip footings)

$v_b = 1 + b/a \cdot \sin(\varphi)$ (instead of 1.0 for strip footings)

- i_c i_d i_b according to DIN 4017 (load inclination coefficients)
- λ_c λ_d λ_b according to DIN 4017 (ground inclination coefficient)
- ξ_c ξ_d ξ_b according to DIN 4017 (base inclination coefficients)
- d_c d_d d_b (depth coefficients), not envisaged in DIN 4017

Depth coefficients d_c , d_d and d_b

The depth coefficients take into account the favourable influence of shear strength in the failure plane above the footing base. In DIN 4017:2006 this effect is not taken into consideration, i.e. all depth coefficients are 1.0. In some European countries, on the other hand, the favourable effect may be considered by adopting depth coefficients > 1.0 .

The following tables show a number of depth coefficient equations, compiled by Ziegler/Tafur (2015) in the context of a PRB project (PRB = *Initiative Praxisgerechte Regelwerke im Bauwesen e.V.*, www.initiative-prb.de).

The coefficient d_b in all cases is:

$$d_b = 1,0$$

For the influence of the embedment depth d_d :

| | | |
|---|---|----------------|
| Brinch Hansen: Bulletin N° 28 (1970) ²⁾ | $d_d = 1 + 2 \cdot (\tan \varphi) \cdot (1 - \sin \varphi)^2 \cdot \frac{d}{b'}$ | $d \leq b'$ |
| | $d_d = 1 + 2 \cdot (\tan \varphi) \cdot (1 - \sin \varphi)^2 \cdot \tan^{-1} \left(\frac{d}{b'} \right)$ | $d > b'$ |
| Lang et al. (Switzerland) ³⁾ | $d_d = 1 + 0,035 \cdot (\tan \varphi) \cdot (1 - \sin \varphi)^2 \cdot \tan^{-1} \left(\frac{d}{b'} \right)$ | |
| IEG7: Plattgrundläggning (Sweden) ⁴⁾ | $d_d = 1 + 0,35 \cdot \frac{d}{b'}$ | $d_d \leq 1,7$ |
| GCOC (Spain) ⁵⁾ | $d_d = 1 + 2 \cdot (\tan \varphi) \cdot (1 - \sin \varphi)^2 \cdot \tan^{-1} \left(\frac{d}{b'} \right)$ | $d \leq 2b'$ |

For the influence of cohesion d_c :

| | | |
|---|--|----------------|
| Brinch Hansen: Bulletin N° 11 (1961) ¹⁾ | $d_c = 1 + 0,35 \cdot \frac{d}{b'}$ | $d \leq b'$ |
| | $d_c = 1 + \frac{0,35}{\frac{b'}{d} + \frac{0,6}{(1 + 7 \tan^4 \varphi)}}$ | $d > b'$ |
| Lang et al. (Switzerland) | $d_c = 1 + 0,007 \cdot \tan^{-1} \left(\frac{d}{b'} \right)$ | |
| IEG7: Plattgrundläggning (Sweden) | $d_c = 1 + 0,35 \cdot \frac{d}{b'}$ | $d_c \leq 1,7$ |
| GCOC (Spain) | $d_c = 1 + 2 \cdot \frac{N_q}{N_c} \cdot (1 - \sin \varphi)^2 \cdot \tan^{-1} \left(\frac{d}{b'} \right)$ | $d \leq 2b'$ |

¹⁾ Brinch Hansen, J. (1961): A general formula for bearing capacity, Bulletin No11, Geoteknisk Institut, Copenhagen

²⁾ Brinch Hansen, J. (1970): A revised and extended formula for bearing capacity, Bulletin No28, Geoteknisk Institut, Copenhagen

³⁾ Lang, H.-J., Huder, J., Amann, P., Puzrin, A. (2011): Bodenmechanik und Grundbau, 9. Auflage, Springer-Verlag

⁴⁾ IEG Rapport 7:2008 (2010): Tillämpningsdokument, EN 1997-1 kapitel 6, Plattgrundläggning, Schweden

⁵⁾ GCOC (2009): Guía de cimentaciones en obras de carretera, Madrid

6.2 Theoretical principles circle/annulus

The bearing capacity of a circular footing is calculated using the equations given in DIN 4017

An equivalent area A' must be determined for eccentric loading. For a rectangle, for example, the equivalent area is given by:

$$A' = (a - e_x) \cdot (b - e_y)$$

where: e_x, e_y = eccentricities

The equivalent area for a circle is calculated as shown in the figure below:

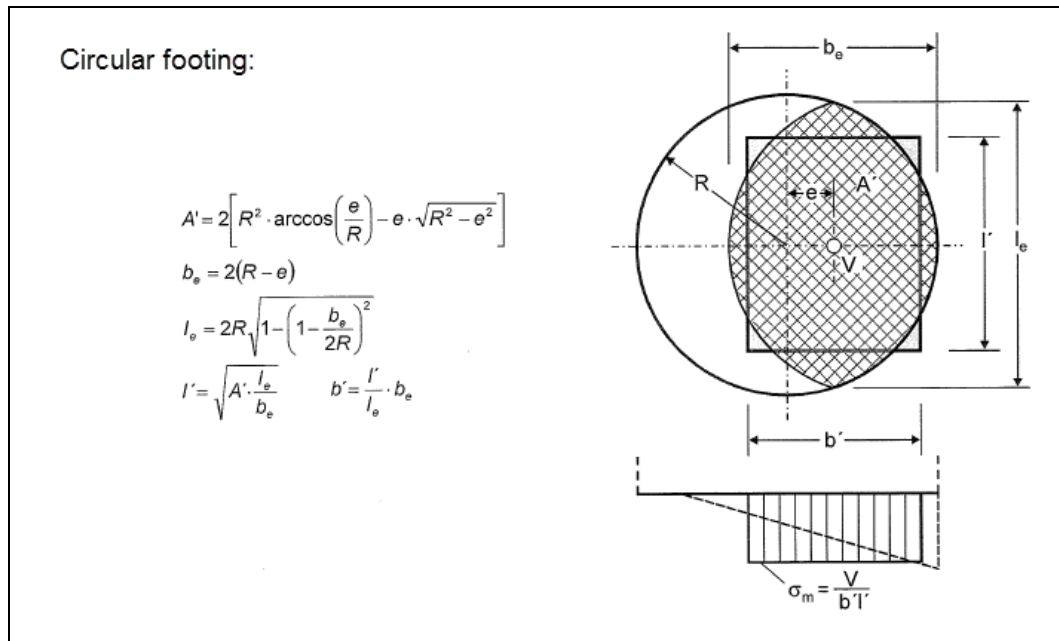


Figure 2 Equivalent area for circle (Leibniz University, Hannover)

The 1st and 2nd core dimensions are also required. For a circle:

Core dimensions for circle:

- 1st core dimension = $D/8$
- 2nd core dimension = $3 \cdot \pi \cdot D/32$

There are no bearing capacity equations for an annulus comparable to those for a circle. The annulus is therefore converted to an equivalent circle. The conversion can be performed using either an equal area circle or a circle with the same moment of inertia.

Core dimensions for annulus:

- 1st core dimension = $[1 + (D_i / D_a)^2] \cdot D_a / 8$
- 2nd core dimension = $3 \cdot \pi \cdot D_a / 32 \cdot [1 - (D_i / D_a)^4] / [1 - (D_i / D_a)^3]$

where: D_i = diameter (inner)
 D_a = diameter (outer)

Settlement analyses are performed using triangular load areas, allowing the loads on a circle or an annulus to be exactly modelled [Dr.-Ing. Johann Buß, *Setzungen und Spannungen unter "Dreiecksfundamenten"* (Settlements and Stresses below Triangular Footings), Geotechnik 22 (1999) No. 1].

The position of the characteristic point is required for settlement analyses. For a circle:

$$\text{Characteristic point for circle} = 0.845 \cdot R$$

The characteristic point cannot be derived for the annular footing. Conservative calculations assume that the characteristic point is in the same location as for a circle

$$\text{Characteristic point for annulus} \rightarrow \text{assumption} = \text{circle} = 0.845 \cdot R_a$$

where: R_a = outer radius

6.3 Determining the mean governing soil properties

DIN 4017 instructs that the mean soil properties of the soil above the bearing capacity failure plane, which is composed of the two linear components of a logarithmic spiral, can be determined for stratified ground. The governing parameters are summarised in the figure:

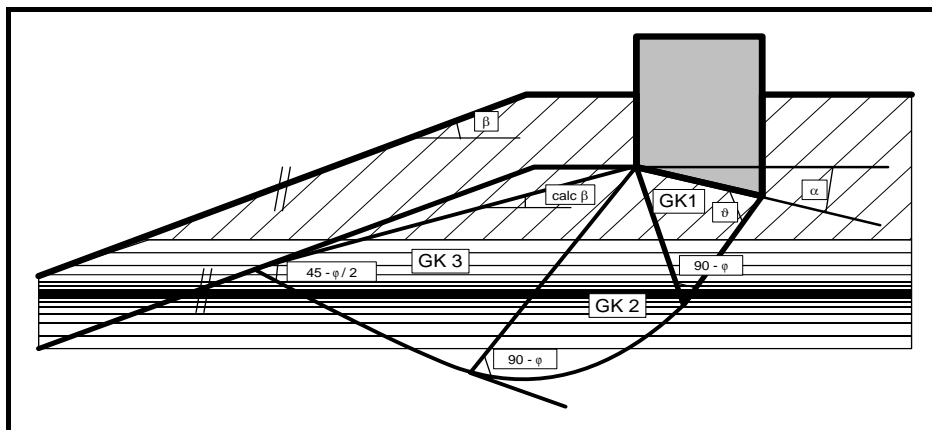


Figure 3 Logarithmic spiral

The mean governing soil properties are determined using the following relationships:

$$\text{cal } \tan \varphi = \frac{\sum \tan \varphi_i \cdot l_i}{\sum l_i}$$

$$\text{cal } c = \frac{\sum c_i \cdot l_i}{\sum l_i}$$

$$\text{cal } \gamma_2 = \frac{\sum \gamma_{2i} \cdot A_i}{\sum A_i}$$

l_i = length within individual layer

A_i = area of individual layer

The weight of the soil above slip body GK 3 is summed, including and distributed and line loads present and converted to an idealised body $\gamma_1 \cdot d$.

Large line loads can generate a substantial increase in an imaginary embedment depth. This is associated with soil pressures, which cannot be activated as calculations would indicate. The DIN 4017, for example, assumes that the ratio between embedment depth d and footing width b will achieve a maximum of 2.0 in order to guarantee the validity of a bearing capacity analysis. You should therefore examine your input data with this in mind. The same effect can be achieved by defining very large embedment depths.

The condition for the permissibility of the mean is that the mean friction angle demonstrates a maximum deviation of 5° to the true friction angles. This condition can be checked by the program. If it is not adhered to, the program reduces the largest friction angle in stages until the condition is met.

6.4 Differences between DIN 1054 (old) and DIN 1054:2005/EC 7

The differences between DIN 1054 (old) and 1054:2005 or EC 7 are minor for bearing capacity analysis.

The failure load, or, using partial safety factors, the characteristic bearing capacity (R_k) is determined identically. This value is subsequently divided by the bearing capacity partial safety factor $\gamma_{\text{bearing capacity}}$ (Table 3 in DIN 1054:2005). This is 1.40 for load case 1, 1.30 for load case 2 and 1.20 for load case 3. This leads to the bearing capacity design value R_d

$$R_d = R_k / \gamma_{\text{bearing capacity}}$$

This value is compared to the design value for the present load (action) V_d . The design value is given by the load present or, using partial safety factors, by the characteristic action V_k multiplied by the partial safety factor for the actions γ_G (permanent) and γ_Q (changeable). According to Table 2 (DIN 1054:2005), the following partial safety factors must be adopted:

Permanent actions: (1.35 LC 1, 1.20 LC 2 and 1.00 LC 3)

Unfavourable changeable actions: (1.50 LC 1, 1.30 LC 2 and 1.00 LC 3)

If the characteristic action consists of a permanent (index G) and a changeable (index Q) action, the design value V_d is

$$V_d = \gamma_G \cdot V_{k,G} + \gamma_Q \cdot V_{k,Q}$$

The bearing capacity has been verified if

$$V_d \leq R_d$$

is shown. A safety factor η according to the global safety factor concept

$$\eta = \text{failure load/present load}$$

is currently not envisaged. However, the safety factor η according to the global safety factor concept has the great advantage that the *distance* to safe conditions is documented with a single number.

e.g. for load case 1 according to the global safety factor concept:

$$\eta = 2.01 = \text{just adhered to for allowable } \eta = 2.00$$

or

$$\eta = 16.26 = \text{generously dimensioned for allowable } \eta = 2.00$$

$$\text{So a utilisation factor } \mu \text{ is defined by } \mu = V_d / R_d$$

A value of μ smaller than **1.0** therefore indicates stable conditions.

A simple example (load case 1) will demonstrate the *differences* between DIN 1054 (old) and DIN 1054:2005.

- **DIN 1054 (old)**
 pres. $V = 1000$ kN
 $V_{\text{Failure}} = 2100$ kN (via bearing capacity analysis)
 $\eta = 2100/1000 = 2.10 > \text{allow. } \eta = 2.00$
- **DIN 1054:2005**
 $V_{k,G} = 400$ kN (permanent) = characteristic permanent load
 $V_{k,Q} = 600$ kN (changeable) = characteristic changeable load
 $V_d = \gamma_G \cdot V_{k,G} + \gamma_Q \cdot V_{k,Q} = 1.35 \cdot 400 + 1.50 \cdot 600 = 1,440$ kN
 $V_d = 1,440$ kN = load design value
 $R_k = V_{\text{Failure}}$ (according to DIN 1054 (old)) = 2,100 kN (via bearing capacity analysis)
 $R_k = \text{characteristic bearing capacity}$
 $R_d = R_k / \gamma_{\text{Bearing capacity}} = 2,100/1.40 = 1,500$
 $R_d = \text{bearing capacity design value}$
 $\mu = V_d / R_d = 1,440/1,500 = 0.96$

An utilisation factor in accordance with the partial safety factor concept can be acquired for the global safety factor concept by dividing the allowable safety factor by the present safety factor.

$$\mu (\text{DIN 1054 (old)}) = \text{allow. } \eta (\text{DIN 1054 (old)}) / \text{pres. } \eta (\text{DIN 1054 (old)}) = 2.00/2.10 = 0.95$$

This value roughly corresponds to the value for the partial safety factor concept. In principle, then, nothing has changed.

From the relationship for the utilisation factor according to the partial safety factor concept

$$\mu = V_d / R_d,$$

an allowable load can be computed if the utilisation factor is set to $\mu = 1.0$.

$$\mu = (\gamma_G \cdot V_{k,G} + \gamma_Q \cdot V_{k,Q}) / (R_k / \gamma_{\text{Bearing capacity}})$$

$$1,0 = (\gamma_G \cdot V_{k,G} + \gamma_Q \cdot V_{k,Q}) / (R_k / \gamma_{\text{Bearing capacity}})$$

$$V_{k,G} = \text{permanent loads}$$

$$V_{k,Q} = \text{changeable loads}$$

If, as in the example, the changeable loads component p is more than 60% of total loads

$$p = V_{k,Q} / (V_{k,G} + V_{k,Q}) = 600 / (600 + 400) = 0.60 [= 60\%]$$

the equation can be *simplified* as follows:

$$1.0 = (\gamma_G \cdot (1 - p) \cdot V_k + \gamma_Q \cdot p \cdot V_k) / (R_k / \gamma_{\text{Bearing capacity}})$$

$$1.0 = (\gamma_G \cdot (1 - p) + \gamma_Q \cdot p) \cdot V_k / (R_k / \gamma_{\text{Bearing capacity}})$$

$$(\gamma_G \cdot (1 - p) + \gamma_Q \cdot p) \cdot V_k = R_k / \gamma_{\text{Bearing capacity}}$$

$$\text{allow. } V_k = R_k / [(\gamma_G \cdot (1 - p) + \gamma_Q \cdot p) \cdot \gamma_{\text{Bearing capacity}}]$$

According to the partial safety factor concept, the characteristic bearing capacity value R_k is calculated identically to DIN 1054 (old).

The equivalent relationship from DIN 1054 (old) is:

$$\text{allow. } V = V_{\text{Failure}} / \eta$$

According to the partial safety factor concept, $\gamma_G = 1.35$, $\gamma_Q = 1.50$ and $\gamma_{\text{Bearing capacity}} = 1.40$ for load case 1. The following values result for the expression

$$(\gamma_G \cdot (1 - p) + \gamma_Q \cdot p) \cdot \gamma_{\text{Bearing capacity}}$$

as a function of the proportion of changeable loads p to total loads:

| p [-] | p [%] | $(\gamma_G \cdot p + \gamma_Q \cdot (1 - p)) \cdot \gamma_{\text{Bearing capacity}}$ $(1.35 \cdot (1 - p) + 1.50 \cdot p) \cdot 1.40$ |
|---------|---------|--|
| 0.000 | 0.0 | 1.89 |
| 0.333 | 33.3 | 1.96 |
| 0.500 | 50.0 | 1.99 |
| 0.667 | 66.7 | 2.03 |
| 1.000 | 100.0 | 2.10 |

The third column in the table can be compared to the constant safety factor according to DIN 1054 (old) of 2.0 (load case 1). The comparison demonstrates that this not noticeably different to the global safety factor of 2.00. This was also the laudable intention of the authors of the partial safety factor concept. If the load component p is around 50%, almost precisely the same results are achieved.

In analogy to the DIN 1054 (old), the DIN 1054:2005 contains tables with allowable footing pressures for various systems in Annex A. The tables and table values are absolutely identical with the values in the old standard. The may appear strange at first glance. But here, too, the authors of the partial safety factor concept have orientated themselves to proven systems and analysis concepts. The allowable footing pressures given here may be compared to existing footing pressures, determined using characteristic loads, i.e. with loads not increased by partial safety factors.

This concept is also utilised by the program when footing analysis diagrams ("**Multiple footings**" switch in menu item "**File/New**" activated) are calculated. You then define, in addition to the old standard, the ration of changeable loads p to the total loads, using the menu item "**Edit/System parameters**"

$$p = V_{k,Q} / (V_{k,G} + V_{k,Q})$$

Using this, the program can compute a substitute global safety factor η' :

$$\eta' = (\gamma_G \cdot (1 - p) + \gamma_Q \cdot p) \cdot \gamma_{\text{Bearing capacity}}$$

For example, for load case 1:

$$\eta' = (1.35 \cdot (1 - p) + 1.50 \cdot p) \cdot 1.40$$

Ask the structural engineer for the proportion of changeable loads in the permanent loads. If you get no answer, set p to 0.5 (50 %, approximately corresponds to the old standard). If you are very unsure, select $p = 1.0$ (100 %). You then get the allowable footing pressures, which are around 5% [$2.00 / (1.50 \cdot 1.40) = 2.00 / 2.10 = 0.95$] below the old standards values for load case 1.

If footing analysis diagrams are computed ("**Multiple footings**" switch in menu item "**File/New**" activated), the program determines the settlements under total load (as previously).

In all, it is shown that bearing capacity analysis according to the partial safety factor concept does not contain anything new. Unfortunately, it has only become a lot more unclear.

6.5 Settlement analysis

Settlement analysis are carried out according to DIN 4019. Once the program has determined the characteristic or allowable footing pressure for the proposed footing, the settlements are determined using these characteristic or allowable values. DIN 4019 Table 1 allows correction coefficients kappa to be taken into consideration for modelling settlements (see menu item "**File/New**", Section 7.1.1).

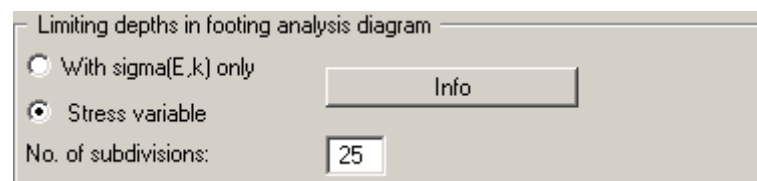
The program calculates stresses and deformations according to the theory of elastic-isotropic half-space. Very comprehensive diagrams and tables were developed, particularly in the time before pocket calculators and personal computers were available. A bibliography of tables can be taken from DIN 4019. Please also see the article "*Spannungsberechnung*" ("Stress analysis") in the Geotechnical Engineering Handbook (1990; Fourth edition). This also contains complete relationships for deformations and stresses below a rectangle in elastic-isotropic half-space (equations 8 to 10 and equations 14 and 15). The program is based on these relationships.

The stress relationships are only utilised for limiting depth calculations and for representation of stress distributions. The deformations are calculated directly from the relationships given in the Geotechnical Engineering Handbook. Numerical integration with associated loss of precision is therefore not necessary. If a base tilt results when analysing a pad footing these relationships can no longer be used because the pressure zone is no longer rectangular. In this case, an analytical-numerical settlement analysis is required.

The limiting depth can be defined in three different ways:

- with a fixed, user-defined value
- as a multiple of the footing width
- as the depth at which the total vertical stress exceeds the overburden stress by x% (as a rule 20%).

The settlement curves in the footing analysis diagram are attained from the footing pressure by linear interpolation. Thus, analysis using the x%-criteria only takes place for the maximum footing pressure of each footing width. However, if you open "**Edit/Analysis options**" menu item and activate the "**Stress variable**" check box, the limiting depth is calculated for a number of stresses (here for 25 stresses).



7 Description of menu items

7.1 File menu

7.1.1 "New" menu item

The dialog box shown in the examples opens. First, select the equation for calculating the bearing capacity in the combo box. In addition to the standard DIN 4017:2006 and DIN 4017 (old) methods, the methods after Terzaghi, Meyerhoff, Hansen and Vesic well known from many literature references may also be selected. If the Terzaghi, Meyerhoff, Hansen or Vesic analysis methods are adopted, the English designations can be used in the bearing capacity equations in addition to the German designations.

You must then specify whether analysis will use the *partial safety factor concept* to EC 7 or DIN 1054:2005 or the old *global safety factor concept*. Decide whether you want to analyse a pad footing (rectangular or circular/annular footing) or multiple footings of a certain type (with footing analysis diagram).

The screenshot shows a dialog box with two main sections. The first section, titled 'Standard:', contains three radio button options: 'Partial safety factor concept (EC 7)' (selected), 'Partial safety factor concept (DIN 1054:2005)', and 'Global safety factor concept (DIN 1054 old)'. An 'Info EC 7' button is located to the right of the first option. The second section, titled 'Type of analysis:', contains three radio button options: 'Multiple footings' (selected), 'Rectangular footing', and 'Circular/annular footing'. To the right of these options is a label 'Analysis and output with:' followed by a dropdown menu showing 'sigma(R,d)' and an 'Info' button. At the bottom of the dialog box, there is a checkbox labeled 'Do not investigate overturning' which is currently unchecked.

With the introduction of EC7, the table value "*Allowable bearing pressure*" used in the tables for spread footing analyses is generally replaced by the table value "*Bearing pressure design value*". Differences to DIN 1054:2005 in terms of footing dimensions do not result from this. If you are working to EC7, "**sigma(R,d)**" for design and output is activated.

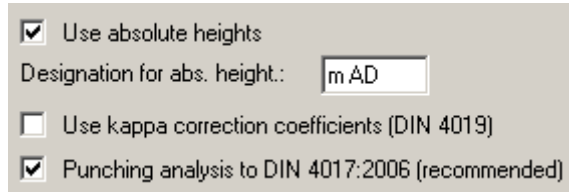
DIN 1054:2005 states that an overturning analysis may be dispensed with for Load Case 3 if sufficient bearing capacity has been demonstrated. This rule is no longer included in Eurocode 7; it is therefore always necessary to perform an overturning analysis. In justified exceptional cases, however, the analysis may be turned off using the "**Do not investigate overturning**" check box.

The next part of the dialog box is only active if you are analysing using *global safety factors*.

The screenshot shows a small dialog box titled 'Ref. parameter (bearing cap.):'. It contains two radio button options: 'Load' (selected) and 'Shear coefficients'.

Here you can specify whether the reference parameter for safety is the "**Load**" or the "**Shear coefficients**" (friction angle and cohesion). In this case you must enter a safety factor for both the friction angle and the cohesion (see menu item "**Edit/System parameters**").

If the "Use **absolute heights**" check box is deactivated, the ground level will be at **0.0** and all depth input is positive downwards. If the check box is activated, enter the layer depths, the groundwater level and the footing base in absolute values (y-axis positive upwards), e.g. in m AD. The designation for the absolute elevation, which you enter below (here: m AD), is shown in the soil properties legend as the depth dimension. Absolute ground level is entered in the "Edit/Ground level" dialog box (see Section 7.2.3).



Use absolute heights
Designation for abs. height.:
 Use kappa correction coefficients (DIN 4019)
 Punching analysis to DIN 4017:2006 (recommended)

DIN 4019 Table 1 allows correction coefficients kappa to be taken into consideration for modelling settlements. These correction coefficients can be activated using the appropriate check box in the dialog box.

DIN 4017:2006 describes a new punching analysis method. To use this new analysis method the "**Punching analysis using new method (recommended)**" check box is activated by default when the program starts. This means it is now only necessary to specify whether a flexible footing is being dealt with in the "Edit/System parameters" dialog box (see Example 1, Section 5.2.2).

If you wish you can enter a description of the problem being worked on in this dialog box; this will then be used in the *General legend*. Otherwise the project identification is entered using the menu item "Edit/Project identification".

After confirming your input with "OK" you will see an info box corresponding to your safety concept with the safety factors or partial factors for the various load cases. Close the box by clicking on the load case of your choice. The safety factor values are automatically used in the system data. If the *partial safety factor concept* is adopted, the load case can be modified at any time using the "Edit/Partial safety factors" menu item (see Section 7.2.10). If a different load case is required when carrying out an analysis using the *global safety factor concept*, proceed via the "File/New" menu item

7.1.2 "Load" menu item

You can load a file with system data, which was created and saved at a previous sitting, and then edit the system.

7.1.3 "Save" menu item

You can save data entered or edited during program use to a file, in order to have them available at a later date, or to archive them. The data is saved without prompting with the name of the current file.

7.1.4 "Save as" menu item

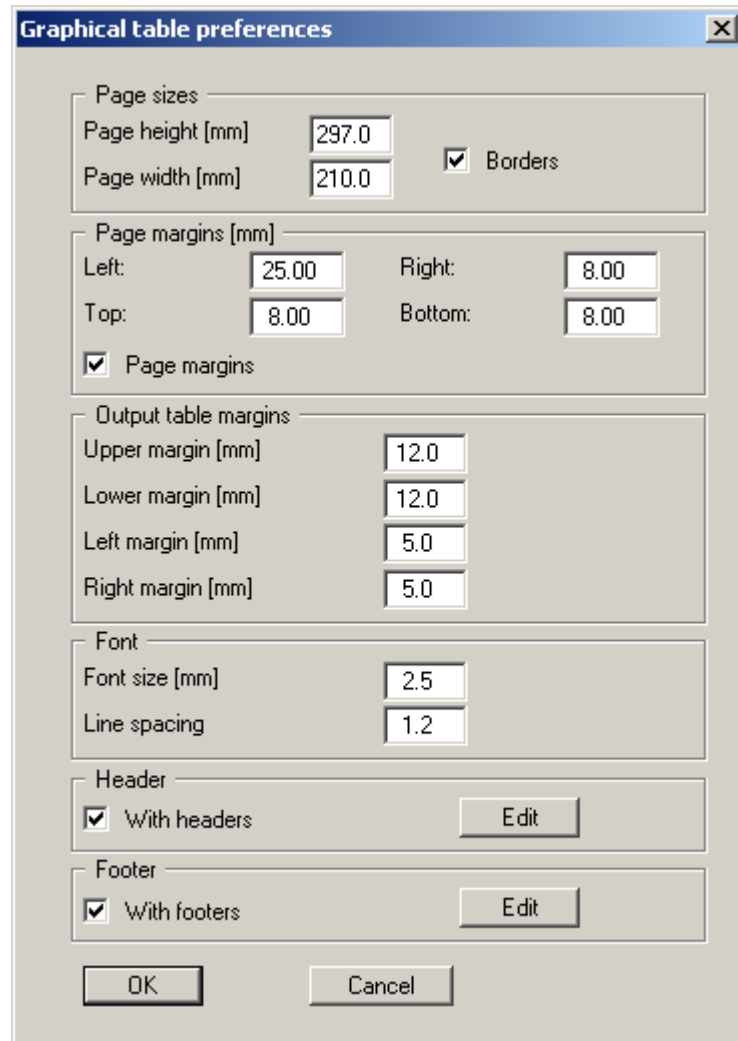
You can save data entered during program use to an existing file or to a new file, i.e. using a new file name. For reasons of clarity, it makes sense to use ".gdg" as file suffix, as this is the suffix used in the file requester box for the menu item "File/Load". If you choose not to enter an extension when saving, ".gdg" will be used automatically.

7.1.5 "Print output table" menu item

7.1.5.1 *Output as graphics*

You can have an output table printed containing all information on the current state of analysis, including the system data.

In a further option box in the "**Multiple footings**" analysis mode it is possible to choose between a graphical output table or one in ASCII format. If you click the "**Output as graphics**" button you will see the following dialog box. In the "**Pad footing**" analysis mode it opens automatically when this menu item is selected.

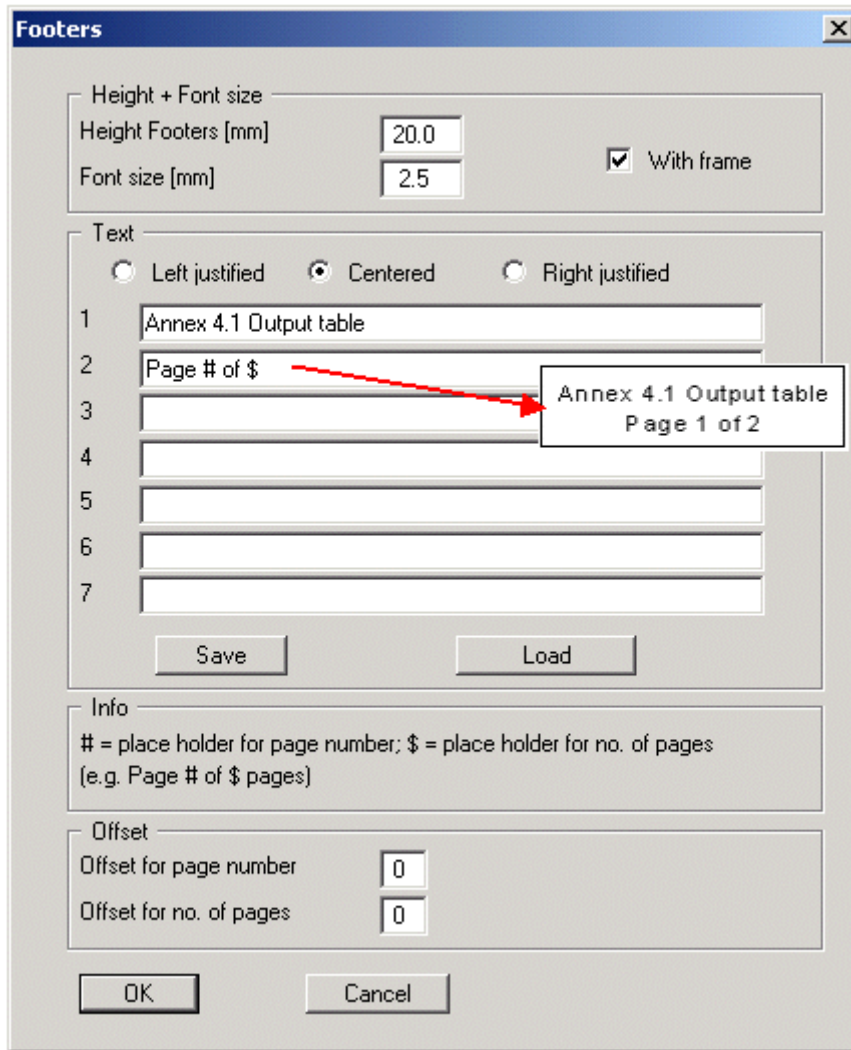


The dialog box titled "Graphical table preferences" contains several sections for configuring the output table:

- Page sizes:** Page height [mm] is 297.0, Page width [mm] is 210.0, and the **Borders** checkbox is selected.
- Page margins [mm]:** Left: 25.00, Right: 8.00, Top: 8.00, Bottom: 8.00. The **Page margins** checkbox is selected.
- Output table margins:** Upper margin [mm] is 12.0, Lower margin [mm] is 12.0, Left margin [mm] is 5.0, and Right margin [mm] is 5.0.
- Font:** Font size [mm] is 2.5 and Line spacing is 1.2.
- Header:** The **With headers** checkbox is selected, with an **Edit** button to its right.
- Footer:** The **With footers** checkbox is selected, with an **Edit** button to its right.

At the bottom of the dialog are **OK** and **Cancel** buttons.

You can define the desired layout for the output table in various areas of the dialog box. If you need to add a header or footer (e.g. for page numbering), activate the appropriate check boxes "**With headers**" and/or "**With footers**" and click on the "**Edit**" button. You can then edit as required in a further dialog box.



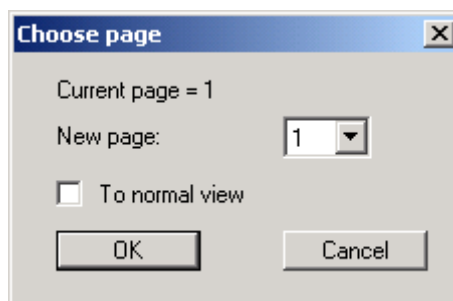
Automatic pagination can also be employed here if you work with the placeholders as described. After exiting the dialog boxes using "OK" you will see a further dialog box in which you can select the parameters to be used in the output table. If you click the "OK" button the output table is presented on the screen page by page. To navigate between the pages, use the arrow tools



in the toolbar. If you need to jump to a given page or back to the graphical representation, click on the



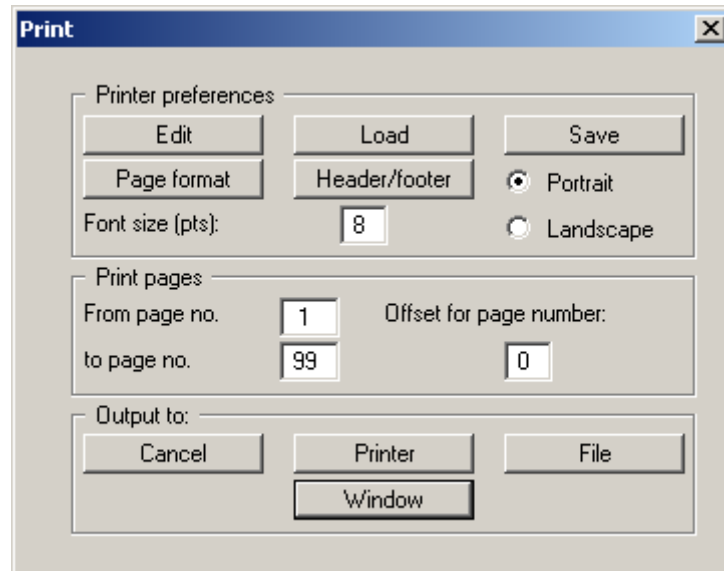
tool. You will then see the following box:



7.1.5.2 Output as ASCII

When in the "**Multiple footings**" analysis mode, you can have your calculation data sent to the printer, without further work on the layout, or save it to a file for further processing using a different program, e.g. a word processing application.

In the option box for this menu item simply press the "**Output as ASCII**" button. You will see the following dialog box for specifying the simple table output:



- "**Printer preferences**" group box
Using the "**Edit**" button the current printer preferences can be changed or a different printer selected. Using the "**Save**" button, all preferences from this dialog box can be saved to a file in order to have them available for a later session. If you select "**GGU-FOOTING.drk**" as file name and save the file in the program folder (default), the file will be automatically loaded the next time you start the program.

Using the "**Page format**" button you can define, amongst other things, the size of the left margin and the number of rows per page. The "**Header/footer**" button allows you to enter a header and footer text for each page. If the "#" symbol appears within the text, the current page number will be entered during printing (e.g. "**Page #**"). The text size is given in "**Pts**". You can also change between "**Portrait**" and "**Landscape**" formats.
- "**Print pages**" group box
If you do not wish pagination to begin with "**1**" you can add an *offset number* to the check box. This offset will be added to the current page number. The output range is defined using "**From page no.**" "**to page no.**".
- "**Output to:**" group box
Start output by clicking on "**Printer**" or "**File**". The file name can then be selected from or entered into the box. If you select the "**Window**" button the results are sent to a separate window. Further text editing options are available in this window, as well as loading, saving and printing.

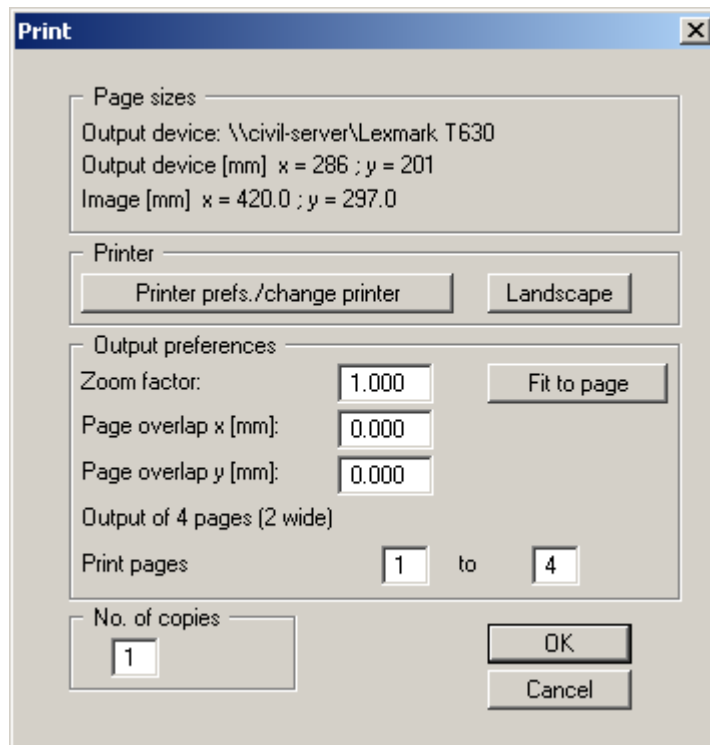
7.1.6 "Printer preferences" menu item

You can edit printer preferences (e.g. swap between portrait and landscape) or change the printer in accordance with WINDOWS conventions.

7.1.7 "Print and export" menu item

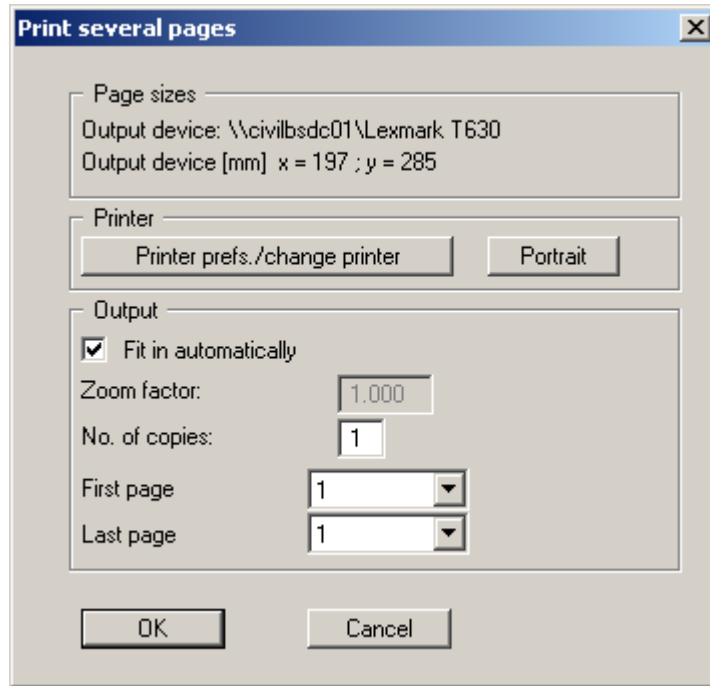
You can select your output format in a dialog box. You have the following possibilities:

- **"Printer"**
allows graphic output of the current screen contents (*graphical representation*) to the WINDOWS standard printer or to any other printer selected using the menu item **"File/Printer preferences"**. But you may also select a different printer in the following dialog box by pressing the **"Printer prefs./change printer"** button.




In the upper group box, the maximum dimensions which the printer can accept are given. Below this, the dimensions of the image to be printed are given. If the image is larger than the output format of the printer, the image will be printed to several pages (in the above example, 4). In order to facilitate better re-connection of the images, the possibility of entering an overlap for each page, in x and y direction, is given. Alternatively, you also have the possibility of selecting a smaller zoom factor, ensuring output to one page ("**Fit to page**" button). Following this, you can enlarge to the original format on a copying machine, to ensure true scaling. Furthermore, you may enter the number of copies to be printed.

If you have activated the *tabular representation* on the screen, you will see a different dialog box for output by means of the "File/Print and export" menu item button "Printer".



Here, you can select the table pages to be printed. In order to achieve output with a zoom factor of 1 (button "Fit in automatically" is deactivated), you must adjust the page format to suit the size format of the output device. To do this, use the dialog box in "File/Print output table" button "Output as graphics".

- "**DXF file**"
allows output of the graphics to a DXF file. DXF is a common file format for transferring graphics between a variety of applications.
- "**GGUCAD file**"
allows output of the graphics to a file, in order to enable further processing with the **GGUCAD** program. Compared to output as a DXF file this has the advantage that no loss of colour quality occurs during export.
- "**Clipboard**"
The graphics are copied to the WINDOWS clipboard. From there, they can be imported into other WINDOWS programs for further processing, e.g. into a word processor. In order to import into any other WINDOWS program you must generally use the "Edit/Paste" function of the respective application.
- "**Metafile**"
allows output of the graphics to a file in order to be further processed with third party software. Output is in the standardised EMF format (Enhanced Metafile format). Use of the Metafile format guarantees the best possible quality when transferring graphics.

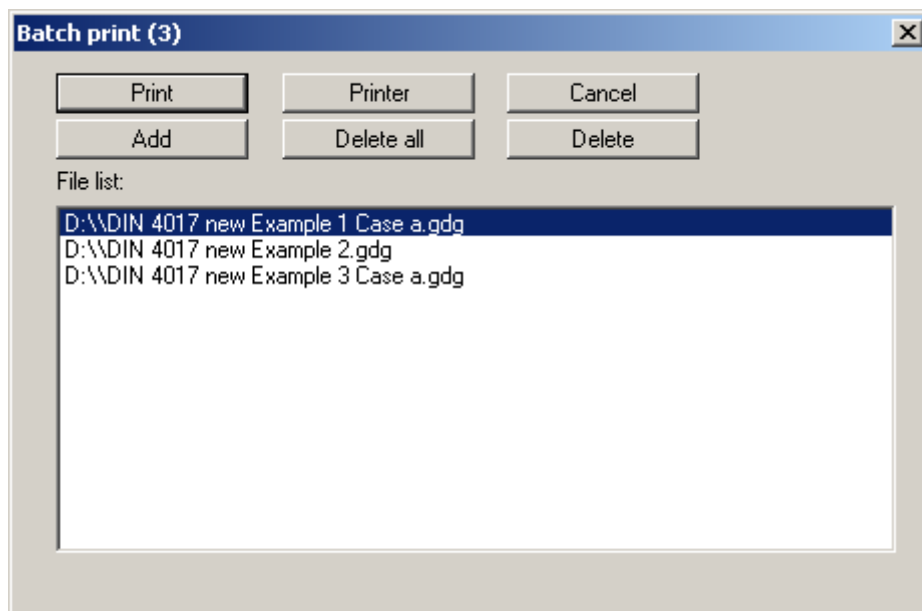
If you select the "Copy/print area" tool  from the toolbar, you can copy parts of the graphics to the clipboard or save them to an EMF file. Alternatively you can send the marked area directly to your printer (see "Tips and tricks", Section 8.4).

Using the "Mini-CAD" program module you can also import EMF files generated using other GGU applications into your graphics.

- **"MiniCAD"**
allows export of the graphics to a file in order to enable importing to different GGU applications with the **Mini-CAD** module.
- **"GGUMiniCAD"**
allows export of the graphics to a file in order to enable processing in the **GGUMiniCAD** program.
- **"Cancel"**
Printing is cancelled.

7.1.8 "Batch print" menu item

If you would like to print several appendices at once, select this menu item. You will see the following dialog box:



Create a list of files for printing using **"Add"** and selecting the desired files. The number of files is displayed in the dialog box header. Using **"Delete"** you can mark and delete selected individual files from the list. After selecting the **"Delete all"** button, you can compile a new list. Selection of the desired printer and printer preferences is achieved by pressing the **"Printer"** button.

You then start printing by using the **"Print"** button. In the dialog box which then appears you can select further preferences for printer output such as, e.g., the number of copies. These preferences will be applied to all files in the list.

7.1.9 "Exit" menu item

After a confirmation prompt, you can quit the program.

7.1.10 "1, 2, 3, 4" menu items

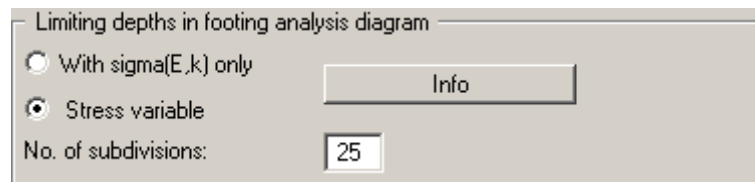
The **"1, 2, 3, 4"** menu items show the last four files worked on. By selecting one of these menu items the listed file will be loaded. If you have saved files in any other folder than the program folder, you can save yourself the occasionally onerous *rummaging* through various sub-folders.

7.2 Edit menu

7.2.1 "Analysis options" menu item

A dialog box opens similar to that for the menu item "**File/New**" (see Section 7.1.1). Only the project identification cannot be entered here.

The dialog box has been extended by the group box "**Limiting depths in footing analysis diagram**", where the type of limiting depth calculation for "**Multiple footings**" is specified (see "**Theoretical principles/Settlement analysis**" in Section 6.5). You can read a brief description by pressing the "**Info**" button.



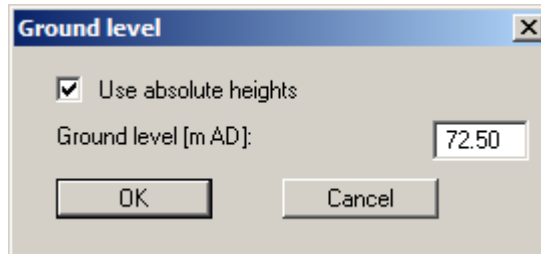
If the pad footing analysis mode ("**Rectangular footing**"/"**Circular/annular footing**") is selected, the "**Limiting depths in footing analysis diagram**" group box is deactivated. Because the footing stress is specified directly in the menu item "**Edit/Footing details**" in this analysis mode (see Section 5.3.3), calculation of the limiting depth by means of stress variables is not required.

7.2.2 "Project identification" menu item

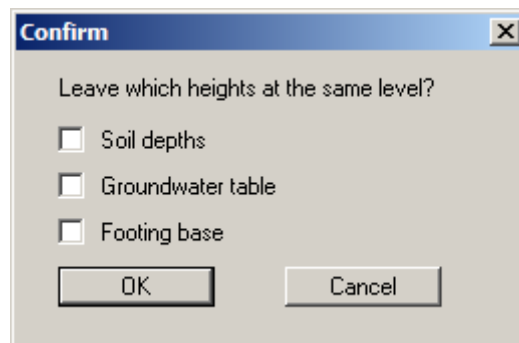
You can enter a description of the current system; this will then be used in the *General legend* (see Section 7.4.5).

7.2.3 "Ground level" menu item

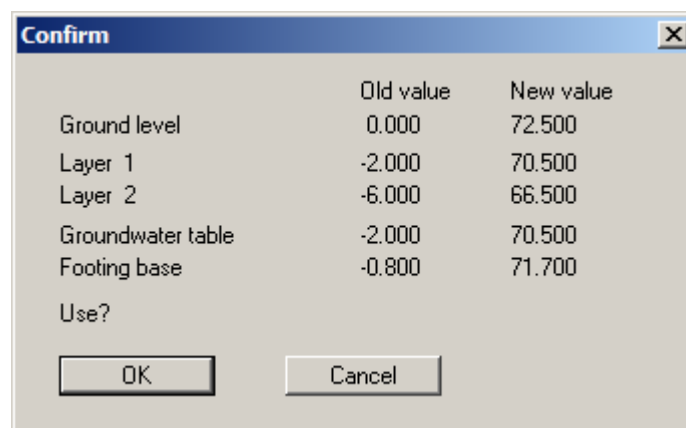
Using this menu item you can activate absolute elevations (e.g. m AD), if you have not already done this in the "File/New" or "Edit/Analysis options" menu items. Subsequently enter the new ground level elevation.



Once you have confirmed your input you will next be presented with a query on how to deal with the existing elevation data for soil strata, groundwater and footing base. If you leave the elevations at the same level, the originally entered data will not be modified.



You would normally deactivate the check box and confirm your input. You will then see a message box, which compares the old and new data for you. If you used any of the previous check boxes mistakenly, you can repeat the process correctly by clicking "Cancel" in the message box. By exiting the dialog box using "OK" the new elevation data are entered into the system data.



7.2.4 "System parameters" menu item

This function can also be accessed using the [F3] function key. The following dialog box opens if "Multiple footings" are selected together with systems analysed to *DIN 4017:2006* and using the *partial safety factor concept*. The partial safety factor values are already entered into the input boxes, depending on the load case selected. If the *global safety factor concept* is selected, only the input boxes for the safety factors change, the remaining buttons and boxes are identical.

The input boxes have already been described in the "Multiple footings" worked example in Section 5.2.2 and in the "Single rectangular footing" worked example in Section 5.3.2.

System parameters

Partial FOS (bearing capacity): 1.40

Partial FOS (permanent actions): 1.35

Partial FOS (changeable actions): 1.50

Ground level [m AD]: 72.50

Groundwater table [m AD]: 70.50

Footing base [m AD]: 71.70

Slope inclination [°]: 0.00

Berm width [m]: 0.00

Slope to DIN 4017:2006

Base inclination [°]: 0.00

Preloading [kN/m²]: 0.00 ?

Surcharge (bearing cap.) [kN/m²]: 0.00 ?

Surcharge (limiting depth) [kN/m²]: 0.00 ?

H/V [-]: 0.00000

Depth coeff.

Calculate using depth coefficients ?

Depth coeff. after: GCOC (ES) ?

Friction angle for bearing capacity failure ?

Depth coefficients for slopes too ?

Verify bearing capacity for short side only

Limit soil pressure

Limit to max. sigma(R,d) [kN/m²] = 200.00 Apply

5° condition

Check and correct Info

Decrement [°]: 0.10

Ratio changeable/total loads [-]:

Ratio [-]: 0.500 Info

Punching analysis

Carry out punching analysis Info

Flexible footing

Done Cancel

If you are working with absolute elevations the value you entered in the menu item "Edit/Ground level" will be displayed. The groundwater level and footing base elevations can be adapted here if necessary (e.g. in m AD).

If you analyse with the "Shear coefficients" reference parameter using the *global safety factors* you must specify two safety factors (friction angle and cohesion).

| | |
|------------------------|-------|
| Safety (friction) [-]: | 1.25 |
| Safety (cohesion) [-]: | 2.00 |
| Ground level [m AD]: | 72.50 |

7.2.5 "Footing details" menu item

Depending on the analysis mode and the safety factor concept selected, you will see a modified dialog box for input of footing sizes and/or stresses (see worked examples; Sections 5.2.3, 5.3.3 and 5.4.3).

The following dialog box opens in the "**Rectangular footing**" analysis mode using partial safety factors:

| | Permanent | Changeable |
|----------------------------|-----------|------------|
| Vertical force [kN]: | 1000.00 | 0.00 |
| Horizontal force (x) [kN]: | 0.00 | 0.00 |
| Horizontal force (y) [kN]: | 0.00 | 0.00 |
| Moment (x) [kN·m]: | 0.00 | 0.00 |
| Moment (y) [kN·m]: | 0.00 | 0.00 |

Enter the dimensions and stresses for the footing. According to the *partial safety factor concept*, you can define differing stresses for permanent and changeable loads (live loads). Instead of the footing analysis diagram seen in the "**Multiple footings**" analysis mode a plan view of a pad footing (rectangle or circle/annulus) is shown with the loading values, among other things.

The friction angle of the soil at the footing base is adopted when analysing the sliding resistance of a pad footing (rectangle or circle/annulus). Any user-defined angle can be adopted by activating the "**Sliding resistance with user-defined angle**" check box. This can be useful if soils with a low friction angle are prevalent below the base of the footing, for example.

GGU-FOOTING can also analyse the torsional stiffnesses of footings. Circular or annular footings are often used for the foundations of wind energy converters. In this program version a circular/annular footing can be selected by going to the menu item "**Edit/Analysis options**". In this menu item you are then presented with a correspondingly modified dialog box for defining the footing (see Example 3: "**Single circular footing**", Section 5.4.3).

In older program versions it was possible to convert the circular or annular footing data to a square footing (see dialog box above) to determine the torsional stiffnesses for a rectangular footing by pressing the "**Equivalent width from circle/annulus**" button in the above dialog box.

7.2.6 "Soils" menu item

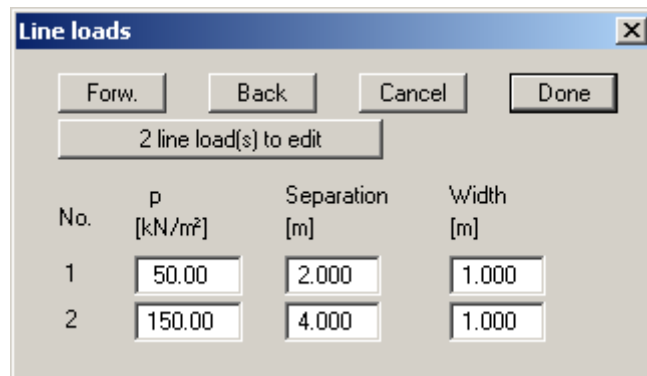
Enter the number of soil layers and the corresponding soil properties here. An explanation of the dialog box can be found in Section 5.2.4.

7.2.7 "Limiting depth" menu item

You can define the way in which the limiting depth is calculated. An explanation of the dialog box can be found in the "**Multiple footings**" worked example in Section 5.2.5.

7.2.8 "Line loads" menu item

You can define up to 5 line loads acting as surcharges on the bearing capacity failure body.



| No. | p [kN/m ²] | Separation [m] | Width [m] |
|-----|------------------------|----------------|-----------|
| 1 | 50.00 | 2.000 | 1.000 |
| 2 | 150.00 | 4.000 | 1.000 |

The number of line loads can be modified using the "x line load(s) to edit" button.

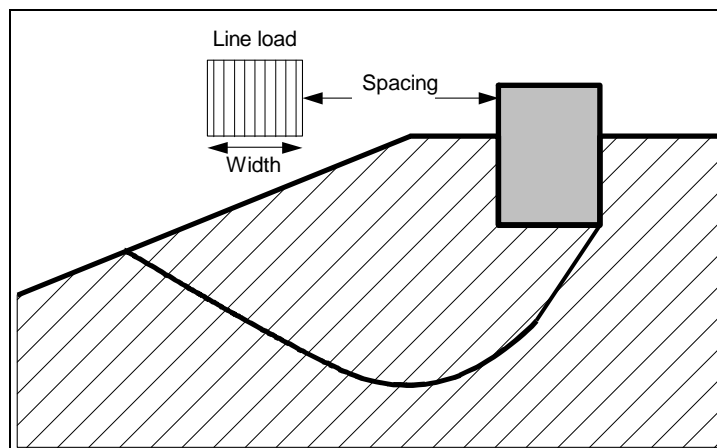


Figure 4 Line load

7.2.9 "Berms" menu item

A maximum of five berms may be defined using this menu item depending on the analysis method selected. The "Slope to DIN 4017:2006" check box in the "Edit/System parameters" dialog box must be deactivated. The berms may not overlap. The program checks that this condition is adhered to and warns of any errors. Any berms defined using "Edit/System parameters" are set to 0.0 if you define one or more berms using this menu item.

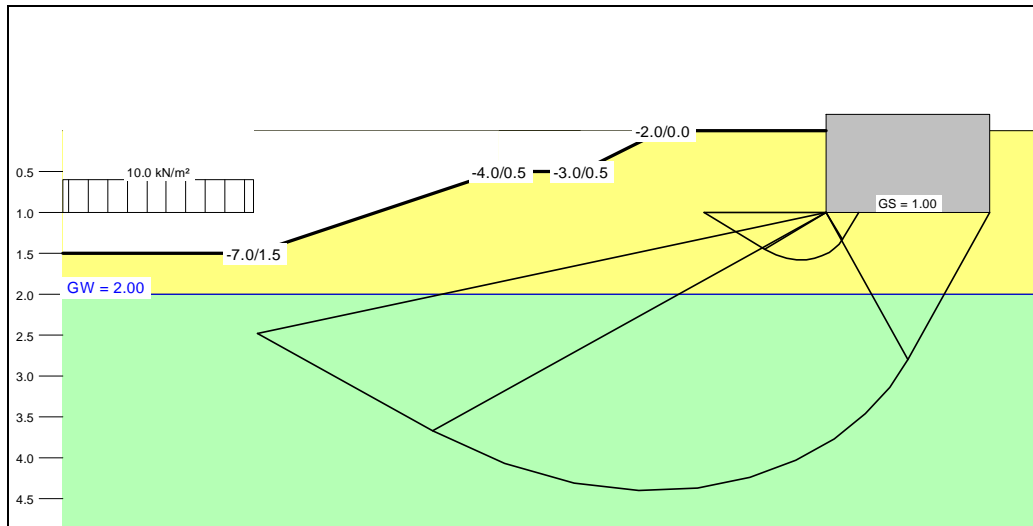


Figure 5 Berms

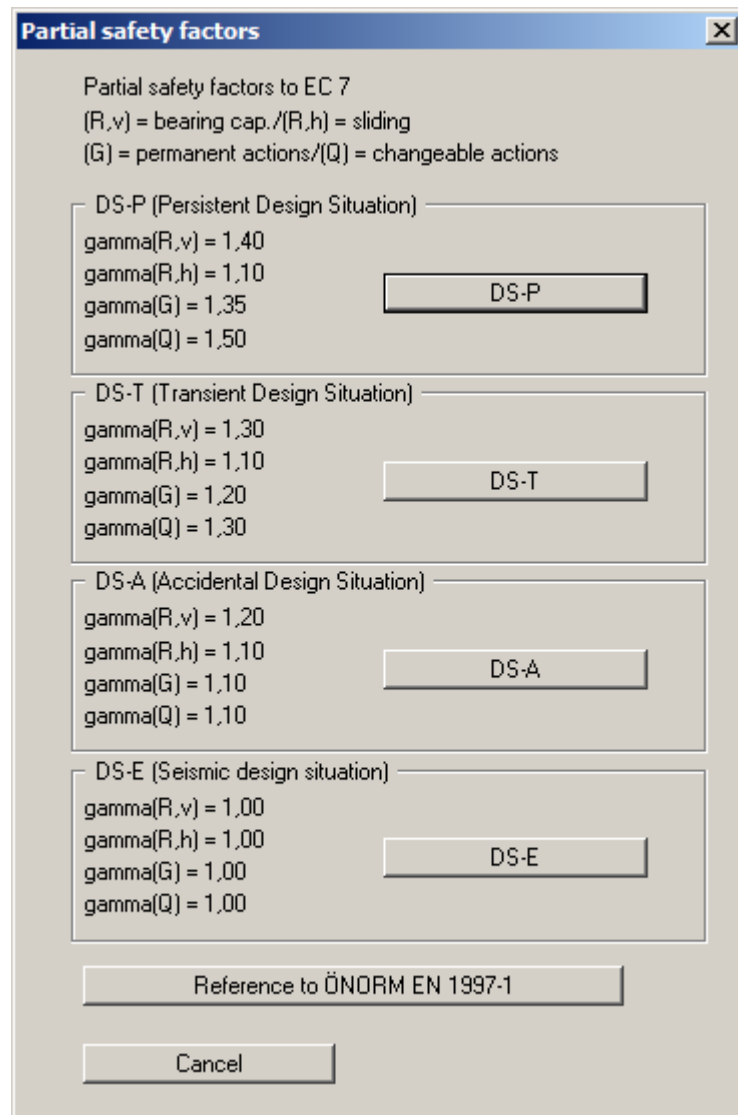
To get the berms shown in Figure 4 enter the values into the dialog box as shown:

| Berms | | | | |
|------------------------|----------|-----------|-------------|--------------------------------|
| Done Forw. Back Cancel | | | | |
| 2 berms to edit | | | | |
| No | left [m] | right [m] | delta h [m] | Surcharge [kN/m ²] |
| 1 | -3.00 | -2.00 | -0.50 | 0.00 |
| 2 | -7.00 | -4.00 | -1.00 | 10.00 |

Enter the x-ordinate of the toe and the head. Define the height of the berm with "delta h". Negative values are also allowed here. Finally, a surcharge load can be specified for the horizontal area behind the head of the berm.

7.2.10 "Partial safety factors" menu item

If you are analysing with the *partial safety factor concept*, you will see a dialog box for defining the partial factors.



By pressing the appropriate button the partial factors for the various load cases given in DIN 1054:2005 and EC 7 can be adopted. The load case designations were altered for the EC 7 partial safety factor concept:

- Load Case 1 is now DS-P: Persistent Design Situation
- Load Case 2 is now DS-T: Transient Design Situation
- Load Case 3 is now DS-A: Accidental Design Situation

In addition, there is a seismic design situation (DS-E). In the DS-E design situation all partial factors = '1,0'. The load case correlation to **ÖNORM EN 1997-1** will be shown by clicking on the corresponding button. The partial safety factors are automatically adopted in the system data (see menu item "**Edit/System parameters**", Section 7.2.3).

7.3 System menu

7.3.1 "Analyse" menu item

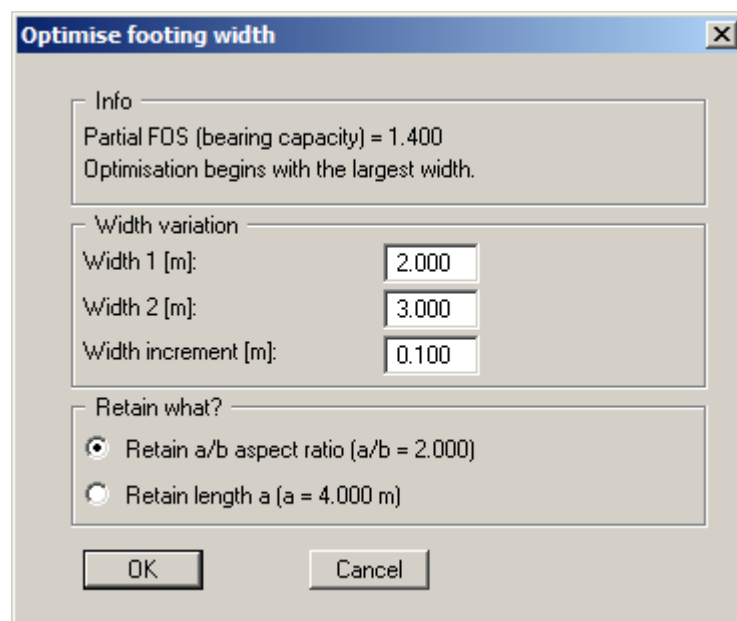
When you edit any of the system data using the "**Edit**" menu item, the diagrams presented do not represent the current analysis results. Only after using this menu item is the modified system re-analysed and subsequently presented with the new results. Alternatively, you can use the [**F5**] function key or the *calculator* in the toolbar. A running analysis can be stopped by pressing the right mouse button.

In the "**Rectangular footing**" analysis mode, the bearing capacity safety is calculated for both directions. Naturally, the smaller value is critical. Information on the conditions in the other direction can be viewed in the "**Pad footing**" legend. Preferences for this can be defined in the "**Output preferences**" menu (see Section 7.4.7, "**For both directions**" check box).

7.3.2 GGU-Software"Optimise footing width" menu item

This menu item is only active in the pad footing analysis mode! Alternatively, footing optimisation can also be started by pressing [**F6**].

If "**Rectangular footing**" is selected, the following dialog box opens:



After confirming with "**OK**" optimisation is carried out, at the end of which you may opt to use the optimum width. A new computation is performed immediately after confirmation. If you choose not to accept the optimum width the menu item is closed.

If "**Circular/annular footing**" is selected, optimisation is performed for the outer circle diameter. The inner diameter is retained.

7.4 Output preferences menu

7.4.1 "Footing analysis diagram" menu item

This menu item only appears in the "Multiple footings" analysis mode. When the "Show footing analysis diagram" check box is activated, you can define preferences for representation of the footing analysis diagram.

The screenshot shows the "Footing analysis diagram" dialog box. It features a title bar with a close button. The main area contains several sections of controls. At the top, there is a checked checkbox labeled "Show footing analysis diagram". Below this are four input fields: "x [mm]: 280.00", "Width: 110.00", "y [mm]: 35.00", and "Height: 175.00". The next section is "Smoothing out method", which has three radio buttons: "Linear" (selected), "Method 1", and "Method 2". Below that is the "Axis definition" section, containing a "User-defined axes" button and a "Use specified fixed scales" checkbox. The "Settlements [cm] / Limiting depths / SR moduli [MN/m²]" section includes "First value: 0.50", "Division: 0.50", and "Last value: 10.00" fields, along with a dropdown menu currently set to "Settlements". The "Display on the ordinate" section has two radio buttons: "Bearing pressure" (selected) and "Strip load". At the bottom of the main area, there are three checked checkboxes: "Only hatch 'allowable' area", "Show sigma(E,k)", and "sigma(E,k) dashed", followed by a checked checkbox "Also show 'allow. sigma'". Finally, there are "OK" and "Cancel" buttons at the very bottom.

You can define and edit the position of the legend using the values "x" and "y". The size of the legend is controlled by the values for "Width" and "Height".

The fastest way to modify the position or size of the legend is to press the [F11] function key and then to either pull the legend to the new position or to move the sides of the legend to their new size with the left mouse button pressed.

In the second group box the smoothing out method for drawing the graphs for settlement, limiting depths or the modulus of subgrade reaction in the footing analysis diagram can be selected:

- "Linear" = no smoothing
- "Method 1" = 'strict' Bezier spline
- "Method 2" = 'loose' Bezier spline

Using the default settings the diagram is automatically scaled. If you select the "**User-defined axes**" button you are first offered the automatic scaling values in a box, which you can then edit as wished. If you activate the "**Use specified fixed scales**" check box, the values entered in the "**Output preferences/Fixed scales**" menu item (see Section 7.4.11) are used.

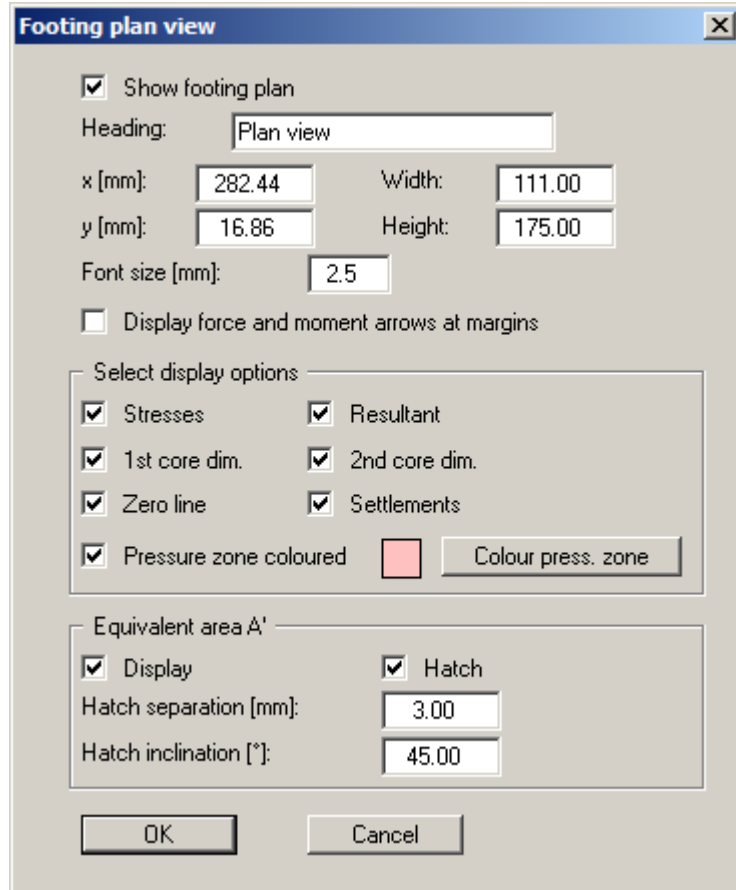
In the fourth group box you can influence the representation of the settlement curves. The settlement curves are represented in the diagram using the three numbers given in the box above. The program calculates the settlements corresponding to a given footing width by means of linear interpolation. If the limiting depth is calculated using the "**% condition**" (see Worked example 1, Section 5.2.5) and you have activated the "**Stress variable**" check box in the "**Edit/System parameters**" menu item (see "**Theoretical principles/Settlement analysis**", Section 6.5), limiting depth curves or SR moduli curves can be represented instead of settlement curves.

The (allowable) bearing pressure, or the (allowable) strip load or point load can be selected for visualisation on the y-ordinate in the diagram when analysing using the *partial safety factor concept*. If the *global safety factor concept* is employed either the allowable footing pressure or the allowable strip or point load can be selected.

If you activate the "**Hatch allowable area**" check box, reference lines are drawn in the allowable area only. Otherwise, lines are drawn across the whole of the plan width and height. Moreover, additional scaling of the footing analysis diagram using the values for $\sigma(E,k)$ can be activated here.

7.4.2 "Footing plan" menu item

This menu item only appears in the pad footing analysis mode ("**Rectangular footing**" / "**Circular/annular footing**"). If the "**Show footing plan**" check box is activated the graphical visualisation can be adapted in the dialog box associated with this menu item.



You can define and edit the position of the legend using the values "**x**" and "**y**". The size of the legend is controlled by the values for "**Width**" and "**Height**". The labelling font size can be altered.

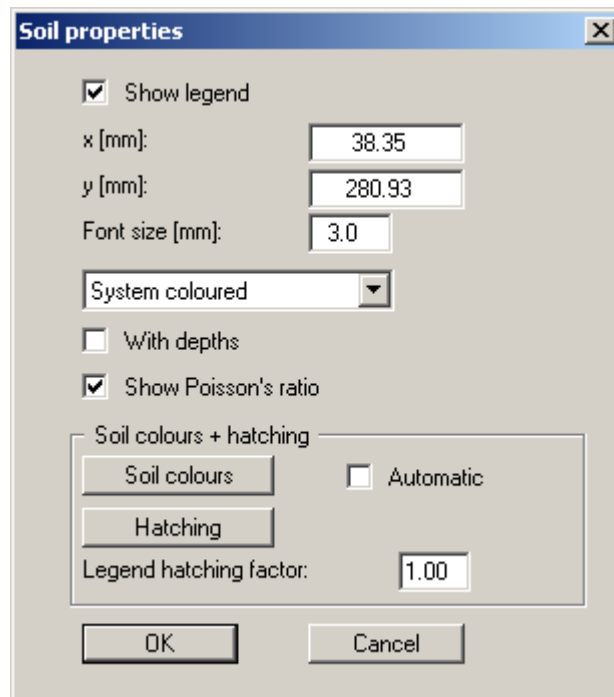
The fastest way to modify the position or size of the legend is to press the [**F11**] function key and then to either pull the legend to the new position or to move the sides of the legend to their new size with the left mouse button pressed.

The force and moment arrows may cover the labelling on some footings. In this case, the arrows can be shown at the sides of the footing by activating the respective check boxes.

Besides position and size of the footing plan view, you can specify a number of preferences for representation of further result data. The dialog box is self-explanatory. Experiment a little. After closing the dialog box the modifications are immediately shown on the screen. However, the system should have been previously analysed.

7.4.3 "Soil properties" menu item

A soil properties legend is shown on the screen when you activate the "**Show legend**" check box. The format and appearance of the legend can be altered using this menu item.



You can define and edit the position of the legend using the values "**x**" and "**y**". The size of the legend is controlled by the values for "**Font size**".

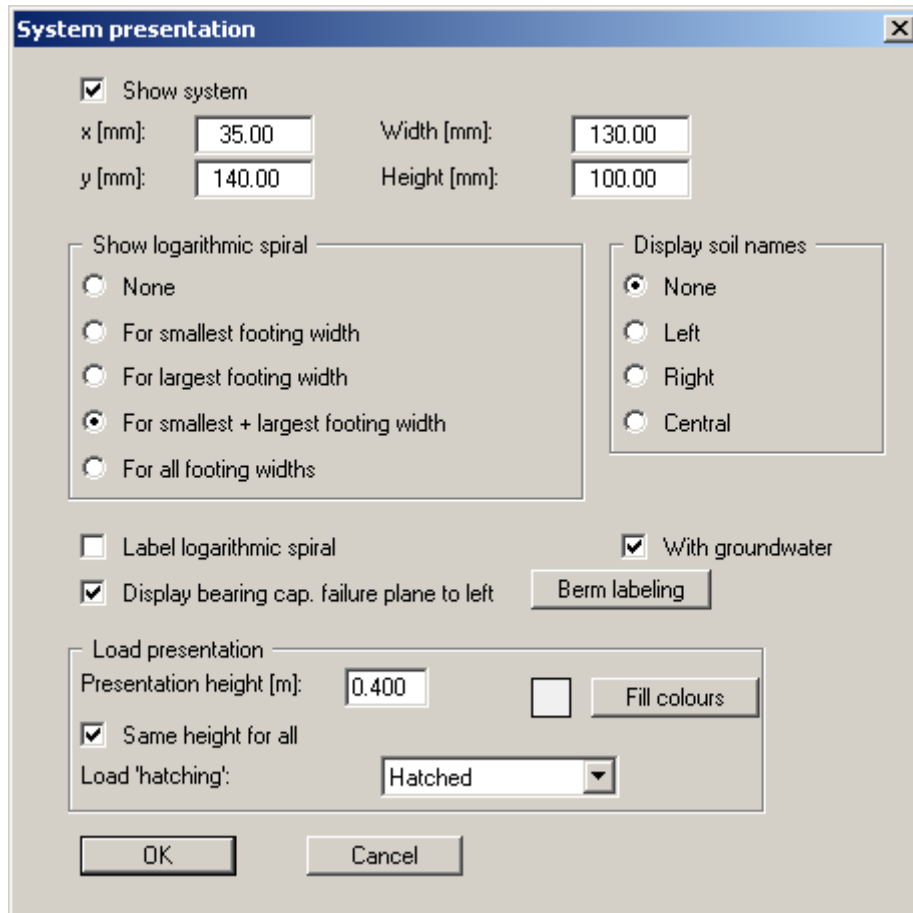
The fastest way to modify the position of the legend is to press the **[F11]** function key and then to pull the legend to the new position with the left mouse button pressed.

The depths of the soil layers can also be entered in the legend. When using absolute elevations, the depth dimension, e.g. "**m AD**", is defined in the "**Edit/Analysis options**" menu item. Poisson's ratio can be switched off in the legend, for example if Poisson's ratio $\nu = 0.0$ for all soils.

If the "**System coloured**" combo-box is activated, the soils will be displayed coloured in the legend and in the system and stress distribution graphics. Otherwise, they will be numbered. If you deactivate the "**Automatic**" check box in the "**Soil colours + hatching**" group box, the soil colours will be selected according to your individual preferences, which you can edit using the "**Soil colours**" button. Alternatively, you have the option of applying a variety of hatches. Using the legend hatching factor, closer hatching of the soil legend can be achieved than is possible in the system and stress influence diagrams.

7.4.4 "System presentation" menu item

You can alter the shape and appearance of the system presentation, when the "Show legend" check box is activated. Here, the dialog box for "Multiple footings" is represented.



You can define and edit the position of the system presentation using the values "x" and "y". The size is controlled by the values for "Width" and "Height". The fastest way to modify the position or size of the legend is to press the [F11] function key and then to either pull the legend to the new position or to move the sides of the legend to their new size with the left mouse button pressed.

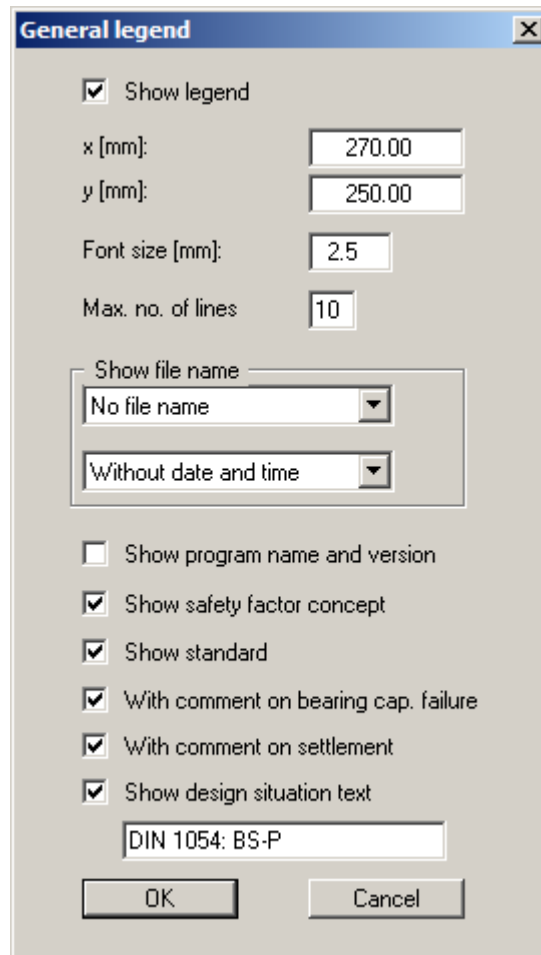
In addition, you can have the logarithmic spiral represented for various footing widths. The soil names can be displayed at the left, central or at the right. If you activate the "Label logarithmic spiral" check box, the x ordinates are shown. You can rotate the graphics by using the "Display bearing cap. failure plane to left" check box; the analysis results do not alter.

If you are working on a system with low-lying groundwater, such that groundwater has no influence on the analysis results, you can deactivate the "With groundwater" check box. The groundwater table will then not be included in the graphical representation. Otherwise, the graphics will be reduced until the groundwater table also fits into the diagram, which can lead to very compact and unclear representations. Of course, the analysis results are not influenced by this check box, even if the groundwater table is later raised into the zone of influence of the logarithmic spiral.

The dimensions of a berm defined as described in Section 7.2.9 can be displayed using the "Berm labelling" button. There are also a number of options available for visualising loads.

7.4.5 "General legend" menu item

A legend with general properties will be displayed on your output sheet, if the "**Show legend**" check box is activated. You can alter the type of visualisation using the dialog box of this menu item.



You can define and edit the position of the legend using the values "**x**" and "**y**". You control the size of the legend using "**Font size**" and "**Max. no. of lines**"; where necessary, several columns are used.

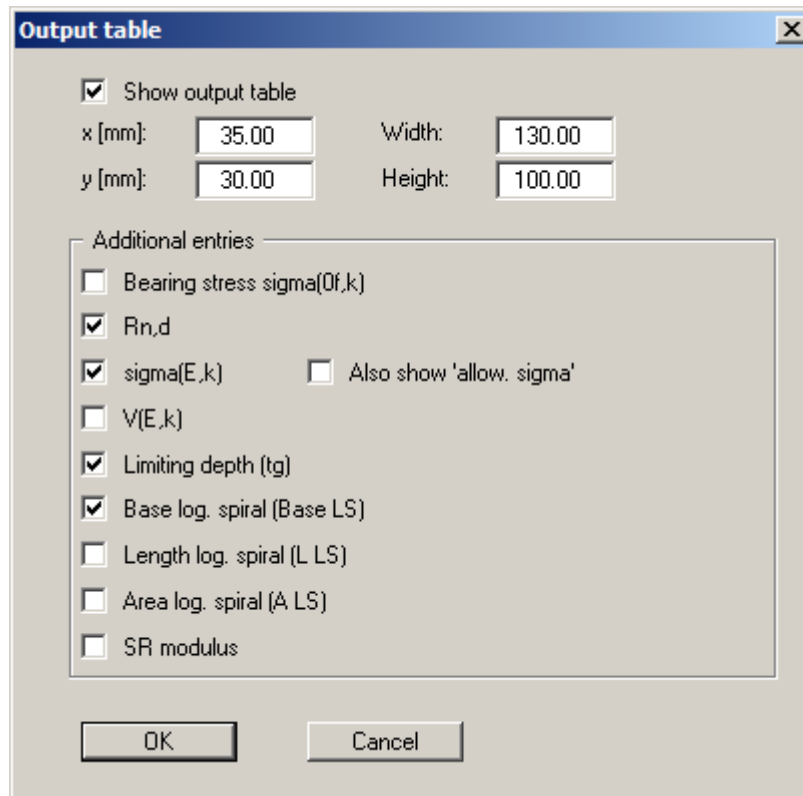
The fastest way to modify the position of the legend is to press the **[F11]** function key and then to pull the legend to the new position.

In the *General legend* you can, if wished, display information on the program (name and version), on the adopted standard, safety factor concept, design situation and on the current file (name, path, time info). Any project identification entered in the "**File/New**" or "**Edit/Project identification**" dialog box will be shown automatically in the *General legend*.

By activating the check boxes "**With comment on bearing cap. failure**" and "**With comment on settlement**" the use of the lines in the footing analysis diagram is explained ("**Multiple footings**" analysis mode). Explanations of the 1st and 2nd core dimensions can be activated when analysing a pad footing ("**Rectangular footing**"/"**Circular/annular footing**" analysis mode).

7.4.6 "Output table" menu item

This menu item only appears in the "**Multiple footings**" analysis mode. You can alter the shape and appearance of the analysis output table, when the "**Show output table**" check box is activated.



You can define and edit the position of the legend using the values "**x**" and "**y**". The size of the legend is controlled by the values for "**Width**" and "**Height**". The font size is adjusted to fit the available space.

The fastest way to modify the position or size of the legend is to press the [**F11**] function key and then to either pull the legend to the new position or to move the sides of the legend to their new size with the left mouse button pressed.

The check boxes at the bottom of the box allow you to select a number of additional parameters to be entered in the output table. If the "**SR modulus**" check box is activated, the characteristic or allowable footing pressure is divided by the corresponding settlement for each footing and shown as the subgrade reaction modulus k_s in [MN/m³].

7.4.7 "Pad footing" menu item

This menu item only appears in the pad footing analysis mode ("**Rectangular footing**" / "**Circular/annular footing**"). An analysis results legend is shown on the screen when the "**Show legend**" check box is activated. The format and appearance of the legend can be altered using this menu item.

The screenshot shows a dialog box titled "Rectangular footing". It has a close button in the top right corner. The "Show legend" checkbox is checked. The "Heading" field contains the text "Pad footing results:". The "x [mm]" field contains "38.00", the "y [mm]" field contains "135.00", the "Font size [mm]" field contains "2.5", and the "Max. no. of lines" field contains "35". Below these fields is a section titled "Select display options" which contains a list of checkboxes, all of which are checked: "Utilisation factors for both directions", "Bearing capacity equation terms", "Coefficients", "Mean settlement (CP)", "Torsion", "Torsional stiffness", "For both directions", "Settlement for all CPs", "Log. spiral", and "EQU analysis". At the bottom of the dialog are "OK" and "Cancel" buttons.

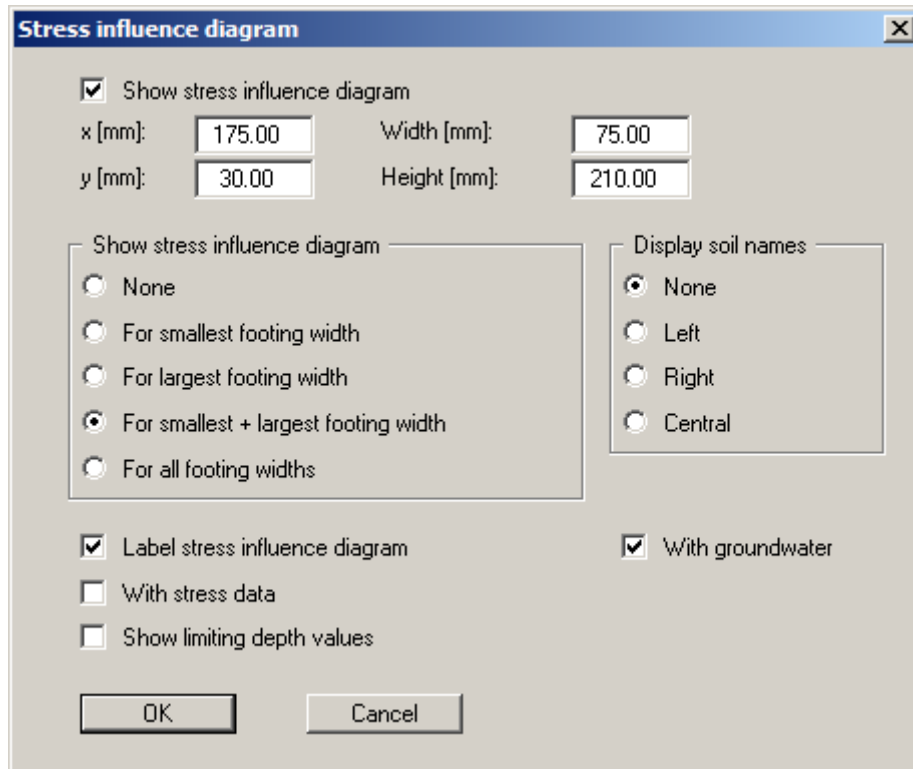
You can define and edit the position of the legend using the values "**x**" and "**y**". You control the size of the legend using "**Font size**" and "**Max. no. of lines**"; where necessary, several columns are used.

The fastest way to modify the position of the legend is to press the **[F11]** function key and then to pull the legend to the new position with the left mouse button pressed.

The check boxes at the bottom of the box allow you to select a number of parameters to be entered in the graphics.

7.4.8 "Stress influence diagram" menu item

You can alter the shape and appearance of the stress influence diagram, if you activate the "**Show stress influence diagram**" check box. The dialog box for the "**Multiple footings**" analysis mode is shown below.



You can define and edit the position of the system presentation using the values "**x**" and "**y**". The size is controlled by the values for "**Width**" and "**Height**".

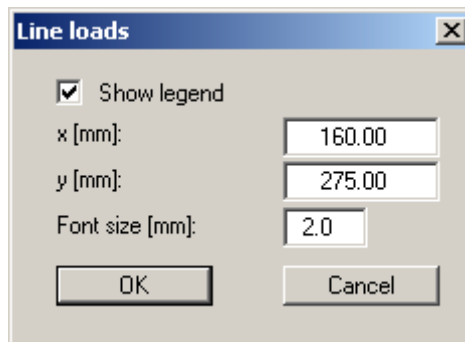
The fastest way to modify the position or size of the legend is to press the [F11] function key and then to either pull the legend to the new position or to move the sides of the legend to their new size with the left mouse button pressed.

In addition, you can have the stress influence represented for various footing widths. The soil names can be displayed at the left, central or at the right. By activating the "**Label stress influence diagram**" or "**Show limiting depth values**" check boxes the corresponding values will be displayed in the representation.

If you are working on a system with low-lying groundwater, such that groundwater has no influence on the analysis results, you can deactivate the "**With groundwater**" check box. The groundwater table will then not be included in the graphical representation. Otherwise, the graphics will be reduced until the groundwater table also fits into the diagram, which can lead to very compact and unclear representations. Of course, the analysis results are not influenced by this check box.

7.4.9 "Line loads" menu item

You can alter the shape and appearance of the "**Line loads**" legend, if you activate the "**Show legend**" check box.



You can define and edit the position of the legend using the values "**x**" and "**y**". You control the size of the legend using "**Font size**".

The fastest way to modify the position of the legend is to press the **[F11]** function key and then to pull the legend to the new position.

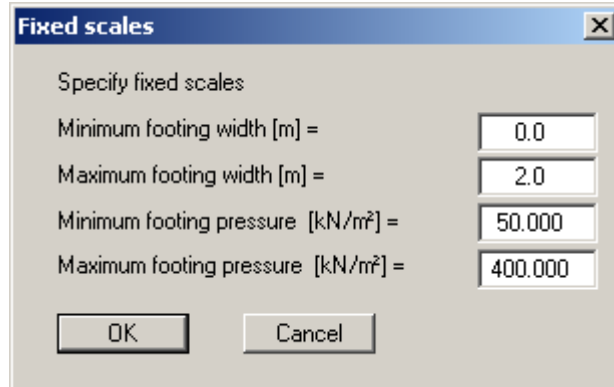
7.4.10 "Reset all graphics to defaults" menu item

Upon selecting this menu item all graphic elements will be reset to default after a confirmation prompt.

7.4.11 "Fixed scales" menu item

This menu item is only important in the "Multiple footings" analysis mode.

The program automatically selects a sensible axes scale for the graphical presentation of the footing analysis diagram. If you would like to draw several footing analysis diagrams for varying bearing capacity values, it can occasionally be desirable to use a uniform scaling. You can enter the desired scaling values in this box.



The "Fixed scales" dialog box is titled "Fixed scales" and contains the following fields and buttons:

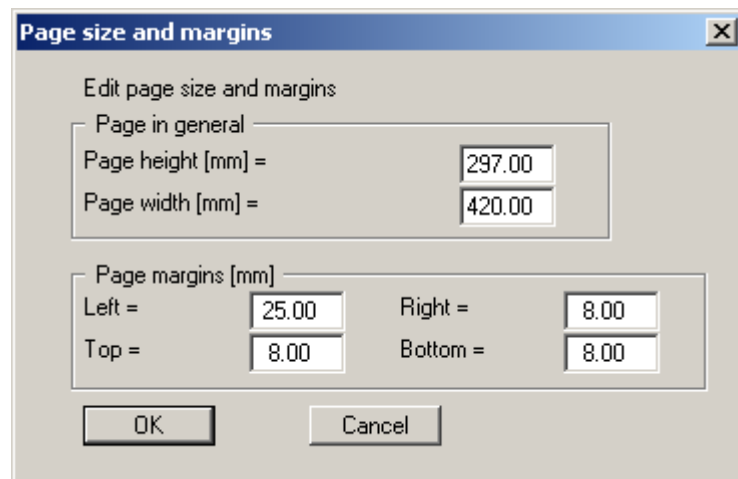
| Field | Value |
|---|---------|
| Minimum footing width [m] = | 0.0 |
| Maximum footing width [m] = | 2.0 |
| Minimum footing pressure [kN/m ²] = | 50.000 |
| Maximum footing pressure [kN/m ²] = | 400.000 |

Buttons: OK, Cancel

The values given here will be used for the axes if you have activated the "Use specified fixed scales" check box in the "Output preferences/Footing analysis diagram" menu item.

7.4.12 "Page size and margins" menu item

The program uses A3 format as default. You can edit the page format in the following dialog box.



The "Page size and margins" dialog box is titled "Page size and margins" and contains the following fields and buttons:

| Field | Value |
|--------------------|--------|
| Page height [mm] = | 297.00 |
| Page width [mm] = | 420.00 |
| Left = | 25.00 |
| Right = | 8.00 |
| Top = | 8.00 |
| Bottom = | 8.00 |


Buttons: OK, Cancel

- "Page in general" defines the size of the output sheet. The program automatically draws thin cutting borders around the page, which are required when using a plotter on paper rolls. The borders can be switched off using the menu item "Graphics preferences/Margins and borders" (see Section 7.5.5).
- "Page margin" defines the position of a frame as a distance to the margins. This frame encloses the subsequent diagram. The margins can be switched off using the menu item "Graphics preferences/Margins and borders" (see Section 7.5.5).

7.4.13 "Move objects" menu item

When you go to this item you can move the various objects and legends with the aid of the mouse. Move the mouse over the object to be moved. When you are located above a moveable object the mouse pointer appears in the shape of a cross. You can now press and hold the left mouse button and drag the object to the required position.

After going to this menu item only one object at a time can be moved using the mouse or its size be altered.

In order to move or edit several objects, this function can be more quickly activated by pressing [F11] or the  icon.

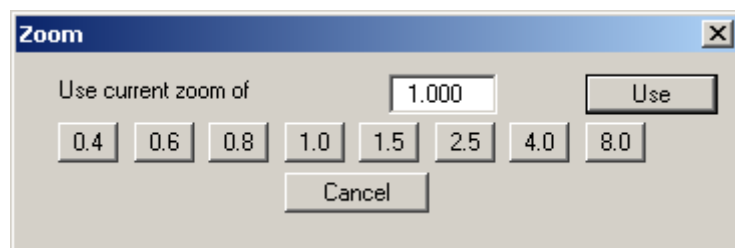
The size of an object can also be altered using this menu item or the [F11] key. If you move over the frame of a changeable object after activating this function the mouse assumed the shape of a double-headed arrow. Hold the left mouse button and move the frame until the element has reached the required size. To retain the ratio of the sides, pull at one corner only. If on one side only is pulled the object will become higher or wider.

7.5 Graphics preferences menu

7.5.1 "Refresh and zoom" menu item

The program works on the principle of *What you see is what you get*. This means that the screen presentation represents, overall, what you will see on your printer. In the last consequence, this would mean that the screen presentation would have to be refreshed after every alteration you make. For reasons of efficiency and as this can take several seconds for complex screen contents, the screen is not refreshed after every alteration.

If, e.g., after using the zoom function (see below), only part of the image is visible, you can achieve a complete view using this menu item.

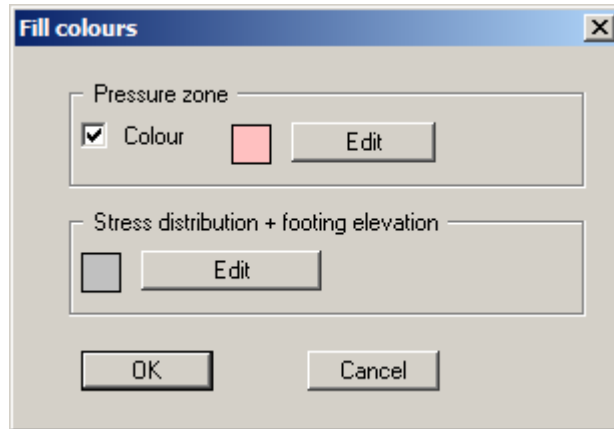


A zoom factor between 0.4 and 8.0 can be entered in the input box. By then clicking on "Use" to exit the box the current factor is accepted. By clicking on the "0.4", "0.6", etc. buttons, the selected factor is used directly and the dialog box closed.

It is much simpler, however, to get a complete overview using [Esc]. Pressing [Esc] allows a complete screen presentation using the zoom factor specified in this menu item. The [F2] key allows screen refreshing without altering the coordinates and zoom factor.

7.5.2 "Fill colours" menu item

When analysing in the "**Pad footing**" mode it is possible to add a coloured backdrop for the pressure zone in the plan view. Activate the "**Colour**" check box in the "**Pressure zone**" group box and selected the required colour using the "**Edit**" button. The colour of the footing can also be edited for the system visualisation and for the stress distribution.



When analysing in the "**Multiple footings**" mode the allowable area in the footing analysis diagram can be colour-filled using this menu item. A "**Diagram colour**" group box is shown in the dialog box in place of the "**Pressure zone**" group box.

7.5.3 "Zoom info" menu item

By clicking two diametrically opposed points you can enlarge a section of the screen in order to view details better. An information box provides information on activating the zoom function and on available options.

7.5.4 "Legend font selection" menu item

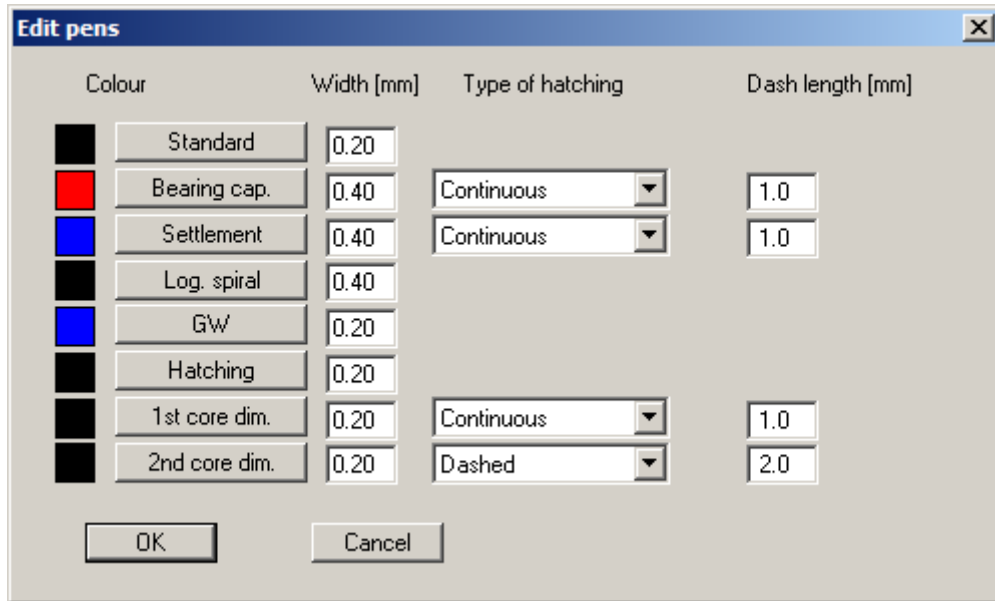
With this menu item you can switch to a different true-type font. All available true-type fonts are displayed in the dialog box.

7.5.5 "Margins and borders" menu item

The program automatically draws thin cutting edges around the page, which are required when using a plotter on paper rolls. Page margins (see menu item "**Output preferences/Page size and margins**") defines the position of a frame as a distance to the cutting border. This frame encloses the subsequent diagram. You can switch off the lines by deactivating the "**With margins**" and "**With borders**" check boxes.

7.5.6 "Pen colour and width" menu item

In order to enhance the clarity of the graphics you can edit the pen settings for various graphic elements.



You can edit the pen widths for the elements shown in the dialog box; by clicking on the button with the element designation you can also edit the pen or fill colours. Furthermore, you can define dashing for the bearing capacity and settlement curves.

On *monochrome printers* (e.g. laser printers), colours are shown in a corresponding grey scale. Graphic elements employing very light colours may be difficult to see. In such cases it makes sense to edit the colour preferences.

7.5.7 "Mini-CAD toolbar" menu item

Using this menu item you can add free text to the graphics and add lines, circles, polygons and images (e.g. files in formats BMP, JPG, PSP, TIF, etc.). A pop-up menu opens, the icons and functions used are described in more detail in the **Mini-CAD** manual provided.

Objects created with the "**Mini-CAD**" tool are based on the page format (in mm). This makes you independent of the coordinate system and keeps you in the same position on the page. You should select the "**Mini-CAD toolbar**" if you wish to place general information on the drawing (company logo, report numbers, plan numbers, stamp etc.). Once you have saved the header information to disk (see **Mini-CAD** user manual), you can load it into completely different systems (with different system coordinates). The saved header information will appear in exactly the same position on the page, which greatly simplifies the creation of general page information

7.5.8 "Toolbar preferences" menu item

After starting the program a horizontal toolbar for menu items appears below the program menu bar. If you would rather work with a popup window with several columns, you can specify your preferences using this menu item. The smart icons can also be switched off.

At the bottom of the program window you find a status bar with further information. You can also activate or switch off the status bar here. The preferences will be saved in the "GGU-FOOTING.gdg_alg" file (see menu item "Graphics preferences/Save graphics preferences") and will be active at the next time the program is started.

By clicking on the tools (smart icons) for the menu items you can directly reach most of the program functions. The meaning of the smart icons appears as a text box if you hover with the mouse pointer over the tools. Some of the tool functions cannot be activated from the normal menu items.



"Next page"/"Previous page"

Using this icon, you can navigate between the individual pages in the *tabular representation*.



"Select page"

If you are in the *tabular representation*, you can use this icon to jump to a specific page or to return to the *normal representation*, that is, to the graphics.



"Zoom out"

If you have previously *zoomed in*, this tool returns to a full screen display.



"Zoom (-)"/"Zoom (+)"

With the zoom functions you can zoom in or out of parts of the image, by clicking the left mouse button.



"Copy/print area"

Use this tool to copy only parts of the graphics in order to paste them, e.g. to a report. You will see information on this function and can then mark an area, which is copied to the clipboard or can be saved in a file. Alternatively you can send the marked area directly to your printer (see "Tips and tricks", Section 8.4).



"Colour/hatching"

Four colour settings are possible; you can click through them in sequence. A colour filled representation is the default setting, the next click shows the hatching, then coloured and hatched. The fourth click shows a representation with neither colour nor hatching. The next click starts again.



"Move object"

Use this icon to position legends and diagrams at the desired position on the output sheet.



"Undo move object"

By clicking this icon the last performed movement of graphical elements made using the [F11] function key or the menu item "**Output preferences/Move objects**" can be undone.



"Restore move object"

By clicking this symbol, the last object movement undo carried out using "**Undo move object**" can be restored.

7.5.9 "Load graphics preferences" menu item

You can reload a graphics preferences file into the program, which was saved using the "**Graphics preferences/Save graphics preferences**" menu item. Only the corresponding data will be refreshed.

7.5.10 "Save graphics preferences" menu item

Some of the preferences you made with the menu items of the "**Graphics preferences**" menu can be saved to a file. If you select "**GGU-FOOTING.gdg_alg**" as file name, and save the file on the same level as the program, the data will be automatically loaded the next time the program is started and need not be entered again.

If you do not go to "**File/New**" upon starting the program, but open a previously saved file instead, the preferences used at the time of saving are shown. If subsequent changes in the general preferences are to be used for existing files, these preferences must be imported using the menu item "**Graphics preferences/Load graphics preferences**".

7.6 Info menu

7.6.1 "Copyright" menu item

You will see a copyright message and information on the program version number.

The "**System**" button shows information on your computer configuration and the folders used by **GGU-FOOTING**.

7.6.2 "Help" menu item

The **GGU-FOOTING** manual is opened as a PDF document. The help function can also be accessed using the [F1] function key.

7.6.3 "GGU on the web" menu item

Using this menu item you can access the GGU Software website: www.ggu-software.com. Keep in touch with new program versions and the regular *download* offers.

If you would like to be automatically notified about program innovations, please register for the Newsletter in our Knowledge Base. Go to the following website: <http://kbase.civilserve.com>.

7.6.4 "GGU support" menu item

This menu item takes to the GGU-Software [Support area](#) at www.ggu-software.com.

7.6.5 "What's new?" menu item

You will see information on program improvements in comparison to older versions.

7.6.6 "Language preferences" menu item

This menu item allows you to switch the menus and graphics from German to English or Spanish and vice versa. The program always starts with the language setting applicable when it was last ended.

8 Tips and tricks

8.1 "?" buttons

Reading of the manual can mostly be dispensed with, because

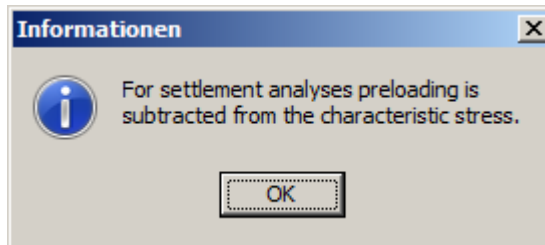
"?" buttons  and "Info" buttons 

dealing with almost all geotechnical and program-specific problems are available in the dialog boxes. You are presented with the necessary information by clicking the "?" or "Info" buttons.

For example, the following check box can be found in the "Edit/System parameters" dialog box:

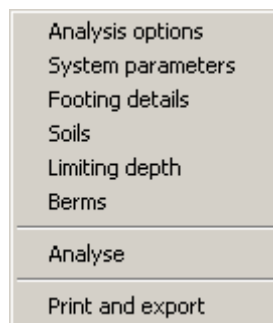


If you click on the question mark, you will see the following message box:



8.2 Keyboard and mouse

If you click the right mouse button anywhere on the screen a context menu containing the principal menu items opens.



By double-clicking the left mouse button on legends or **Mini-CAD** objects, the editor for the selected element immediately opens, allowing it to be edited.

You can scroll the screen with the keyboard using the cursor keys and the [**Page up**] and [**Page down**] keys. By clicking and pulling with the mouse, with [**Ctrl**] pressed, you activate the zoom function, i.e. the selected section will fill the screen. Furthermore you can use the mouse wheel to zoom in/out or scrolling the screen presentation. The following mouse wheel functions are available:


- Mouse wheel up = move screen image up
- Mouse wheel down = move screen image down
- [**Ctrl**] + mouse wheel up = enlarge screen image (zoom in)
- [**Ctrl**] + mouse wheel down = shrink screen image (zoom out)
- [**Shift**] + mouse wheel up = move screen image right
- [**Shift**] + mouse wheel down = move screen image left

8.3 Function keys

Some of the function keys are assigned program functions. The allocations are noted after the corresponding menu items. The individual function key allocations are:

- [**Esc**] refreshes the screen contents and sets the screen back to the given format. This is useful if, for example, you have used the zoom function to display parts of the screen and would like to quickly return to a complete overview.
- [**F1**] opens the manual file.
- [**F2**] refreshes the screen without altering the current magnification.
- [**F3**] opens the menu item "**Edit/System parameters**".
- [**F5**] opens the menu item "**System/Analyse**".
- [**F6**] opens the menu item "**System/Optimise footing width**".
- [**F11**] activates the menu item "**Output preferences/Move objects**".

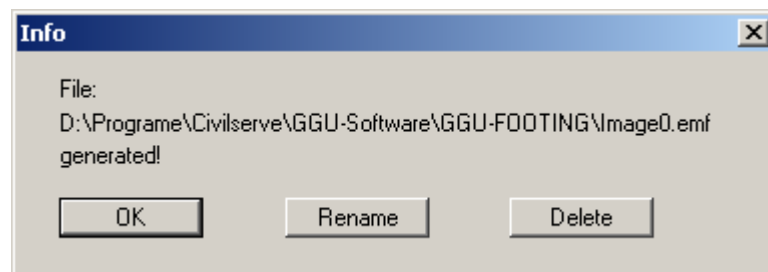
8.4 "Copy/print area" icon

A dialog box opens when the "**Copy/print area**" icon  in the menu toolbar is clicked, describing the options available for this function. For example, using this icon it is possible to either copy areas of the screen graphics and paste them into the report, or send them directly to a printer.

In the dialog box, first select where the copied area should be transferred to: "**Clipboard**", "**File**" or "**Printer**". The cursor is displayed as a cross after leaving the dialog box and, keeping the left mouse button pressed, the required area may be enclosed. If the marked area does not suit your requirements, abort the subsequent boxes and restart the function by clicking the icon again.

If "**Clipboard**" was selected, move to the MS Word document (for example) after marking the area and paste the copied graphics using "*Edit/Paste*".

If "**File**" was selected, the following dialog box opens once the area has been defined:



The default location of the file is the folder from which the program is started and, if several files are created, the file is given the file name "**Image0.emf**" with sequential numbering. If the "**Rename**" button in the dialog box is clicked, a file selector box opens and the copied area can be saved under a different name in a user-defined folder. Saving can be aborted by pressing the "**Delete**" button.

If the "**Printer**" button was pressed in the first dialog box, a dialog box for defining the printer settings opens after marking the area. Following this, a dialog box for defining the image output settings opens. After confirming the settings the defined area is output to the selected printer.

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