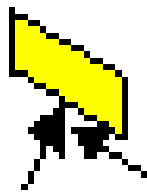


Analysis of the stability of a slope slice

GGU-SLICE

VERSION 7



Last revision:
Copyright:
Technical implementation, layout and sales:

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Prof. Dr. Johann Buß
Civilsolve GmbH, Steinfeld

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1 Preface

The **GGU-SLICE** program facilitates the analysis of a slope slice to DIN 4084 or in accordance with the Recommendations of the Working Group on "*Geotechnical Aspects of Landfill and Brownfield Sites*" (*Geotechnik der Deponien und Altlasten - GDA*).

For input select between:

- a single layer system;
- a multi-layer system;
- a system using geogrids or
- a wave pressure analysis.

Analysis can be performed using either the *global safety factor concept* given in DIN 1054 (old) or the *partial safety factor concept* given in DIN 1054:2005 or EC 7.

Data input is in accordance with WINDOWS conventions and can therefore be learned almost without a manual. Graphics 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. PDF and DXF files can also be imported by means of the integrated **Mini-CAD** module (see the "**Mini-CAD**" manual).

The program system has been thoroughly tested. 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

GGU software is provided with the WIBU-Systems CodeMeter software protection system. For this purpose the GGU-Software licences are linked to a USB dongle, the WIBU-Systems CmStick, or as CmActLicense to the respective PC hardware.

It is required for licence access that the CodeMeter runtime kit (CodeMeter software protection driver) is installed. Upon start-up and during running, the **GGU-SLICE** program checks that a licence on a CmStick or as CmActLicense is available.

3 Language selection

GGU-SLICE is a bilingual 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 "**Spracheinstellung**" (for German) or "**Language preferences**" (for English).

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 5.1.1). 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.

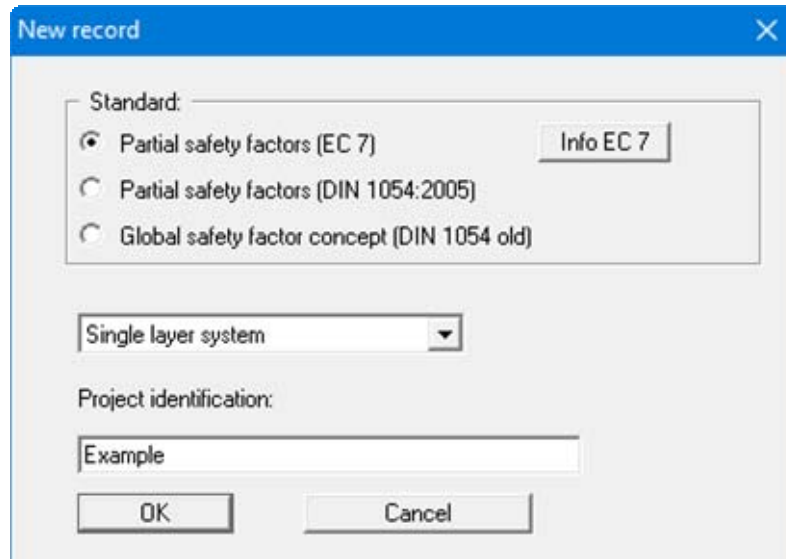
The program works on the principle of *What you see is what you get*. This means that the screen presentation represents, overall, what you will see on your printer. In the last consequence, this would mean that the screen presentation would have to be refreshed after every alteration you make. For reasons of efficiency and as this can take several seconds for complex screen contents, the GGU-SLICE 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 A4 format sheet.

5 Description of menu items

5.1 File menu

5.1.1 "New" menu item

Use this menu item to create a new system.



In the upper group box of this dialog box select the safety factor concept for analysing your new system. The type of system can be specified in the middle drop-down list box. Select from the following settings:

- Single layer system;
- Multi-layer system;
- System with geogrid;
- Wave pressure analysis.

You may elect to enter a descriptive project identification, which will subsequently be displayed in the *File name legend* (see Section 5.4.1).

5.1.2 "Load" menu item

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

5.1.3 "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. Loading again later creates exactly the same presentation as was present at the time of saving.

5.1.4 "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 ".lam" 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, ".lam" will be used automatically.

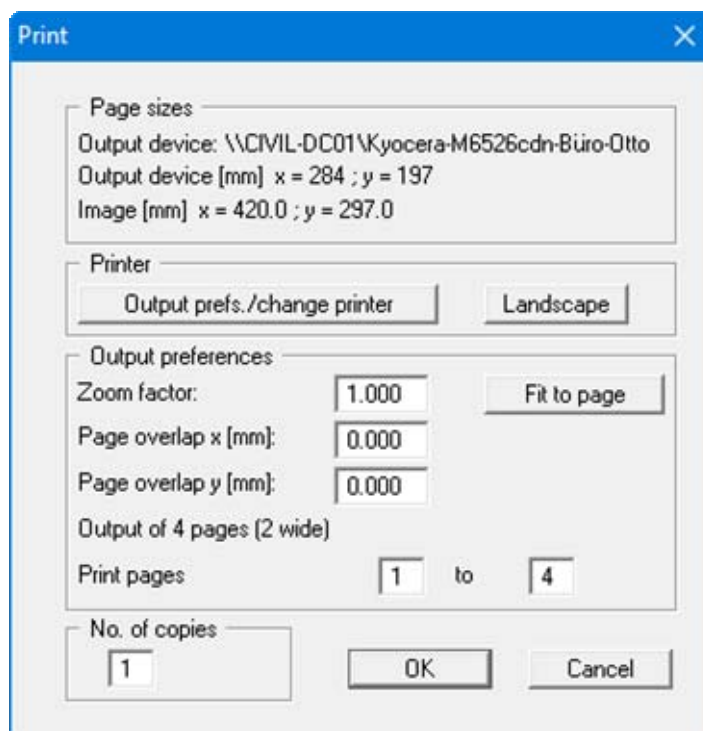
5.1.5 "Output preferences" menu item

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

5.1.6 "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 default printer or to any other printer selected using the menu item "File/Output preferences". But you may also select a different printer in the following dialog box by pressing the "Output 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.

- "**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.
- "**GGU-CAD file**"
allows output of the graphics to a file, in order to enable further processing with the **GGU-CAD** 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.

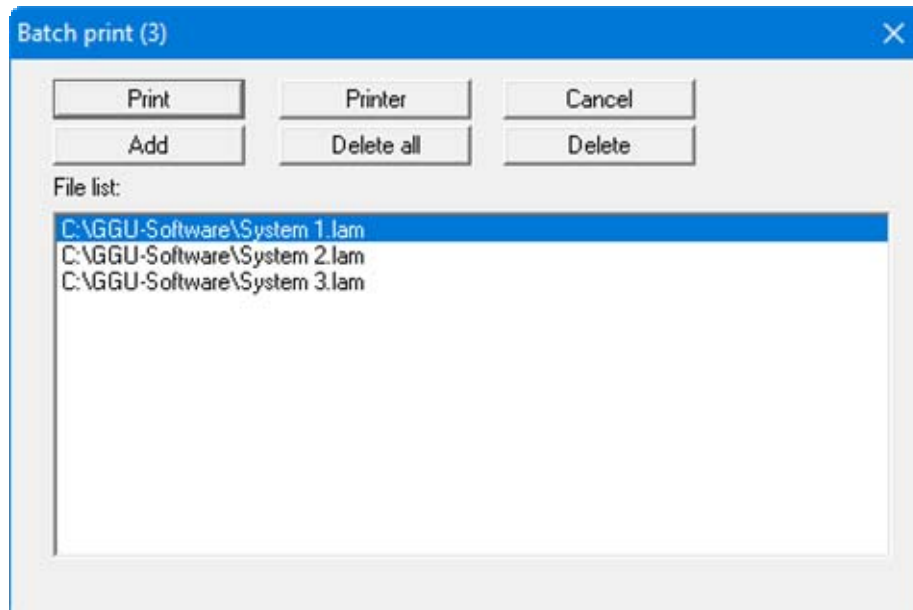
If you select the "**Copy/print area**" tool  from the toolbar, you can copy parts of the graphics to the clipboard or save them to an EMF file. Alternatively you can send the marked area directly to your printer (see "**Tips and tricks**", Section 6.3).

Using the "**Mini-CAD**" program module you can also import EMF files generated using other GGU applications into your graphics (see Section 5.5.5).

- "**Mini-CAD**"
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.

5.1.7 "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 output 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.

5.1.8 "Exit" menu item

After a confirmation prompt, you can quit the program.

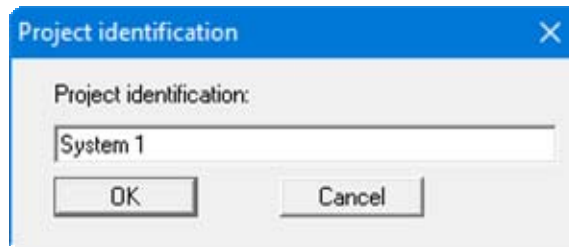
5.1.9 "1, 2, 3, 4" menu items

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.

5.2 Edit menu

5.2.1 "Project identification" menu item

You can enter a description of the current system; this will then be used in the *File name legend* (see Section 5.4.1).



5.2.2 "Analysis options" menu item

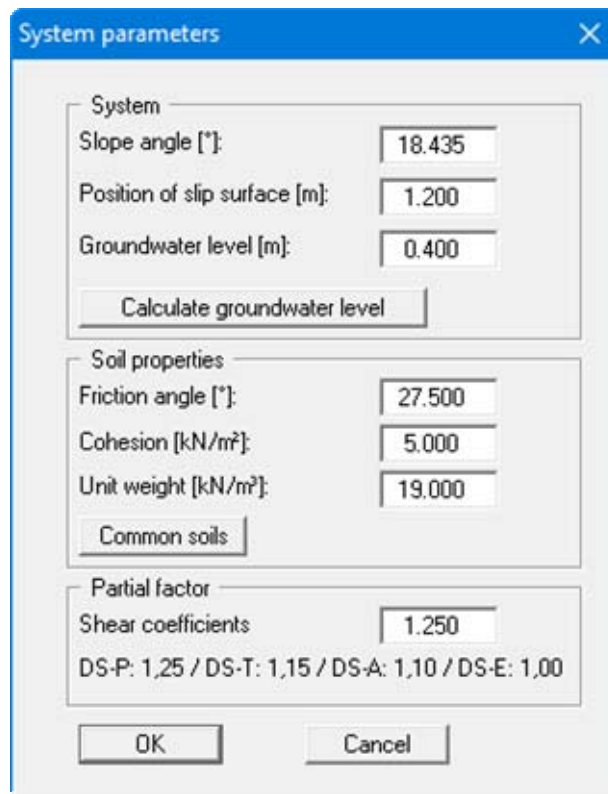
The safety concept and the type of system can be changed by going to this menu item. You will see almost the same dialog box as for the menu item "**File/New**" (see Section 5.1.1).

5.2.3 "System parameters" menu item

The system geometry is defined using this menu item. Different input boxes open depending on the type of system selected.

5.2.3.1 Single layer system

In a single layer system the system geometry is defined using the following dialog box.

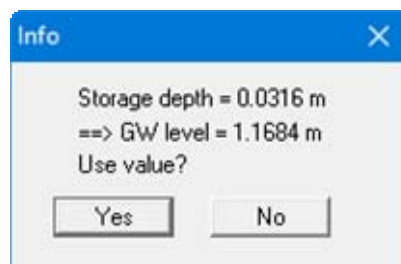


The "System parameters" dialog box is divided into three sections:

- System:** Contains input fields for "Slope angle [°]" (18.435), "Position of slip surface [m]" (1.200), and "Groundwater level [m]" (0.400). A "Calculate groundwater level" button is located below these fields.
- Soil properties:** Contains input fields for "Friction angle [°]" (27.500), "Cohesion [kN/m²]" (5.000), and "Unit weight [kN/m³]" (19.000). A "Common soils" button is located below these fields.
- Partial factor:** Contains an input field for "Shear coefficients" (1.250) and a text label "DS-P: 1,25 / DS-T: 1,15 / DS-A: 1,10 / DS-E: 1,00".

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

You enter the slope angle, the position of the slip surface and a groundwater level in [m] below the crest of the slope. Alternatively, the water table can be calculated as a storage depth after **DRESCHER**. To do this, click the "**Calculate groundwater level**" button. You will see a dialog box for entering the appropriate values for the rainfall event and can then have the results calculated by the program by clicking "**Calculate**". The program displays the results of the groundwater level calculations in a message box:



The "Info" dialog box displays the following text:

Storage depth = 0.0316 m
==> GW level = 1.1684 m
Use value?

At the bottom are "Yes" and "No" buttons.

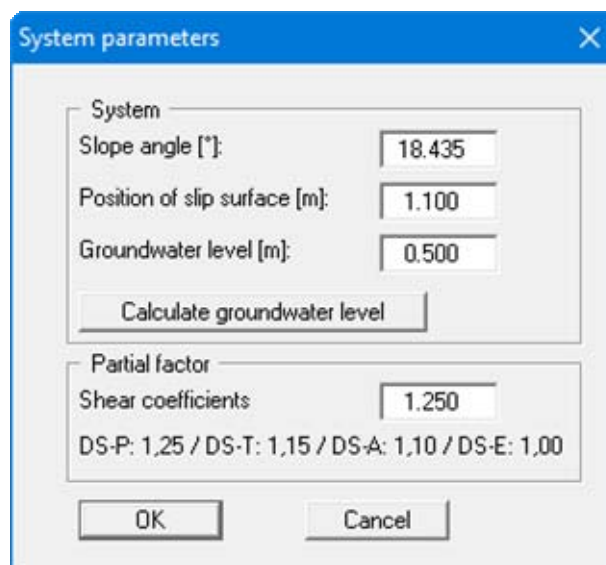
If you click "Yes" the groundwater level is adopted in the "**System parameters**" dialog box.

In the central group box of the main dialog box you can define the soil properties for a single layer system. Using the "Common soils" button, you can easily select the soil properties of many common soils from a database or determine intermediate values. In the dialog box, which you open by pressing the "Common soils" button, open the "Soils_english.gng_ggu" file when first starting the program in English ("Edit table"/"Load" buttons). Then save the data set in the "Soils.gng_ggu" file on the program level in order to open your modified database file when the program starts. You can also enter your own data ("Edit table"/"x soils to edit" button) and save it in the "Soils.gng_ggu" file. You can also use your adapted file in other GGU programs by means of the "Common soils" function if you copy the file into the appropriate GGU program folder.

In a further input box you can enter the partial safety factors of the shear coefficients.

5.2.3.2 Multi-layer system

For a multi-layer system you will see the following dialog box for defining the system geometry using the same group boxes "System" and "Partial factor" as for single layer systems.



Only the soil properties are defined in the multi-layer system-specific "Edit/Soils" menu item (see Section 5.2.4). If you are using the *partial safety factor concept*, you can also enter the partial safety factor for the shear coefficients in the dialog box.

5.2.3.3 System with geogrid

If your system employs a geogrid you will see an extended dialog box when using this menu item:

Section	Parameter	Value	Partial Safety Factor (DS)
Slope	Angle [°]	18.435	
	Length [m]	21.500	
Partial factors	Sliding:	1.100	
	DS-P: 1,10 / DS-T: 1,10 / DS-A: 1,10 / DS-E: 1,00		
	Permanent actions:	1.350	
	DS-P: 1,35 / DS-T: 1,20 / DS-A: 1,10 / DS-E: 1,00		
	Changeable actions:	1.500	
	DS-P: 1,50 / DS-T: 1,30 / DS-A: 1,10 / DS-E: 1,00		
Soil	Thickness [m]	1.100	
	gamma [kN/m³]	19.000	
	gamma' [kN/m³]	11.000	
	Friction angle [°]	27.500	
	<input type="checkbox"/> With active earth pressure Ea		
	<input checked="" type="checkbox"/> With passive Ep		
Partial factor (Ep):	1.400		
DS-P: 1,40 / DS-T: 1,30 / DS-A: 1,20 / DS-E: 1,00			
Water	Design rainfall [l/s/ha]	120.0	
	Permeability [m/s]	1.00E-3	
	Runoff coefficient [-]	1.000	
	GW (constant) [m]	0.000	
Geogrid	Short-term strength [kN/m]	150.000	
	Factor A1 [-]	1.670	
	Factor A2 [-]	1.400	
	Factor A3 [-]	1.000	
	Factor A4 [-]	1.000	
	Partial factor (Geogrid) [-]	1.400	
DS-P: 1,40 / DS-T: 1,30 / DS-A: 1,20 / DS-E: 1,00			
Friction angle [°]	14.000		
Cohesion [kN/m²]	5.000		
Installation equipment	Weight [kN]	110.000	
	Width [m]	2.000	
	Impact factor [-]	1.250	
	Braking force component [-]	0.333	

You enter the governing values for the slope, soil, water, geogrids and installation equipment in the respective group boxes. If the *partial safety factor concept* is selected you can also enter the respective partial safety factors in the dialog box.

5.2.3.4 Wave pressure analysis

If a wave pressure analysis was selected in "Edit/Analysis options", the following dialog box opens allowing the corresponding system parameters to be entered:

System parameters

System

Slope angle beta [°]: 18.435

With lateral forces

Crack depth [m]: 0.200

Crack length [m]: 1.000

Wave height Hs [m]: 2.000

Wave pressure factor [-]: 24.000

(Wave pressure = factor · tan(beta) · 10,0 · Hs)

Surcharge beside crack [kN/m²]: 0.00

Partial factor

Shear coefficients: 1.250

DS-P: 1,25 / DS-T: 1,15 / DS-A: 1,10 / DS-E: 1,00

Soil properties

Work. cu [kN/m²]: 5.000

With weight

Unit weight [kN/m³]: 19.000

Root cohesion [kN/m²]: 0.000

Root cohesion (depth) [m]: 0.200

For req. pore space

Dry unit weight [kN/m³]: 14.000

Grain density [g/cm³]: 2.750

Nat. water content [-]: 0.320

Liquid limit [-]: 0.420

Plastic limit [-]: 0.220

cu (Plastic limit)

Automatically Manually

cu (Plastic limit) [kN/m²]: 50.000

OK Cancel

5.2.4 "Soils" menu item

This menu item is only activated for multi-layer systems.

The soil properties input for other systems is carried out in the menu item "**Edit/System parameters**".

In a multi-layer system the system's soil properties are defined in the following dialog box:

- Base of soil layer [m]
- Unit weight of moist soil γ [kN/m³]
- Unit weight of buoyant soil γ' [kN/m³]
- Friction angle ϕ [°]
- Cohesion c [kN/m²]

	Designation	Base	gamma	gamma'	phi	Cohesion
		[m]	[kN/m ³]	[kN/m ³]	[°]	[kN/m ²]
1	Topsoil	1.00	20.0	19.0	27.5	0.00
2	Drainage layer	1.30	19.0	18.0	35.0	0.00
3	KDB	1.32	19.0	18.0	15.0	0.00
4	Clay	1.82	21.0	20.0	20.0	0.00
5	Levelling course	2.32	19.0	18.0	32.5	0.00

Using the "**Common soils**" button, you can easily select the soil properties of many common soils from a database or determine intermediate values. In the dialog box, which you open by pressing the "**Common soils**" button, open the "**Soils_english.gng_ggu**" file when first starting the program in English ("**Edit table**"/"**Load**" buttons). Then save the data set in the "**Soils.gng_ggu**" file on the program level in order to open your modified database file when the program starts. You can also enter your own data ("**Edit table**"/"**x soils to edit**" button) and save it in the "**Soils.gng_ggu**" file. You can also use your adapted file in other GGU programs by means of the "**Common soils**" function if you copy the file into the appropriate GGU program folder.

If you would like to display a soil structure using either less or more layers, you can define the necessary number of layers using the "**Edit no. of soils**" button. Click the "**Sort**" button to sort the soil layers according to depth; however, this is performed automatically when you click "**OK**" to leave the dialog box. This eliminates the possibility of input errors.

You can also use this function to eliminate a soil from the table.

Simply assign the soil to be eliminated a greater layer depth and then click the "**Sort**" button. The corresponding soil is now the last soil in the table and can be *deleted* by reducing the number of soils.

5.3 System menu

5.3.1 "Results" menu item

You will see a message box containing the results of the analysis of the user-defined slip surface.

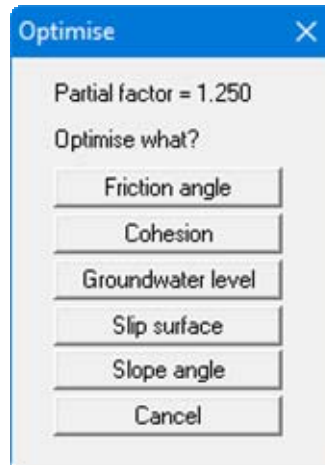


You will also be presented with the result box after closing the menu items in the "**Edit**" menu.

5.3.2 "Optimise" menu item

This menu item is only activated for single layer systems.

In a single layer system you are given the opportunity of having the program perform an optimisation. Select the desired parameter from the dialog box.

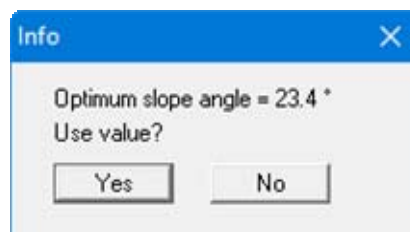


If you are using the *global safety factor concept* you can enter the allowable safety in the dialog box. When using the *partial safety factor concept* the partial safety factor for the shear coefficients as defined in "Edit/System parameters" is displayed.

For example, if you would like to optimise the slope angle, click the appropriate button and you will see the following dialog box:



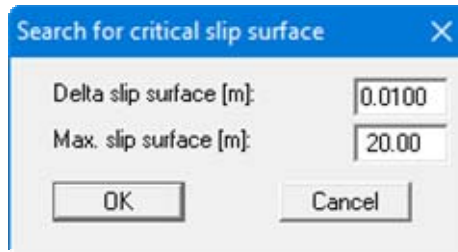
Enter the minimum, maximum and delta for the selected parameter, here the slope angle, and click "OK". The optimum value is shown in a message box, in this example the optimum slope angle for a safety factor of 1.41. You can now decide whether to adopt the optimised value in the system parameters. If you do not want to use this value click "No".



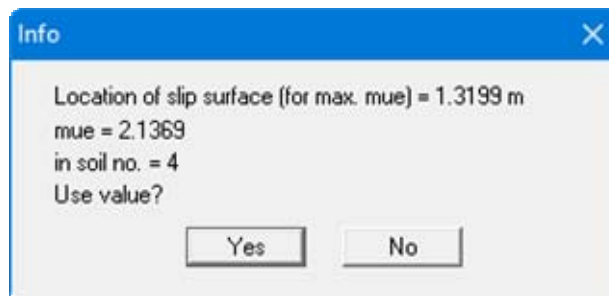
5.3.3 "Search for critical slip surface" menu item

This menu item is only activated for multi-layer systems.

In a multi-layer system it is possible to have the program search for the most unfavourable slip surface. You will see the following dialog box for specifying search criteria.



If you close this box by pressing "OK" the program performs the calculation and then displays the result of the search in a message box.



If you click "Yes" the position of the slip surface is adopted in the "System parameters" dialog box (see Section 5.2.3.2) and drawn in the system visualisation at the identified depth.

5.3.4 "Monte-Carlo simulation (Safety)" menu item

If you are not sure precisely how to achieve the parameters given in the dialog box on-site, the Monte-Carlo simulation provides an estimate of the influence exerted by the individual parameters. The dialog box for this menu item varies depending on the selected system. For a single layer system the menu item is divided into three parts dealing with safety, cohesion and friction angle. Below, you can see the dialog box that opens for a multi-layer system:

Monte-Carlo-Simulation (Safety)

Monte-Carlo

Number of runs = 50000

Fractile value [-] 0.0250

Number of class subdivisions [-] 15

Standard deviation as multiple of mean values

System (mean values/standard deviations)

Slope angle [°]: 18.435 Stdab. [-] 0.100

Position of slip surface [m]: 1.100 Stdab. [-] 0.010

Groundwater level [m]: 0.500 Stdab. [-] 0.010

Soil properties (mean values/standard deviations)

Friction angle [°]: All soils Stdab. [-] 0.050

Cohesion [kN/m²]: All soils Stdab. [-] 0.100

Unit weight [kN/m³]: All soils Stdab. [-] 0.030

Partial factor

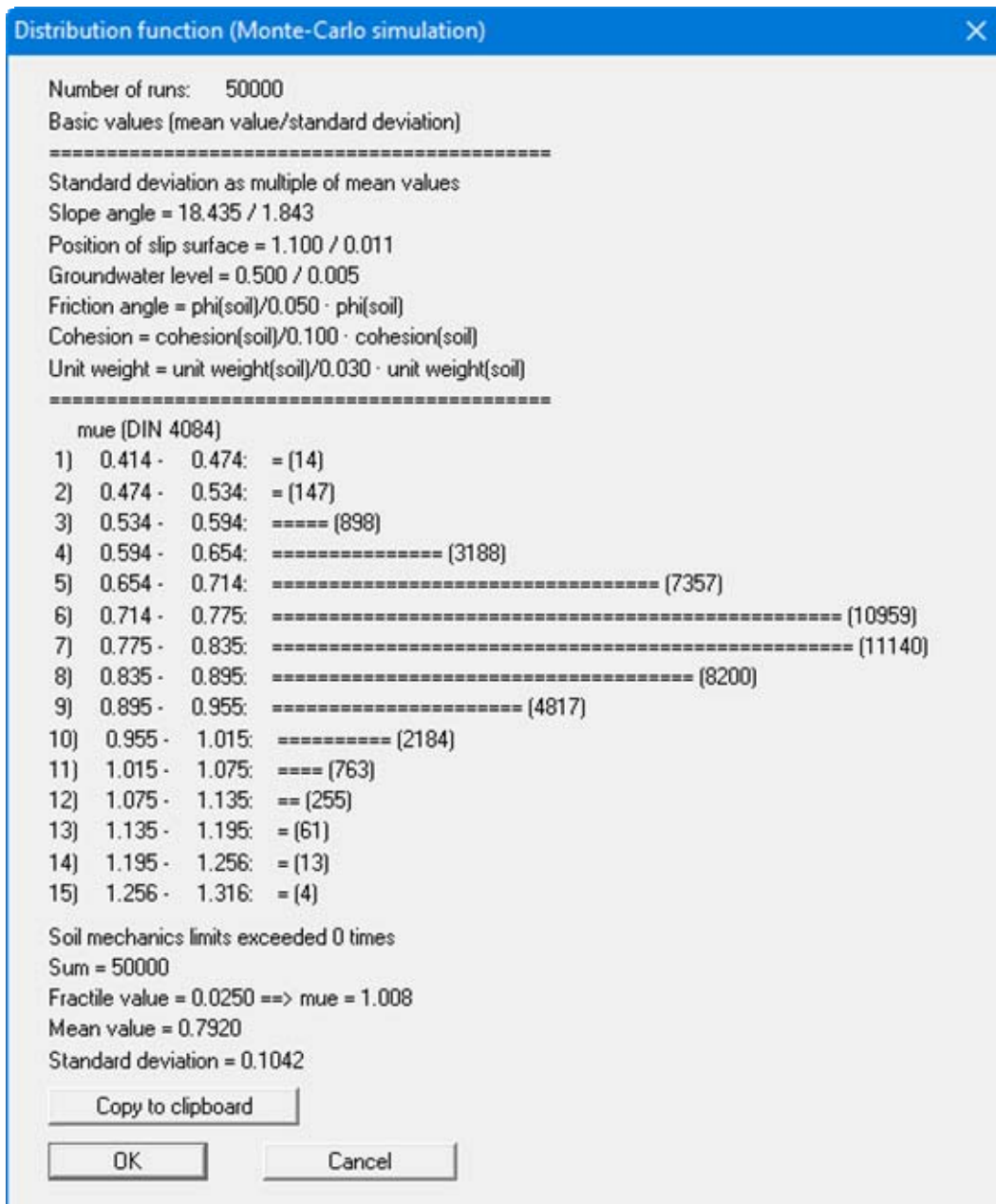
Shear coefficients 1.250

DS-P: 1,25 / DS-T: 1,15 / DS-A: 1,10 / DS-E: 1,00

OK End Cancel

The mean and the standard deviation are given for each parameter. If the check box "**Standard deviation as multiple of mean values**" is activated you will be presented with a percentage standard deviation relative to the mean value of the parameter. Deactivate this check box if a fixed value is to be used in calculations.

After confirming by pressing "**OK**" the program performs the specified number of calculations (50,000 computations in the box above). The parameters are randomly varied within the specified limits. The result is a distribution function for η/μ_e , or for the tensile force for geogrid systems. In addition, a fractile value is determined, which can be defined in the above dialog box as a **percentage value**. For example, entering 0.025 (see above) means that 2.5% of the computed results are below the fractile value (see the following result box: $\eta = 1.205$) and 97.5% of the computed results are above it.

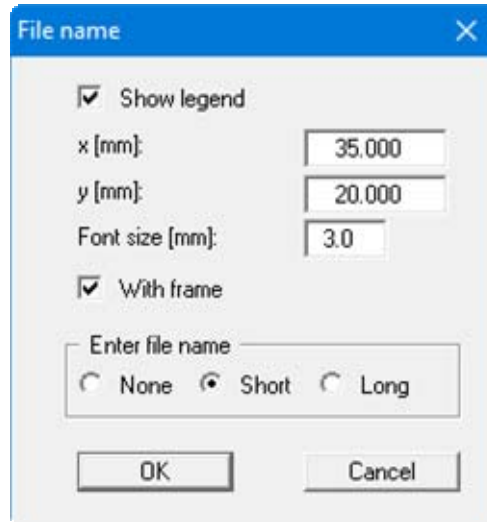


If you close the result box by pressing "OK" you will return to the input box for this menu item, where you are able to compute further variations. You can leave this menu item by pressing "End" in the input box or by pressing the "Cancel" button.

5.4 Output preferences menu

5.4.1 "File name legend" menu item

A legend with file information will be displayed on your output sheet if you have activated the "Show legend" check box. Using this menu item you can alter the type of presentation.

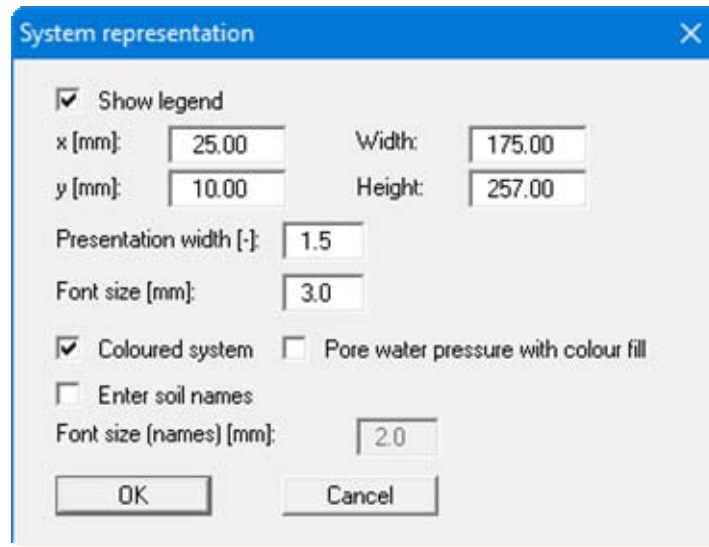


You can define and edit the position of the legend using the values "x" and "y". You control the size of the legend using "Font size". The fastest way to modify the position of the legend is to press the [F11] function key and then to pull the legend to the new position with the left mouse button pressed.

The legend can be displayed with a frame. The file name can be switched off ("None" option button) or be displayed automatically with or without the path by selecting the appropriate "Short" or "Long" option button. Any project identification entered in the "File/New" or "Edit/Project identification" dialog box will also be shown in this legend.

5.4.2 "System legend" menu item

You can alter the visualisation of the slope system and the analysis results represented within it by means of the following dialog box.



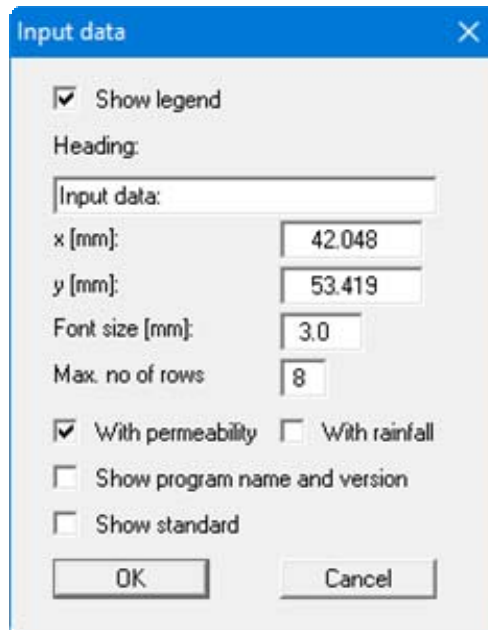
The visualisation is activated using the "**Show system**" check box and for the coordinates defined in "**x**", "**y**", "**Width**" and "**Height**". The visualisation can be varied further by way of the "**Presentation width**" factor as well as the "**Font size**". The fastest way to modify the position of the legend is to press the [F11] function key and then to pull the legend to the new position while holding the left mouse button

If the "**Coloured system**" check box is activated, the visualisation will use the soil colours defined in "**Graphics preferences/Pen colour and width**" (see Section 5.5.4) or, in multi-layer systems, in "**Output preferences/Soil properties legend**" (see Section 5.4.5). If you also activate the "**Pore water pressure with colour fill**" check box, the area between the pore water pressure line and the selected slip surface will be colour-filled. The colours can be edited in "**Graphics preferences/Pen colour and width**".

In *multi-layer systems*, the soils are labelled with the corresponding names if the "**Enter soil names**" check box is activated. A different font size can be used for the soil names than for the remaining labelling. For a *wave pressure analysis* it is possible to activate an additional "**Force polygon with values**" check box.

5.4.3 "Input data legend" menu item

If you activate the "**Show legend**" check box in the dialog box for this menu item the analysis input data are displayed in a legend.



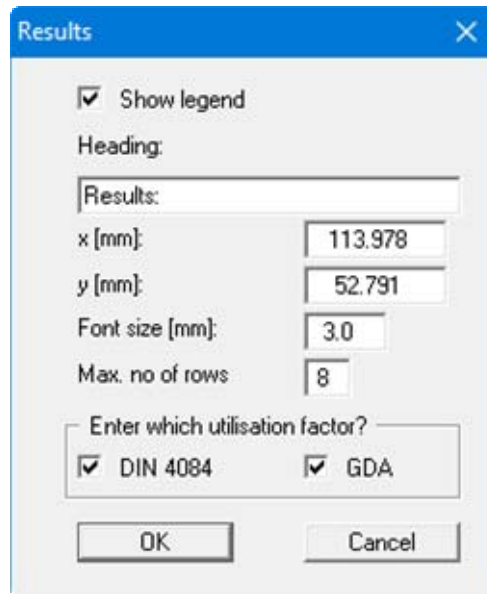
You can define and edit the position of the legend using the values "**x value**" and "**y value**". You control the size of the legend using "**Font size**" and "**Max. no. of lines**"; where necessary, several columns are used. The fastest way to modify the position of the legend is to press the **[F11]** function key and then to pull the legend to the new position with the left mouse button pressed.

Activating the two check boxes "**With permeability**" and "**With rainfall**" is only useful if you have determined the groundwater level as the storage depth after *DRESCHER*.

In a system using geogrids the geogrid analysis can also be shown by simply activating the displayed check box. Additional information on the program (name and version) and the adopted standard can also be activated in the legend.

5.4.4 "Results legend" menu item

If you activate the "**Show legend**" check box in the dialog box for this menu item the safety factors are displayed in a separate box on your output sheet



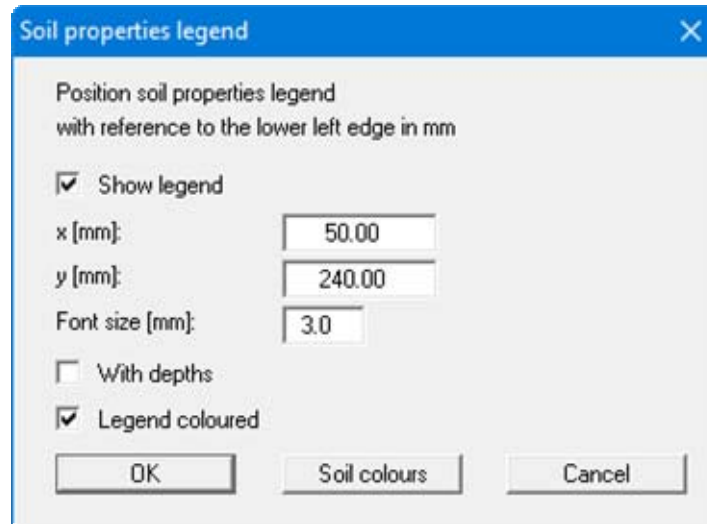
You can define and edit the position of the legend using the values "**x value**" and "**y value**". You control the size of the legend using "**Font size**" and "**Max. no. of lines**"; where necessary, several columns are used. The fastest way to modify the position of the legend is to press the [F11] function key and then to pull the legend to the new position with the left mouse button pressed.

In single layer and multi-layer systems, you can decide whether to display the safety factors or, when employing the partial safety factor concept, the utilisation factors to DIN 4084 and/or in accordance with the Recommendations of the Working Group on "*Geotechnical Aspects of Land-fill and Brownfield Sites*" (**GDA**).

In a system utilising geogrids you can display the results with or without geogrid verification. If you deactivate the "**With geogrid verification**" check box, the corresponding check box in the input data legend will also be deactivated. The force polygon values resulting from a wave pressure analysis can also be displayed in the result legend.

5.4.5 "Soil properties legend" menu item

A legend with the soil properties of the individual layers will be displayed on your output sheet if you have clicked the "**Show legend**" check box. Using this menu item you can alter the type of presentation or turn off the legend completely.

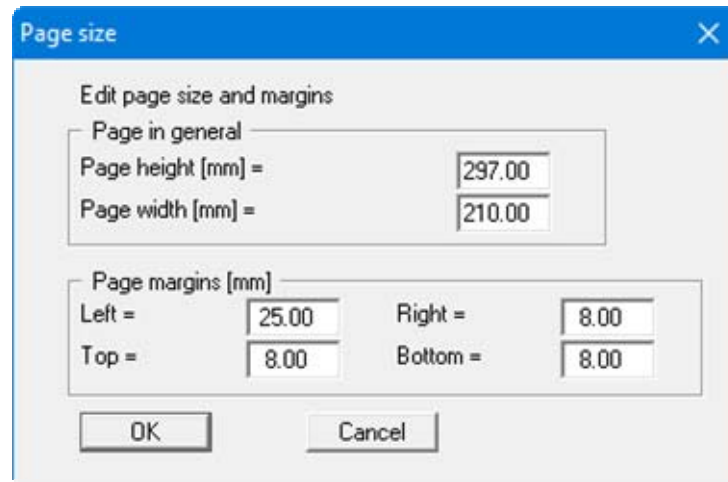


You can define and edit the position of the legend using the values "**x**" and "**y**". You control the size of the legend using "**Font size**". The fastest way to modify the position of the legend is to press the [F11] function key and then to pull the legend to the new position with the left mouse button pressed.

- "**With depths**"
The depths of the individual soil layers will be shown in the soil properties legend.
- "**Legend coloured**"
The soils are displayed in the legend with the colours individually defined using the "**Soil colours**" button. If the check box is not selected,, the soil number will be adopted.
- "**Soil colours**"
You will see a dialog box, in which you can define your preferences. After clicking the button with the desired number you can assign each soil layer a new number or reorganise using the "**Soil colours/Reorganise**" command button. You can save your colour preferences to a file with "**Soil colours/Save**" and use them for different systems by means of the "**Soil colours/Load**" command button. In the lower group box you can also transfer the colour preferences to the Windows colour management dialog box, or vice versa, as user-defined colour preferences for example. You can read a further description by pressing the "**Info**" button.

5.4.6 "Page size and margins" menu item

The default page set-up is A4 when the program is started. You can edit the page format in the following dialog box.



- **"Page in general"** defines the size of the output sheet. The A4 format is set as default. 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 **"With borders"** menu item (see Section 5.4.7).
- **"Page margin"** defines the position of a frame as a distance to the margins. This frame encloses the subsequent diagram.

In order to achieve 1:1 output on an A4 printer the borders must be switched off and the page height and page borders be adapted to the printable area of the printer.

5.4.7 "With borders" menu item

The program automatically draws thin cutting borders around the page, which are required when using a plotter on paper rolls. You can switch off the lines by deactivating this menu item.

5.4.8 "Move objects" menu item

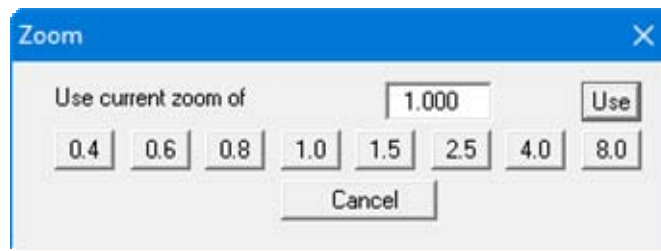
Select this menu item in order to position legends or other graphical elements at the desired position on the output sheet. You can also move objects by pressing [F11] and then positioning the legend box with the left mouse button pressed. In that case an info-box appears no more.

5.5 Graphics preferences menu

5.5.1 "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.

5.5.2 "Zoom info" menu item

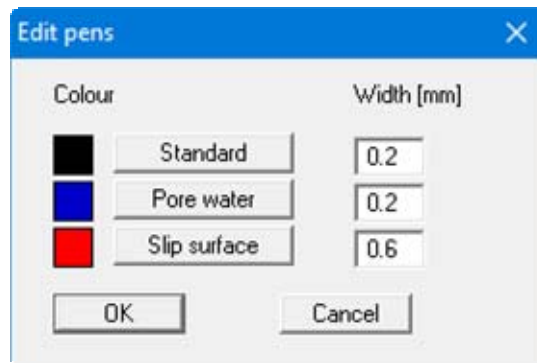
By clicking two diametrically opposed points you can enlarge a section of the screen in order to view details better. An information box provides information on activating the zoom function and on available options.

5.5.3 "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.

5.5.4 "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 (pore water, slip surface, soil in single layer system or with geogrid). 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.



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.

5.5.5 "Header toolbar" menu item

Using this menu item you can add free text, lines, circles, polygons and images (e.g. files in formats BMP, JPG, PSP, TIF, etc.) to the main program graphics. PDF files can also be imported as images. A pop-up menu opens; the icons and functions used are described in more detail in the "**Mini-CAD**" manual saved in the 'C:\Program Files (x86)\GGU-Software\Manuals' folder during installation..

Objects created with the **Header CAD** 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 this menu item 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.

5.5.6 "Toolbar preferences" menu item

After starting the program a horizontal toolbar for the 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-SLICE.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.



"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 6.3).



"Colour on/off"

If you need to remove the colour from the system presentation, to create a black and white print-out, for example, use this on/off switch.

5.5.7 **"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.

5.5.8 **"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-SLICE.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"**.

5.6 Info menu

5.6.1 "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-SLICE.

5.6.2 "Help" menu item

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

5.6.3 "GGU on the web" menu item

Using this menu item you can access the GGU Software website: www.ggu-software.com.

Get information on updates and modifications on a regular basis from your program module page. You can also subscribe to email notifications, which provide information on all modifications on a monthly basis.

5.6.4 "GGU support" menu item

This menu item takes to the GGU-Software Contact area at www.ggu-software.com.

5.6.5 "What's new?" menu item

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

5.6.6 "Language preferences" menu item

This menu item allows you to switch the menus and the graphics from German to English and vice versa. To work in German, deactivate the two check boxes "**Dialoge + Menüs übersetzen (translate dialogues, menus)**" und "**Graphiktexte übersetzen (translate graphics)**".

Alternatively, you can work bilingually, e.g. with German dialog boxes but with graphic output in English. The program always starts with the language setting applicable when it was last ended.

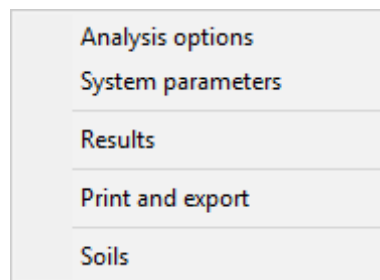
6 Tips and tricks

6.1 Keyboard and mouse

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

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, you will immediately move to the editor for the selected object and can then edit it.

6.2 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.
- [**F5**] opens the menu item "**System/Results**".
- [**F6**] opens the menu item "**System/Optimise**" when using a single layer system.
- [**F6**] opens the menu item "**System/Search for critical slip surfaces**" when using a multi-layer system.
- [**F11**] activates the menu item "**Output preferences/Move objects**".

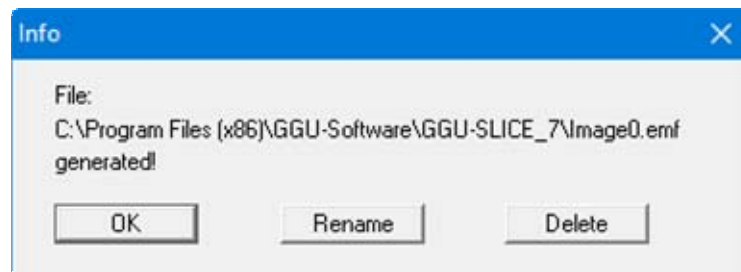
6.3 "Copy/print area" icon

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.

7 Worked examples

7.1 Single layer system

7.1.1 Systemdaten

Slope angle $\beta = 18.43^\circ$ (1 : 3)
 $\varphi = 27.5^\circ$
 $c = 5.0 \text{ kN/m}^2$
 $\gamma = 19 \text{ kN/m}^3$
Position of slip surface $t_g = 1.20 \text{ m}$
GW = 0.4 m below top of slope
 $u = \text{PWP} = (1.20 - 0.40) \cdot 10.0 = 8.0 \text{ kN/m}^2$

(see provided file *ExampleSingleLayerGlobal.lam*)

7.1.2 Calculations using old standard

$$\eta(\text{DIN 4084}) = \frac{[(\gamma \cdot t_g - u) \cdot \tan(\varphi) + c \cdot \cos(\beta)]}{[\cos(\beta) \cdot \sin(\beta) \cdot \gamma \cdot t_g] - \tan(\beta) \cdot \tan(\varphi)}$$
$$\eta(\text{GDA}) = \frac{[c + (\gamma \cdot t_g - u) \cdot \cos(\beta) \cdot \tan(\varphi)]}{(\gamma \cdot t_g \cdot \sin(\beta))}$$

Req. $\eta \geq 1.40$ (LC 1)

$$\eta(\text{DIN 4084}) = \frac{[(19.0 \cdot 1.20 - 8.0) \cdot \tan(27.5) + 5.0 \cdot \cos(18.43)]}{[\cos(18.43) \cdot \sin(18.43) \cdot 19.0 \cdot 1.20] - \tan(18.43) \cdot \tan(27.5)}$$
$$\eta(\text{DIN 4084}) = 1.65$$

$$\eta(\text{GDA}) = \frac{[5.0 + (19.0 \cdot 1.20 - 8.0) \cdot \cos(18.43) \cdot \tan(27.5)]}{(19.0 \cdot 1.20 \cdot \sin(18.43))}$$
$$\eta(\text{GDA}) = 1.71$$

7.1.3 Calculations using new standard

$$\gamma_\varphi = 1.25 \text{ (LC 1)}$$
$$1/\mu(\text{DIN 4084}) = \frac{((\gamma \cdot t_g - u) \cdot \tan(\varphi)/\gamma_\varphi + c/\gamma_\varphi \cdot \cos(\beta))}{[\cos(\beta) \cdot \sin(\beta) \cdot \gamma \cdot t_g] - \tan(\beta) \cdot \tan(\varphi)/\gamma_\varphi}$$
$$1/\mu(\text{GDA}) = \frac{[c/\gamma_\varphi + (\gamma \cdot t_g - u) \cdot \cos(\beta) \cdot \tan(\varphi)/\gamma_\varphi]}{(\gamma \cdot t_g \cdot \sin(\beta))}$$

Req. $\mu = \text{utilisation factor} \leq 1.00$

$$1/\mu(\text{DIN 4084}) = \frac{((19.0 \cdot 1.20 - 8.0) \cdot \tan(27.5)/1.25 + 5.0/1.25 \cdot \cos(18.43))}{[\cos(18.43) \cdot \sin(18.43) \cdot 19.0 \cdot 1.20] - \tan(18.43) \cdot \tan(27.5)/1.25}$$
$$1/\mu(\text{DIN 4084}) = 1.32$$
$$\mu(\text{DIN 4084}) = 0.76$$

$$1/\mu(\text{GDA}) = \frac{[5.0/1.25 + (19.0 \cdot 1.20 - 8.0) \cdot \cos(18.43) \cdot \tan(27.5)/1.25]}{(19.0 \cdot 1.20 \cdot \sin(18.43))}$$
$$1/\mu(\text{GDA}) = 1.37$$
$$\mu(\text{GDA}) = 0.73$$

7.2 Multi-layer system

The calculations for a multi-layer system are analogous to those for the single layer system.

7.3 System with geogrid

7.3.1 System parameters

Slope angle $\beta = 18.43^\circ$ (1 : 3)
Slope length $L = 21.5$ m
 $\gamma/\gamma' = 19/11$ kN/m³
Thickness $d = 1.10$ m
 $\phi = 14.0^\circ$
 $c = 5.0$ KN/m²
Storage depth at toe $h_w = 0.774$ m
Short-term strength (geogrid) = 150 kN/m
 $A_1 = 1.67$
 $A_2 = 1.40$
 $A_3 = 1.00$
 $A_4 = 1.00$
Weight (installation equipment) = 110.0 kN
Weight (width) = 2.0 m
Impact factor = 1.25 (≥ 1.0)
Braking force component = 0.333

(see provided files *ExampleGeogridGlobal.lam* and *ExampleGeogridPartial.lam*)

7.3.2 Calculations using old standard

Req. $\eta = 1.30$

$\eta_{\text{Geogrid}} = 1.75$

$G = 0.774 \cdot 0.5 \cdot 11.0 \cdot 21.5 + (1.1 - 0.774 \cdot 0.5) \cdot 19.0 \cdot 21.5 = 382.8$ kN/m

$P = 110.0/2.0 = 55.0$ kN/m

$S = 10.0 \cdot 0.774 \cdot 0.5 \cdot \sin(18.43) \cdot 21.5 = 26.3$ kN/m

B (braking force) = $0.333 \cdot 55.0 = 18.3$ kN/m

$T = G \cdot \sin(\beta) + \text{impact factor} \cdot P \cdot \sin(\beta) + B + S$

$T = 382.8 \cdot \sin(18.43) + 1.25 \cdot 55.0 \cdot \sin(18.43) + 18.3 + 26.3 =$
 $121.0 + 21.7 + 18.3 + 26.3 = 187.4$ kN/m

Passive earth pressure:

$k_{\text{pgh}} = 2.03$ (where $\phi = 27.5^\circ$ after Caquot/Kerisel)

$e_{p1} = (1.10 - 0.774) \cdot 19.0 \cdot 2.03 = 12.6$ kN/m²

$e_{p2} = [(1.10 - 0.774) \cdot 19.0 + 0.774 \cdot 11.0] \cdot 2.03 = 29.9$ kN/m²

$E'_p = (1.10 - 0.774) \cdot 0.5 \cdot 12.6 + (12.6 + 29.9) \cdot 0.5 \cdot 0.774 = 18.5$ kN/m

$E_p = E'_p \cdot \cos(\beta)$

$E_p = 18.5 \cdot \cos(18.43) = 17.6$ kN/m

$R = [(G + P) \cdot \cos(\beta) \cdot \tan(\phi) + c \cdot L] + E_p$

$R = [(382.8 + 55.0) \cdot \cos(18.43) \cdot \tan(14.0) + 5.0 \cdot 21.5] + E_p = 228.6$ kN/m

$$\text{Req. } F = \text{req. } \eta \cdot T - R = 1.3 \cdot 187.4 - 228.6 \text{ kN/m}$$

$$\text{Req. } F = 243.6 - 228.6 = 15.0 \text{ kN/m}$$

$$\text{Working } F = 150.0 / (A_1 \cdot A_2 \cdot A_3 \cdot A_4 \cdot \eta_{\text{Geogrid}}) = 36.7 \text{ KN/m}$$

$$\text{Safety factor } \eta = 36.7 / 15.0 = 2.44 \text{ (verification successful)}$$

7.3.3 Calculations using new standard

$$\gamma_G = 1.35 \text{ (LC 1)}$$

$$\gamma_Q = 1.50 \text{ (LC 1)}$$

$$\gamma_{\text{Sliding}} = 1.10 \text{ (LC 1)}$$

$$\gamma_{E_p} = 1.40 \text{ (LC 1)}$$

$$\gamma_{\text{Geogrid}} = 1.40 \text{ (LC 1)}$$

$$G_k = 0.774 \cdot 0.5 \cdot 11.0 \cdot 21.5 + (1.1 - 0.774 \cdot 0.5) \cdot 19.0 \cdot 21.5 = 382.8 \text{ kN/m}$$

$$P_k = 110.0 / 2.0 = 55.0 \text{ kN/m}$$

$$S_k = 10.0 \cdot 0.774 \cdot 0.5 \cdot \sin(18.43) \cdot 21.5 = 26.3 \text{ kN/m}$$

$$B_k \text{ (braking force)} = 0.333 \cdot 55.0 = 18.3 \text{ kN/m}$$

$$T_d = \gamma_G \cdot G_k \cdot \sin(\beta) + \gamma_Q \cdot \text{impact factor} \cdot P_k \cdot \sin(\beta) + \gamma_Q \cdot B_k + \gamma_G \cdot S_k$$

$$T_d = 1.35 \cdot 382.8 \cdot \sin(18.43) + 1.50 \cdot 1.25 \cdot 55.0 \cdot \sin(18.43) + 1.50 \cdot 18.3 + 1.35 \cdot 26.3 =$$

$$163.4 + 32.6 + 27.5 + 35.5 = 259.0 \text{ kN/m}$$

Passive earth pressure:

$$k_{pgh} = 2.03 \text{ (where } \varphi = 27.5^\circ \text{ after Caquot/Kerisel)}$$

$$e_{p1,k} = (1.10 - 0.774) \cdot 19.0 \cdot 2.03 = 12.6 \text{ kN/m}^2$$

$$e_{p2,k} = [(1.10 - 0.774) \cdot 19.0 + 0.774 \cdot 11.0] \cdot 2.03 = 29.9 \text{ kN/m}^2$$

$$E_{p,k} = (1.10 - 0.774) \cdot 0.5 \cdot 12.6 + (12.6 + 29.9) \cdot 0.5 \cdot 0.774 = 18.5 \text{ kN/m}$$

$$E_{p,d} = E_{p,k} \cdot \cos(\beta) / \gamma_{E_p}$$

$$E_{p,d} = 18.5 \cdot \cos(18.43) / 1.40 = 12.5 \text{ kN/m}$$

$$R_{t,d} = 1.0 / \gamma_{\text{Sliding}} \cdot [(G_k + P_k) \cdot \cos(\beta) \cdot \tan(\varphi) + c \cdot L] + E_{p,d}$$

$$R_{t,d} = 1.0 / 1.10 \cdot [(382.8 + 55.0) \cdot \cos(18.43) \cdot \tan(14.0) + 5.0 \cdot 21.5] + E_{p,d} = 204.4 \text{ kN/m}$$

$$F_{B,d} = 259.0 - 204.4 = 54.6 \text{ kN/m}$$

$$\text{Working } F_{B,d} = 150.0 / (A_1 \cdot A_2 \cdot A_3 \cdot A_4 \cdot \gamma_{\text{Geogrid}}) = 45.8 \text{ KN/m}$$

$$\text{Utilisation factor } \mu = 54.6 / 45.8 = 1.19 \text{ (verification successful)}$$

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