



GGU-SLICE manual

Slope lamella stability analysis

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Theorie. Und Praxis.

Geotechnische Softwarelösungen können so einfach sein. Denn Theorie und Praxis lassen sich mit **GGU-Software** und den neuen Angeboten der **civilserve Academy** prima kombinieren: Knackige theoretische Aufgaben lösen und als Sahnehäubchen Ihr

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1 GGU-SLICE: 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.

The program includes convenient data input. The system is permanently displayed on the screen. Every change to the data is displayed on the screen, so that optimum control of the input data is guaranteed.

There are "?" and "Info" buttons in the dialog boxes for many technical and program-specific questions. Click on the "?" buttons or "Info" buttons to obtain the necessary information.

The graphic output supports the true type fonts provided by WINDOWS, so that an excellent layout is guaranteed. Colour output and numerous graphic formats (BMP, TIF, JPG etc.) are supported. PDF and DXF files can also be imported via the integrated **Mini-CAD** system (see "**Mini-CAD**" manual).

The program has been extensively tested. No errors 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 GGU-SLICE: Licence protection

To protect the GGU software from unauthorised access, each GGU program is equipped with the **CodeMeter software protection system** from WIBU-Systems. Each GGU program is bound to a so-called **CmContainer** via a licence with the corresponding product code.

To be able to use the GGU licences in a CmContainer, a runtime environment, the **CodeMeter Runtime Kit**, must be installed on your computer via driver software. You can obtain the current version from [Software for Users - Wibu-Systems](#) (CodeMeter User Runtime for Windows).

You can work with the following CmContainer types on your PC with the CodeMeter Runtime Kit installed (= **CodeMeter licence server**):

- **CmStick**
The licence for your GGU program is stored in a USB dongle.
- **CmActLicense** (soft licence, not for virtual PC/servers)
The licence for your GGU program is stored in a licence file that is linked to the hardware of a computer.
- **CmCloudContainer**
The licence is located on a CmCloud server of WIBU-Systems and is mirrored to your CodeMeter licence server. The advantages of this type of licence binding are described on the following website: [Licence binding | GGU Software](#).

The GGU programs check at start-up and during runtime whether a corresponding license is available in a CmContainer.

3 GGU-SLICE: Language selection

The GGU programs can be used in German and English. The program always starts with the language in which it was terminated.

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 GGU-SLICE: Starting the program

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

- File
- Info

After clicking the "**File**" menu, either an existing system can be loaded by means of the "**Load**" menu item, or a new system can be entered using "**New**". After clicking "**File/New**" you will first see a dialog box for selecting rectangular or triangular foundations for the following analysis. Then, the menu bar will show ten menus:

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

After clicking one of these menus, the so-called 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 screen is not refreshed after every alteration.

If you would like to refresh the screen contents, press either **[F2]** or **[Esc]**. The **[Esc]** key also resets the screen display to your current image zoom, which is usually preset to 1.0, which corresponds to an A3 or A4 sheet in most GGU programs (see menu item "**Graphics preferences/Refresh and zoom**").

5 Tips and tricks

5.1 GGU-SLICE: Keyboard and mouse

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.

In most dialog boxes, the buttons for leaving the box or buttons for decisive functions are marked thickly and can be reached by clicking the **[Enter]/[Return]** key.

In dialog boxes in which you have to make entries, e.g. change soil properties, the quickest way to jump to the next input box is to use the **[Tab]** key. The previous value is marked and can be overwritten directly with the new entry. You do not have to move to the box with the mouse and delete the old entry in advance.

In input boxes with numerical values, you can use the calculation operations listed in "**Tips and tricks: Mathematical functions in input boxes with numbers**" to change them.

You can scroll the screen with the keyboard using the cursor keys and the **[Page up]** and **[Page down]** keys. After activating the zoom functions, click on an area of the screen to enlarge or reduce the display by a factor of 2. Alternatively, by clicking and dragging the mouse while holding down the **[Ctrl]** key, you define a window section which is then displayed in full screen. By clicking and dragging the mouse while holding down the **[Shift]** and **[Ctrl]** keys, you zoom into your system graphic, i.e. you change the scale of your system representation.

You can also use the mouse wheel to zoom in or out or to move the screen display. When the program is started for the first time, the default setting for mouse wheel operation is activated according to Windows conventions:

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

[Strg] + mouse wheel down = reduce screen image (zoom out)

If you want to change the system coordinates and the scale of your system using the mouse wheel, activate the "**Mouse wheel operation with global coordinates**" check box in the dialog box of the "**Graphics preferences/Zoom info**" menu item. If you close the program with this setting, the setting is still activated the next time you start it. You can now use the following mouse wheel functions to change the system:

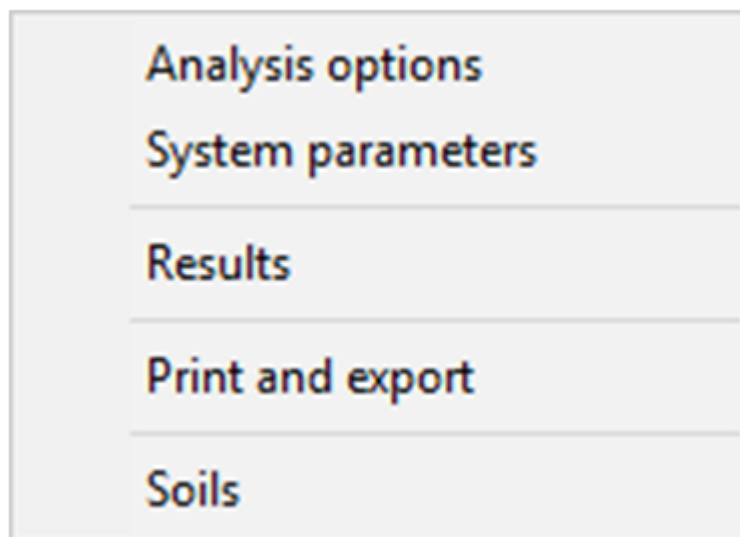
- **[Shift]** + mouse wheel up = move system graphics up
- **[Shift]** + mouse wheel down = move system graphics down

- **[Shift] + [Strg]** + mouse wheel up = move system graphics right
- **[Shift] + [Strg]** + mouse wheel down = move system graphics left
- **[Strg]** + mouse wheel up = enlarge system graphics (change of scale)
- **[Strg]** + mouse wheel down = reduce system graphics (change of scale)

From a zoomed representation you return to the full screen with **[Esc]**. You can undo a change in scale or system coordinates with **[F9]** (= menu item "**Page size + margins/Auto-resize**").

You can view the changed system coordinates in the menu item "**Page size + margins/Manual resize (editor)**" and, if necessary, adjust them manually by entering more precise numbers.

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



5.2 GGU-SLICE: 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 content and resets from a screen section to your current image zoom, which is usually preset to 1.0 (see “
- **[F1]** opens the manual file.
- **[F2]** refreshes the screen without altering the current magnification.
- **[F11]** activates the menu item "**Move objects**", which appears in the GGU programs under various menu titles, e.g. "**Page size + margins**", "**Graphics preferences**" or "**Output preferences**".

In this GGU program, the following function keys are also assigned to program functions:

- **[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.

5.3 GGU-SLICE: "Copy/print area" icon

A dialog box opens when the "**Copy/print area**" icon

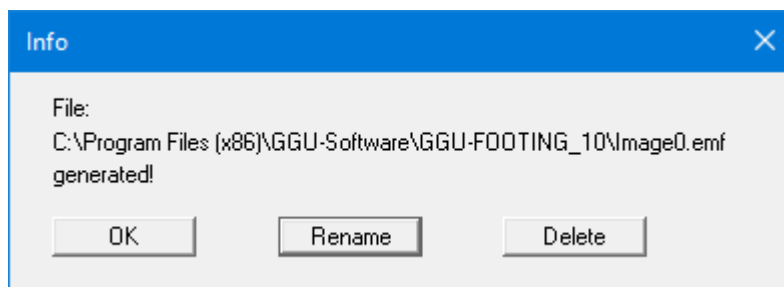


in the menu toolbar is clicked, describing the options available for this function. For example, using this icon it is possible to either copy areas of the screen graphics and paste them into the report, or send them directly to a printer.

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 appears after defining the area, shown here as an example for the **GGU-FOOTING** program:



The default location of the file is the folder from which the program is started (here: GGU-FOOTING_10) and, if several files are created, the file is given the file name "**Image0.emf**" with sequential numbering. If the

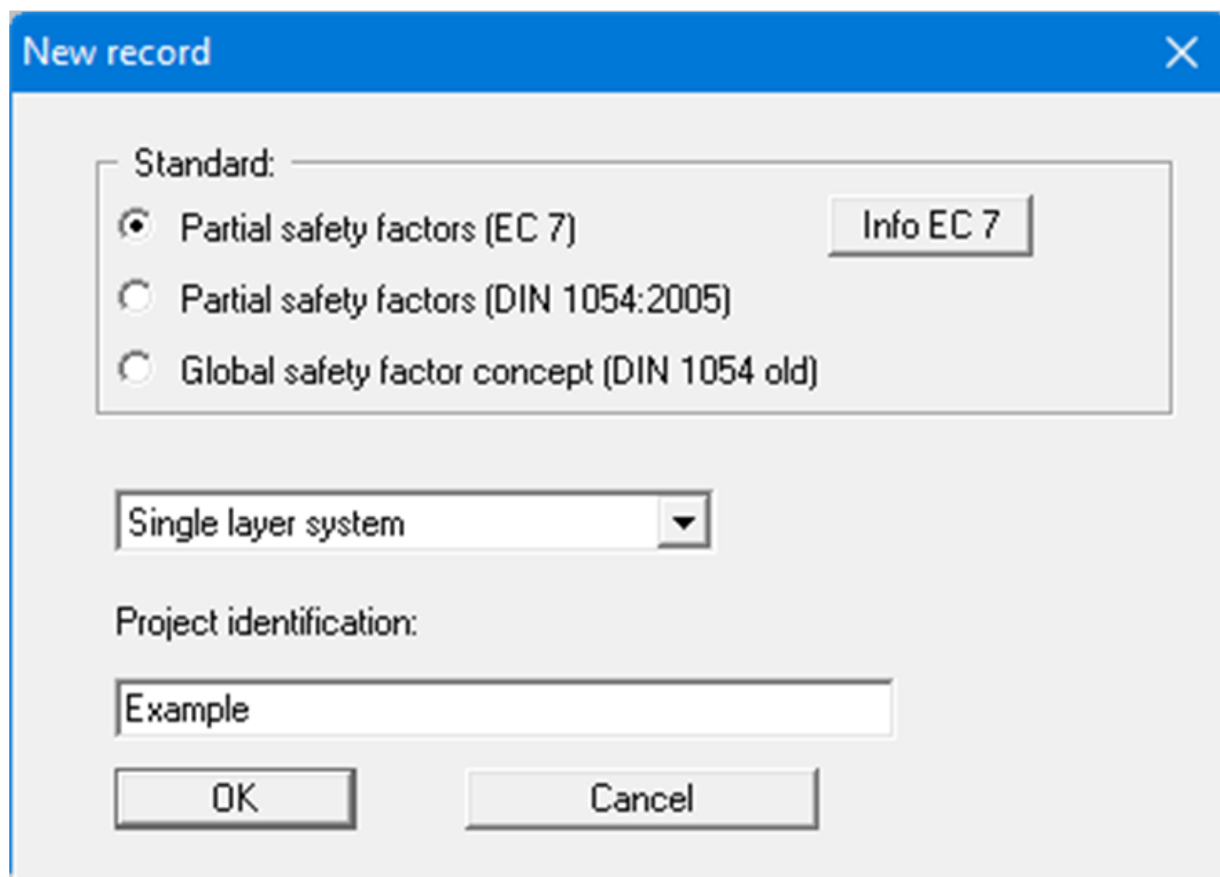
"**Rename**" button in the dialog box is clicked, a file selector box opens, and the copied area can be saved under a different name in a user-defined folder. Saving can be aborted by pressing the "**Delete**" button.

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.

6 File menu

6.1 GGU-SLICE: "New" menu item

Use this menu item to create a new system.



The screenshot shows the 'New record' dialog box. It features a blue title bar with the text 'New record' and a close button (X). The main area is light gray. At the top, there is a group box labeled 'Standard:' containing three radio buttons: 'Partial safety factors (EC 7)' (which is selected), 'Partial safety factors (DIN 1054:2005)', and 'Global safety factor concept (DIN 1054 old)'. To the right of the first radio button is a button labeled 'Info EC 7'. Below the radio buttons is a drop-down menu currently showing 'Single layer system'. Underneath the drop-down is the label 'Project identification:' followed by a text input field containing the word 'Example'. At the bottom of the dialog are two buttons: 'OK' and 'Cancel'.

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**.

6.2 GGU-SLICE: "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.

6.3 GGU-SLICE: "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.

6.4 GGU-SLICE: "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.

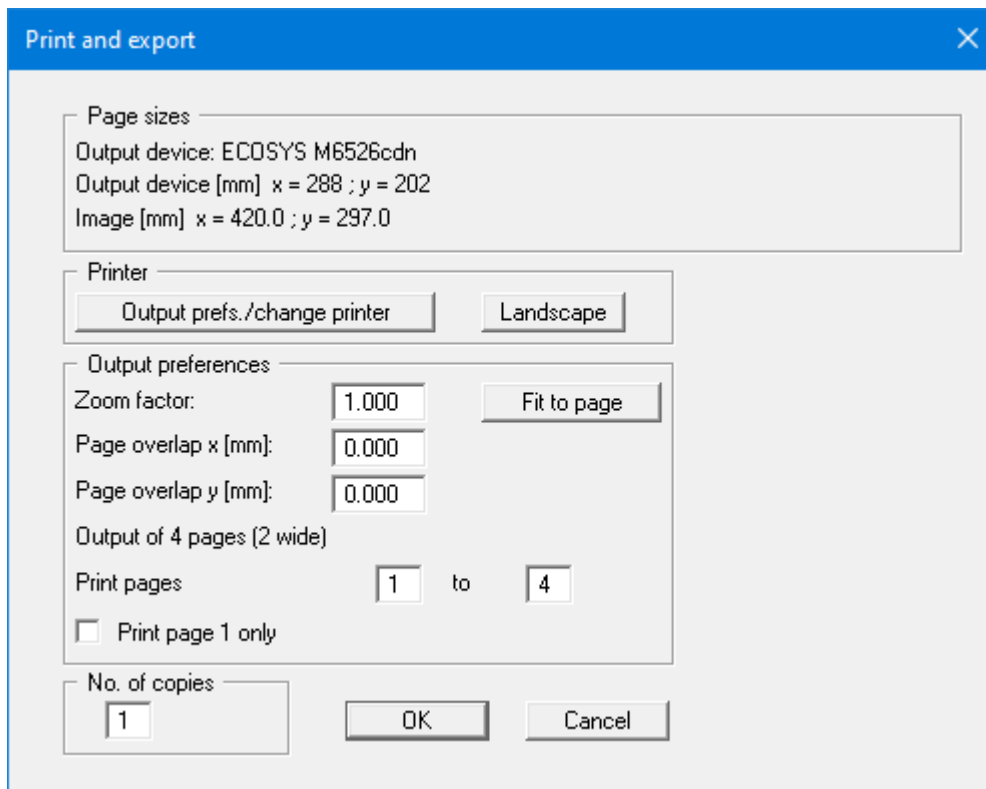
6.5 GGU-SLICE "Output preferences" menu item

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

6.6 GGU-SLICE "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/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). 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. You can also print only the 1st page with zoom factor = 1.0, in which case the bottom left-hand area is printed. Furthermore, you may enter the number of copies to be printed.

I

- **"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"**).

Using the **"Mini-CAD"** program module you can also import EMF files generated using other GGU applications into your graphics (see menu item **"Graphics preferences/Mini-CAD"**).

- **"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"**

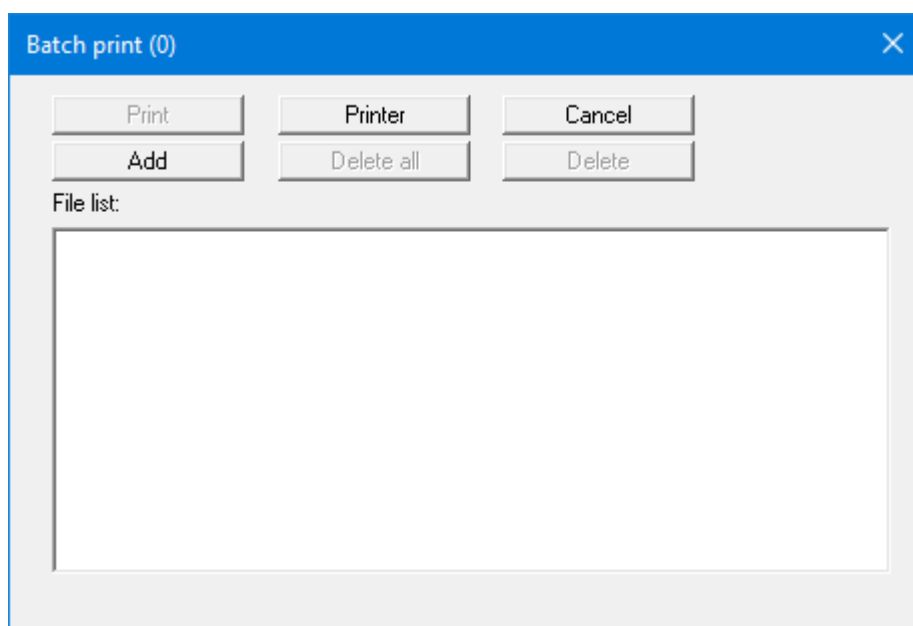
allows export of the graphics to a file in order to enable processing in the GGUMiniCAD program.

- **"Cancel"**

Printing is cancelled.

6.7 GGU-SLICE "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.

6.8 GGU-SLICE "Exit" menu item

After a confirmation prompt, you can quit the program.

6.9 GGU-SLICE "1, 2, 3, 4" menu items

If you have not stored a working directory for the program icon, the program jumps to the program directory after starting to load or save a file.

Under the menu items "**1,2,3,4, ...**", the most recently edited files are displayed with the respective storage path. Selecting one of these files loads the selected file. The next time you call up the menu items "**File / Load**" or "**File / Save**", the program is automatically located in the directory of the last file loaded.

7 Edit menu

7.1 GGU-SLICE: "Project identification" menu item

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



7.2 GGU-SLICE: "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"**.

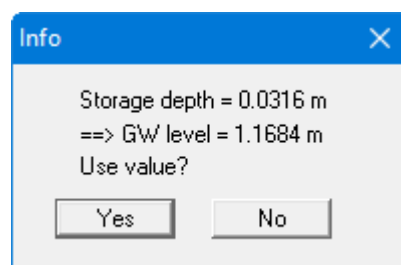
7.3 "System parameters" menu item

7.3.1 GGU-SLICE: Single layer system

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



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:



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.

7.3.2 GGU-SLICE: 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. 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.

7.3.3 GGU-SLICE: System with geogrid

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



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.

7.3.4 GGU-SLICE: 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:



GGU-SLICE: "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 [kN/m³]
- Unit weight of buoyant soil

 γ

' [kN/m³]

- Friction angle

 ϕ

[°]

- Cohesion c [kN/m²]



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.

8 System menu

8.1 GGU-SLICE: "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.

8.2 GGU-SLICE: "Optimise" menu item

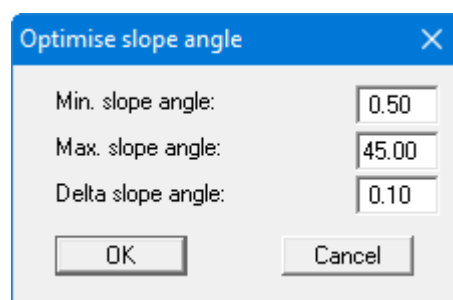
This menu item is only activated for single layer systems.

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.

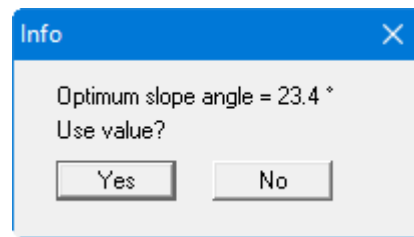


If you are using the **global safety factor concept** you can enter the allowable safety in the dialog box. When using the **partial safety factor concept** the partial safety factor for the shear coefficients as defined in "**Edit/System parameters**" is displayed.

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**".



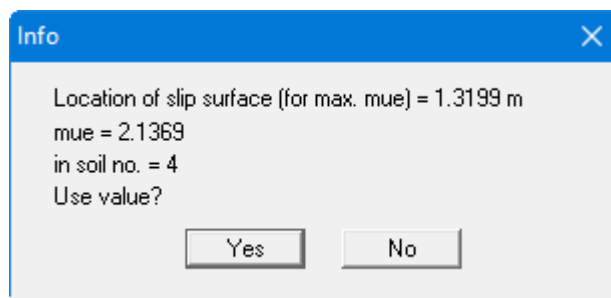
8.3 GGU-SLICE: "Search for critical slip surface" menu item

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 and drawn in the system visualisation at the identified depth.

8.4 GGU-SLICE: "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:



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 , 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.

Distribution function (Monte-Carlo simulation)
✕

Number of runs: 50000

Basic values (mean value/standard deviation)

=====

Standard deviation as multiple of mean values

Slope angle = 18.435 / 1.843

Position of slip surface = 1.100 / 0.011

Groundwater level = 0.500 / 0.005

Friction angle = $\phi(\text{soil})/0.050 \cdot \phi(\text{soil})$

Cohesion = $\text{cohesion}(\text{soil})/0.100 \cdot \text{cohesion}(\text{soil})$

Unit weight = $\text{unit weight}(\text{soil})/0.030 \cdot \text{unit weight}(\text{soil})$

=====

mue (DIN 4084)

1) 0.414 - 0.474: = (14)	
2) 0.474 - 0.534: = (147)	
3) 0.534 - 0.594: ===== (898)	
4) 0.594 - 0.654: ===== (3188)	
5) 0.654 - 0.714: ===== (7357)	
6) 0.714 - 0.775: ===== (10959)	
7) 0.775 - 0.835: ===== (11140)	
8) 0.835 - 0.895: ===== (8200)	
9) 0.895 - 0.955: ===== (4817)	
10) 0.955 - 1.015: ===== (2184)	
11) 1.015 - 1.075: ===== (763)	
12) 1.075 - 1.135: ===== (255)	
13) 1.135 - 1.195: ===== (61)	
14) 1.195 - 1.256: ===== (13)	
15) 1.256 - 1.316: ===== (4)	

Soil mechanics limits exceeded 0 times

Sum = 50000

Fractile value = 0.0250 ==> mue = 1.008

Mean value = 0.7920

Standard deviation = 0.1042

Copy to clipboard

OK

Cancel

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.

9 Output preferences menu

9.1 GGU-SLICE: "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.

9.2 GGU-SLICE: "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"** or, in multi-layer systems, in **"Output preferences/Soil properties legend"**. 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.

9.3 GGU-SLICE: "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.

9.4 GGU-SLICE: "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 Landfill 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.

9.5 GGU-SLICE: "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.

9.6 GGU-SLICE: "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.
- **"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.

9.7 GGU-SLICE: "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.

9.8 GGU-SLICE: "Move objects" menu item

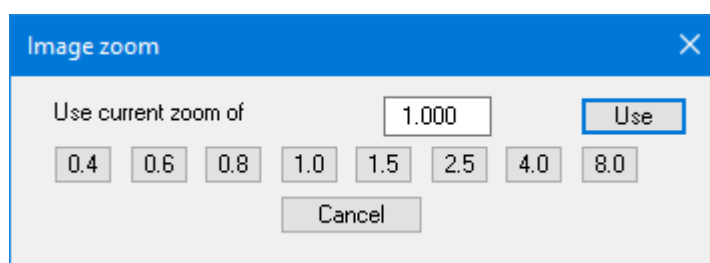
Select this menu item in order to position legends or other graphical elements at the desired position on the output sheet. You can also move objects by pressing **[F11]** and then positioning the legend box with the left mouse button pressed. In that case an info-box appears no more.

10 Graphics preferences menu

10.1 GGU-SLICE: "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.

10.2 GGU-SLICE: "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.

10.3 GGU-SLICE: "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.

10.4 GGU-SLICE: "Pen colour and width" menu item

In order to enhance the clarity of the graphics you can preset the pen settings for various graphic elements in the GGU programs

You can change the pen widths for the elements listed in the dialog box and adjust the pen and/or fill colours by clicking on the button with the element name. In some GGU programs you can also define a line colour for selected elements.

For the graphic output of colours on **monochrome printers** (e.g. laser printers), colours are replaced by an equivalent shade of grey. In the case of very light colours, the corresponding graphic elements are then barely visible on the printer. In such cases, it makes sense to change the colour setting to darker colours.

10.5 GGU-SLICE: "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.

10.6 GGU-SLICE: "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-3D-SSFLOW.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 called up via normal menu titles and menu entries.

Not all of the icons described below are available in all GGU programs.



"Next page"/"Previous page"

You can use these icons to scroll forwards and backwards between individual pages. In many GGU programs, you can use this in the **output table representation**.



"Select page" or "Diagram/Output table"

If you are in the **output table representation**, you can use this symbol to jump to a specific page or switch back to the normal display, i.e. your graphic display.



"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"**).



"Colour on/off" or "Colour/hatching"

If you want to remove the colour from the system display, e.g. to create a black and white printout, you can do this using this on/off switch.

In several GGU programs, 4 colour and hatching settings are possible via this icon, which you can click through 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.

**"Construction phase back"/"Construction phase forward"**

If you are in the display of construction phases, you can use these icons to scroll back and forth between the individual construction phases.

10.7 GGU-SLICE: "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.

10.8 GGU-SLICE: "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**".

11 Info menu

11.1 GGU-SLICE: "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 the GGU program.

11.2 GGU-SLICE: "Help" menu item

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

11.3 GGU-SLICE: "GGU on the web" menu item

Using this menu item, you can access the [GGU Software website](#).

Check the page of your program module at regular intervals for information about updates and changes. On the "**Changelogs**" subpage, you can also subscribe to an e-mail notification that informs you of all changes on a monthly basis.

11.4 GGU-SLICE: "GGU support" menu item

This menu takes you directly to the [GGU Software Support Portal](#).

Here you can enter your support request directly and upload your edited GGU program file.

11.5 GGU-SLICE: "What's new?" menu item

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

11.6 GGU-SLICE: "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.

12 Worked examples

12.1 Single layer system

12.1.1 GGU-SLICE: 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**)

12.1.2 GGU-SLICE: Calculations using old standard

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

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

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

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

$$\eta(\text{DIN 4084}) = 1.65$$

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

$$\eta(\text{GDA}) = 1.71$$

12.1.3 GGU-SLICE: Calculations using new standard

$$\gamma_\phi = 1.25 \text{ (LC 1)}$$

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

$$1/\mu(\text{GDA}) = [c/\gamma_\phi + (\gamma \cdot t_g - u) \cdot \cos(\beta) \cdot \tan(\phi)/\gamma_\phi] / (\gamma \cdot t_g \cdot \sin(\beta))$$

Req. μ = utilisation factor ≤ 1.00

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

$$1/\mu(\text{DIN 4084}) = 1.32$$

$$\mu(\text{DIN 4084}) = 0.76$$

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

$$1/\mu(\text{GDA}) = 1.37$$

$$\mu(\text{GDA}) = 0.73$$

12.2 GGU-SLICE: Multi-layer system

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

12.3 System with geogrid

12.3.1 GGU-SLICE: 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*)

12.3.2 GGU-SLICE: Calculations using old standard

$$\text{Req. } \eta = 1.30$$

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

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

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

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

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

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

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

Passive earth pressure:

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

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

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

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

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

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

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

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

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

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

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

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

12.3.3 GGU-SLICE: Calculations using new standard

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

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

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

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

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

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

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

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

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

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

$$T_d = 1.35 \cdot 382.8 \cdot \sin(18.43) + 1.50 \cdot 1.25 \cdot 55.0 \cdot \sin(18.43) + 1.50 \cdot 18.3 + 1.35 \cdot 26.3 = 163.4 + 32.6 + 27.5 + 35.5 = 259.0 \text{ kN/m}$$

Passive earth pressure:

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

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

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

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

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

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

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

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

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

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

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