

User Guide

ROCK3D

Three-Dimensional Rock Block Analysis Based Key Block Theory

geo&soft[®]
international

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Chapter 1 - Introduction to the program

Introduction to the program

ROCK3D is a program for stability analysis of removable blocks on planar rock slopes. It identifies and analyses all the blocks that have formed under each kinematic mode. Once the geometry of the rock blocks has been identified, the bolt forces necessary to reach a required safety factor are calculated.

The structural geology data collection is carried out through the introduction of the joint orientations and the coordinates of the end points of the joint traces that are visible on the slope surface.

The rock slope orientation and the rock mass parameters are also necessary for the evaluation of the safety factors and for the design of the rock bolts.

The analysis of the discontinuities is performed through hierarchical and non-hierarchical clustering procedures, that allow one to identify the joint sets. The kinematic modes that could give rise to the formation of removable blocks are determined using the Goodman and Shi "Key Block Theory".

The program calculates the maximum closed contours that result from the intersection of the joint traces, which follow a given kinematic mode. The procedure should be repeated for each kinematic mode to identify the worst safety conditions.

The program then calculates the shape of the complex blocks that can be obtained as a union of all the elementary polyhedra that are compatible with the selected kinematic mode, and which are contained within the closed contours identified in the previous stage.

The volume and surfaces of each block are then calculated. The computation ends with the determination of the rock block safety factors and of the rock bolt forces that are necessary to obtain the required stability conditions.

As an option, the program can generate a random distribution of the joints on the rock slope face, to formulate hypotheses on the behaviour of the slope after a subsequent stage of excavation.

The output is made up of the projection on equal-angle stereonet of the joint sets, the plot of the joint traces on the slope face, the polar stereographic projection used in the "Key Block Theory" and the perspective projection of the rock blocks. It is also possible to produce a left and a right view of the blocks, which can be seen in three dimensions with a common stereoscope.

Listings that include the input data and the results of the various calculations can also be generated.

Chapter 2 - System requirements and program installation

System requirements

- Pentium® class processor
- Microsoft® Windows® 95 OSR 2.0, Windows 98, Windows Me, Windows NT®* 4.0 with Service Pack 5 or 6, Windows 2000, or Windows XP
- 64 MB of RAM (128 MB recommended)
- 100 MB of available hard-disk space
- CD-ROM drive
- A printer driver **must** be installed, even if the printer itself is not connected to the PC.

Program installation

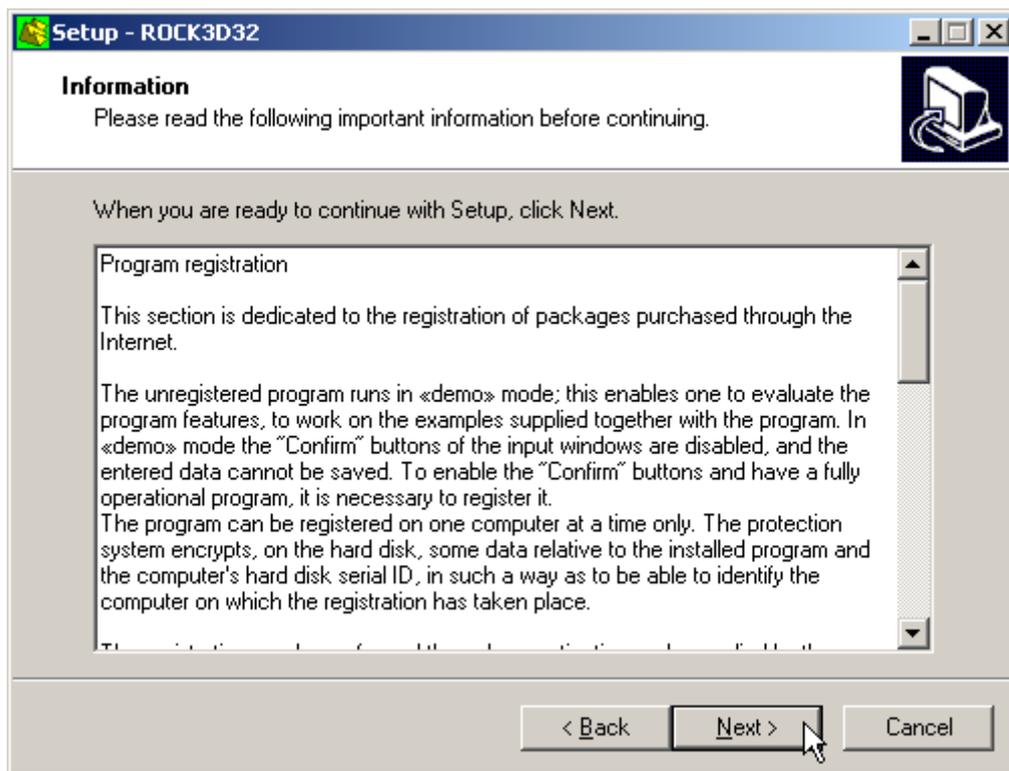
To install the ROCK3D program, run **ROCK3D32SETUP.EXE** from the CD-ROM or from the folder where you downloaded and saved the setup program.



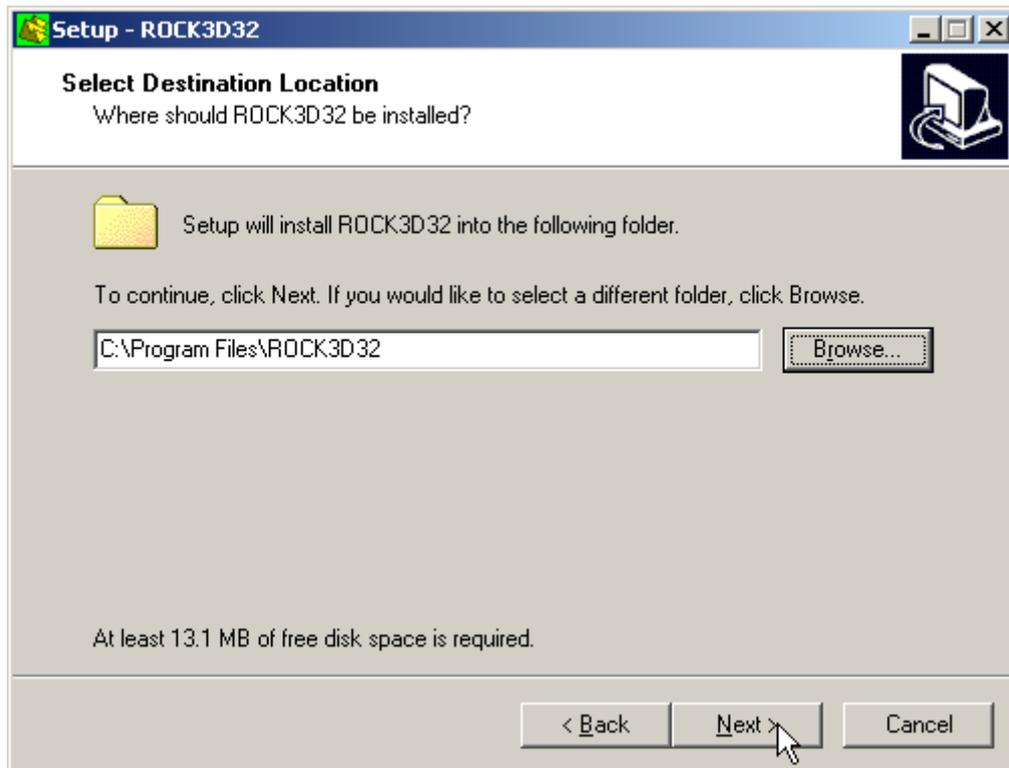
Press the **NEXT** button to start the installation.



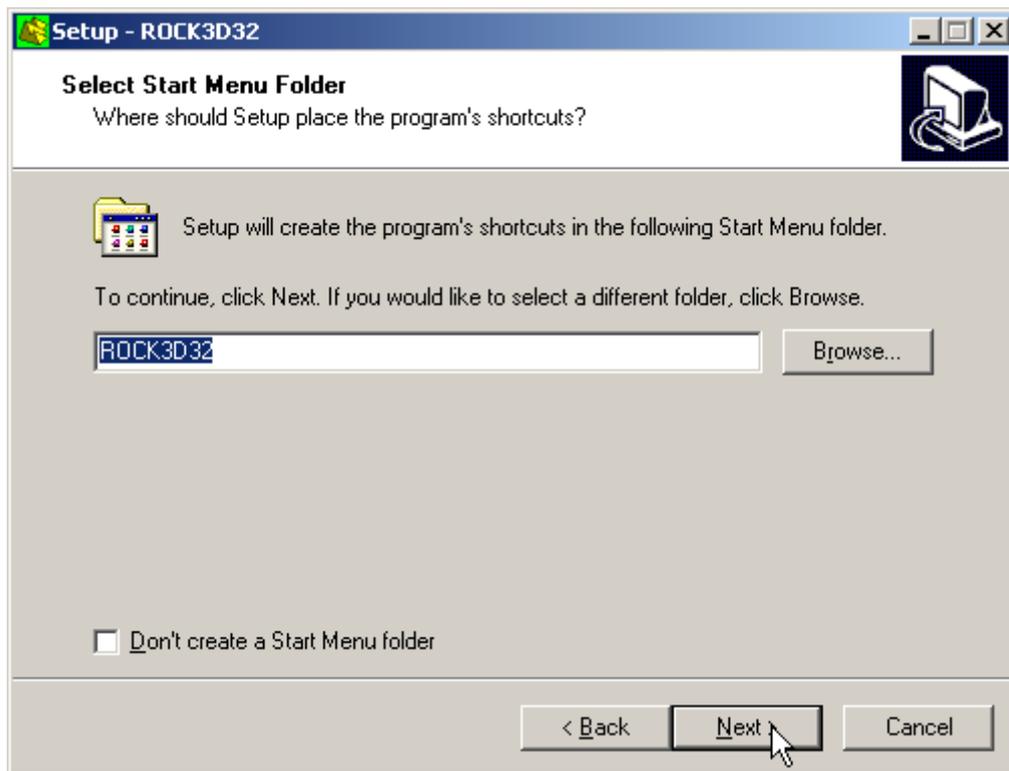
Carefully read the License Agreement and press the **NEXT** button.



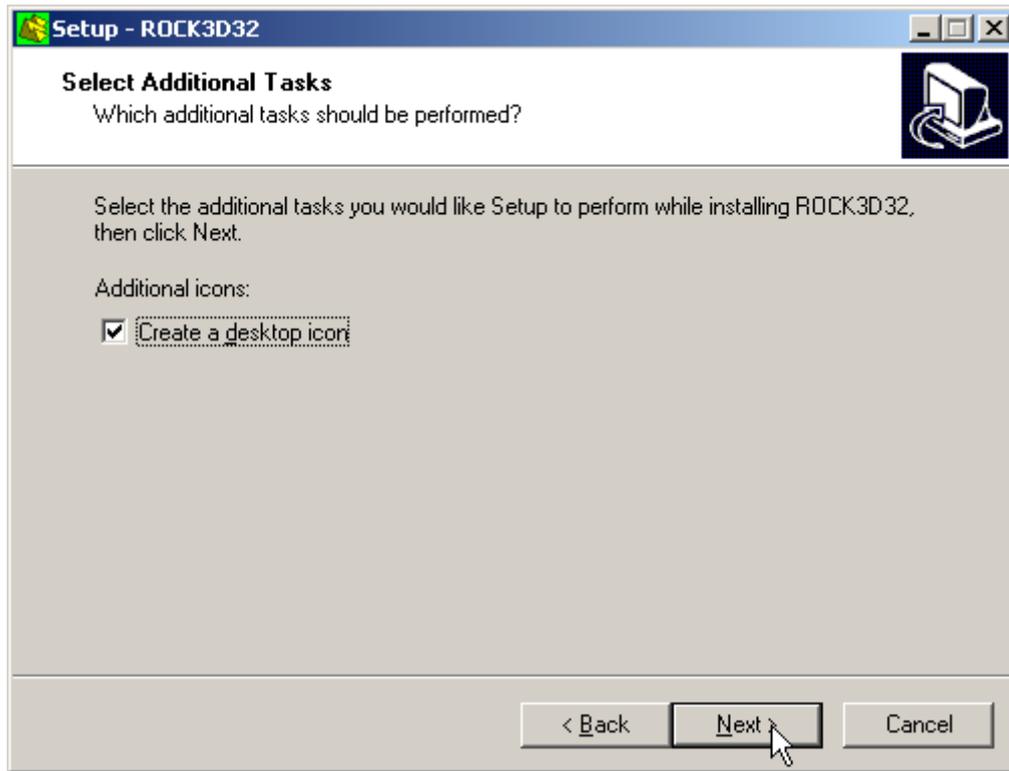
Carefully read the informations about the registration of the software and press the **NEXT** button.



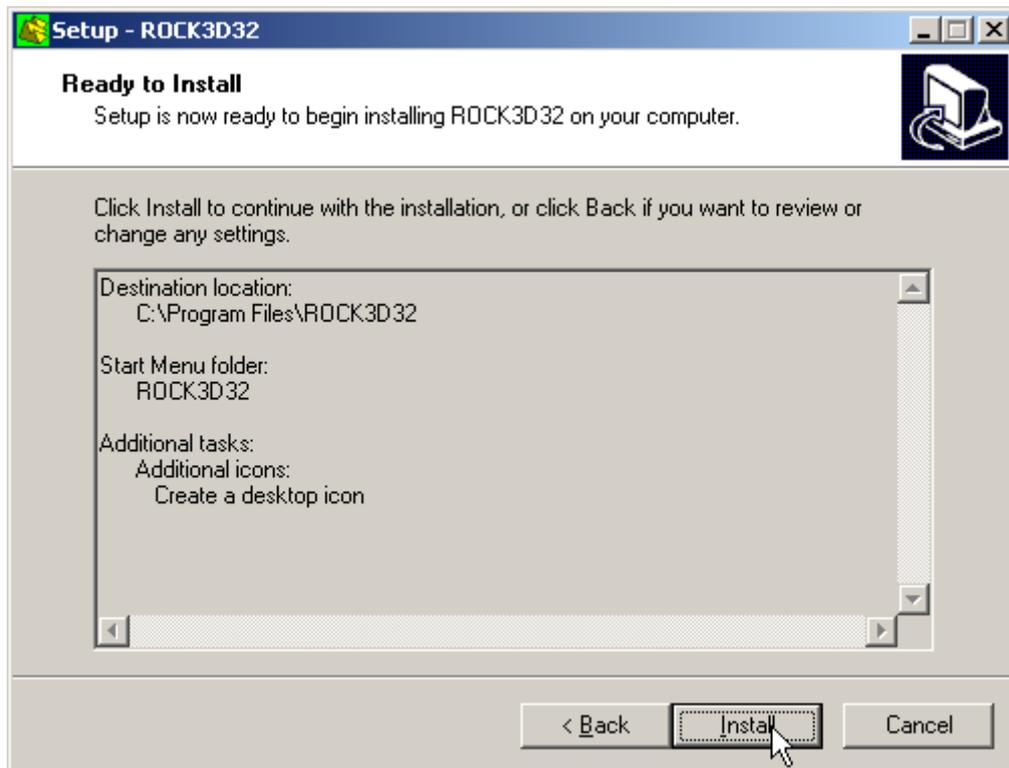
Select the folder where the **ROCK3D32** directory would be created and press the **NEXT** button.



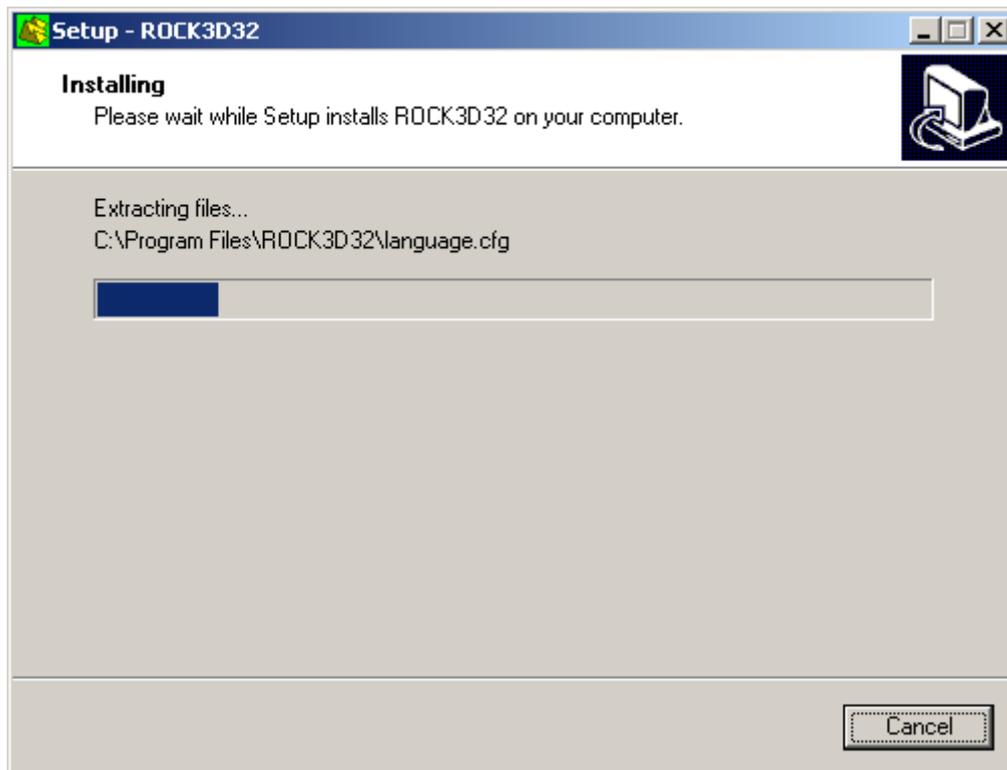
Press the **NEXT** button to create the **ROCK3D32** group in the Start menu.



Choose if you want an icon to be created on your desktop, or not.



Press the **INSTALL** button to continue the installation procedure ...



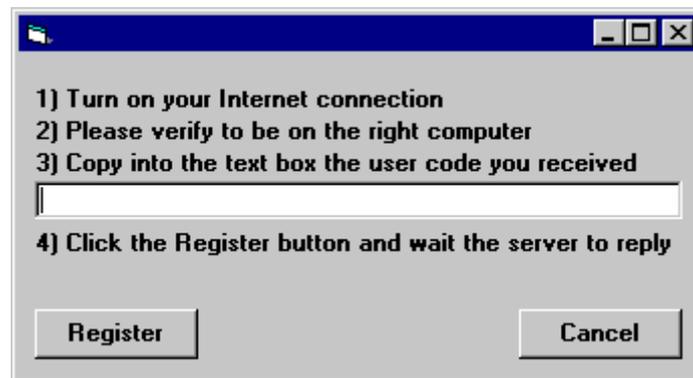
Once completed the installation, press the **END** button to exit the setup procedure and to start **ROCK3D32**.

ROCK3D32 can be run by clicking the **Start** button, then selecting the **ROCK3D32** group in the **Programs** menu, and clicking **ROCK3D32**.

Chapter 3 - The program protection

Program registration

This section is dedicated to the registration of packages purchased through the Internet.



The unregistered program runs in «demo» mode; this enables one to evaluate the program features, working on the examples supplied together with the program. In «demo» mode the «Confirm» buttons of the input windows are disabled, and the entered data cannot be saved. To enable the «Confirm» buttons, and have a fully operational program, it is necessary to register it.

The program can be registered on one computer only at a time. The protection system encrypts, on the hard disk, some data relative to the installed program and to the computer hard disk serial ID, in such a way as to be able to identify the computer on which the registration has taken place.

The registration can be performed, by the manufacturer or supplier, with an **activation code**.

We would like to stress that the encrypted protection data on the hard disk are bound in a unique way to the hard disk itself: subsequently, one can no longer use the activation code to install the program on other computers.

Let us describe the procedure for the registration of the software:

1. select the **Registration** command from the Help menu.
2. turn on your Internet connection
3. copy into the box the activation code you received
4. click the <Registration> button and wait the server to replay

Chapter 4 - How to update the program

Procedure for updating the program

We believe that the best advertising is a client who shows to the colleagues a state-of-the-art product, so we have always made available the free updates of our packages.

Now a new service is available for free: **AutoUpdater** automatically searches and downloads the new components from our web site **www.geoandsoft.com**, saving the older versions in a backup folder.

If you prefer, you still can download the updated full setup from our web site, of course.

To download the updated components with AutoUpdater, follow this procedure:



1. Start the program
2. Click the "**Update**" button at the bottom of the first window.
3. Wait for the program to verify if some updated component is available on our servers. If the program finds new components, it shows the list: each component has a check box which allows to choose if a single component has to be downloaded, or not. AutoUpdater automatically checks the boxes of the components whose download is suggested, and leaves unchecked the files which could have been modified by the user, like the colour configuration files.
4. Select the files you want to download and click the "**Update**" button.
5. Once the files have been installed, AutoUpdater runs the updated program.

AutoUpdater can also be configured to automatically start at each run of the program. Simply check the “update at startup” check box, and AutoUpdater will automatically search for new components each time the program is run.



Autoupdating requirements and troubleshooting

The autoupdating procedure requires an active Internet connection.

The search for new components is directly performed by the program, while the download is performed by AutoUpdater: for this reason, both the main program and AutoUpdater need the right to access to the Internet.

All the autoupdating procedures use the HTTP protocol, port 80, and automatically recognize if a proxy server is used on the local network to access the Internet.

If you experience some problems with the autoupdating procedure, they may be due to a FIREWALL: ask your System Administrator to give the right to access the Internet to the executable of the program (*32.exe) and to the AutoUpdater.exe module, in the program folder. No “act as a server” right is needed.

If particularly hard security rules disallow giving those access rights, remember you can download the updated full setup, from our web site, through your web browser.

Chapter 5 - User Interface

Usage Notations

Some typographical notations and keyboard formats are used in this manual to help locate and interpret information more easily.

Bold print is used to indicate command names and related options. Characters appearing in bold print should be typed exactly as printed, including spaces.

Words written in *italics* indicate a request for information.

CAPITAL letters are used to indicate computer, printer, directory, and file names.

User Interface and Data Entering

The user interface is designed to be easy to use and powerful and is supported by complete on-line help. This help contains practical hints and the theoretical background, where applicable. It should reduce the requirement of frequently consulting the printed manuals.

All the commands are located inside a menu bar. Each menu contains a list of commands that one can select with the mouse or the keyboard. The arrangement of the menus, designed with ergonomic criteria, follows the logical order of the operations, inhibiting the access to further operations until all the necessary data have been entered.

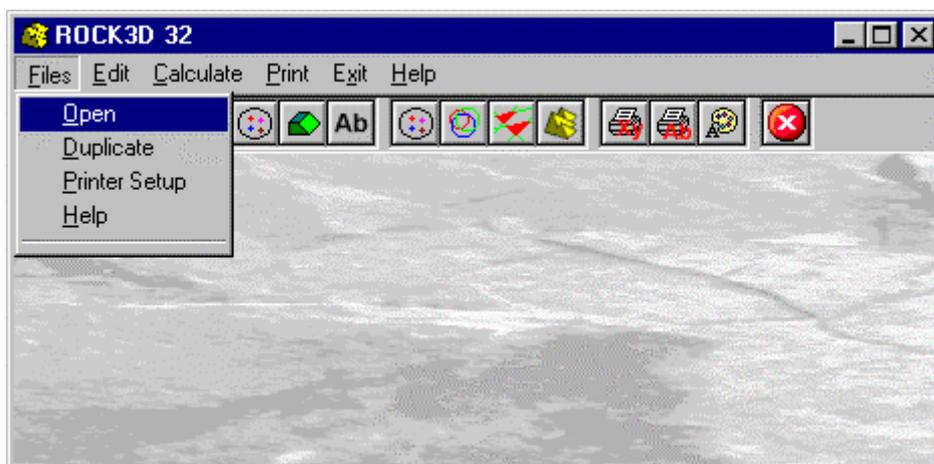
The interface layout is maintained in all of our programs, to simplify, as much as possible, the transition from one program to another to avoid having to learn different commands and procedures for similar functions (such as entering data or managing files).

Let us examine the general components that are available in the user interface of geo&soft programs.

User Interface: Menu Bar and Menus

The Menu Bar manages the access to all the program commands. The goal of the menu design is to offer an ergonomic, simple, and understandable arrangement of the commands.

The menus used to perform a complete operation are normally ordered left to right and top to bottom. When possible, the following scheme is used: definition of the name of the project, entering the required data, performing the calculation, and generating the output as a preview or final print.



The programs automatically disable some menus or commands when the execution of such menus or commands is not yet feasible. Typical examples are: a calculation menu is disabled when not all the data needed for the calculation have been completely entered, or a print menu is disabled if not all the calculations have been executed.

To choose a command from a menu, use the following procedures:

- ☞ Point the menu that is to be activated, click the left button of the mouse, then point the command to be activated, and click the left button of the mouse again. If one does not wish to select any command from the menu that is open, exit the area of the menu before releasing the mouse button.

The Input Dialogue Windows

The different menu commands can perform an immediate action, or display a dialogue window in order to input or edit the various data sets.

When a dialogue window is visible, all the actions that do not pertain to it are ignored. Hence, it is necessary to close the dialogue window to resume the normal use of the program.

Some fundamental tools are used inside the dialogue windows: data fields such as text and list boxes, and buttons.

The text boxes are used to input numerical values and text strings. Most of the editing keys (HOME, END, INS, DEL, etc.) can be used inside these fields. If one sees a small arrow pointing down on the right side of the data field, one has a list box.

To scroll the list box and select an item, do as follows:

- ☞ click the arrow, and then click the item to be selected.

There are three buttons in the dialogue window:

- <Ok> - this button saves the entered information and goes on to the next phase.
- <Cancel> - this button closes the Dialogue window without saving the just entered data, or without executing the command.
- <Help> - this opens a window that contains general information on how to use the dialogue windows.

To use the buttons:

- ☞ click the button

To edit the data inside the dialogue window, use the following keys:

- TAB - moves the cursor to the next field; when the cursor is inside the last visible field the cursor goes to the first control button of the Dialogue window. To return to the previous field, press SHIFT+TAB.
- ENTER - moves the cursor to the next field. If the cursor is positioned on one of the window buttons, the corresponding command is executed.
- BACKSPACE - cancels the last character that has been entered.
- DEL - cancels the character to the right of the cursor.

- ESC - closes the Dialogue window without saving the entered values or without executing the command. The <Cancel> button will do the same.
- UP ARROW/ DOWN ARROW - these are used in multiple fields, or those fields that have a list box.
- LEFT ARROW/ RIGHT ARROW - moves the cursor to the previous or next field.
- HOME -moves the cursor to the beginning of the field.
- END - moves the cursor to the end of the field.

A yellow box with a short text that explains the meaning of the value to be entered, can be seen in the lower part of the window. If the text is not completely visible, click the yellow box to read the complete text.

Data Input With Tables

Tables are used to enter long sequences of numerical values and/or text strings. The keys to be used are the following:

N.	Dip [*]	Dip dir. [*]	Abcissa [m]	Ordinate [m]	Length [m]	Phi [*]	Cohesion [kN/m ²]
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

This is the discontinuity dip in degrees from the horizontal.

Ok Cancel Insert Delete Help

- TAB - moves the cursor to the first button in the window. When one presses this key again, the cursor is moved to the next button.
- SHIFT+TAB - moves the cursor to the previous button.
- ENTER - moves the cursor into the next input field. If the cursor is positioned on one of the window buttons, the corresponding command is executed.
- PAGE UP - moves the cursor up 15 lines.
- PAGE DOWN - moves the cursor forward 15 lines.
- UP arrow - moves the cursor to the input field directly above.
- DOWN ARROW - moves the cursor to the input field directly below.
- LEFT ARROW / RIGHT ARROW - moves the cursor to the field respectively to the left or to the right of the current position.
- HOME - moves the cursor to the beginning of the line.
- END - moves the cursor to the end of the line.
- F2 - copies the field contents to the extended editing field under the title bar in order to facilitate the editing

of the long strings. When working in this editing field, please **REMEMBER** to press ENTER, even before clicking the <Ok> button. Double-clicking a field has the same effect as pressing the F2 key.

The tables have two additional buttons:

- <Insert> - creates an empty line before the one in which the cursor is positioned.
- <Delete> - deletes the line in which the cursor is positioned.

IMPORTANT SUGGESTION: you can copy data to or from other programs such as Microsoft Excel:

The data entered in the table can be copied in order to be pasted into another table. To copy the table's contents:



press the key combination CTRL+C. The contents will be copied into the Clipboard of Windows.

To paste the Clipboard contents into the table:

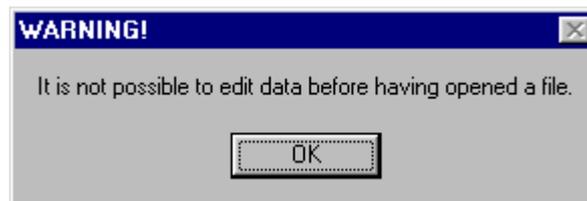


press the key combination SHIFT+INS, or CTRL+V.

A yellow box with a short text that explains the meaning of the value to be entered, can be seen in the lower part of the window. If the text is not completely visible, click the yellow box to read the complete text.

Message Windows

The function of these windows is to give information to the user concerning the system status, as in the case of an error due to an improper use of the program.



Help On Line

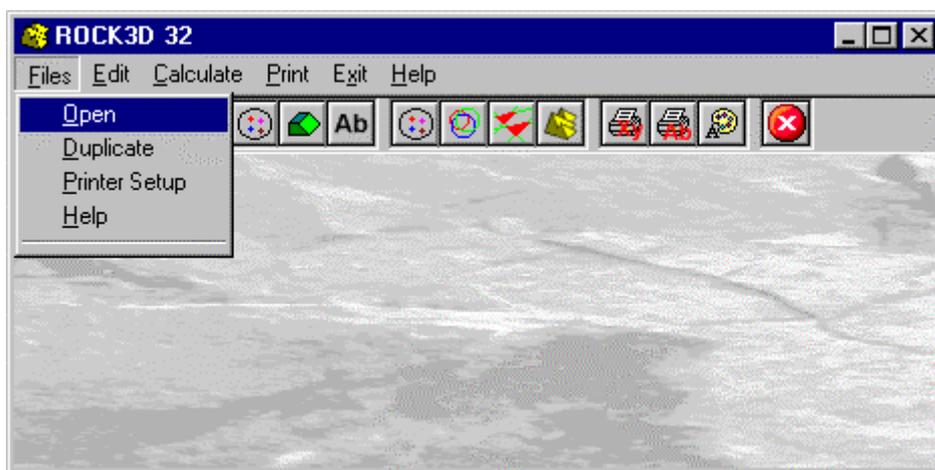
A complete Help On Line is available. It is possible to ask for information or suggestions related to the commands or the use of the program. In order to access the help on line, proceed as follows:

1. Position the cursor on a field of a dialogue window and press F1.
2. Use the Summary from the Help menu.

Chapter 6 - Commands

Files Menu

This menu contains all the commands that are used to open and duplicate the files which contain all the project data.



Open Command

To open a new file:

- ☞ from the menu, choose Open by first clicking on the Files menu, then on the Open command. In the File Name field type the name of the new file and confirm.

The name of the file in use will be reported in the title bar of the main window.

The name of the file should not contain spaces and/or punctuation marks. It is not necessary to indicate an extension, since the extensions will be automatically added to each data set.

In the program there is no specific command to save data, as these are automatically saved after any data entry or elaboration.

Duplicate Command

Allows the duplication of an entire data set; this option can be useful, for example, to save the analyses of each kinematic mode as different data sets. To duplicate a file:

- ☞ from the menu, choose Duplicate by first clicking on the Files menu, then on the Duplicate command. type the name of the new file in the File Name field and confirm.

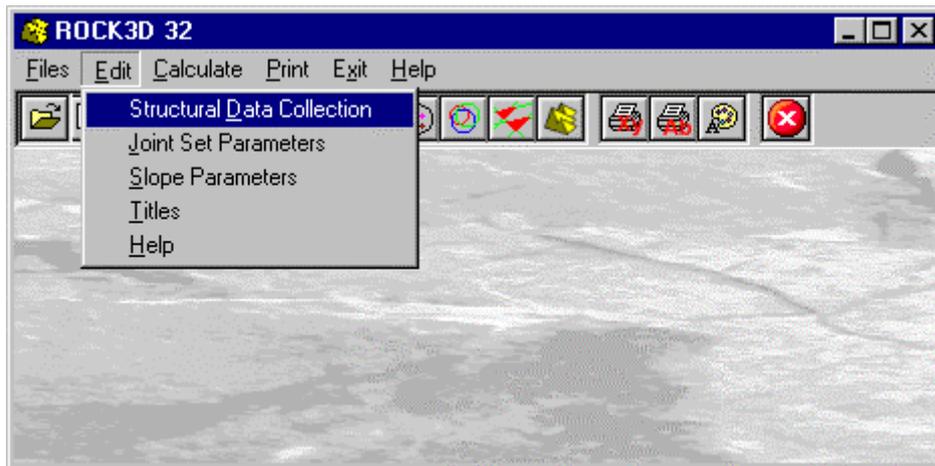
The program will duplicate the file in the current directory unless otherwise specified. To duplicate a file in a different disk or directory, type the full path before the file name in the File Name field.

Printer Setup Command

By selecting this command one goes to "Print" dialog box. Here one can verify and modify the Default printer's Setup or select another printer from those installed one ones system.

Edit Menu

This menu is used to enter and edit the input data used for the rock stability analysis.



Structural Data Collection Command

This enables one to enter and edit the geometrical and geomechanical data acquired with the structural geology data collection.

The "Structural Data Collection Sheet" Dialogue Box

In the "Structural Data Collection Sheet" dialogue box, one can input the following data:

N.	Dip [°]	Dip dir. [°]	Abscissa [m]	Ordinate [m]	Length [m]	Phi [°]	Cohesion [kN/m ²]
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

This is the discontinuity dip in degrees from the horizontal.

Ok Cancel Insert Delete Help

- *Dip*: this is the discontinuity dip in degrees from the horizontal;
- *Dip dir.*: this is the discontinuity dip direction in degrees from the North;
- *Abscissa, Ordinate*: this is the position of the discontinuity on the slope face. The program uses local coordinates with the origin in the lower left corner of an imaginary rectangle that represents the slope face. The X-axis is horizontal; the Y-axis has the same dip as the slope. Only the lower end point of each discontinuity trace must be defined, because the other one is automatically calculated as a function of the

orientation of the discontinuity and of the slope. If the discontinuity trace is horizontal, the leftmost end point must be entered.

- *Length*: this is the length of the trace in meters;
- *Phi*: this is the friction angle along the discontinuity in degrees; this parameter is optional because it can be assigned to each joint set after the cluster analysis;
- *Cohesion*: this is the cohesion along the discontinuity in kN/m^2 ; this parameter is optional because it can be assigned to each joint set after the cluster analysis.

Joint Set Parameters Command

This command enables one to enter and edit the geomechanical parameters of the joint sets, and can only be used if the cluster analysis has already been performed.

The “Joint Set Parameters” Dialogue Box

The joint sets obtained from the cluster analysis are shown in the “Joint Set Parameters” dialogue box, and it is possible to enter/modify the average values of the friction angle and cohesion.

N.	Dip [°]	Dip dir. [°]	Phi [°]	Cohesion [kN/m ²]
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Dip of the joint sets in degrees from horizontal.

Ok Cancel Insert Delete Help

- *Dip*: dip of the joint sets in degrees from the horizontal;
- *Dip Dir*: dip direction of the joint sets in degrees from the North;
- *Phi*: average friction angle of the joint set discontinuities in degrees; this should be the value that is measured along the discontinuity surface and not the value of the hard rock;
- *Cohesion*: average cohesion of the joint set discontinuities in kN/m^2 ; this should be the value that is measured along the discontinuity surface and not the value of the hard rock.

These parameters are used for the wedge stability analysis.

Slope Parameters Command

This command enables one to enter and edit the slope parameters.

The “Slope Parameters” Dialogue Box

In the “Slope Parameters” dialogue box, one can input the following data:

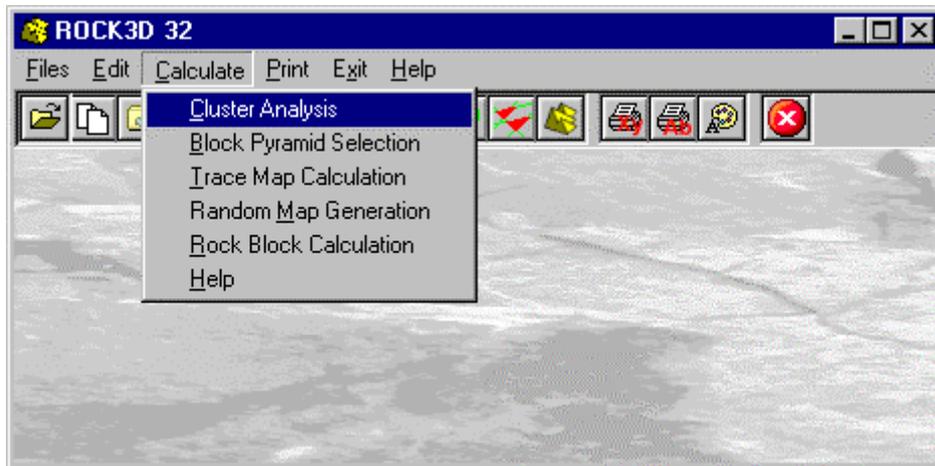
- *Gamma*: rock unit weight (kN/m^3);
- *Slope Dip*: dip of the slope (degrees);
- *Slope Dip Direction*: dip direction of the slope (degrees);
- *Slope width*: the program uses local coordinates with the origin in the lower left corner of an imaginary rectangle that represents the slope face. The Slope width is the width of this rectangle (meters);
- *Slope height*: this is the height of the imaginary rectangle that represents the slope face (meters); the Y-axis has the same dip as the slope, so this value usually does not coincide with the elevation difference between the top and the bottom of the rectangle.

Titles Command

This command enables one to enter and edit a title and three sub-titles.

Calculate Menu

This menu is used to execute the sequence of calculation steps that are necessary to complete the rock stability analysis. The commands contained in this menu are ordered following the logical sequence of the required calculation steps.



Cluster Analysis Command

This command enables one to perform the cluster analysis of the collected structural geology data. The program recognises the discontinuity sets of a rock mass through hierarchical and non-hierarchical clustering procedures that are derived from the multivariate analysis.

These clustering procedures operate directly on the collected data instead of on their statistical distribution; the results are consequently closer to the geomechanical reality.

The interactivity of the clustering procedure offers the operator a better control of the full sequence of operations since it is possible to choose the clustering level (and hence the size of the clusters), as well as the algorithms for the assignment of the joints to the discontinuity sets.

With this command the stereographic projection of the discontinuities is drawn (on the upper hemisphere). The poles are shown as circles, with larger diameters if discontinuities with the same orientation are present.

The clustering can be executed even though the position and length of the discontinuities have not been entered, since only the orientation is used for this operation.

Hierarchical clustering means that a tree is built through a process of cluster aggregation; starting with n clusters, each of which contains only one pole, the two closest clusters are aggregated into one at each step and, after n steps, only one cluster is obtained that contains n poles.

This procedure offers three methods to calculate the distance between two clusters:

- the Group Mean method in which the distance is equal to the mean of all the distances between all the pairs of the poles of the two clusters;
- the Nearest Neighbour method in which the distance is equal to the distance between the two nearest poles of the clusters;
- the Furthest Neighbour method in which the distance is equal to the distance between the two furthest poles of the clusters.

The operator can then analyse the tree and choose the optimal clustering level.

An optional stage of non-hierarchical clustering can be performed to refine the results obtained with the hierarchical clustering. This method is based on the following steps:

1. the operator defines a limit angle: a pole can only belong to a cluster if the angular distance from the cluster centre is lower than the given angle.
2. the positions of the cluster centres are calculated as the weighted vectorial sum of the poles that belong to the clusters.
3. the poles are reassigned to the clusters taking the limit angle and the new cluster centre position into consideration.

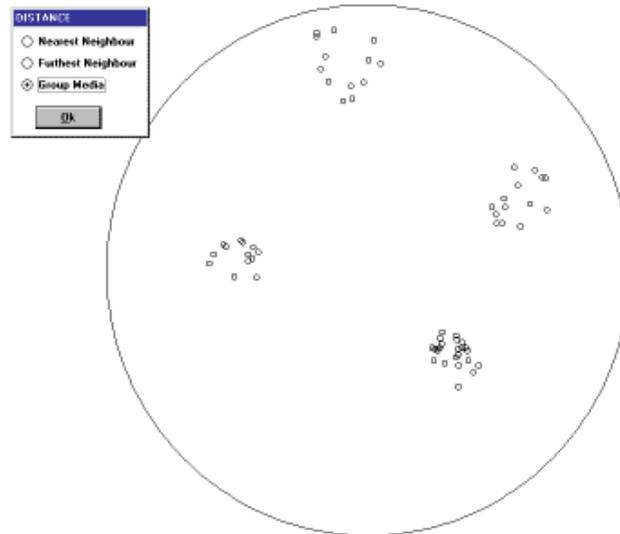
Steps 2 and 3 are repeated until a stable configuration is reached.

Non-hierarchical clustering must be used with caution, and it is necessary to verify that all the poles belong to a

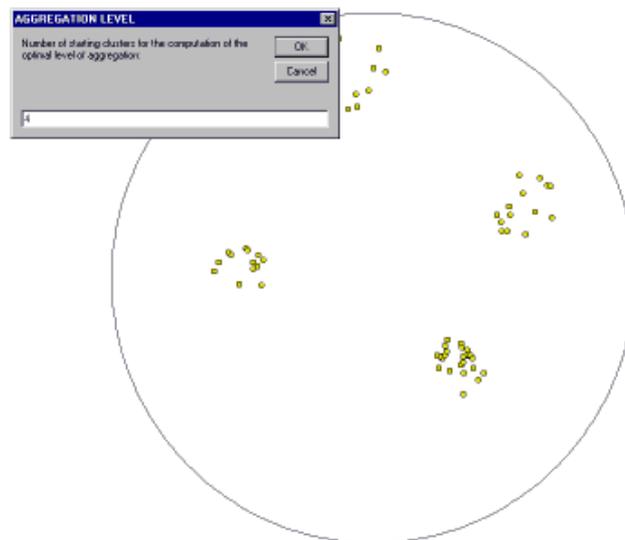
cluster before proceeding with the rock slope stability analysis.

USING THE CLUSTERING PROCEDURE

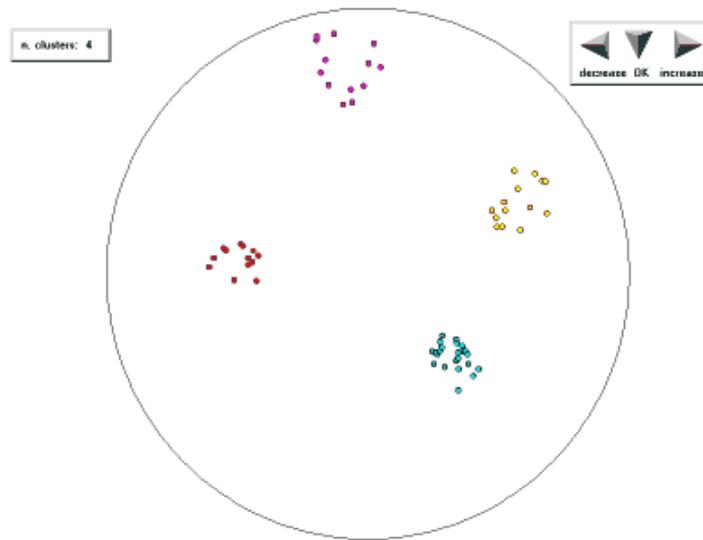
Select the algorithm for the calculation of the distance between two clusters by clicking one of the option buttons.



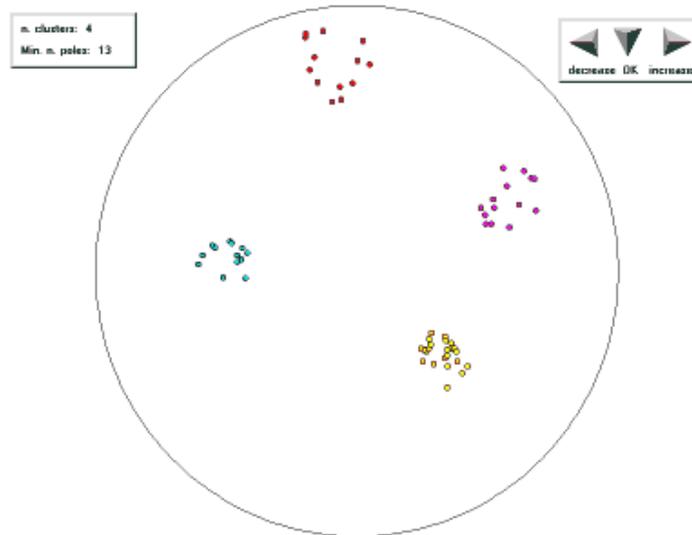
Once the cluster tree has been completed, it is possible to select an initial clustering level by entering the initial number of clusters into the dialogue box.



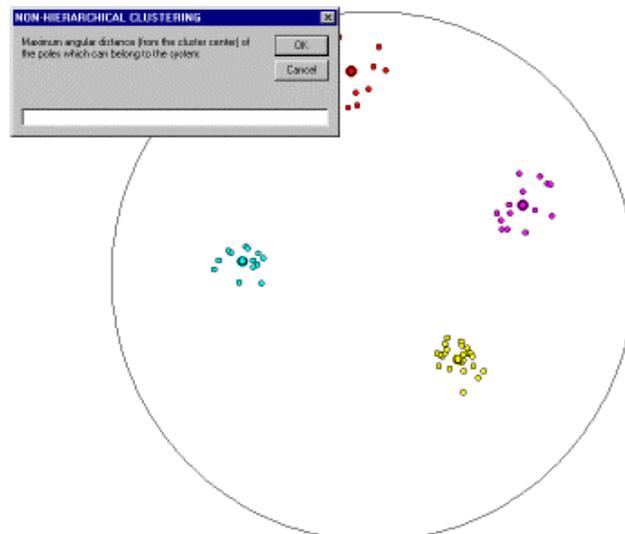
Click the <Increase> and <Decrease> buttons to analyse the tree and to choose the optimal clustering level, then click the <OK> button.



Click the <Increase> and <Decrease> buttons to choose the number of significant clusters, then click the <OK> button. **Do not decrease** the number of significant clusters if the rock slope stability has to be performed.



It is now possible to perform the non-hierarchical clustering. A value for the limit angle should be entered into the field, and the <OK> button should be clicked. If the field is left blank (or a zero value is entered) the non-hierarchical clustering is not performed. **Do not perform** the non-hierarchical clustering if the rock slope stability has to be performed.



At this point, it is possible to confirm the obtained results by clicking the <Ok> button. To repeat the clustering procedure, click the <Back> button.

Once done, the program calculates the average geomechanical parameters of the joint sets, which can be modified with the Joint Set Parameters command of the Edit menu.

If the values of the friction angle and cohesion have not been individually assigned to each discontinuity, they **must** be manually assigned to each joint set with the Joint Set Parameters command of the Edit menu.

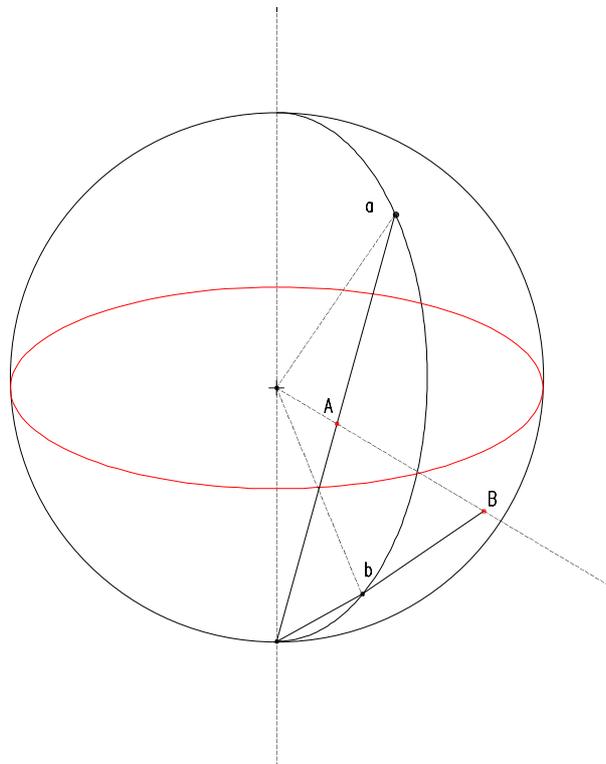
Once the Cluster Analysis has been performed, it is possible to execute the Block Pyramid Selection.

Block Pyramid Selection Command

The kinematic modes that could give rise to the formation of removable blocks are determined using the Goodman and Shi "key block theory".

The program calculates the maximum closed contours that result from the intersection of the joint traces, which follow a given kinematic mode. The procedure should be repeated for each kinematic mode to identify the worst safety conditions.

A particular projection of the joint sets is shown with the Block Pyramid Selection Command. On the usual stereonet the great circles can only be drawn on the lower hemisphere. In the projection used in the "key block theory", given a reference circle (red) that represents the intersection of the sphere with the horizontal projection plane, the points on the upper hemisphere are projected inside the reference circle; the points on the lower hemisphere are instead projected outside the reference circle (see figure).



The planes are projected as circles, and the intersection lines of the planes appear as intersection points of the circles.

If at least three joint sets are added, the projection plane results to be divided into a certain number of areas: each of these areas represents a joint pyramid and is identified by a code composed "0" and "1" digits.

The joint sets (i.e. the circles) are numbered, and the position of the "0" and "1" digits refers to the number of the joint sets.

The meaning of "1" is "the joint pyramid is under the plane", and "0" means "the joint pyramid is over the plane".

For example, a joint pyramid "0010" is over planes 1,2,4 and under plane 3.

The special **green** circle which can be seen in the projection represents the slope face. To obtain a finite rock block, a joint pyramid must never cross the slope face circle, as this would mean that the pyramid is partially directed inside the rock mass, and partially outside.

The joint pyramids that cross the slope face circle must be ignored.

The joint pyramids that lie completely inside the reference circle face completely upwards and must also be ignored.

A special digit must be added to transform the joint pyramids into block pyramids. This digit tells the program whether the rock mass is under (digit="1") or over (digit="0") the slope face.

If the rock mass is under the slope face: choose only (and all) the joint pyramids that lie completely inside the slope face circle from the set of pyramids that have not been ignored, and add the digit "1" at the end of the code.

If the rock mass is over the slope face: choose only (and all) the joint pyramids that lie completely

outside the slope face circle from the set of pyramids that have not been ignored, and add the digit "0" at the end of the code.

For example, in the figure below we have:

Joint pyramids ignored because they cross the **green** slope face circle:

0000, 1000, 1001, 1101, 1111, 0111, 0110, 0010

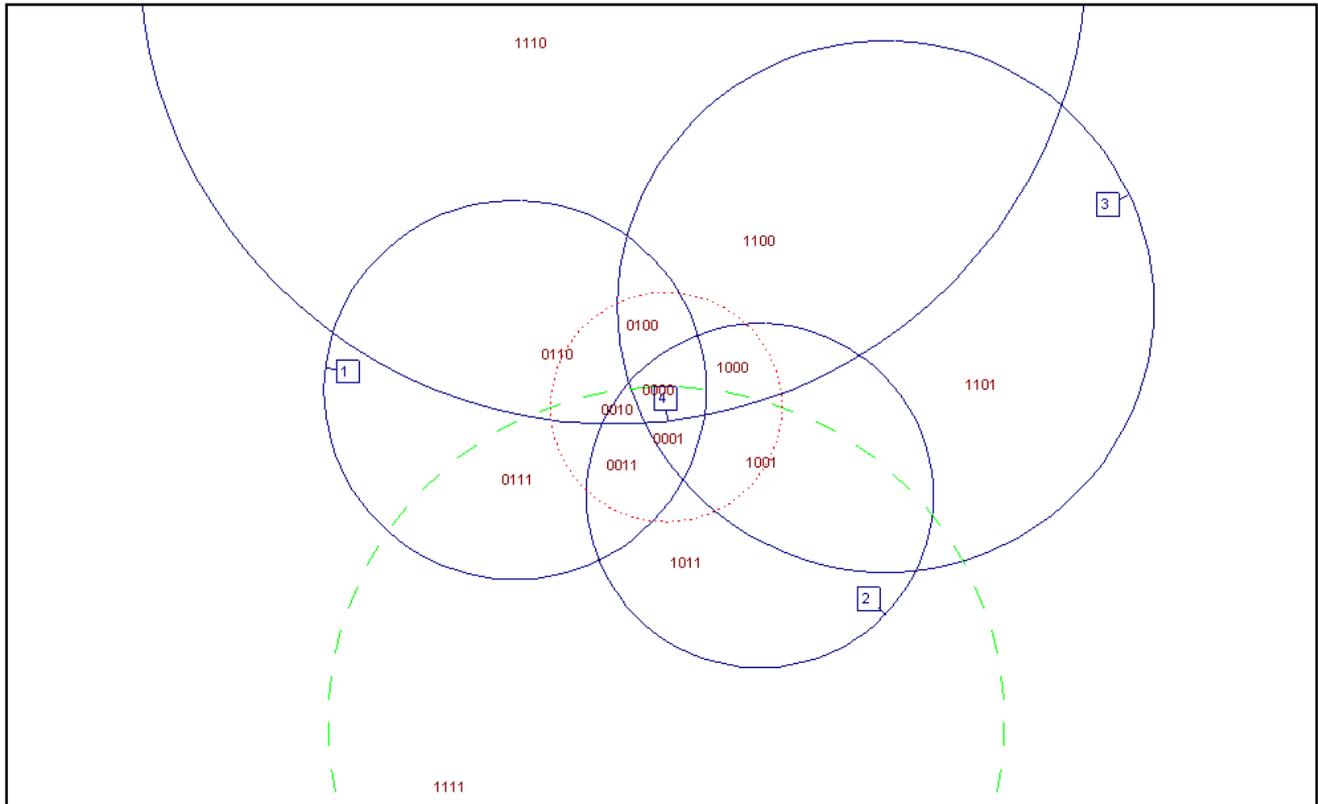
Joint pyramids ignored because they are completely inside the **red** reference circle:

0001 (note: 0010 and 0000 have already been excluded)

Valid Block pyramids:

00111, 10111 (if the rock mass is under the slope face)

01000, 11000, 11100 (if the rock mass is over the slope face)



The Block Pyramid Selection Command must be repeated for all the valid Block pyramids, otherwise one risks ignoring the kinematic modes that can give rise to the formation of removable blocks with safety factors that are lower than the previously calculated ones.

Once the Block Pyramid Selection has been performed, it is possible to execute the Trace Map Calculation.

The Trace Maps Calculation and the Rock Block Calculation **must be repeated for each Block pyramid**.

For further information on the method used by the program, reference can be made to specific literature, and to the book by Goodman R. & Shi G. "Block theory and its application to rock engineering" Prentice Hall, inc., London (1985).

Trace Map Calculation Command

The program calculates the maximum closed contours that result from the intersection of the joint traces, which follow a given kinematic mode. The procedure **must** be repeated for each kinematic mode to identify the worst safety conditions

After the calculation the Print Preview window is shown to allow one to check the trace map.

Once the Trace Map Calculation has been performed it is possible to execute the Rock Block Calculation.

Random Map Calculation Command

This command is used in some special cases but it is usually unnecessary to execute it.

It generates a random distribution of the position of the discontinuities on the slope face.

The main purpose of this operation is to obtain a statistical analysis of the volume of the rock blocks. This can be useful when structural data have been collected on only a portion of a large slope, and the results should be extended to the whole slope face. The procedure should be repeated to obtain a sufficiently large number of

results to allow the statistical analysis to be performed.

It sometimes occurs that one has an old structural data set, collected without measuring the positions and the lengths of the discontinuity traces. In this case it is possible to make a guess at the trace lengths, to assign 0,0 as the endpoint position of each trace, and then to perform a statistical analysis of the obtained results.

After this calculation the Print Preview window is shown, to allow one to check the trace map.

Once the Random Map Calculation has been performed, it is possible to execute the Rock Block Calculation.

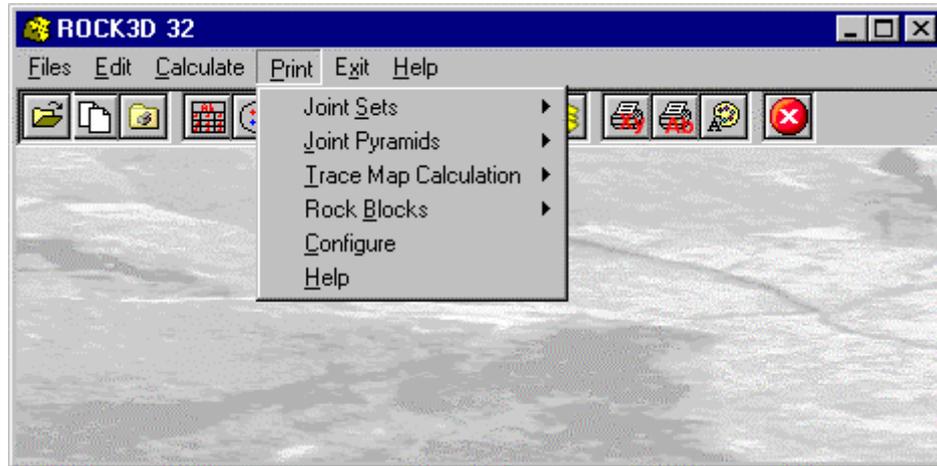
Rock Block Calculation Command

This command calculates the shape of the complex blocks that can be obtained as a union of all the elementary polyhedra that are compatible with the selected kinematic mode, and which are contained within the closed contours identified in the Trace Map Calculation stage.

The volume and surfaces of each block are then calculated. The computation ends with the determination of the rock block safety factors and of the rock bolt forces in the sliding direction, that are necessary to obtain the required stability conditions. The stability analysis neglects toppling instability phenomena.

Print Menu

The Print menu is used to configure the graphical output and to plot the partial and final results: joint sets, joint pyramids, trace map and rock blocks.



Joint Sets Command

The Joint Sets Command prints graphics and listings of the results of the cluster analysis.

Graphics Command

Selecting this command, the Print Preview window is opened, and the results of the cluster analysis are shown. An equal-angle projection on the upper hemisphere is used, to be compatible with the Joint Pyramid projection. Each joint set is drawn in a different colour, and is represented by a different graphical symbol to also allow black and white outputs.

The Graphical Output Preview Window

The Toolbar is located in the upper side of the preview window.

The Toolbar allows fast access to the commands with the mouse. Click the corresponding icon, to select one of the commands that belong to the Toolbar. The Toolbar displays the following commands:



- **Zoom +** : clicking the first icon activates the ZOOM function (it can only be used with the mouse) that permits the enlargement of part of the drawing. The function remains active until the Zoom - icon is selected. To enlarge a part of the drawing:
 - ☞ click the icon, and then select the area to be enlarged by clicking the upper-left corner and dragging the mouse pointer to the lower-right corner. At this point, release the mouse button. Note: due to the low resolution of the screen, the texts could appear in a slightly different scale at different zoom levels. This does not affect the quality of the final printouts.
- **Zoom -** : click this icon to return to the original scale of the preview.
- **Arrows**: click the arrow icons, in "Zoom + " mode, to pan the on-screen preview.
- **Print**: click the print icon to send the drawing to the default printer.
- **Resized print**: click this icon to send the drawing to the default printer. The image will be resized to fit the current paper size.
- **DXF**: one can export the graphic output as a DXF file by clicking this icon; it gives access to a dialogue window that enables one to assign a different name to the DXF file, which has, by default, the same name as the current project.
- **EMF/W**: This icon allows the graphic output to be exported to a version of the Enhanced Windows Metafile which is compatible with Microsoft Word. Clicking this icon gives access to a dialogue window that enables one to assign a different name to the EMF file, which has, by default, the same name as the current project.

- **EMF/D**: This icon allows the graphic output to be exported to a version of the Enhanced Windows Metafile which is compatible with Corel Draw. Clicking this icon gives access to a dialogue window that enables one to assign a different name to the EMF file, which has, by default, the same name as the current project.
- **BMP**: one can export the graphic output as a BMP file by clicking this icon; it gives access to a dialogue window that enables one to assign a different name to the BMP file, which has, by default, the same name as the current project.
- **GIF**: one can export the graphic output as a GIF file by clicking this icon; it gives access to a dialogue window that enables one to assign a different name to the GIF file, which has, by default, the same name as the current project.
- **JPG**: one can export the graphic output as a JPG file by clicking this icon; it gives access to a dialogue window that enables one to assign a different name to the JPG file, which has, by default, the same name as the current project.
- **Exit**: click this icon to close the preview window and return to the main menu.

Listing Preview Command

With this command, it is possible to preview the listings of the calculation results. The listings cannot be changed in the preview window.

The scroll bar, the UP arrow and DOWN arrow keys, or the PAGE UP e PAGE DOWN keys can be used to scroll the page. To exit press ESC or double-click any point of the window.

Listing Direct Print Command

With this command, it is possible to directly send the listings of the calculation results to the printer.

Listing Export to DOC

With this command, it is possible to export the listings of the calculation results into the DOC format (Microsoft Word 97 compatible).

The program creates a file with the same name as the current project but with the ".DOC" extension; the file is saved in the same directory as the data files.

The file is automatically opened if the program finds the Microsoft Word executable.

Listing Export to TXT

With this command, it is possible to export the listings of the calculation results into the TXT format (Microsoft Notepad compatible).

The program creates a file, with the same name as the current project but with the ".TXT" extension; the file is saved in the same directory as the data files.

The file is automatically opened if the program finds the Microsoft Notepad executable.

Listing Export to SLK

With this command, it is possible to export the listings of the calculation results into the SLK format (Microsoft Excel 97 compatible).

The program creates a file, with the same name as the current project but with the ".SLK" extension; the file is saved in the same directory as the data files.

The file is automatically opened if the program finds the Microsoft Excel executable.

Joint Pyramids Command

The Joint Pyramids Command allows one to print the projection that is used in the Key Block Theory.

Graphics Command

Selecting this command, the Print Preview window is opened, and the projection of the joint pyramids that is used in the Key Block Theory is shown.

The Joint Pyramids are presented as they are described in the "Block Pyramid Selection Command" section.

A second projection is present in the graphical output, in which the sliding planes for each kinematic mode are shown.

Examples of the used codes:

- 23 wedge sliding on planes 2 and 3
- 3 planar sliding on plane 3
- 0 vertical fall (for example, from an underground roof)

blank sliding is not possible

The red dotted circle represents the reference circle; the green dashed circle represents the slope face. The numbered blue circles represent the joint sets.

Trace Map Command

The Trace Map Command prints the map of the discontinuity traces on the slope face.

Graphics Command

Selecting this command, the Print Preview window is opened, and the map of the discontinuity traces on the slope face is shown. The maximum closed contours that result from the intersection of the joint traces are highlighted in a different colour.

Listing Preview Command

With this command, it is possible to preview the listings of the calculation results. The listings cannot be changed in the preview window.

The scroll bar, the UP arrow and DOWN arrow keys, or the PAGE UP e PAGE DOWN keys can be used to scroll the page. To exit press ESC or double-click any point of the window.

Listing Direct Print Command

With this command, it is possible to directly send the listings of the calculation results to the printer.

Listing Export to DOC

With this command, it is possible to export the listings of the calculation results into the DOC format (Microsoft Word 97 compatible).

The program creates a file with the same name as the current project but with the ".DOC" extension; the file is saved in the same directory as the data files.

The file is automatically opened if the program finds the Microsoft Word executable.

Listing Export to TXT

With this command, it is possible to export the listings of the calculation results into the TXT format (Microsoft Notepad compatible).

The program creates a file, with the same name as the current project but with the ".TXT" extension; the file is saved in the same directory as the data files.

The file is automatically opened if the program finds the Microsoft Notepad executable.

Listing Export to SLK

With this command, it is possible to export the listings of the calculation results into the SLK format (Microsoft Excel 97 compatible).

The program creates a file, with the same name as the current project but with the ".SLK" extension; the file is saved in the same directory as the data files.

The file is automatically opened if the program finds the Microsoft Excel executable.

Rock Blocks Command

The Rock Blocks Command prints graphics and listings of the results of the rock block calculation.

Graphics Command

Selecting this command, a special preview window is opened, and the calculated rock blocks are shown.

The rock blocks are animated, with an anti-clockwise rotation around the Z-axis.

There are some buttons that allow one to choose the best way to print the rock blocks.

- <Angle> it is possible to choose the vertical angle of the view point by entering the new angle into the appropriate field and clicking the <Angle> button.
- <Stop> clicking this button, the rotation is stopped. It is mandatory to stop the rotation if one wants to produce a left and a right view that can be seen in three dimensions using a stereoscope.
- <Restart> clicking this button, the rotation restarts, allowing one to choose a different view point.
- <Multiple> clicking this button, the program shows four contemporary views of the rock blocks: top view,

front view, side view and perspective view.

- <Single> clicking this button, the program again shows the only perspective view.
- <Lines>|<Colour> Clicking this button, one can choose whether the final output is to be a wireframe or a solid shaded view. The preview of the blocks is not affected by this button. The current caption indicates the status of this option.
- <Central>|<Left>|<Right> Clicking this button, one can choose whether the final output is to be a central, left or a right view. The left and right view should only be used if the rotation has been stopped, and one wants to produce a left and right view that can be seen in three dimensions using a stereoscope. The current caption indicates the status of this option.
- <Print> Clicking this button, the Print Preview window is opened and it is then possible to print the graphical output.
- <Exit> clicking this button, the block preview window is closed.

Listing Preview Command

With this command, it is possible to preview the listings of the calculation results. The listings cannot be changed in the preview window.

The scroll bar, the UP arrow and DOWN arrow keys, or the PAGE UP e PAGE DOWN keys can be used to scroll the page. To exit press ESC or double-click any point of the window.

Listing Direct Print Command

With this command, it is possible to directly send the listings of the calculation results to the printer.

Listing Export to DOC

With this command, it is possible to export the listings of the calculation results into the DOC format (Microsoft Word 97 compatible).

The program creates a file with the same name as the current project but with the ".DOC" extension; the file is saved in the same directory as the data files.

The file is automatically opened if the program finds the Microsoft Word executable.

Listing Export to TXT

With this command, it is possible to export the listings of the calculation results into the TXT format (Microsoft Notepad compatible).

The program creates a file, with the same name as the current project but with the ".TXT" extension; the file is saved in the same directory as the data files.

The file is automatically opened if the program finds the Microsoft Notepad executable.

Listing Export to SLK

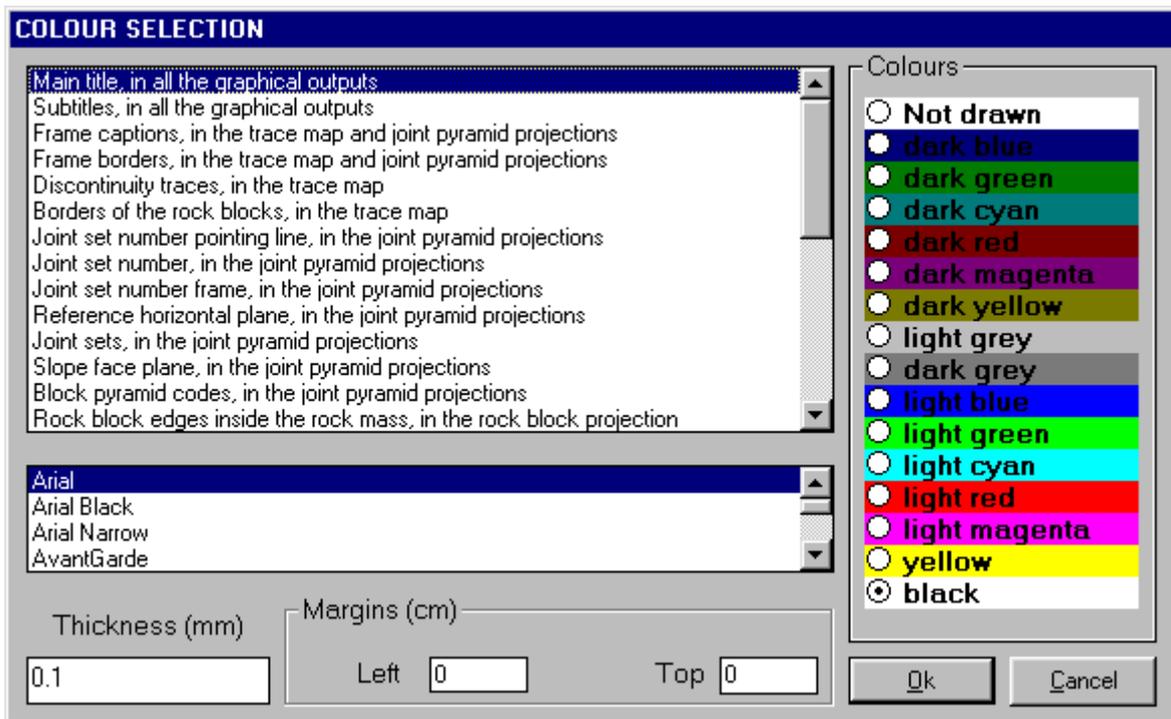
With this command, it is possible to export the listings of the calculation results into the SLK format (Microsoft Excel 97 compatible).

The program creates a file, with the same name as the current project but with the ".SLK" extension; the file is saved in the same directory as the data files.

The file is automatically opened if the program finds the Microsoft Excel executable.

Configure Command

With this command, one can define the graphical properties of the different objects in the graphical output.



One can associate a colour, a line thickness and a character font to each object. Notice that not all the objects have both a line thickness and a character font: for example, a *title* only requires the colour and the character font to be defined.

- Click an object to select it (use the scroll bar to see the entire list)
- Click one of the option buttons, in the “colours” frame, to select the colour that has to be associated to the selected object. The *Not drawn* option hides the object of the graphical output.
- If the object contains texts, one can choose a character font from the list (use the scroll bar to see the entire list)
- If the object contains lines, one can assign a thickness to the lines (in mm). If the value is zero, the program uses the thinnest line on the output device.
- It is possible, as an option, to assign a left and a top margin (in cm) to the whole graphical output.

NOTE: although the available set is limited to fifteen colours, they can be manually customised; double-click the coloured bar to open the Colour Dialogue Box and choose a different RGB value associated to the selected colour.

Exit Menu

This command allows one to exit the program. There is no specific command to save the entered data as these are automatically saved each time they are modified.

Chapter 7 - References

References

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