



Version 6.17

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A. INTRODUCTION.

CPT-pro is a program designed for complex realization of all operations essential for documenting of **CPT** soundings, interpretation of the soundings and elaboration of relevant geotechnical documentation with geotechnical cross sections.

The program consists of five main modules:

- **CPT Explorer**
- **Interpretation**
- **CPT-CAD**
- **Geo DB**
- **Seismic**

Interpretation module performs the following operations:

- Correction of measurement data files.
- Numerical operations on measurement data files (incl. averaging, integrating, computing the value of polynomials, etc.).
- Appending of data files (necessary in situations, e.g. of re-sounding in the same bore).
- Plotting the graphs of basic sounding parameters q_c , f_s and u as well as a number of derivative parameters utilized in the interpretation of soundings, such as q_t , f_t , R_t , B_q .
- Interpretation of **CPT** soundings in the scope of soil classification.
- Interpretation of **CPT** soundings in the scope of determining the values of basic parameters characterizing the soil examined, such as I_D , M , M_0 , s_u , K_0 , Φ .
- Calculation and plotting graph of hydrostatic pressure.
- Serial interpretation and batch printing.
- Printout of sounding sheets with graphs of arbitrarily selected basic parameters, derivative parameters and parameters resulting from interpretation. The sounding sheet may also contain the interpretation result in the scope of classification, presented in the form of corresponding geological symbols and descriptions.

CPT-pro gives the unique possibility to change the language of output – see chapter D.6.

CPT-CAD module enables plotting geotechnical cross sections and maps.

The cross section can be provided with:

- Graphs of any parameters measured, calculated or interpreted from CPT-CPTU soundings,
- Soil sticks with geological symbols presenting interpreted types of soils,
- All CAD type graphic objects like lines etc. (resulting from geological interpretation performed by the operator),
- Any text descriptions (with customized letter type, size, color, inclination, etc.). A number of descriptions can be generated automatically from CPTU files or Data Editor database. Additionally **CPT-CAD** module is designed for presentation of CPT and other type of soundings on map, for edition of vector maps of format DWG and DXF and also for creation of own vector maps.

→ *CPT-CAD module is compatible to AutoCAD and MicroStation software. Includes quite similar tools, functions and user interface, as well as DXF and DWG format.*

These functions enable effective execution of professional geotechnical documentation.

Data Editor for creating database containing information on User's borehole logs and geotechnical parameters which have structure [**Value vs. Depth**]. All results are saved in local database, however, due to structure of **Data Editor**, database file can be shared in local network. All borehole logs as well as a graphs of parameters can be easily and automatically added to cross sections generated with **Cross Section** module. Additionally, the location and type of soil samples can be saved in database. Implemented log maker allows to create borehole logs.

System requirements. The advanced graphics of **CPT-pro** enable the execution of effective and professional documentation, but this however involves relatively high equipment requirements. The minimum configuration necessary for installing and correct running **CPT-pro** includes:

- Windows 7/8.1/10/11 operating system,
- RAM – relevant to operating system Windows,
- Free memory on disk 200 MB,
- Mouse,
- Printer (it is recommended to use A4 format color printer for plotting sounding sheets and A2 format color printer with continuous print for plotting geotechnical cross sections).

B. PROGRAM INSTALLATION.

B.1. Installation directly from pendrive.

- Insert HASP key to computer.
- Insert pendrive with installation files to USB port and run INSTALL.EXE.
- Click relevant buttons to install CPT-pro software and HASP drivers.
- Close installation software.



Fig. B-1. CPT-pro Installer.

→ Installation onto a computer with Windows 8/ Windows 10 operating system should be performed by a user with administrator login. In case, when installation software does not install HASP key driver properly, run CD/Additional/Key/Setup.exe to complete the installation.

B.2. Installation CPT-LOG software.

(available only with Geotech NOVA registration system).

CPT-pro installation software may include additionally module for installation CPT-LOG logging software. This option is available only for users of CPT data acquisition system of **Geotech AB**. In this case it is possible to perform interpretation of CPT test in real time during sounding.

B.3. Upgrade.

Upgrade of **CPT-pro** software is quite easy – you need to run new installation CD or run **Setup.exe** file delivered by Internet, exactly in the same way like during first installation. All settings that had been saved previously in *ini* files, should not be changed during upgrading, as upgrade installation procedure does not overwrite *ini* files. There can be some exceptions for upgrading version older than 5.60. In case like that please contact Geosoft directly for precise instructions.

In case, when it is necessary to change all initial settings to default ones, deleting of all files saved in folder [.../Geosoft/CPTpro] and in folder [.../ProgramData/Geosoft/CPT-pro] (see chapter D.6) is recommended before upgrading. This may be necessary for instance in case when User had “modified” incorrectly some *ini* files “manually” using some text editor.

WARNING.

1. *Folders [Functions], [Language], [Project] and [Template] should not be deleted, as they may include the User's individual settings.*
2. *The format of *.CPD file since the ver. 5.61 is modified and older software cannot read new *.CPD file. New version of software (5.61 and higher) can read old *.CPD format without any problems.*

Upgrading the **CPT-pro** software to newer version requires also upgrading the protection key and communication procedures between software and key. New keys can be upgraded by exchanging internal software and this can be simply done by User with application files delivered by Geosoft. However, very old keys must be replaced.

As upgrading the software requires precise information about version of software and type of protection key, checking the key and sending appropriate record to Geosoft is recommended.

To check the key do the following:

1. Insert protection key to computer with installed CPT-pro software.
2. Run **GKeyServices1.exe** file (delivered on installation CD in [Addition/Key] folder or, on request, from Geosoft by e-mail).
3. Point mouse cursor on relevant icon on left pane and read instruction.
4. Click [**Check Key**] button (see Fig. B-2) and then, depending on status of current connection with Internet, [**Save File and Send e-Mail**] or [**Save File**] button.
 - ☐ [**Save File and Send e-Mail**] automatically creates e-mail with attached info about key status.
 - ☐ [**Save File**] option creates the text file with info about the key, that is expected to be delivered to Geosoft later. Name of record file can be changed, however it is not obligatory.
5. Send key record file [**Key File.gkf2**] to Geosoft by e-mail.

→ We do declare that key record file [Key File.gkf2] includes only data concerned to just checked version of CPT-pro software and protection key. No other kind of data is generated during execution of GKeyServices.exe.

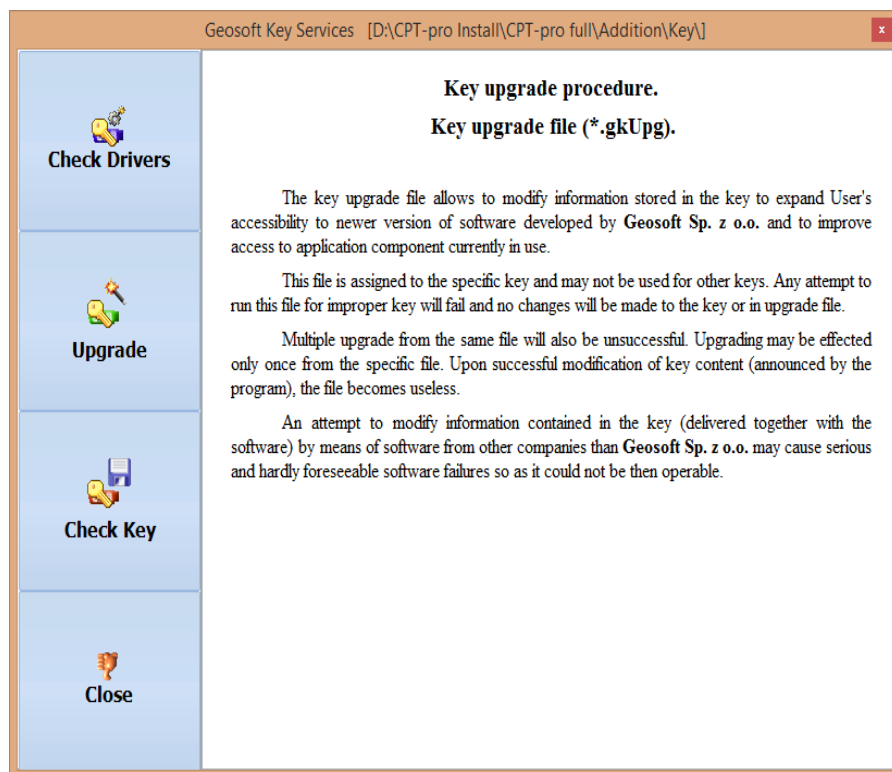


Fig. B-2. Checking and upgrading the key.

Having the upgrading file **[*.gkUpd]** delivered by Geosoft, please do the following:

1. Insert protection key to computer in which former version of CPT-pro had been installed.
2. Copy **[*.gkUpd]** file (which includes new key settings) delivered by Geosoft, to some folder on this same computer.
3. Run **GKeyServices1.exe** file (delivered on installation CD or, on request, from Geosoft by e-mail).
4. Click **[Upgrade]** button, find and highlight **[*.gkUpd]** file and click **[Open]** button.

Both, the software and key, are now ready for running. In case of any problems or questions please do not hesitate to contact with Geosoft

→ It is recommended to upgrade the software in first step and upgrade the key on this same computer.
 → Some updates to the Geo DB module require changes to the database configuration. In this case, it is necessary to contact Geosoft..

C. STARTING UP CPT-pro.

C.1. Installation of protection key.

Before starting up the program, insert the protection key in **USB** port. **USB** hard lock can be plugged in any free **USB** port.

- All operations during which cables connecting the computer with the peripherals or the installed "protection key are removed or inserted, should be performed with the computer switched off.
- It is strongly recommended to install protection key drivers only using files delivered by Geosoft on installation CD or downloaded from Geosoft's web site.

C.2. Registration.

It is strongly recommended to register your software as it helps a lot in case of any questions, problems and future upgrades. Registration process is fully automatic.

This what you need is just run **CPT-pro** on computer being connected with Internet and having installed Outlook Express or similar software, edit some basic data, click [**Submit**] button and send automatically generated e-mail with registration data.

Registration

Title: First name: Last name:

Business/Organization name: Purchase date:

Street Address or P.O. Box:

City: Postal / Zip code: Country:

Telephone: Fax number:

E-mail: Web page address:

Dealer Name:

We do confirm that registration file includes only data edited by User, data concerned to just installed version of CPT-pro software and licence.
No other kind of data is generated by registration process nor included in registration file.

Fig. C-1. Registration form.

When CPT-pro is run first time after installation, the registration window appears (Fig. C-1). There are editing fields, where basic info about User should be filed, as well as the date of purchasing and Dealer name. The calendar is opened upon pressing of [▼] symbol.

Registration e-mail includes text file attachment, where all edited data are saved, as well as info about version of installed CPT-pro software.

If there are any reasons not to register just after first installation, you can do that any time. To postpone the registration just click [**Register later**] button and come back to registration process clicking **About/Registration** from main menu.

→ We do confirm that registration file includes only data edited by User, data concerned to just installed version of CPT-pro software and license. No other kind of data is generated during installation process nor included in registration file.

C.3. Starting up software.

During installation, the installation program creates files **CPTExplorer.exe**, **CPTSoil.exe** and a number of associated files in the folder indicated by the installer. Simultaneously, the folder of **CPT-pro** programs has been created in **Program Files (or Program Files (x86))**.

Configuration files are saved in **Program Data** directory that is usually hidden. To access to that directory, for instance to copy/paste configuration files, just click **File/Tools/Open config directory**.

CPT-pro can be started directly from the directory in which it is installed by a **double click** on **CPTExplorer.exe** program icon or relevant **CPT-pro** icon. However it is possible to run directly Interpretation module, it is recommended to run **CPT Explorer** one where some basic settings are available. Additionally – **CPT Explorer** has implemented effective browsing functions.

C.4. CPT Explorer.

C.4.1. General.

CPT Explorer module is used for:

1. **CPT** file management.
2. Creation of project structures.
3. Opening other modules of **CPT-pro** by clicking the name of module from the list.
4. Brief zooming selected CPT tests.
5. Conversion *.CPT files to CPD format.
6. Completion of header info (test number, water table, co-ordinates etc.).
7. Selection of language for printouts.
8. Adding seismic wave velocity to *.CPD files for further analysis.
9. Adding dynamic penetration test data (DPT and SPT) to *.CPD files for further analysis.
10. Selection of data files for further analysis.

After starting the program the **CPT Explorer** window with selected [**Thumbnails**] page shown on Fig. C-2 appears. The header data of selected file appears only for moment once some thumbnail is selected. To have it permanently connected to this page click pin symbol in right upper corner. Pane[**Thumbnails**] displays thumbnails of all CPT data files that are saved in directory selected in pane [**Folders**].

Pane [**Map**] (see Fig. C-3) displays symbols and names of all CPT data files that are saved in directory selected in pane [**Folders**].

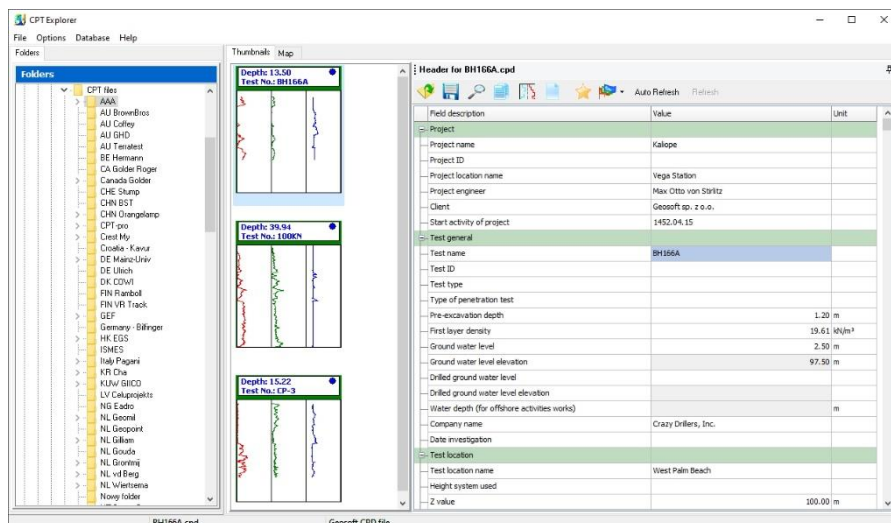


Fig. C-2. [CPT Explorer] window. [Thumbnails] page with thumbnails and header.

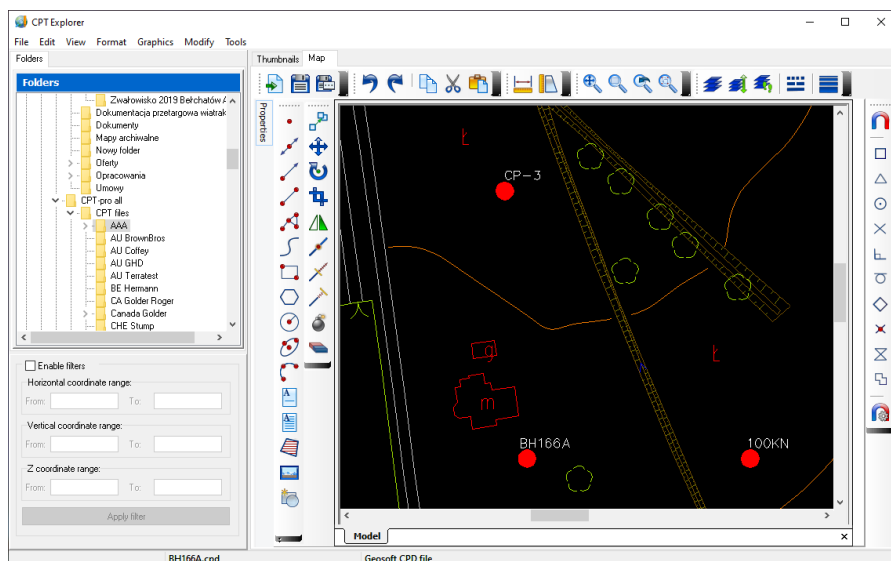


Fig. C-3. [CPT Explorer] window. [Map] page with locations of tests and CAD map as background. Main menu is relevant for CAD functions.

- ➔ Pane **[Map]** is fully functional CAD window in version with CPT-CAD module only.
- ➔ Only tests that have saved co-ordinates X and Y are presented on map.
- ➔ Main menu in **[Thumbnails]** page includes functions relevant to thumbnails, however menu in **[Map]** page includes CAD functions.

C.4.2. [Map] page with CAD window.


Window that appears on **[Map]** page is active and fully functional CAD window in version with CPT-CAD licence. All tests that have saved co-ordinates X and Y are presented on map as circles filled with red color and descriptions – names of tests. To adjust screen to see all tests click right mouse button and select **[Zoom extents]** from context menu. To zoom the map with locations of tests use mouse wheel like in CAD type programs.

To select test from map click the name of test or click the border of symbol (circle but not the filling) or use the method standard for CAD programs – rectangular with left click. Once some test is selected click right button to open context menu:

- ☐ Open
- ☐ Preview
- ☐ Unselect all


Function **[Open]** is active only when single test is selected. If more than one tests are selected, only **[Preview]** and **[Unselect all]** are active.


- ➔ Selection of CPT test and right click activates context menu relevant for CPT tests, however selection of any other object on background map and right click activate menu standard for CAD objects.

Locations of test may be presented on CAD map background (available with CPT-CAD module). To insert such map click **[Insert]** icon  from CAD toolbar and select relevant CAD file (DWG or DXF).

- ➔ To remove inserted background map change directory with CPT data files and come back to relevant one.

C.4.3. Header of CPT data file.

Header list in right pane can be modified by User. That modification can be done in **[Select header elements]** window (see Fig. C-4) activated by clicking star icon . To select/unselect header elements check/uncheck relevant checkboxes. To save selection in *ini* file just click **[OK]** button. Exactly the same selection and access to it is available from **Interpretation** module. Modification performed in one module may be changed in another one.

- ➔ CPT-pro may create sounding logs and printouts in any language selected by User. To change language click **Flags icon**  to scroll down list of languages and select one. That selection will be saved in configuration files.
- ➔ Each translated description for each language may be edited and saved any time.

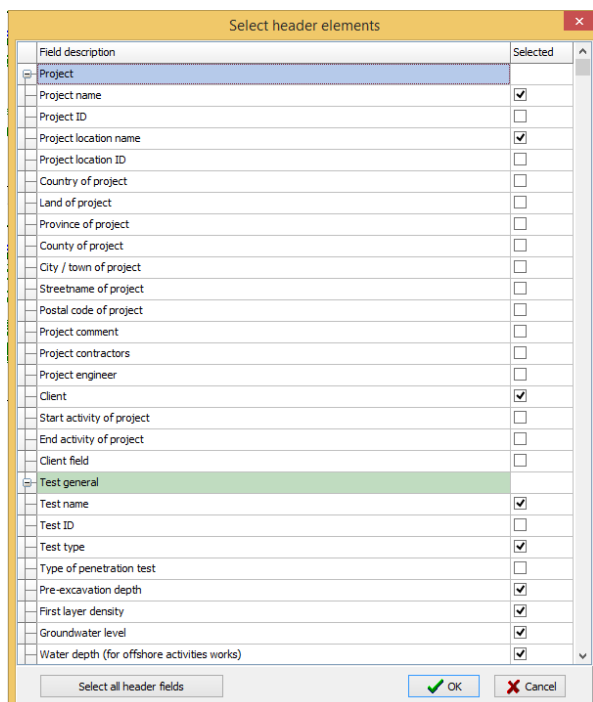


Fig. C-4. Selection of header elements.

All header elements are grouped in four groups for easy searching:

- **Project**
- **Test general**
- **Test location**
- **Equipment**

Selected elements are not only visible in header pane but also may be printed as additional report for each CPT test in **Interpretation** module.

The following functions are available on top of header pane (see descriptions on Fig. C-5):

1. Open selected file with **Interpretation** module – button **A**.
2. Save selected and modified file in CPD format – button **B**.
3. Zoom selected CPT test – button **C**.
4. Copy selected file to freely selected directory – button **D**.
5. Add zone parameters to selected CPD file – button **E**.
6. Create empty CPD file with zone parameters – button **F**.
7. Selection of visible header elements **to Favorites** and saving that selection – button **G**.
8. Selection of language used for printouts – button **H**.



Fig. C-5. Icons of CPT Explorer module.

C.4.4. Joining CPT data files.

Some CPT systems (like for instance Van den Berg WISON and Geomil ORCA) do not provide continuous CPT test in selected location but a number of tests alternately with drilled sections. Such tests can be joined into one continuous test with use **File/Join files** function, activated from menu **File**.

Once you click **File/Join files** function the selection window appears. Select relevant folder in left pane and highlight relevant CPT files to join them into one.

Once you click **[Open]** CPT-pro automatically groups selected files according to **[Hole name]** (the name/number of hole) and joins files connected to selected hole into single CPT tests.

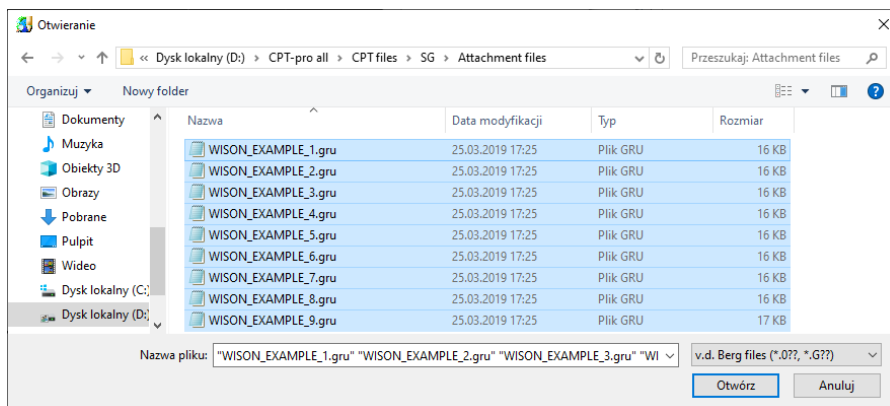


Fig. C-6. Selection CPT data files for joining.

- ➔ Depending on native data format the selection and linking relevant fields of file header and hole name can be different. In van den Berg data format the [Test name] is linked to [Test name] (=the name of hole) and [Test number] is linked to [Test number] (= the number of test in selected hole).
- ➔ In Geomil format the [Job number] is considered as hole name.
- ➔ In GEF format the [TESTID] field is considered as hole name.
- ➔ The automatic procedure of linking files works correctly only if above assumptions are fulfilled.

The result of joining is presented in **[Join files]** window (Fig. C-6). Once you highlight the selected hole (consisting of the joined relevant CPT tests) the common graph of CPT files and list of relevant CPT files with partial test numbers are generated. To save result click **[Save file]** button, enter file name and click **[Save]**.

To see selected part of joined test relevant to selected partial test - highlight relevant file name on file list.

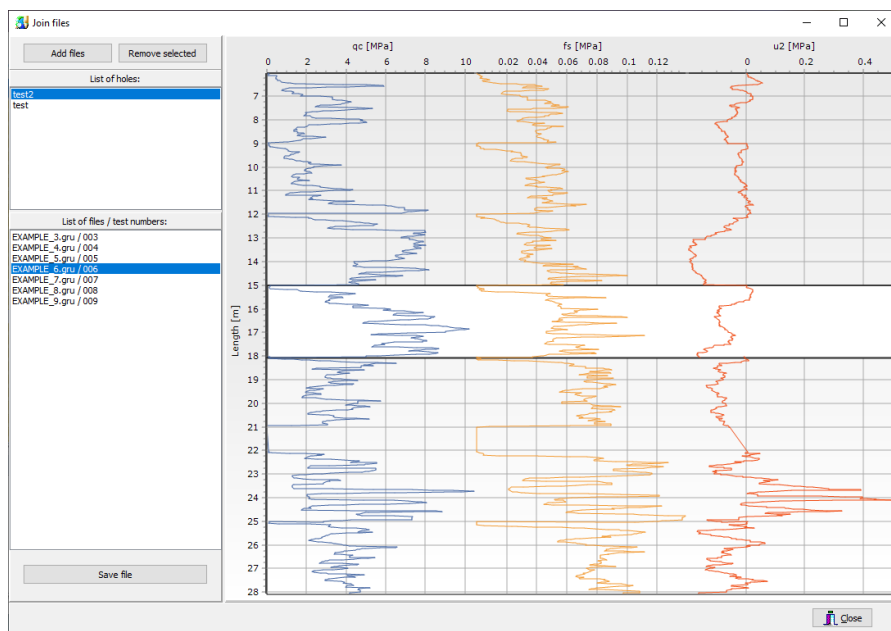


Fig. C-7. [Join files] window with results of joining and lists of holes.

C.4.5. Creating project structure (in reconstruction).

The **CPT Explorer** module includes tools to group CPT sounding files more efficiently into a project structure. This function is called out from the main menu - [**Options/Projects F2**], or by clicking the **F2** function key.

To add new project click [**New project**] button. To change the name of selected project highlight it and double click the project name to move to edition mode.

To add CPT file (of format *.CPD) to project click [**Add CPT file**] button and select the relevant file from standard Windows tree.

To see the content of project just highlight the selected project in left pane. All files that are associated with project are listed in right one.

To delete selected file from project highlight the selected project in left pane, highlight selected file in right pane and click [**Remove CPT file**] button. The relevant path will be deleted from project structure, however, the file will not be deleted.

To delete selected project highlight it and click [**Remove project**] button. Project will be deleted with entire content.

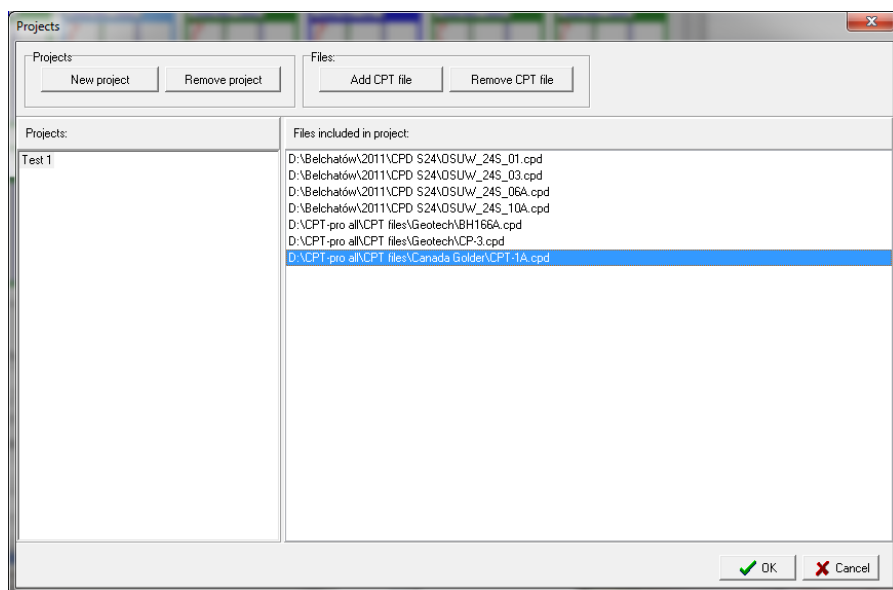


Fig. C-8. [Projects] window.

C.4.6. CPT Explorer module settings.

The **CPT Explorer** module enables broad customization to one's own requirements. Starting of [**Options/Settings F3**] function or pressing of **F3** function key opens [**Options**] window in which customization of appearance and functions of the module takes place.

In this window three pages identified with bookmarks are available:

- View options
- Channel options
- File settings.

On page [**View options**] (Fig. C-9) the following settings are made:

- Sizes of thumbnails
- mask hiding/revealing data files in various formats
- color of background for thumbnails of files in various formats
- chart presentation type [**CPT-pro** format / **Dutch** format]
- two data lines from header on individual thumbnails
- presenting information about any interpretations completed with respect to classification

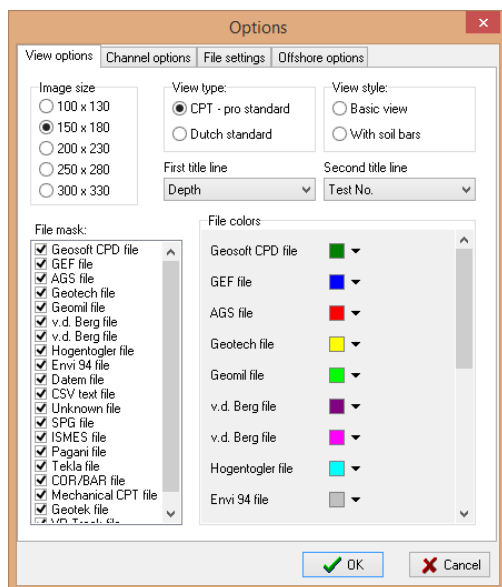


Fig. C-9. [Options] window, [View options] page.

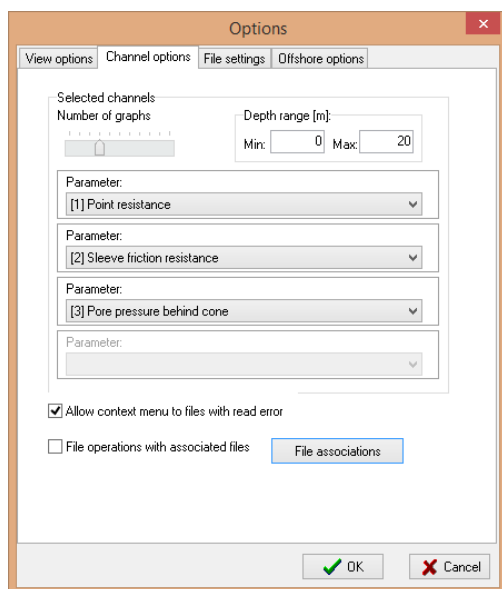


Fig. C-10. [Options] / [Channel options] page.

On page [Channel options] (Fig. C-10) settings of chart number, type of parameters and ranges of them presented on thumbnails are made. On [Number of graphs] bar you choose number of charts, and in [Parameter] windows you choose appropriate parameters from the list.

Highlighting of [Allow context menu to files with read error] checkbox enables you to present data for files with errors, highlighting of [File operations with associated files] checkbox causes that such operations as copying and moving of CPT data files will simultaneously result in copying and moving of any associated files (dissipation, classification files etc.).

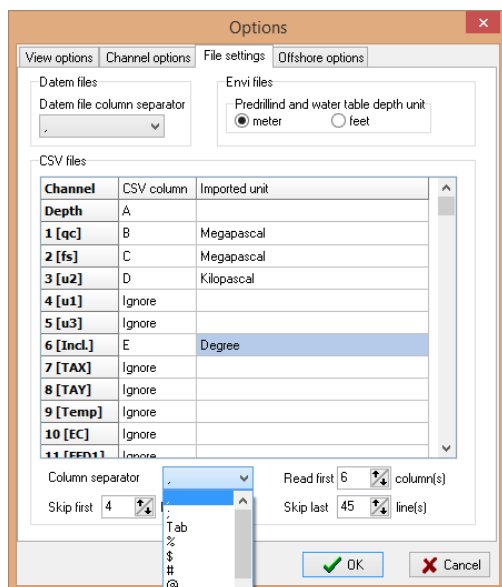


Fig. C-11. [Options] / [File settings] page.

On page [File settings] (Fig. C-11) settings of data files saved in **Datem** and **ASCII** format in columns divided by any separator are made. The separator is chosen from the list opened upon pressing of symbol.

In **CSV** files it is also possible to set the number of omitted lines in the file being imported (many data files like this contain header data in the first lines), limit number of columns read and assign meaning to individual columns.

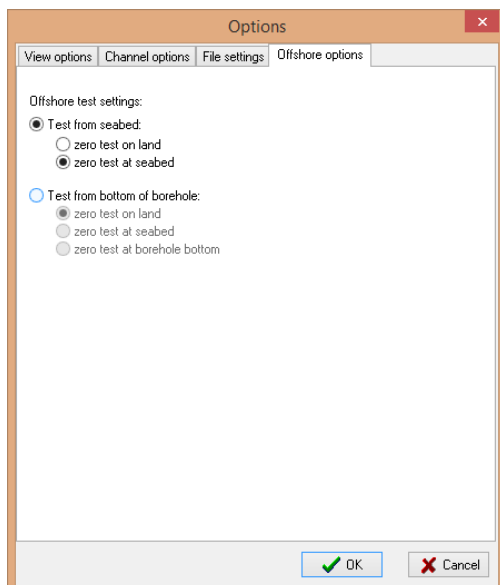


Fig. C-12. [Options] / [Offshore settings] page.

It is essential for correct calculation pore pressure values to add information where initial zero test (before sounding) was performed. That selection is saved in ini files and will be considered with each new opened file.

C.4.7. Preview selected file.

You may see detailed graphs and track values of selected parameters of selected file (see Fig. C-13). To open **Zoom** window click loop icon **C** (Fig. D-9)

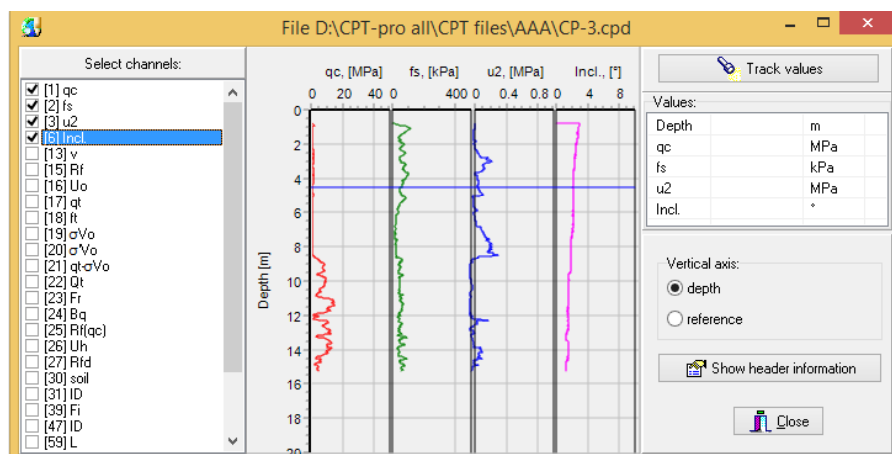


Fig. C-13. [Zoom] window.

Select parameters by checking relevant checkboxes on left. To track and read values of parameters at selected depth click [**Track values**] button on right upper corner. Once you click that button vertical line appears and values of parameters at depth pointed by that line are shown in right pane.

C.4.8. Adding zone parameters.

Parameters generated in dynamic penetration tests **DPT** and **SPT**, as well as values of velocity of seismic waves, can be added to *.CPD files for further interpretation. That option is particularly useful for seismic wave velocity, as that test, named **SCPT**, is commonly performed with **CPT/CPTU** one.

These parameters are defined for soil zones, usually of thickness 0.2 m for **DPT** and **SPT**, and 0.5 or 1 m for velocity of seismic waves, so we call them **zone parameters**.

C.4.8.1. Adding zone parameters to CPD file.

Seismic tests **SCPT** are commonly performed together with **CPTU** test, so adding values of wave velocity to **CPD** file with results of **CPTU** test is very useful option. You can present **CPT** and **SCPT** results on the same logs in **Interpretation** module and plot **CPT** and **SCPT** graphs on the same cross section generated in **CPT-CAD** module. Additionally, having **SCPT** results in **CPD** file, you can use **Interpretation** module tools for further interpretation to estimate such geotechnical parameters like **small strain modulus** G_0 , **Young's modulus** E_0 , **Poisson's ratio** ν and others.

Dynamic tests **DPT** and **SPT** cannot be performed in the same hole together with **CPT/CPTU** tests, however, if these tests are done very near, the common presentation on the same log and cross section makes sense. Despite of that, you can use *Formula Editor* of *Interpretation* module for further estimation of geotechnical parameters¹.

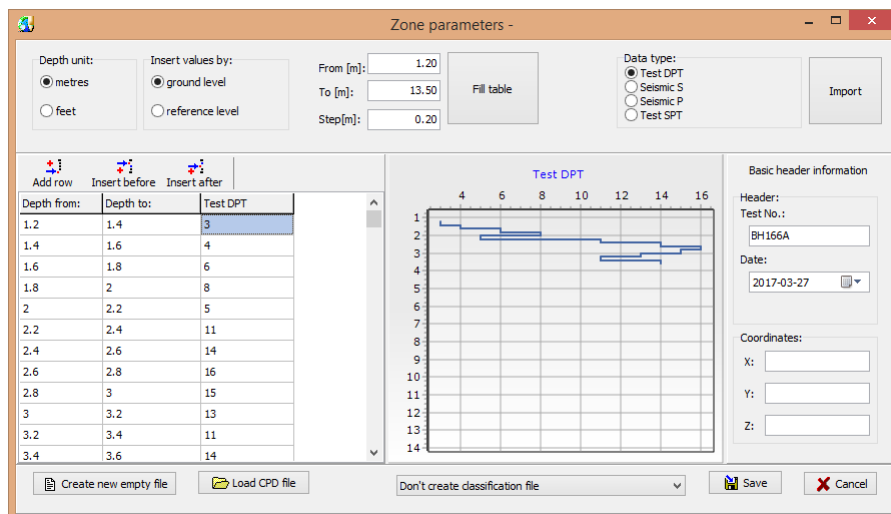


Fig. C-14. Zone parameters edition window.

To add values of zone parameters to existed **CPD** file, highlight the relevant thumbnail in right upper pane and click button **E [Zone parameters]** (Fig. D-9) to open *Zone parameters* edition window – see Fig. C-14.

To “manually” enter zone parameter select the type of parameter (**DPT/SPT**, **Seismic S** or **Seismic P**) in right upper corner and fill the table in left lower one. The table can be filled in standard way, just by adding rows and editing values, but to speed up the entry it is recommended to define the depth **From** and **To**, and set the **Step** (thickness of single zone) in upper central part (see Fig. C-14). The depth values in table are automatically filled and only the values of parameter should be edited. The graph of entered parameter is plotted in real time. The test number should always be inserted.

It may happen that in the same hole both **S** and **P** waves are investigated. Additionally, near that hole the **DPT/SPT** test can be performed and is expected to be “added” to the same CPD file. That can be done step by step i.e. after inserting one zone parameter values you can select the second one and repeat entry. Zone parameters already existed or entered are highlighted by bold font in *[Data type]* pane

It is possible to import values of zone parameters from relevant files (see N.1.3), however, that option works only for:

¹ The presentation and interpretation of dynamic soundings is fully implemented in the Geo DB module.

- seismic wave velocity estimated in *Seismic* module of **CPT-pro** and saved in *.SCPD file – see chapter N.
- dynamic test **DPT** and **SPT** registered in *Geotech AB* systems.

Once zone parameters are added click [**Save**] button to save selected (by highlighting thumbnail) *.CPD file with all inserted values of zone parameters.

Any time you can load new *.CPD file or create an empty one by clicking [**Load CPD file**] or [**Create new empty file**] buttons. In such case you will be asked for confirmation of saving already existed entries.

C.4.8.2. Adding zone parameters to empty CPD file.

Values of dynamic tests and velocity of seismic waves can be added to CPD file without any CPT test results. To do that click button **E** (Fig. D-9) and fill relevant fields exactly in the same way as in described in C.4.8.1.

C.4.9. Completing and edition of header data.

The header data (test number, date, co-ordinates etc.) are presented in right lower pane once some thumbnail is highlighted. These descriptions can be edited in standard Windows way and saved to CPD file. The same option can be used for conversion of *.CPT and other formats to *.CPD one.

C.4.10. Additional functions of CPT Explorer module.

- ☐ Opening data files for proceeding in *Interpretation* module. To open selected data file highlight relevant thumbnail or symbol (circle with filled interior) on map and double click it.

➔ To highlight symbol of CPT test on map click the border of symbol or the name of test.

- ☐ Copying data files to selected directory.
- ☐ Renaming files. To rename selected file click right mouse button on thumbnail of this file, chose **Rename** from menu and enter new name. Press <**OK**> button to accept new name.

D. INTERPRETATION MODULE FUNCTIONS. *File menu.*

Interpretation module is the main module of **CPT-pro** software package. It is designed to perform basic operations on data files received from **CPT** and **DMT** soundings, its reduction, interpretation and creation of sounding logs.

A number of raw data formats include only basic measured CPT parameters, that may not be sufficient for performing relevant interpretation. For instance - CPT test performed from bottom of borehole (predrilling) needs information about bulk density of first predrilled layer for calculation overburden stress, which is necessary for most classifications and evaluations. Another issue is necessary information whether test was performed on land or offshore (what has influence on values of pore pressure and tip resistance). Some CPT data formats, like **Datam**, have filled **[Water depth]** and file with filled **[Water depth]** value is automatically treated as offshore and field **[Offshore options]** is not generated. To avoid permanent asking about offshore option for on land tests just select **[Always treat as "on land" test]** radiobutton – see Fig. D-1.

In any of listed above parameters or options needs User's action, the following window (Fig. D-1) or part of it appears. Values that should be entered before performing interpretation are included in panels marked with red bar.

Fig. D-1. File import settings.

There are implemented two methods of estimating bulk soil density – by **Robertson '86** and by **Robertson, Cabal '2010**. The choice of that estimation should also be made before import of CPT file.

- First running CPT-pro on new computer generates window with selection of **vertical axis unit**. That selection is saved in **ini** file and is used for next CPT-pro sessions. Next sessions use unit selected previously. The vertical axis unit can be changed any time with right click on generated sounding log.
- Loading *.CPD file does not involve generating **[File import settings]** window, as all required selections, including estimation of unit weight, are saved in *.CPD file.
- The **[Read from file]** option for **Unit weight** is a default one for *.CPT files.

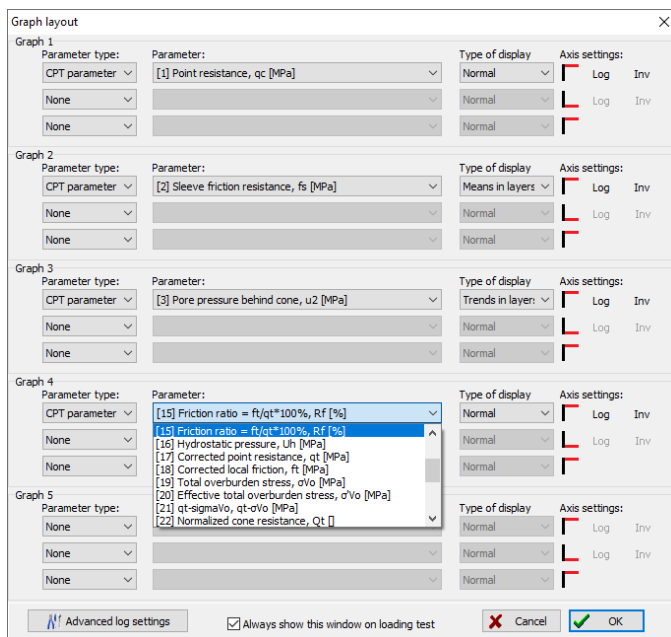


Fig. D-2. Graph layout configuration window.

→ All settings available in **File import settings** (Fig. D-1) are available also from main menu – by clicking **File/Import/export settings**.

→ Loading *.CPD file does not involve generating [**File import settings**] window, as all required selections, including estimation of unit weight, are saved in *.CPD file.

→ Settings concerning unit weight, adding pore pressure channel and first layer bulk density may be saved by highlighting [**Always use**] checkbox and used in import of next CPT files. These settings may be modified any time from menu of **Interpretation** modules.

→ NOTE. Once option [**Always use...**] is checked the relevant panel of window [**File import settings**] is hidden unless User's action is necessary. To show that panel and change that option go to menu **File / Import/export settings**.

D.1. Sounding log. Basic format.



Once you double click selected thumbnail in **CPT Explorer** module or double click relevant symbol of CPT test on map (see chapter C.4.1) or load new CPT file by clicking icon A (see Fig. D-9), the [**Graph layout**] window (Fig. D-2) appears.

The following settings of sounding log are directly available from that window:

- Number of graphs/diagrams presented (maximum 5) – by selection relevant [**Parameter type**] and [**Parameter**]. Selecting [**None**] disables the diagram.
- Selection of parameter for each graph – by selection relevant [**Parameter**].

- Type of graph – by scrolling down the [*Type of display*] list and relevant selection from that list. The following options are available:
 - ☐ **Normal**
 - ☐ **Mean values** calculated for layers defined in classification process
 - ☐ **Trend lines** calculated for layers defined in classification process
- Type of horizontal axis – by highlighting relevant button in [*Axis settings*] column:
 - ☐ **Inverted**
 - ☐ **Logarithmic**

→ The sequence of parameters on list can be changed – see chapter 0. List can be sorted by number of channel, name of parameter, abbreviation and type of physical parameter.

→ For each graphic field the first from top parameter is connected to upper axis, second one to bottom axis and third one also to top axis. Upper and bottom axes are marked with symbols   - see Fig. D-2.

→ Pointing mouse cursor on the selected parameter name abbreviation shows hint with full name of parameter.

Additional log settings like vertical axis type, vertical scale, water level presentation, soil stick presentation, log templates and selection of header table layout are available by clicking [*Advanced log settings*] button. That action generates window [*Advanced log settings*] (Fig. D-3) with relevant options. The same window can be activated any time from main menu of *Interpretation* module.

→ The maximum number of graphic fields created with graphs/diagrams amounts to 5 plus an additional field with the geological profile. The program automatically sets their width on the printout.

→ Header table on sounding sheet can be customized – see chapter D.3.1. The layout of table can be selected from attached ones. The content of cells can be directly selected by double click of relevant cell.

→ Header table can be hidden. In such case graph can be enlarged up to lower margin or empty space can be left, depending on status of checkbox [*Enlarge graph*] – see Fig. D-3.

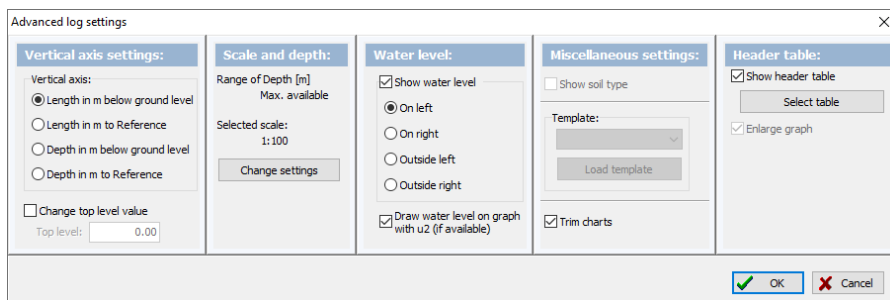


Fig. D-3. [*Advanced log settings*] window.

→ Water level symbol can be generated on first left chart (despite of selected parameter) or on chart with pore pressure. To select that option check or uncheck the checkbox [*Draw water level on graph with u2 (if available)*].

→ The [**Show soil type**] checkbox shows result of classification saved in relevant file and marked as “current”, for which all evaluations were calculated. It is active only when some classification is performed.

→ To trim upper extensions of charts (see Fig. D-4) highlight [**Trim charts**] checkbox.

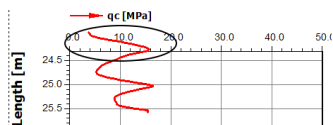


Fig. D-4. Optional upper extension of chart.

Right click on selected graph generates [**Graph settings**] window (Fig. D-5), where parameters presented on that graph and basic display settings can be selected.

Fig. D-5. [Graph settings] window.

Mean values calculated for soil layers can be activated by checking checkbox [**Means in layers**]. That selection is active only when some classification is completed. Trend lines calculated for soil layers can be activated by checking checkbox [**Trends in layers**]. That selection is active only when some classification is completed.

→ **NOTE.** Means and trends are calculated for soil layers, so classification should be performed before selecting that options.

Channel properties

Channel:

Name:

Shortcut:

Unit:

Group: Unit: Display unit:

Ranges [Megapascal]

Minimum: Maximum: Grid step:

Line settings:

Base:

Color: Style: Width:

Alternative:

Color: Style: Width:

Channel properties like the name of parameter, shortcut ranges, line attributes and others can be modified in window [**Channel properties**] – see Fig. D-6. To activate that window double click any parameter name in [**Graph settings window**] – see Fig. D-5.

Fig. D-6. [**Channel properties**] window.

A number of settings of sounding log are available directly on sounding log with use right click on any chart

• Vertical axis unit	• Show/hide water levels
• Vertical axis (depth/length) selection	• Show/hide soil bar with classification results
• Vertical axis settings	• Soil bar filling
○ Length below ground level	○ Colors
○ Length to reference	○ Lithology symbols
○ Depth below ground level	• Soil bar description font
○ Depth to reference	• Show soil layer bottom depth/elevation
• [Trim chart] option	• Soil layer bottom description font
• Show/hide header table	• The presence of the left and right axes

Depth unit >

Vertical axis settings >

Trim charts

☒ Show header table

☒ Show water levels

Show soil bar

Soil bar filling >

Soil bar description font

☒ Show soil layer bottom depth/elevation

Soil layer bottom description font

Length below ground level

Length to reference

Depth below ground level

Depth to reference

☒ Show left axis

☒ Show right axis

Fig. D-7. Sounding log settings available from right click menu.

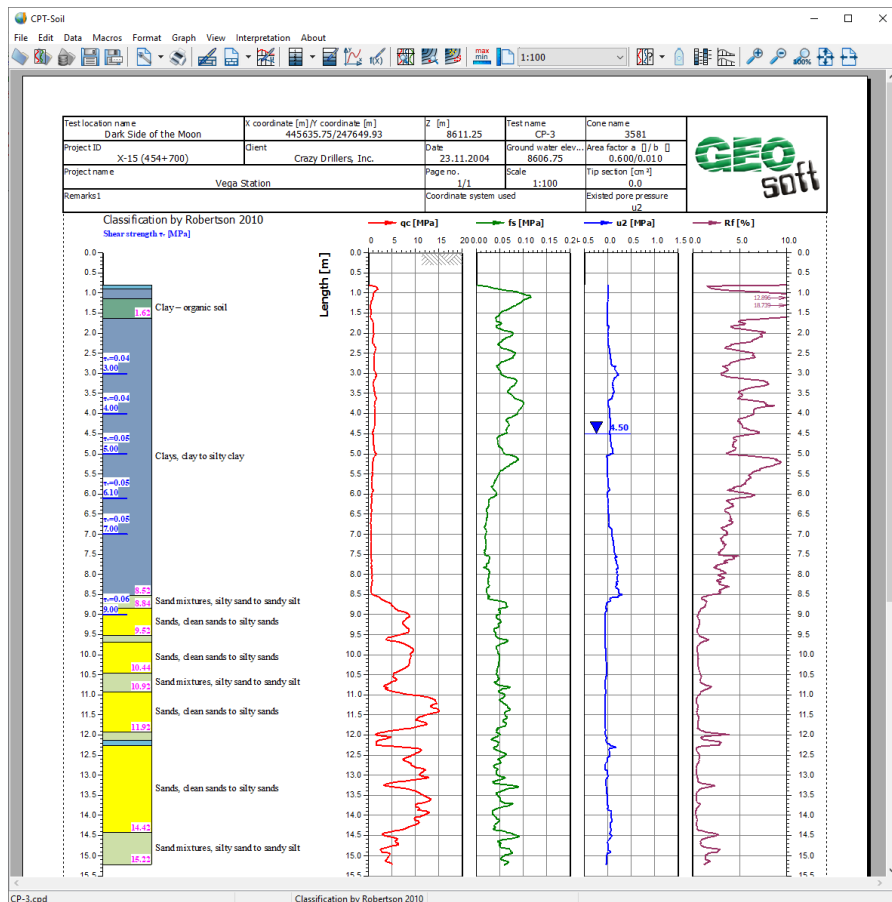


Fig. D-8. Main window of Interpretation module.

Main window of **Interpretation module** (Fig. D-8) consists of main menu, functional icons and graphic field with current layout of sounding log. That graphic field can be treated as **print preview** as it exactly shows the current status and layout of sounding log. The current classification (if any exists) is listed on bottom bar. The name of loaded CPT data file is listed in left down corner.



Fig. D-9. Interpretation module main menu and icons.

The log consists of three main fields. There is an optional header table at the top or bottom of the page. Below or above the table on the left side there is a field presenting the classification result with a description of the depth / elevation of the bottom of the layers² and basic information about the FVT tests related to CPT test³ i.e. sounding depth / elevation and *shear strength* τ_v – see Fig. D-8. The field for the parameter graphs is on the right.

For a detailed description of the probing profile, the sounding log contains three vertical scales and a soil stick and on both sides of the field for plots. Additionally, depending on the settings, the value of the depth/elevation of the bottom is given on the soil stick for each layer of sufficient thickness.

D.2. Basic operations on data files.

File menu drops down with the box having the following list of functions:

Load	AGS Files
Open test from database	GEF Files
Save	CSV files
Save as	Datam Files
Close file	Export
Run module	Copy selected page to clipboard
Tools	Export page to WMF
Open config directory	Report
Restart application	Page setup
Language	Print
Append file	Batch printing
Import/Export settings	Exit
CPD files	

D.3. Loading a CPT data file.

File/Load function enables loading a **CPT** data file. After clicking the *File/Load* function (the same is obtained by clicking on icon [A] (see Fig. D-9), denoting opening of the directory), select the folder containing the selected file. **Double click** or highlight the selected file and click [*Open*] causing it to be loaded by **CPT-pro**.

Clicking the icon [B] opens **CPT Explorer** module with all its functions and allows to load new CPT data file.

➔ The sounding sheet configuration window [Graph settings] can be re-accessed, during any analyzing phase of the CPT data file loaded, by clicking the icon [W] in the Interpretation module main menu or executing **Graph/CPT-pro standard** function.

² If the layer thickness is too low, this information is omitted

³ Related vane test means vane test performed in the close proximity to the CPT test

D.3.1. Header table layout.

To select relevant table layout click icon **I** (see Fig. D-9) or [**Select table**] button from Advanced log settings window (see Fig. D-2). There are already included some most common used standard tables, however, if necessary - additional ones can be added on User request.

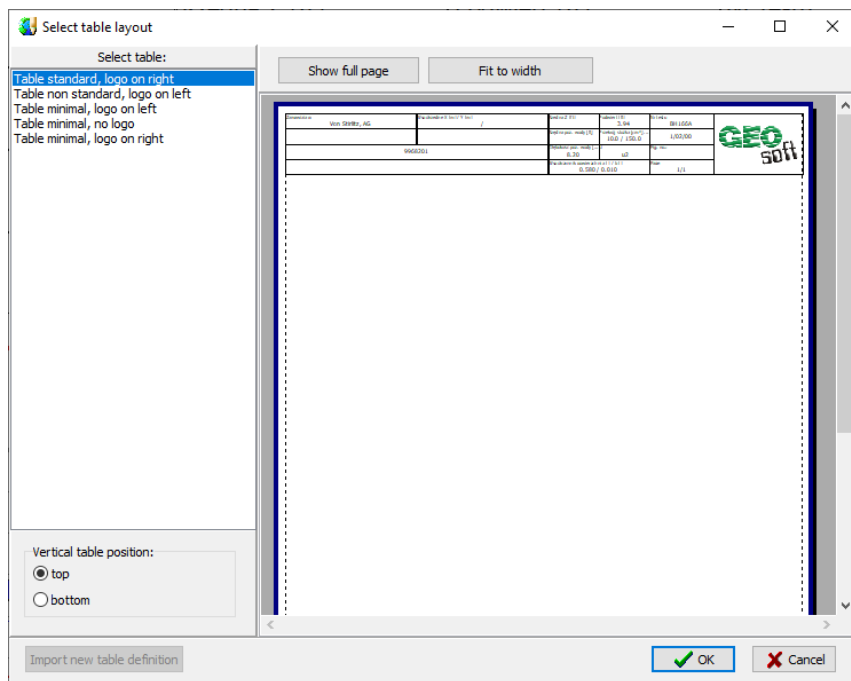


Fig. D-10. Header table selection.

The content of each cell can be selected directly from sounding log by double click of relevant one. Each cell can be treated as single one (i.e. with one header parameter) or as a double one (with two header parameters). The separator in double cell can be selected by User.

Header fields can be selected directly from the same list as in **Selected header elements** (see E.1) or from the list of special fields (like logo, page number etc.) that are not connected to CPT tests.

As the length of description of header parameter is usually too long to enter it to table cell⁴, User can shorten it by clicking [**Edit table description**] and entering own abbreviation. Shortened version of header parameter description is saved together with relevant translations and can be edited also from the [**Edit language**] window (see Fig. D-18).

⁴ Table description is taken from the [**Table description**] column in the [**Edit language**] window (Fig. D-18)

Own logo can be inserted in any cell of table, however it is recommended to use the cell with relevant size. To enter logo assign relevant cell using **[Logo]** selection in **table header** source selection and follow instruction in chapter H.4.1,

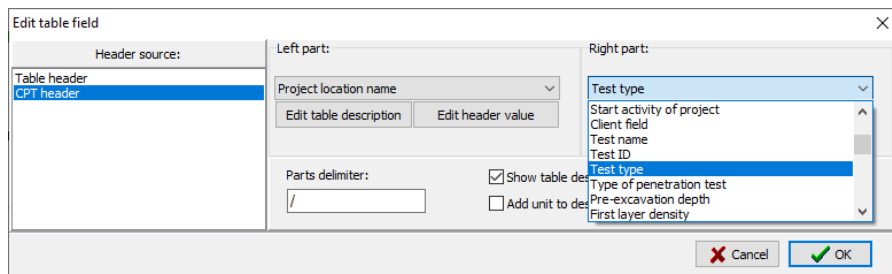


Fig. D-11. Edition of header table cells.

Any time the table layout can be changed by clicking icon **I** (see Fig. D-9) and selection from the list.

D.3.2. Range of sounding depth.

The chart length setting on the hole card page is defined in the **[Advanced log settings]** window opened from the main hole card configuration window - see Fig. D-3. In the **[Vertical axis settings]** panel, enter the top level value, which shifts all sounding charts down (usually top level = 0). Then, in the **[Scale]** window (Fig. D-12), which opens after pressing the **[Change settings]** button, enter/change the settings regarding the length of the chart on one side and the vertical scale.

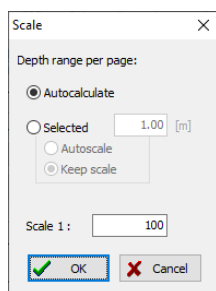


Fig. D-12. Set the vertical scale and length range of the chart on the page.

Selecting the **[Keep scale]** and **[Selected]** options when setting a specific chart length will generate a sounding log in which each page will contain a fragment of the chart with a given length at a given scale, regardless of the selected paper size.

Selecting the **[Autocalculate]** option will generate a log, which will show the maximum possible sounding length on each page, taking into account the page size and set margins. Changing the vertical scale is possible at any time in the **U** panel of the main menu.

D.3.3. Definition of vertical axis.

Definition of vertical axis is realized in windows **[Advanced log settings]** and **[Graph settings]** – (see Fig. D-3 and Fig. D-5) as a:

- 1) Length⁵ in m or ft below ground level (just the length along rods).
- 2) Length in m or ft to reference (approximate elevation over the sea level etc. – used when depth is not available and inclination if test is low).
- 3) Depth in m or ft below ground level (available only when inclination is saved).
- 4) Depth in m or ft to reference (exact elevation over the sea level etc. available only when inclination is saved).

D.3.4. Presenting the geological profile on sounding log.

CPT-pro enables presenting the geological profile resulting from former **CPT** data file interpretation on the sounding sheet, performed by means of the selected method. Detailed description of performing interpretation is presented in chapter 0. The selection of whether soil bar with interpretation result is to appear on the sounding sheet or not, is performed in [*Graph settings*] window. This selection is done by activating or deactivating [*Show soil type*] checkbox (see Fig. D-2) or with right click on soil stick.

D.3.5. Cone description on sounding log.

CPT-pro enables presenting basic description of cone used in investigation. The number of cone, tip area, sleeve area, area factors **a** and **b** as well as info about existence pore pressure sensor and location of pore pressure filter can be presented in header table as long as they are selected in *Select header elements* list and filled.

D.3.6. Ground water level symbol.

Ground Water Level symbol – color filled triangle with value of depth or elevation - can be automatically presented on log in case when depth/elevation of water is saved in data file. The value of depth of water level can be edited in [*Header and data options*] window (see E.1). That symbol can be generated on left/right side inside the first left graphic field or outside that field on depth scale (see Fig. D-13). The size and color of that symbol can be defined in [*Options/Graph/Lines*] window – see Fig. H-8.

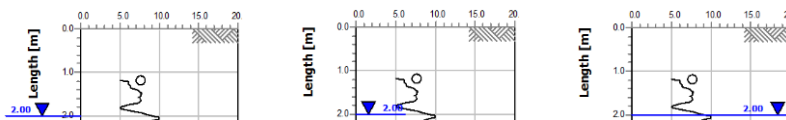


Fig. D-13. Alternative locations of water level symbol.

D.4. Loading DMT files.

DMT files *.DAT registered in Marchetti's dilatometer system DMT can be imported to **CPT-pro** and interpreted. In case the DMT test is performed in proximity to the CPT test, the data contained in the DAT files can be imported and added to the CPT data. In this case, all data will be saved under the name of the CPT test file and the header data will be integrated. If the DMT test is CPT independent, it can also be imported into the program and analyzed.

⁵ Counted along the rod column (= total length of inserted rods)

To add DMT test to already loaded CPT test click **Edit / DMT test** from main menu or the icon **X** on Fig. D-9. To open separate DMT file click **File / Open** from main menu or icon **A**, select [**DMT files (*.dat)**] and click [**Open**].

Once DMT loading option is started the empty (i.e. without graphs) [**Dilatometer test**] window appears. Click [**Load DMT test**] button, select relevant test and click open to load it. All graphs of all available parameters are automatically generated.

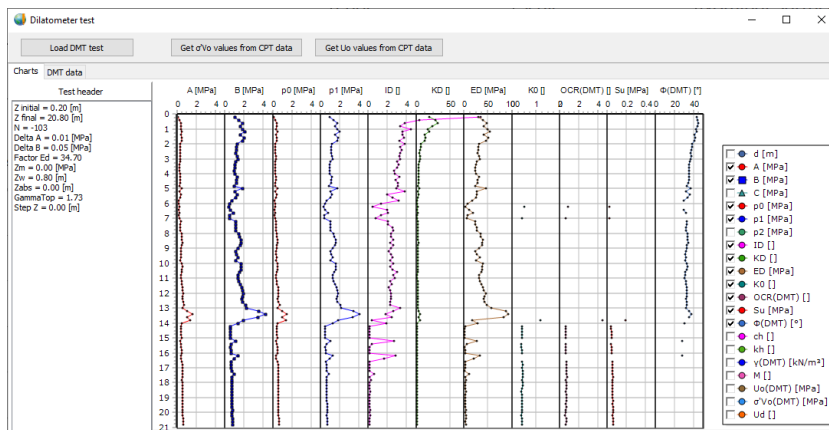


Fig. D-14. [**Dilatometer test**] window with loaded DMT file.

Once DAT file with DMT surveys is loaded, the list [**Parameter type**] in [**Graph layout**] window has included DMT parameters next to CPT parameters – see Fig. D-15. All standard settings like **upper/lower axis**, **logarithmic and inverted** types of axis are available for DMT parameters as well. As DMT parameters are not a continuous ones⁶, trend lines and mean values are not available.

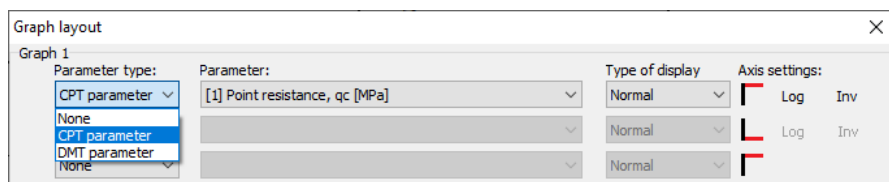


Fig. D-15. [**Graph layout**] window with added DMT parameters.

Once parameter type [**DMT parameter**] is selected, the list [**Parameter**] contains only parameters obtained from selected DMT test, native and interpreted – see Fig. D-16.

⁶ CPT parameters are not continuous as well, however due to very small distance between measurements (usually 1-2 cm), such test can be treated as continuous one. DMT test are usually performed at a vertical distance 0.5 m or more.

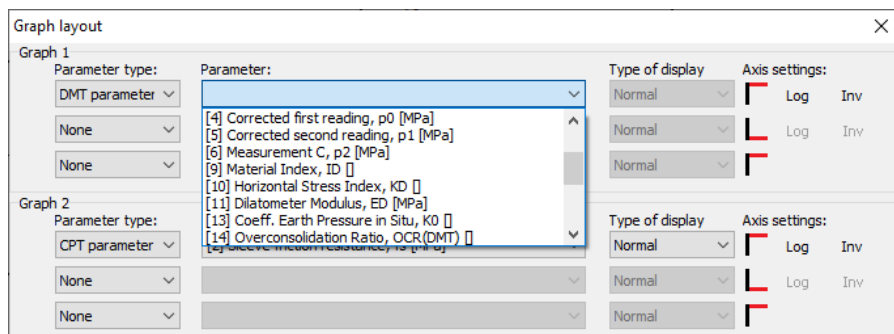


Fig. D-16. [Graph layout] window with selected DMT parameter and scrolled down list of available DMT parameters.

All attributes of DMT⁷ parameters can be set in window [Point parameter settings] – see Fig. D-17. To open this window click **Format / Point parameter attributes** in main menu.

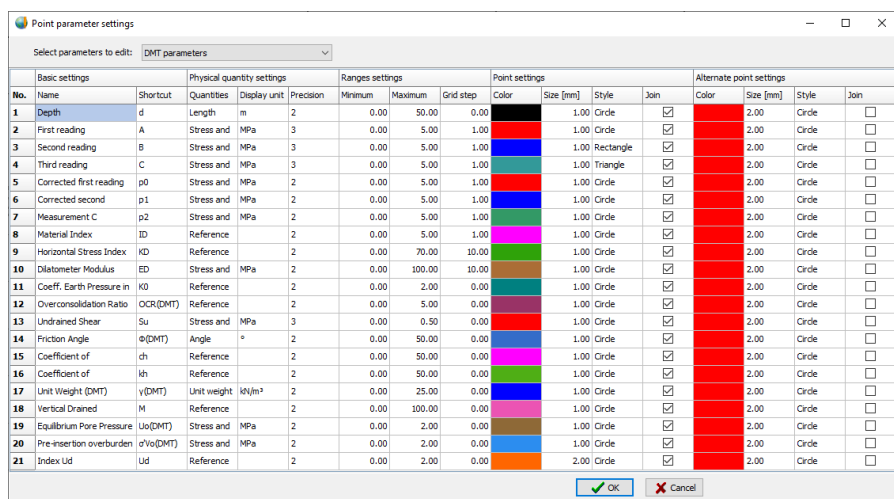


Fig. D-17. [Point parameter settings] window.

⁷ Native or interpreted from DMT

D.5. Saving data files.

In any phase of analyzing data files, the current state can be saved. All changes entered in the numerical layer of **CPT** data file, i.e. new channels created with interpretation results, data corrections, etc., will get saved in the file of edited name.

If the file loaded is a direct entry of **CPT** sounding, then after performing **File/Save as** function, **CPT-pro** will create a file of selected name with extension ***.CPD**. All channels selected in window Options/File/Saving (see **Fig. H-13**) will be saved.

→ ***.CPD** (Cone Penetration Data) format has been formulated for CPT-pro requirements and any similarity of the name of its extension with extensions used in other programs is purely incidental.

→ Some data associated with the CPT results such as classification results, dissipation test results etc. in some native formats are saved in separate files. In the XCPD format all such data are included in one ***.XCPD** file.

If a file created earlier by **CPT-pro** is loaded, then execution of **File/Save** function (or clicking icon **[E]**) will cause saving of its current version.

By means of **File/Save as** function, it is possible to save the analyzed file under a changed name.

D.6. Tools

The following functions are scrolled down after pointing **Tools** by mouse cursor:

- Open config directory – for opening directory [.../ProgramData/Geosoft/CPT-pro] with CPT-pro configuration files
- Restart application
- Langue – for selecting and modification current language

To select relevant language click **Tools / Language** and name of language. It may happen that not all translations are entered or some of them need corrections. To correct entries click [Edit language] on the same list to activate [Edit language] window (Fig. D 7). To edit or add translations just select relevant cell in right column and edit.

For easier searching all entries are grouped in 3 lists and few following groups:

Basic descriptions	Classifications	Extended header descriptions
Extended pore pressure	Robertson 86	Project
Scale	Robertson 90	Test general
Fig.	Robertson 86(b)	Test location
File	Robertson 90(b)	Equipment
Depth	Robertson 2010	Test circumstances
Length	Robertson 2016	
Above sea level	PN-B-04452	
Classification by	Geosond	
Elevation	Meigh 1987	
	Senneset 1989	

The column [**Table description**] contains the shortened version of header parameter name that appears in header table. If table description does not exists, the full header parameter name appears in relevant cell.

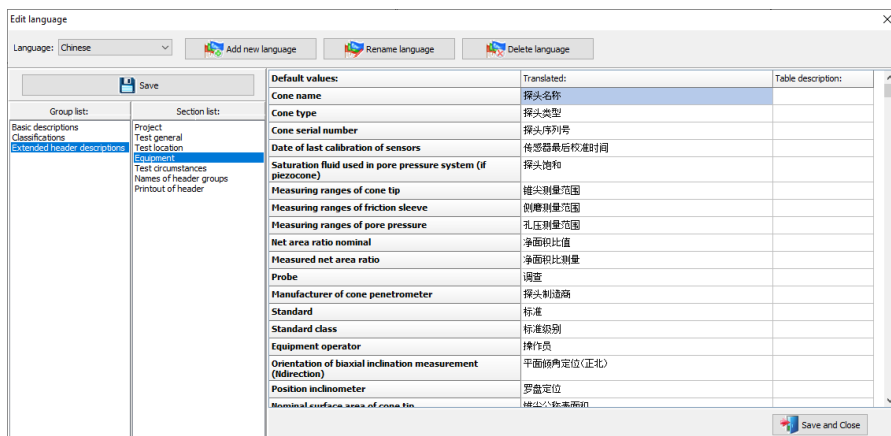


Fig. D-18. Edit language window.

In case when some descriptions have no translation, the default (English) word/description is automatically inserted.

To add new language click [**Add new language**] button, edit and save name of that language and finally edit all relevant entries. Name of language may be modified. If necessary – language and all associated entries may be deleted and removed from list.

➔ *NOTE It may happen that due to User's preferences some header descriptions are expected to be different than used in CPT-pro descriptions equivalent to AGS ones. In case like that User can "add" extra English language and "translate" descriptions according to own preferences.*

➔ *Graphic objects created in Interpretation module cannot be saved for further edition. It is only possible to save the created objects in the form of graphic files *.EMF and *.WMF by performing File/Export as graphic file function or copying the drawings into Clipboard by performing File/Copy to Clipboard function.*

D.7. Appending data files. *Append function.*

During **CPT** soundings, a situation may arise in which it is necessary to extend the sounding performed earlier. Such a situation arises, e.g. when sounding is interrupted because of encountering a layer of very high resistance to sounding and it becomes necessary to re-drill the bore. **File/Append** function enables "sticking on" a second sounding performed as an extension, to a preceding **CPT** sounding.

After activation of **File/Append** function, [**Append CPT file**] window appears in which two panels are visible. The depth of first sounding is selected in **Upper File** panel whereas the initial and final depths of the second sounding are selected in the **Lower File** panel, appended as an extension of the first sounding (see Fig. D-19).

Fig. D-19. Append CPT file window.

After selecting the appropriate depth range and clicking <OK> button, the program appends the selected range of the second sounding to the selected range of the first sounding.

➔ *Only *.cpd files created by CPT-pro can be appended thus it is necessary to import original CPT files and save CPT data as *.cpd file.*

➔ *It is recommended to "stick" CPT data files before any further operation on CPT data, including any calculation and interpretation.*

D.8. Import/Export settings. CPD, AGS, GEF and CSV files.

CPT-pro enables saving processed **CPT** logs in **CPD**, **GEF**, **AGS** and **CSV** formats. All necessary settings connected with these formats are available on window **[Settings]** (see Fig. D-20) activated from menu **File/Import/Export** settings.

The selection of relevant procedure and format is realized in left panel, details relevant for that selection can be set in right panel appropriate for selection in left one. Menus **Import settings** and **Export settings** refer to general settings, menus called format name refer to relevant format.

→ Some import settings are not included in raw data file but may be necessary during the file import procedure. If this happens, than relevant panels of **[File import settings]** window are generated during import – see chapter D and Fig. D-1.

Fig. D-20. Import and export settings.

AGS format are available on windows **AGS channel settings** (Fig. D-21) and **Classification settings** (Fig. D-22). The last one sets the relation between user's geological codes of soil and codes of graphic symbols and this same codes used in **CPT-pro**.

→ The unit of parameter exported to **AGS** is the one selected as **Display Unit** – see chapter H.2.

Settings

Import/export settings

- CPD files
- AGS files
- GEF files
- CSV files
- Datam files

Channels settings

Channel name:	Column name	Export
Depth	STCN_DEPTH	<input checked="" type="checkbox"/>
Point resistance	STCN_RES	<input checked="" type="checkbox"/>
Sleeve friction resistance	STCN_FRES	<input checked="" type="checkbox"/>
Pore pressure behind cone	STCN_PWP1	<input checked="" type="checkbox"/>
Pore pressure on cone	STCN_PWP2	<input checked="" type="checkbox"/>
Pore pressure behind sleeve	STCN_PWP3	<input checked="" type="checkbox"/>
Inclination	STCN_SLP1	<input checked="" type="checkbox"/>
Inclination X		<input type="checkbox"/>
Inclination Y		<input type="checkbox"/>
Temperature	STCN_TEMP	<input checked="" type="checkbox"/>
Electric conductivity	STCN_CON	<input checked="" type="checkbox"/>
Fuel Fluorescence Detector 1		<input type="checkbox"/>
Time		<input type="checkbox"/>
Speed of penetration		<input type="checkbox"/>
Fuel Fluorescence Detector 2		<input type="checkbox"/>
Friction ratio = ft/qt*100%		<input type="checkbox"/>
Dissipated pore pressure		<input type="checkbox"/>
Corrected point resistance		<input type="checkbox"/>
Corrected local friction		<input type="checkbox"/>
Total overburden stress		<input type="checkbox"/>
Effective total overburden stress		<input type="checkbox"/>
qt-sigmaVo		<input type="checkbox"/>
Normalized cone resistance		<input type="checkbox"/>
Normalized friction ratio		<input type="checkbox"/>

OK Cancel

Fig. D-21. AGS channel settings.

Settings

Import/export settings

- CPD files
- AGS files
- GEF files
- CSV files
- Datam files

Classification settings

Classification: Robertson 1986

Soil name:	"GEOIL" code	"LEG" code
Unknown	100	2000
Sensitive fine grained	101	2001
Organic material	102	2002
Clay	103	2003
Silty clay to clay	104	2004
Clayey silt to silty clay	105	2005
Sandy silt to clayey silt	106	2006
Silty sand to sandy silt	107	2007
Sand to silty sand	108	2008
Sand	109	2009
Gravelly sand to sand	110	2010
Very stiff fine grained	111	2011
Sand to clayey sand	112	2012

OK Cancel

Fig. D-22. AGS classification settings.

CSV format is not standardized. In particular, order of columns, units. etc. are not normalized. The import procedure implemented in CPT-pro allows User to assign own CSV columns to CPT-pro parameters (channels) with relevant unit. Additionally, User may omit several start and end rows and define number of columns for import by selecting relevant values in right panel – see Fig. D-23. CSV settings are available once you highlight CSV files on [Settings] window – see Fig. D-23.

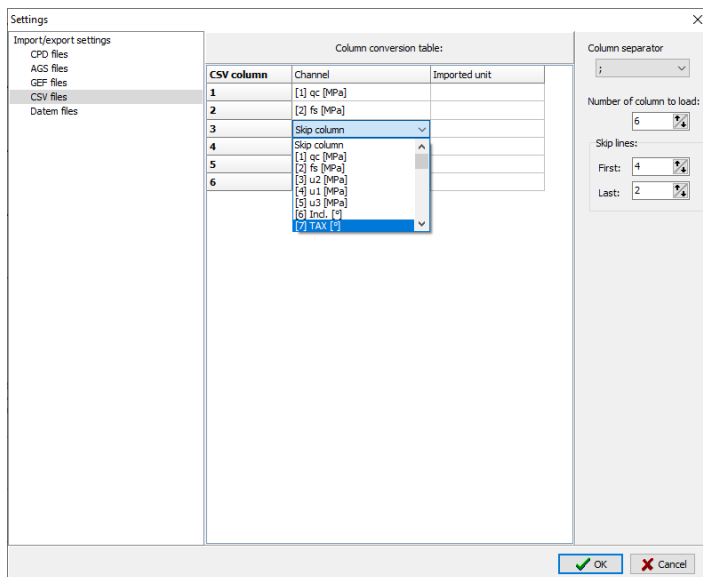


Fig. D-23. CSV import settings.

To select relevant CPT-pro channel scroll down the list by clicking right part of [Channel] column and selecting the parameter. Column separator used in imported data file may be selected from list scrolled down in [Column separator] window in right panel.

D.9. Export data contained in single file.

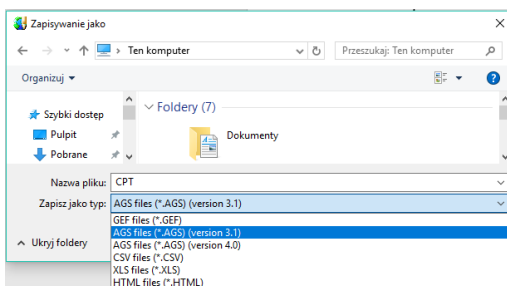


Fig. D-24. Export window.

To export data file click **Export** function, select relevant format, directory where file should be saved and click [OK] button.

D.10.

The **CPT-pro** program enables export of CPT package data along with properties (classification results, interpreted values of geotechnical parameters, etc.) to the **IFC (Industry Foundation Classes)** format, which is the basic standard for exchanging information on building objects designed in **BIM** technology.

D.11. Export soil bar.

It is possible to save the current log (soil bar and graphs) in WMF format. To perform this operations just click [**Export page to WMF**], edit the name of file and select folder where it will be saved.

D.12. Report.

he program enables making tabular printouts of chosen data, including all interpreted channels and the soil type. All **report** options are available from **Report** window, presented in Fig. D-25.

Report consists of header lines on top and table with sounding results. Header information can be selected according to User needs (see Fig. D-26) in window [**Add report header elements**], activated by clicking the button [**Select report header elements**]. Header info can be adjusted to left or right by selecting the relevant radiobutton in pane [**Alignment**]. Fonts used in header can be also selected in standard windows manner after clicking button [**Header font**] .

Table with sounding results can be adjusted to User needs. Not only can User choose channels with values of parameters, but also it is possible to rename each column (standard column title is the name of parameter used in CPT-pro). Editable report title is included on top of report, on bottom - there is included report summary. Fonts used in table can be selected by clicking the button [**Data font**].

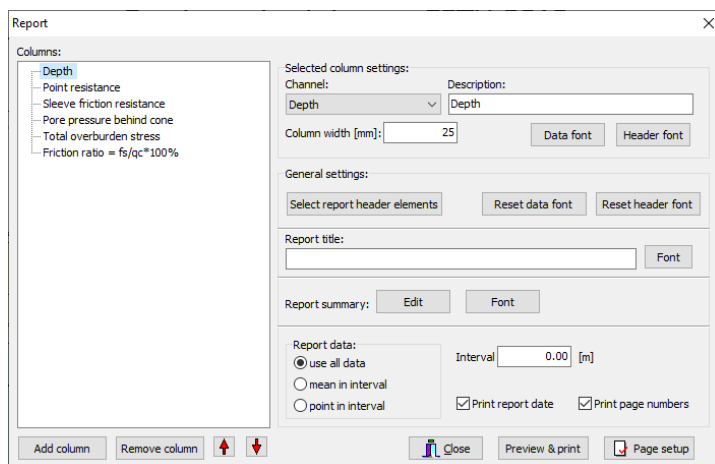




Fig. D-25. Report settings window.

Depth description is always added to report, however, the sequence of presentation the depth column can be changed. If necessary, depth description column can be repeated by adding [**Depth**] channel in the same way as other channels.

Width of column can be defined separately for each column. To define it highlight the chosen channel in **[Columns]** pane on right side and edit the requested value (in mm) in **[Size]** edition window.

To add column click **[Add column]** button (Fig. D-25) and chose relevant channel in **[Add new column]** window Fig. D-27). To remove column highlight it in **[Columns]** pane and click **[Remove column]** button.

To change the sequence of columns highlight the chosen column and move it up or down by clicking arrow icons   below the right pane with listed channels.

[Page setup] button opens standard window with page and printer settings. **[Preview & print]** button is opening print preview and printing options.

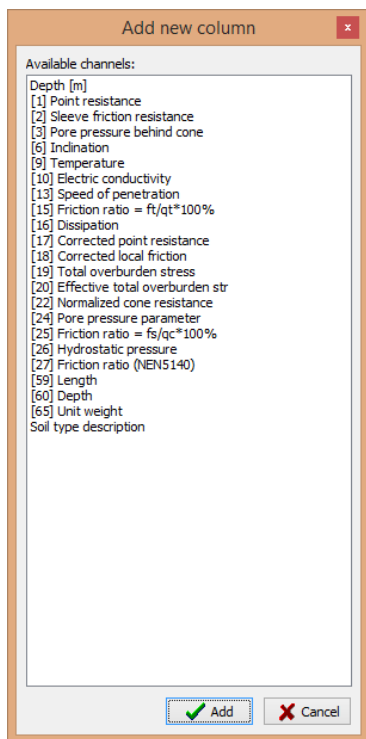


Fig. D-27. Selection of channels to report.
Only available channels are listed.

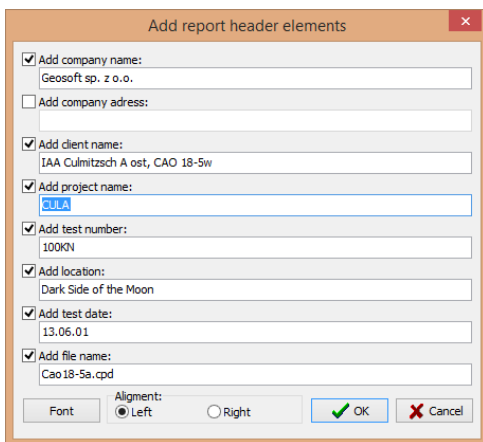


Fig. D-26. Selection of header lines to report.

D.13. Printing.

The program enables making printouts on any paper format accepted by **Windows** system and the printer possessed. To set/change the printout format, open **[File/Print]** menu or click on **[G]** icon (see

Fig. D-9) and perform the appropriate changes of settings. The access to printer settings is available by clicking [**Properties**] button. Clicking [**OK**] button activates printing current log.

Page setup is available by clicking the icon [**F**] (see Fig. D-9). Quick page selection is available by clicking ▼ symbol nest to icon [**F**].

D.14. Batch printing.

CPT-pro is provided with the option of automatic printing of sounding sheets for all the selected, adequately prepared ***.CPD** data files from the set directory and according to set templates (see point I.5).

Activation of **File/Print file list** function causes appearance of [**Batch printing Dialog**] window, containing two pages with [**File list**] and [**Templates**] markers. Selection of files for printing is performed on [**File list**] page. Selection of templates is performed on [**Templates**] page.

Adequate preparation of ***.CPD** files consists in:

- Selection, execution and saving of **Ist** and **IInd** order interpretation results (see 0 and K.7).
- Copying all the files envisaged for automatic printing into one, freely selected directory.
- Precisely defining the selection of ***.CPD** files. This selection is done by moving the visible files from [**Available files**] list to [**Selected files**] list. For this purpose, highlight the selected file and click the button with [>] symbol. The operation should be repeated for consecutive selected files. If all the files from the indicated directory are to be analyzed, clicking the button with [>>] symbol causes moving of all the files to [**Selected files**] list.
- On [**Template list**] page templates of sounding sheets are selected. Selection of templates (entered in ***.TEM** files) is the same as selection of CPT data files.
- To use present layout just check checkbox [Use current template] on [Templates] page.

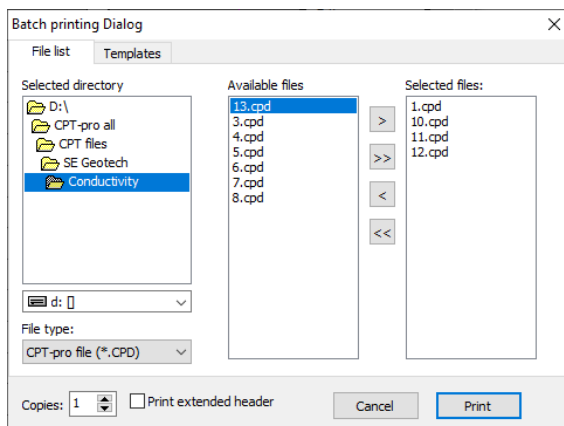


Fig. D-28. Batch printing dialog window.

→ All the selected ***.CPD** files should contain all the interpretation results (entered into the corresponding channels), required by the selected sounding sheet template.

→ Using of macro M5 (see point G.5) for preparing a batch of ***.CPD** files enables avoiding errors and non-consistencies.

→ *There should be selected at least one template from list or highlighted checkbox [Use current template] to execute batch printing procedure.*

In the bottom part of [**Batch printing Dialog**] window, there is box [**Copies**] where the required number of printouts is set by clicking ▲ ▼ symbols.

E. EDITING FUNCTIONS. *Edit* menu.

E.1. Header content edition.

Activation of **Edit/Header** function or clicking on [H] icon (Fig. D-9) gives access to edit/read basic information characterizing the **CPT** sounding executed (Fig. E-1).

Field description	Value	Unit
Project		
Project name	Vega station	
Project ID		
Project location name	Dark Side of the Moon	
Project engineer	Max Otto von Stirlitz	
Client	Geosoft sp. z o.o.	
Start activity of project		
Test general		
Test name	BH166A	
Test ID		
Test type	CPTU	
Type of penetration test		
Pre-excavation depth		1.20 m
First layer density		18.63 kN/m ³
Ground water level		2.50 m
Ground water level elevation		8845.50 m
Water depth (for offshore activities works)		m
Company name		
Date investigation	23.04.2025	
Test location		
Test location name	West Palm Beach	
Height system used		
Z value		8848.00 m
X coordinate		4456347.00 m
Y coordinate		5567489.00 m
Equipment		
Cone name	3281	
Cone type		

Select header elements

☒ OK and print
 ☒ OK
 ☐ Cancel

Fig. E-1. CPT header selection window.

The list of header values contains only elements selected by User in [Select header elements] window (Fig. E-2) window activated by clicking relevantly named button in left down corner. The list may be changed any time.

The list of header elements may be very long (it may include among others all fields required by **GEF 1.1.3** and **AGS 4.0** formats). For easier searching all fields are grouped in five categories – **Project**, **Test general**, **Test location**, **Equipment** and **Test circumstances**.

Field description	Selected
Project	
Project name	<input checked="" type="checkbox"/>
Project ID	<input checked="" type="checkbox"/>
Project location name	<input checked="" type="checkbox"/>
Project location ID	<input type="checkbox"/>
Country of project	<input type="checkbox"/>
Land of project	<input type="checkbox"/>
Province of project	<input type="checkbox"/>
County of project	<input type="checkbox"/>
City / town of project	<input type="checkbox"/>
Streetname of project	<input type="checkbox"/>
Postal code of project	<input type="checkbox"/>
Project comment	<input type="checkbox"/>
Project contractors	<input type="checkbox"/>
Project engineer	<input checked="" type="checkbox"/>
Client	<input checked="" type="checkbox"/>
Start activity of project	<input checked="" type="checkbox"/>
End activity of project	<input type="checkbox"/>
Client field	<input type="checkbox"/>
Test general	
Test name	<input checked="" type="checkbox"/>
Test ID	<input checked="" type="checkbox"/>
Test type	<input checked="" type="checkbox"/>
Type of penetration test	<input checked="" type="checkbox"/>
Pre-excavation depth	<input checked="" type="checkbox"/>
First layer density	<input checked="" type="checkbox"/>
Ground water level	<input checked="" type="checkbox"/>
Ground water level elevation	<input checked="" type="checkbox"/>

Select all header fields

Fig. E-2. [Select header elements] window.

Some header descriptions are acquired from **CPT** raw data file (depending on the manufacturer of **CPT** equipment and logging software) or imported while loading a **GEF** or **AGS** one. The remaining data should be supplemented during office work. This option also enables entering corrections to header data, which will be taken into consideration while creating the printout, saving data as *.CPD basic file and exporting to other formats.

➔ **NOTE.** Due to limited space in header table only few descriptions are included in log. All remaining required ones should be printed as separate report.

Most of descriptions visible in the [**CPT header (selected)**] window can be edited. However, there are few of them of “read only” type with inactive edition like *End depth of penetration test* or presence of some sensors. These fields are inactive and grayed.

- ➔ *The basic system in **CPT-pro** is metric system, however you may have vertical axis with ft as display unit.*
- ➔ ***Groundwater level** is equal to depth of water table in reference to ground level. It should be positive when water table is below ground level and negative when water table is over ground level (testing under water).*
- ➔ *When **Water table** value exists and checkbox [**Water table**] is highlighted, appropriate symbols with description are created on sounding sheet. Also hydrostatic pressure (U_h) is automatically calculated and saved in channel 26.*
- ➔ *When pre-drilling depth is set, First layer density (=unit weight of predrilled layer) should be also set.*
- ➔ *It is very important to correctly give the pre-drilling depth, density of the 1st layer (in which predrilling is performed) and geometrical factors **a** and **b** characterizing the measuring cone, since this data directly affects the calculation results in interpretation procedures.*
- ➔ *If the full program version with CPT-CAD module is used, enabling creation of geotechnical cross sections, it is absolutely essential to enter the coordinates $X [m]$, $Y [m]$ and $Z [m]$, which are automatically read out and used while creating cross sections.*

E.2. Offshore options.

The interpretation procedure is slightly bit different for offshore soundings, as it should take into consideration where zero test had been performed - over the water level (on boat, platform etc.) before sounding, at seabed level (in case of soundings from seabed) and finally – at the bottom of borehole. Depending on that, **CPT-pro** automatically makes all relevant corrections depending on offshore settings and use corrected values of pore pressure u_2 and point resistance q_c , according to procedure described in [1].

It is assumed, that the information whether sounding was performed on land or offshore is included in raw data file and for offshore tests water depth value is included in it (most of CPT manufacturers have relevant position in logging files). In such case CPT-pro recognizes file with water depth value as offshore test and proceeds it in relevant way. However, if such settings does not exist or needs correction, it can be done in **CPT header (selected)options** window just by entering relevant water depth or groundwater level value.

Offshore options can be set in [**Offshore options**] window (see Fig. C-12), which can be activated directly from **Format/General Options** menu.

- ➔ *Offshore settings are saved in **INI** files.*
- ➔ *For **On land** soundings offshore settings are irrelevant and do not effect on interpretation procedure.*

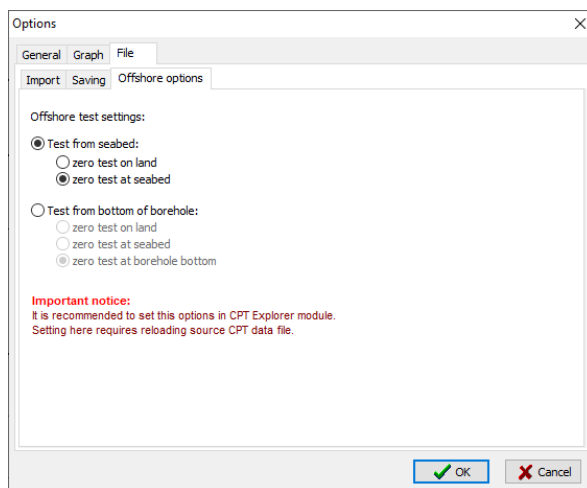


Fig. E-3. [Offshore options] settings.

E.3. Edition of *in situ* pore pressure u_0 .

If pore pressure dissipation test was performed during the sounding process and the value of dissipated pressure were written into the file, the program automatically performs entry of the relevant values into the tables.

No	Depth [m]	U_0 [MPa]	Use for calculation	Print
7		0.21	<input checked="" type="checkbox"/>	<input type="checkbox"/>
8.6		0.28	<input checked="" type="checkbox"/>	<input type="checkbox"/>
9.9		0.35	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Fig. E-4. *In situ* pore pressure table.

If pore pressure dissipation test was not performed and information about pore pressure distribution from other sources (e.g. from piezometers installed) is available, the **Pore Pressure In Situ** function enables entering this data into the program. Data about pore pressure distribution will be taken into account in sounding interpretation.

After actuating **In Situ Pore Pressure U_0** function, [In Situ Pore Pressure U_0] relevant window appears for edition existed values or entering the new ones. After completing edit/entry, click <Save & Exit> button.

The size of symbols on graphs can be selected in [Point size] window.

E.4. Piezometers.

Piezometers function enables editing water depth levels in maximum three stand pipe piezometers mounted close to CPT sounding.

Piezometers:

Depth below ground level

Piezometers:

Code:	Outer pipe:	Inner pipe:	Water level:	Visible
A1	1 [m]	12 [m]	0 [m]	<input checked="" type="checkbox"/>
	Filter top:	Filter bottom:		
	9 [m]	11 [m]		
A2	0 [m]	0 [m]	0 [m]	<input checked="" type="checkbox"/>
	Filter top:	Filter bottom:		
	0 [m]	0 [m]		
A3	0 [m]	0 [m]	0 [m]	<input checked="" type="checkbox"/>
	Filter top:	Filter bottom:		
	0 [m]	0 [m]		

Colors:

Water filling:	Filter filling:	Lower arrow:
Water pattern:	Filter pattern:	Upper arrow:

Fig. E-5. Data/ Piezometers / window.

After actuating **Edit/ Piezometers** function, the [**Piezometers**] window appears (see Fig. E-5), where You can insert/edit parameters of up to three stand pipe piezometers.

To activate edition highlight checkboxes [**Visible**] on right side. Now You can edit values in all fields in standard way. [**Code**] (max. three characters) means a symbol of piezometer, [**Outer pipe**] means the length of pipe over the ground level, [**Inner tube**] means the length of pipe below the ground level. [**Water level**] is the depth of water table below the ground level.

After edition of all necessary values and clicking <OK> button, the sounding sheet with symbols of piezometers appears. The length of piezometer bars, both over the ground level and below the ground level, is proportional to length of pipes (unless there is no space over the chart area).

Piezometer data are saved in extra file ***.spp** and can be edited any time. Values of water

level are printed inside the piezometer bars.

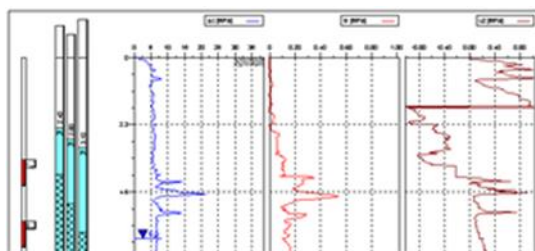


Fig. E-6. Sounding log with piezometers.

E.5. DMT test.

Procedure of loading and interpreting DMT test is described in chapter D.4.

F. OPERATIONS ON DATA FILES. *Data* menu.

CPT-pro enables performing a number of operations on data files recorded by **CPT** sounding process. Access to all the functions is possible from the main menu of **Interpretation** module after actuating **Data** function.

→ Channels **1**, **2** and **3** with **qc**, **fs** and **u** parameters are used in sounding interpretations and the changes introduced in the data in these channels will directly affect the interpretation results.

F.1. Copying the channels.

CPT-pro is provided with a number of functions to change the values of parameters in the individual channels. For greater work safety, we recommend prior creation of copies of selected channels and to perform operations on these copies. In case of any incorrect operations whatsoever, it is then possible to reproduce the original values. After performing suitable operations on the data files (in the copied channels) and checking that the operations performed are correct, the corrected channels can be copied onto the basic channels **1**, **2** and **3** and the calculation procedures started (presented further in this instruction).

Copying of channels is performed as follows:

- Open **Data** menu and activate **Copy channels** function. **[Copy]** window appears (see Fig. F-1), in which all the channels existing in the *.CPD file processed are visible, along with edit window of source channel number and destination (final) channel number.
- Enter the source channel number *x* and destination channel number *y*.
- Click **<OK>**.

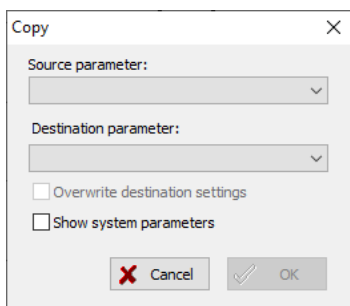


Fig. F-1. *[Copy] window.*

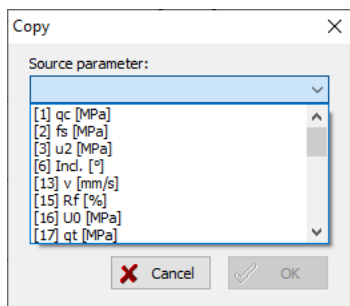


Fig. F-2. *[Copy] window with source channels scrolled down.*

Execution of the above operations caused the creation of new channel [y] in which all the values for every depth are identical to the values entered in source channel [x]. After actuating the sounding sheet configuration window [*Graph settings*] (by clicking on icon [W] (see Fig. D-9), the newly formed channel [y] is visible.

MACRO M1 (see point G.1) is provided as an additional safeguard. It automatically copies channels **1, 2** and **3** containing the basic parameters **q_e**, **f_s** and **u** respectively, on channels **71, 72** and **73**.

F.2. Depth correction of recorded parameters.

The design of the probe (viz. mutual location of tip cone, friction sleeve and porous filter) introduces certain shifts in the plumb of measured parameters. To increase the accuracy of interpretation, **Depth correction** function has been introduced enabling the entry of reading depth corrections for all the parameters. Since the tip cone level is used as the reference level in most designs, and all the other sensors are located higher, **Depth correction** function enables shifting the graphs/diagrams in one direction only.

Depth correction of recorded parameters is performed as follows:

- Open **Data** menu and activate **Shift** function. [*Dialog*] window appears (see Fig. F-3), in which all the channels existing in the *.CPD file processed are visible.
- Choose channel and distance of shifting.
- Click <OK>

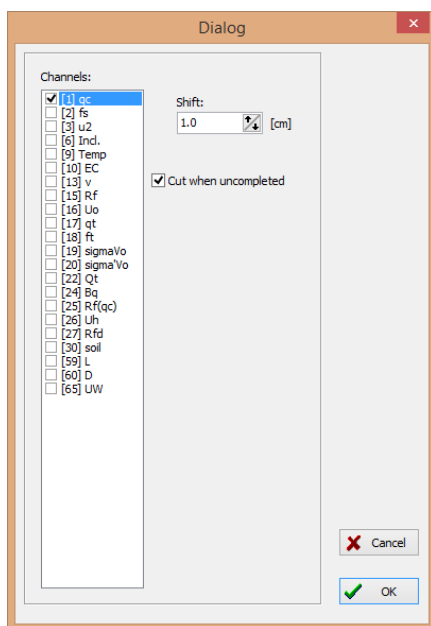


Fig. F-3. [Shift] function.

- ➔ If the selected shift value is not consistent with the distance between measurements, the program performs the corresponding corrections automatically.
- ➔ The operation of depth correction should be performed before actuating interpretation.
- ➔ Highlighting [Cut when uncompleted] checkbox will cut part of graph where one or more channels have no values.

F.3. Reduction of zero spikes.

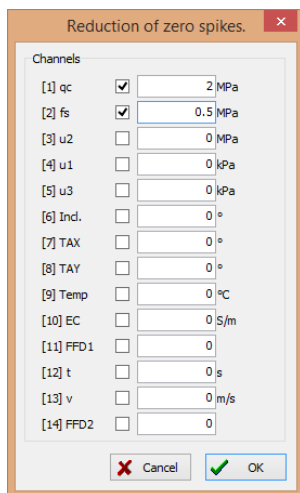


Fig. F-4. Reduction of zero spikes window.

During sounding, it happens that values approaching zero, not resulting from actual measurement, get recorded (e.g. while advancing CPT rods). **Reduction of zero spikes** option enables automatic substitution of all measurement values less than the set value in any arbitrarily selected channel with mean values, calculated in the “zero spike” point environment

After actuating *Data/ Reduction of zero spikes* function, [Reduction of zero spikes] window appears (Fig. F-3.) in which the channels should be marked together with the depth measurement below which relevant reduction will be performed.

After editing all the fields in [Reduction of zero spikes] window, click <OK>.

- ➔ The units appeared on right side of edition fields are Unit 1, which are used in many options of software (see H.2.).
- ➔ The zero interval should be selected individually for each sounding parameter.

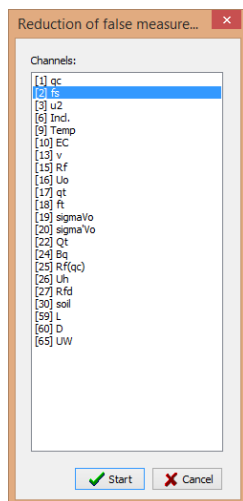
F.4. Reduction of false measurements.

Reduction of false measurements function written in *Data* menu as **Reduction of ...**, enables eliminating measurements resulting from the effects of external factors and not representing the actual properties of soil. An example of such a measurement is the recorded value of cone resistance q_c while encountering a small stone. In the initial phase, substantial increase occurs of q_c parameter and after a while (after pushing away or crushing the stone) its drop to preceding values. High value of q_c entered into the interpretation procedure in effect gives a false result and should therefore be eliminated earlier.

Reduction of false measurements function enables substituting the values of measurements considered by the operator as false with mean values from the nearest vicinity of the false measurement zone.

After actuating *Data/reduction of false measurements* function, [Reduction of false measurements] window appears. Visible in this window, in [channels] panel are all the channels existing

in the *.CPD file being analyzed. Select the channel in which reduction of false measurements and range of depth will be conducted.



After selecting the channel, click <START> to open [*Reduction of false measurements*] window. Depth of sounding is on the vertical axis and the parameter value on the horizontal one.

Fig. F-5. Reduction of false measurements window.

The visible red (Start) and blue (End) lines whose location can be changed by the left or right button of the mouse, determines the location of the area which will be additionally enlarged. The depth corresponding to the location of the lines is visible in relevant windows. To zoom selected area just "draw" rectangle with mouse cursor from left upper corner to right down one.

After setting the proper location of red and blue lines (i.e. location in the area in which the false values will be eliminated), click the button [*Interpolate*] to remove all values between marking lines and interpolate relevant values. After eliminating all the measurements considered by the operator as false, return to the main menu via the [*Save changes and exit*] or [*Exit without save*] button.

Fig. F-6. Reduction of false measurements 2nd window.

F.5. Calculating mean values in selected intervals.

Mean function in **Data** menu enables substituting the values of any selected parameter with its mean values calculated in any intervals selected by the operator.

After actuating [**Data/ Mean**] function, [**Mean values in ranges**] window appears.

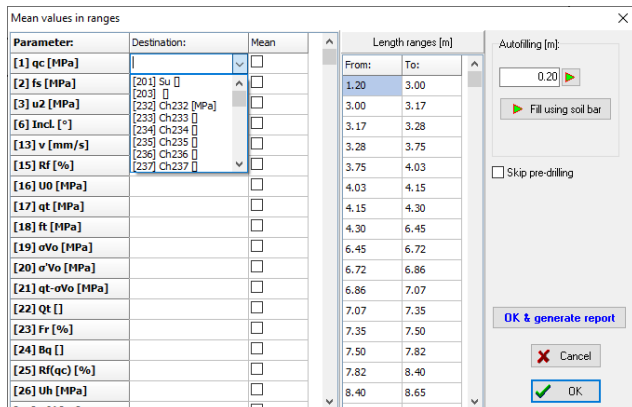


Fig. F-7. Mean values in ranges.

All channels existing in the *.CPD/XCPD file being analyzed are visible in this window in [**channels**] panel. By highlighting the appropriate fields, select the channels in which averaging of measurements is to occur. As it is recommended not to change “original” values of parameters, mean values are calculated only on copies of

chosen channels. Destination channels can be chosen from lists.

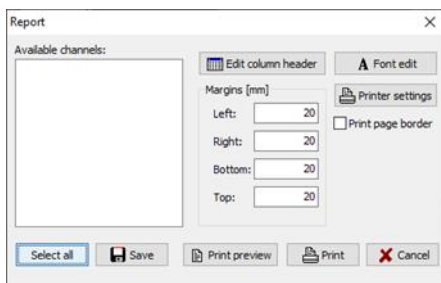



Fig. F-8. [Report] window.

In the panel [**Depth ranges [m]**] panel, edited in standard way are the depths determining the subdivision of the full depth range of sounding into intervals in which the mean values will be calculated. The edit field is changed by using the mouse or the direction arrows ←, →, ↑ and ↓ on the keyboard.

It is also possible to fill [**Depth ranges [m]**] panel in automatic way with constant interval by setting this interval and pressing icon  in right upper panel [**Autofilling**]. Report function is activated by pressing [**OK & create report**] button. Report, page and printer settings are standard for Windows system.

After clicking [**OK & create report**] button [**Report**] window appears. You can customize report by editing all info in header. Printer settings are also available from this window. Click [**Save**] button to save reported data as **TXT** or **CSV** file.

F.6. Basic statistical functions.

The CPT-pro program allows for basic statistical analysis of the variability of recorded and interpreted parameters. These functions are available in the **Data / Basic statistical functions** menu – see [Local values of statistical functions] window .

For each depth **H** at which the sounding parameter values are recorded, the following statistics are calculated:

- Local mean value μ_L in the neighborhood of depth **H**
- Local standard deviation σ_L in the neighborhood of depth **H**
- Local coefficient of variation V_L in the neighborhood of depth **H**

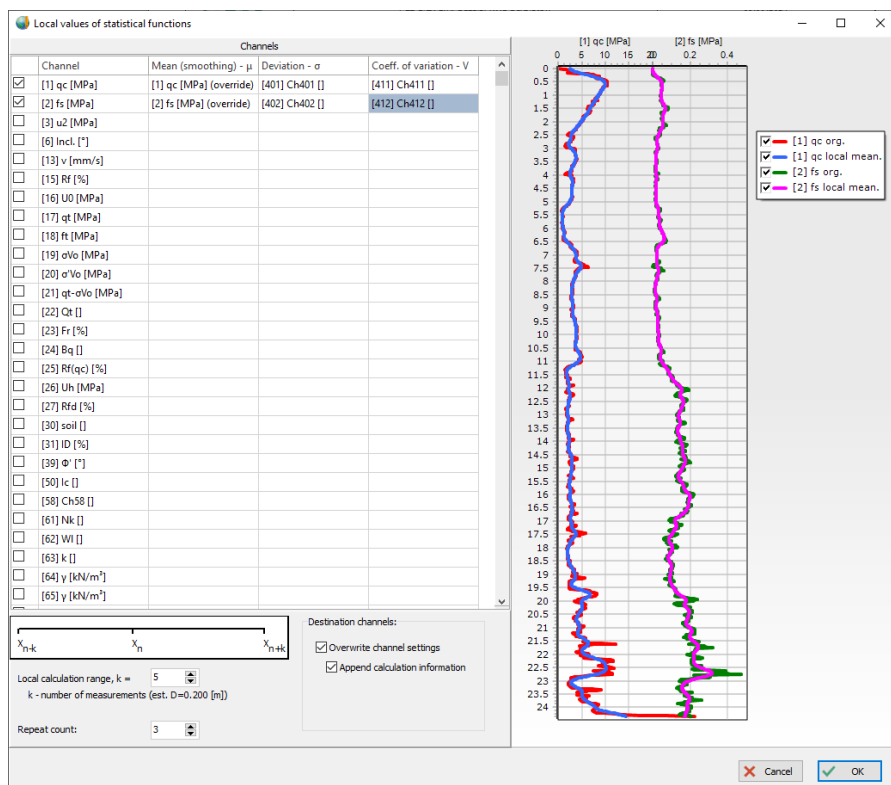


Fig. F-9. [Local values of statistical functions] window.

The size of the neighborhood (radius – see Fig. F-9) is defined by the User by specifying the number of measurements **k** above and below depth **H**. For the selected **k**, the diameter of the surroundings is estimated – the size of the depth interval (**H-Δh**, **H+Δh**). The size of the neighborhood is common to all the above statistics.

Checking the checkboxes and selecting the target channels for individual statistics results in performing calculations and saving the results on the selected channels – see Fig. F-9.

F.6.1. Local mean value μ_L .

The **Local mean value** function allows for calculating the **local mean value** μ_L in the neighborhood defined by the User, i.e. in the depth range $(H-\Delta h, H+\Delta h)$, where Δh is the radius of the neighborhood above and below the depth H .

Calculations are performed for each depth H and for channels selected by the User. The result of the calculations can overwrite the output values (then replacing the original parameter values with the average value from the environment defined by the User) or be saved on a channel selected by the User.

In the case of saving the local average value of the parameters q_c , f_s and u_z on the output channels, these average values can be taken for further interpretation if averaging took place before further analysis.

After executing the **Data/Statistical functions** function, the **[Local values of statistical functions]** window appears (Fig. F-9). In this window, you should select the channels to be “averaged” and specify the size of the environment in which the average value will be calculated. For each depth H at which a measurement x_n is made, the environment is defined by specifying the number of measurements k above and below that depth, from which the average value will be calculated – see Fig. F-9.

F.6.2. Local standard population deviation σ_L .

Local **standard population deviation** σ_L is defined as:

$$\sigma_L = \sqrt{\frac{\sum (X_i - \mu_L)^2}{N}}$$

Where X_i – individual parameter values in the depth range $(H-\Delta h, H+\Delta h)$
 μ_L – the average value in the set of values of parameter X in the interval $(H-\Delta h, H+\Delta h)$
 N – number of measurements

The value of the local standard deviation σ_L of the parameter X at depth H is defined as the standard deviation in the population of determinations of this parameter estimated/measured in the depth interval $(H-\Delta h, H+\Delta h)$, where Δh is the radius of the environment above and below the depth H .

→ It is recommended to copy the channels for safety before performing smoothing operations on them.

F.6.3. Local coefficient of variability V_L .

Local coefficient of variability V_L at depth H is a measure of the variation of the parameter X value in the population of the parameter values *estimated/measured* in the depth range $(H-\Delta h, H+\Delta h)$, where Δh is the radius of the environment above and below the depth H .

In contrast to the local standard deviation σ_L , the coefficient of variation V_L is a relative measure, dependent on the local mean value μ_L of the parameter X in the interval $(H-\Delta h, H+\Delta h)$.

The *local coefficient of variation* is defined as

$$v_L = \frac{\sigma_L}{\mu_L}$$

Where σ_L - the value of the local standard deviation in the range $(H-\Delta h, H+\Delta h)$
 μ_L - the mean value in the set of parameter X values in the range $(H-\Delta h, H+\Delta h)$

F.6.4. Integration.

Integration function can find application in engineering calculations, particularly those involving the designing of piles. For an arbitrarily selected value of parameter Y and depth H , this function causes calculation of the value.

$$(1) \int_0^H Y(h)dh$$

After actuating **Data/Integration** function, **[Integration]** window appears in which the integrated channel/parameter should be highlighted together with the destination channel number. Clicking <OK> causes creation of the new channel in which the values at depth H are equal to $\int_0^H Y(h)dh$

F.6.5. Differentiation.

The operation of differentiating the parameter values provides information about the "speed" of the increase of the parameters with respect to depth.

F.6.6. File set statistics.

Basic statistics concerning set of selected files are implemented. To run this option (see Fig. F-10) click **[Statistics]** from menu **[Data]**.

To generate statistics for the set of files do the following:

1. Click **[Add files]** for selection of data files. The selection is standard for Windows system and standard system windows are used for this operation. To select file just highlight it and click open. To select more files use **[Shift + right button]** and/or **[CTRL + right button]** functions.
2. Select classification method from list scrolled down.
3. Click **[Calculate]** button for scanning all selected files and generate statistical report.

The following information can be generated automatically for list of selected files:

- Total length of each type of soil calculated individually for each data file and for each classification method performed earlier
- Percentage share of each type of soil calculated individually for each data file and for each classification method performed earlier
- Total length of each type of soil calculated collectively for selected files
- Percentage share of each type of soil calculated collectively for selected files
- Depth/Length of each selected file
- Total Depth/Length of all selected files
- Results of calculation can be exported to **Excel *.XLS** format.

The content of the header fields in selected CPT tests is visible in the **[Header]** tab. This option is intended to quickly check the completeness of the data in the headings of individual tests.

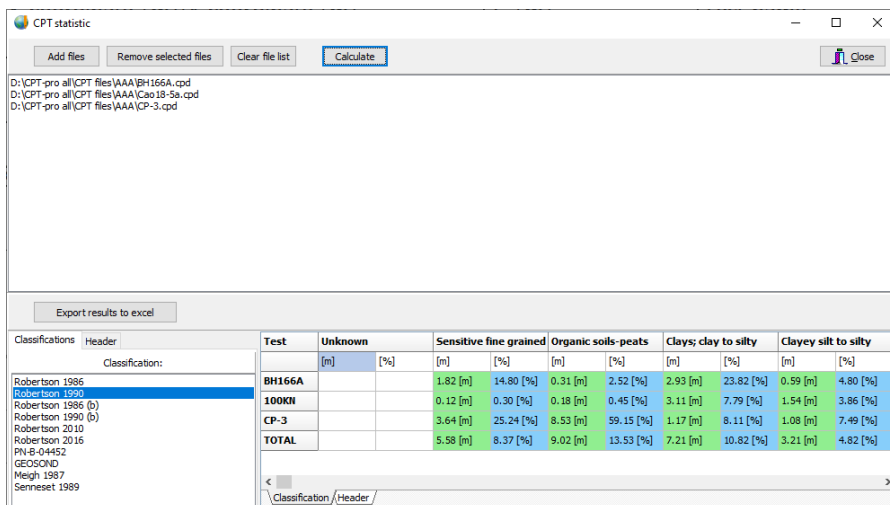


Fig. F-10. Statistics. Tab [Classifications]. The percentage of types of soil in the CPT tests.

→ It may happen that selected files contain more than one section with results of different classifications. In case like that only selected classifications will be considered.

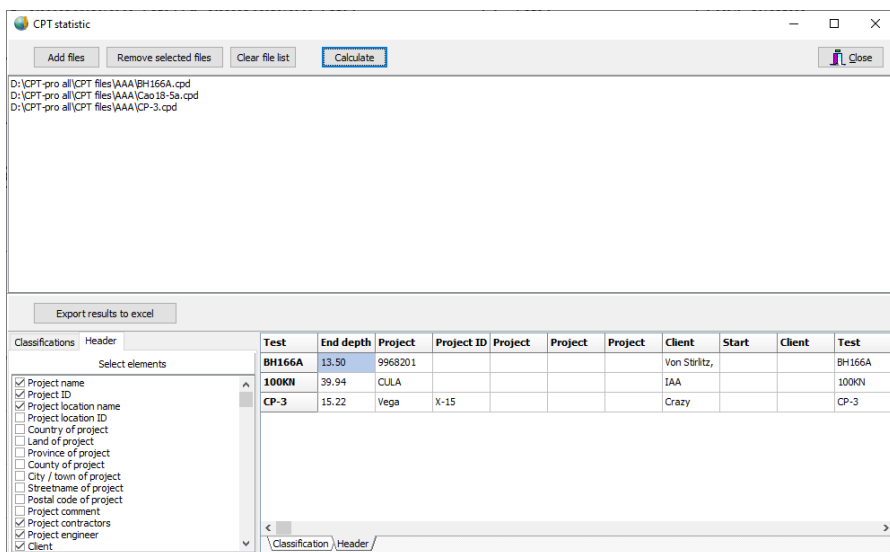


Fig. F-11. Statistics. Tab [Header]. Header content in the CPT tests.

F.6.7. Characteristic values of parameters.

The characteristic value of parameter \mathbf{X} for a given soil layer is the most representative estimate of its value. According to engineering practice, such an estimate seems to be the average value μ of parameter \mathbf{X} determined for the entire layer, but in reality it is possible to calculate the average value only for a very limited set of \mathbf{X} parameter values in a given layer. The average of these values usually differs significantly from the average of the entire layer, so the problem to be solved is to estimate the "true" value of the mean values of variable \mathbf{X} for the entire layer based on the available set of markings (laboratory tests, CPT tests, other field tests, etc.) and statistical methods.

According to **Eurocode 7**, the characteristic value of parameter \mathbf{X} is the *five percent quantile* of the probability distribution of variable \mathbf{X} . However, such an estimate generates major problems in engineering practice, resulting from the fact that the variability of the parameter \mathbf{X} value is influenced not only by random factors but also by the natural variability inherent to the soil.

Directly adopting the **EC7** requirement (5% quantile) in many cases results in an excessive underestimation of the characteristic value, which in turn generates specific problems during design.

A number of statistical methods are used in the CPT-pro program to estimate the characteristic value of parameters. As a rule, it is assumed that the statistical analysis is carried out on the values of the parameters \mathbf{q}_c and \mathbf{f}_s , and after estimating the characteristic values of these parameters, appropriate correlation equations are then imposed.

Taking into account the fact that in some circumstances the **5% quantile** should be used and in others the **95%**⁸, the following procedures have been implemented in the **CPT-pro** program to estimate the characteristic values of geotechnical parameters:

- i. The mean value $\mu(\mathbf{X})$ of the parameter \mathbf{X} calculated from the available values of \mathbf{X}
- ii. According to *Polish standard PN-81/B-03020* : [*the mean value from the sample – population standard deviation $m(\mathbf{X})-\sigma(\mathbf{X})$*]
- iii. According to method by Schneider – [*the mean value from the sample – half of the sample standard deviation $m(\mathbf{X})-s(\mathbf{X})/2$*]
- iv. According to method by Schneider – [*the mean value from the sample + half of the sample standard deviation $m(\mathbf{X})+s(\mathbf{X})/2$*]
- v. [*the mean value from the sample – sample standard deviation $m(\mathbf{X})-s(\mathbf{X})$*]
- vi. [*the mean value from the sample + sample standard deviation $m(\mathbf{X})+s(\mathbf{X})$*]
- vii. According to Eurocode 7 – [*5% quantile of the probability distribution of variable \mathbf{X} = $\mu(\mathbf{X})-1.645\sigma(\mathbf{X})$*]
- viii. According to Eurocode 7 – [*95% quantile of the probability distribution of variable \mathbf{X} = $\mu(\mathbf{X})+1.645\sigma(\mathbf{X})$*]
- ix. First-quarter method⁹ - [*$(m(\mathbf{X}) + X_{min})/2$*] (where X_{min} – minimum value from the sample)

⁸ The rule is to adopt safer values

⁹ The *first/fourth quarter method* is not based on statistics and has no mathematical support. It is an easy-to-use approximate method used in some countries.

-
- x. Fourth-quarter method - $[(m(X) + X_{max})/2]$ (gdzie X_{max} – maximum value from the sample)
 - xi. According to method *3-sigma* by Duncan – [55% *quantile of the probability distribution of variable* $X = \mu(X) - 1.645\sigma(X)$] where $\sigma(X)$ is estimated as $\sigma(X) = 1/6 (X_{max} - X_{min})$
 - xii. According to method *3-sigma* by Duncan – [95% *5% quantile of the probability distribution of variable* $X = \mu(X) + 1.645\sigma(X)$] where $\sigma(X)$ is estimated as $\sigma(X) = 1/6 (X_{max} - X_{min})$

Characteristic values of parameters can be calculated independently for *geological-engineering layers*, for *geotechnical layers* and for *lithological layers*.

In the first two cases, the *characteristic values* are calculated jointly for the selected set of soundings, while for lithological layers they are calculated separately in each CPT test.

G. MACROS.

To simplify and accelerate work with **CPT-pro** package, certain standard operations performed frequently have been automated by means of macros. Activation of **Macros** function causes opening of the access panel to the individual macros.

G.1. Copying of channels 1, 2 and 3. Macro 1.

Actuation of **Macros/M1 Copy channels 1,2,3** function causes opening of [**Macro 1**] window.

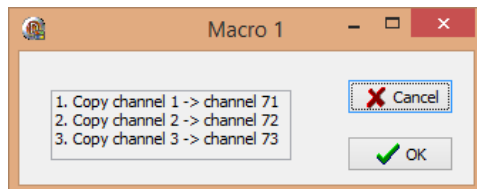


Fig. G-1. [**Macro 1**] window.

Clicking <OK> causes creation of new channels of numbers **71**, **72** and **73**, on which channels **1**, **2** and **3** with parameters q_c , f_s and u will get copied. It is recommended to take advantage of q_c , f_s and u in situations in which operations on sounding parameters q_c , f_s and u in further work are envisaged.

In case of performing incorrect operations on sounding parameters entered in channels **1**, **2** and **3**, it is possible to reproduce the original values in these channels by re-copying from channels **71**, **72** and **73**.

G.2. Smoothing channels 1 and 2. Macro 2.

Macro **M2 – Smoothing channels – 1** and **2** enables calculation of relevant *local mean values* (see chapter F.6.1) for channels **1** and **2**, and saving results on source channels.

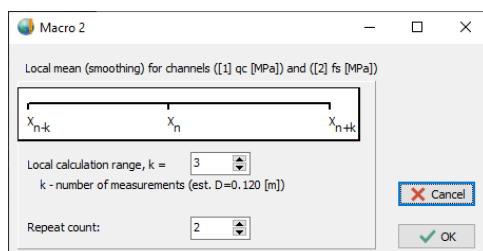


Fig. G-2. [**Macro 2**] window.

The procedure realized by macro **M2** consists in executing the following operations the number of times times defined in [Repeat count] edition window.

- * For each measuring depth of sounding parameters written in channels **1** and **2** (with the exception of the first and the last two measurements), the mean value is calculated in the environment of range [$k \pm 2$ measurements] according to the formula:

$$Z_n = \frac{Y_{n-2} + Y_{n-1} + Y_n + Y_{n+1} + Y_{n+2}}{5}$$

- For each depth (for each measurement), values of Y_n parameters in channels **1** and **2** are substituted with calculated mean values of Z_n .

G.3. Elimination of thin layers. Macro 3.

Irrespective of the method of interpreting soil classification, very thin layers of thickness equal to the distance between measurements and which generally do not reflect the actual geological structure, may occur as a result of interpretation. **Macro M3 - elimination of thin layers** enables elimination of all layers of thickness less than that selected by the operator, through their horizontal subdivision and assigned to layers lying above or below. Activation of **Macros/Macro M3 – elimination of thin layers** function causes appearance of [Elimination of thin layers] window in which the minimum layer thickness in soil classification bar should be specified.

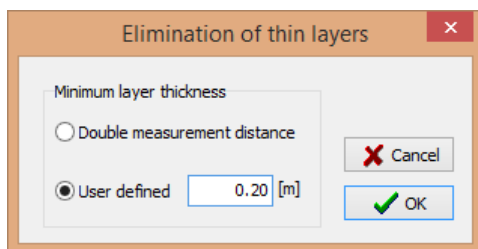


Fig. G-3. [Elimination of thin layers] window.

Selection of **User defined** option activates the box in which the minimum thickness should be edited in units of length [m]. Clicking <OK> button causes elimination of all layers thinner than the defined value. See also chapter 0.

G.4. Depth correction. Macro 4.

The design of a standard measuring cone causes measurements of individual sounding parameters q_c , f_s and u (and eventually others also) assigned to one depth (generally defined by location of tip cone and measurement q_c) in reality concern different ground zones, distant from each other by a few centimeters. Macro 4 enables mutual shifting of sounding graphs/diagrams so as to eliminate the effect of the measuring cone geometry and hence obtain greater accuracy of interpretation.

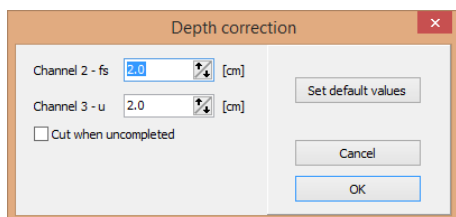


Fig. G-4. [Depth correction] window.

Activation of **Macros/Macro 4 – Depth correction** function causes appearance of [Depth correction] window in which the amount of shift for **channel 2** with parameter f_s and **channel 3** with parameter u should be edited.

Clicking <**Set default values**> button causes setting of shift distance to 8 cm for channel **2** and 2 cm for channel **3**. Clicking <**OK**> button causes shifting of graphs/diagrams of channels **2** and **3** by the defined values.

- ➔ *The program adapts the selected amount of shift to the distance between measurements.*
- ➔ *Shifting of other channels is realized by means of Shift function described in point F.2.*
- ➔ *Macro M4 can be executed only once. As the information about executing this macro is saved in *.CPD file, it cannot be repeated even after loading next time. If something must be corrected after executing **Macro M4**, use **Depth Correction** function (see F.2). Additional information is in right side of lower status bar.*

G.5. Batch processing of set of CPT data files. Macro 5.

The scope of **CPT** sounding interpretations often proceeds according to certain fixed concepts. It happens that a number of **CPT** data files (particularly those performed in one area within the framework of one project) are analyzed and interpreted in exactly the same way, and bore sheets are created according to identical concept. Macro **5** – **batch processing** enables executing identical standard operations simultaneously for all selected CPT data files, creation of relevant *.CPD files with operation results and their entry into the selected directory.

- ➔ *Execution of **macro 5** should be preceded by copying of all the files that are to be analyzed simultaneously, into one (freely selected) directory.*
- ➔ *Execution of **macro 5** should be preceded by selection of 1st order interpretation method.*
- ➔ *CPT-pro “remembers” the 1st order interpretation method selected last (information on the selected method is available on the bar in the bottom part of the screen). If this method is the proper one, the select method procedure need not be repeated.*

If you wish to change the **1st order interpretation method**, perform the following operations:

- a) Activate **Tools/Classification methods** function (see chapter 0).
- b) Select the interpretation method by clicking symbol **6** beside the box with the name of the method and click the mouse left button on the selected method.
- c) Click <**New**> button.

Activation of **Macros/Macro 5 – batch processing** function gives access to macro **5** functions. These functions are grouped on six pages marked as:

- **File list**
- **General**
- **Description**
- **Channel oper.**
- **Units**
- **Output**

and lower panel visible with all pages.

[File list] page.

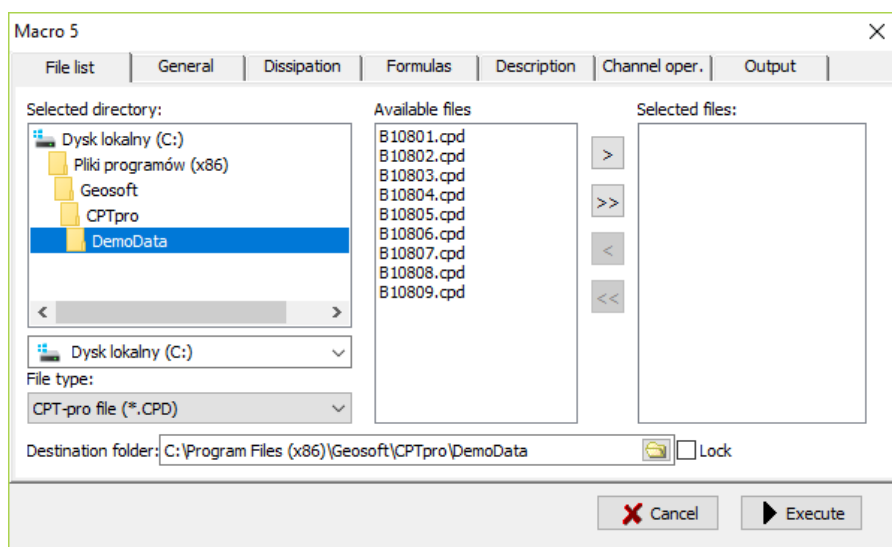


Fig. G-5. [Macro 5 / File list] window.

On [File list] page, the following functions are realized:

- Selection of directory containing analyzed **CPT** data files (standard as for **Windows** system).
- Selection of type of analyzed **CPT** data files.
- Selection of **CPT** data files envisaged for further analysis.
- This selection is realized by “tossing” visible files from [Available files] list to [Selected files] list. To do so, highlight the selected file and click the key with symbol [>]. Repeat the operation for consecutive selected files. If all files from the indicated directory are to be analyzed, then clicking the key with symbol [>>] causes “tossing” of all files to [Selected files] list.

[General] page.

In [Macro 5/General] window (see Fig. G-6), the following functions are realized:

- * Selection of other macros that are to be executed simultaneously. The selection is done by checking (symbol ✓) box beside the name of the macro.
- * Setting the minimum layer thickness – by editing the minimum layer thickness (in [m], [ft] or [in]) in the [Minimum layer thickness] edit box.
- * Selection of **Ist order interpretation method**, activated by clicking <Select classification> button (see chapter 0)
- * Selection of **IInd order interpretation method**, activated by clicking <Select evaluation> button (see chapter K.7).
- * Edition of predrilled soil density. The value edited in lower panel is considered only in case when CPT data file does not include it.
- * Edition of area factors **a** and **b** common for all selected files. Values edited in **General** page are considered only in case when CPT data files do not include them.

- * Activating the filter [**Zero spikes reduction**] removing spikes and its settings.
- * Activating the procedure of calculation standard parameters (see chapter K.1).
- * Setting the vertical axis type (common for all sounding sheets).
- * Adding value of water level (common for all files or added separately for each of them).

Fig. G-6. [Macro 5 / General] window.

[Dissipation] tab.

It happens sometimes that irrelevant dissipation tests are saved while testing. Page [Dissipation] has included tools for quick automatic removing all dissipation tests that are estimated as incorrect according to criteria depth and duration of dissipation test.

You may select the depth criterium as just depth or percentage of depth of penetration. The time criterium is just time of test. On [Formulas] page, the selection of own formulas (see 0) executed in batch processing is realized. Each formula is described with its name, additionally the channel on which the result is saved is listed. In case of conflict of destination channels (two or more formulas with the same destination channel) you can directly go to the settings of formulas by clicking [Configure formulas] button and modify them in relevant way.

➔ Selecting two or more formulas with the same destination channel results in overwriting results of calculation by next formulas, so first results are lost.

Fig. G-7. [Macro 5 / Dissipation] window.

[Formulas] tab.

Formula name	Destination channel
<input checked="" type="checkbox"/> Relative density	[85] Ch85

Fig. G-8. [Macro 5 / Formulas] window.

[Description] page.

Project name: ☐ Overwrite

Project ID: ☐ Overwrite

Location: ☒ Overwrite

Client: ☒ Overwrite

Comments: ☒ Overwrite

Coordinates:

Fig. G-9. [Macro 5 / Description] window.

On [Description] page, the function of temporary filling [Project name, Project ID, Location, Client, Comments] fields for creation and printing sounding log is performed. To save changes to header data permanently in *.CPD files, go to **Macro 7**.

- Leaving one or more non-filled fields on **[Description]** page causes the program to read the respective fields from files entered and analyzed serially and places corresponding entries in table fields on the sounding sheets.
- Overwriting function is active only when appropriate **[Overwrite]** checkboxes are checked.
- Filling one or more fields on **[Description]** page causes the program to place these entries in tables on the sounding sheets irrespective of existing entries in files analyzed serially.

[Channel operations] page.

On **[Channel oper.]** page, functions of copying channels and multiplying values are realized in selected channels by setting arbitrary factors. These functions are useful, among others, during automatic change of units in selected channels.

- Copy operation can be performed simultaneously for 5 channels.
- Multiplication operation by constant factors can be performed simultaneously for all channels from 71 to 100 inclusive.

The screenshot shows the 'Macro 5' window with the 'Channel oper.' tab selected. It contains two main sections: 'Copy channels' and 'Multiplication'.

Copy channels: A table with 'Source' and 'Destination' columns. The values are as follows:

Source	Destination
1	85
2	86
3	87
0	0
0	0

Multiplication: A table with 'Channel' and 'Coefficient' columns. The channels listed are 71 through 77.

Channel	Coefficient
71	
72	
73	
74	
75	
76	
77	

Warning:
Set coefficients only in appropriate lines to activate multiplication

At the bottom, there are 'Cancel' and 'Execute' buttons.

Fig. G-10. [Macro 5 / Channel oper.] window.

[Output] page.

On [Output] page you can choose the format of data files created as result of batch processing and saving options.

➔ **NOTE.** Only AGS and CPT formats allow to save all interpreted parameters including classification results.

AGS settings are activated by clicking <General Settings> and <Code conversion> buttons.

After performing all the functions mentioned above and clicking [Execute] key, automatic execution occurs of operations and interpretations set above in all selected CPT data files along with entry of interpretation results into corresponding and selected files.

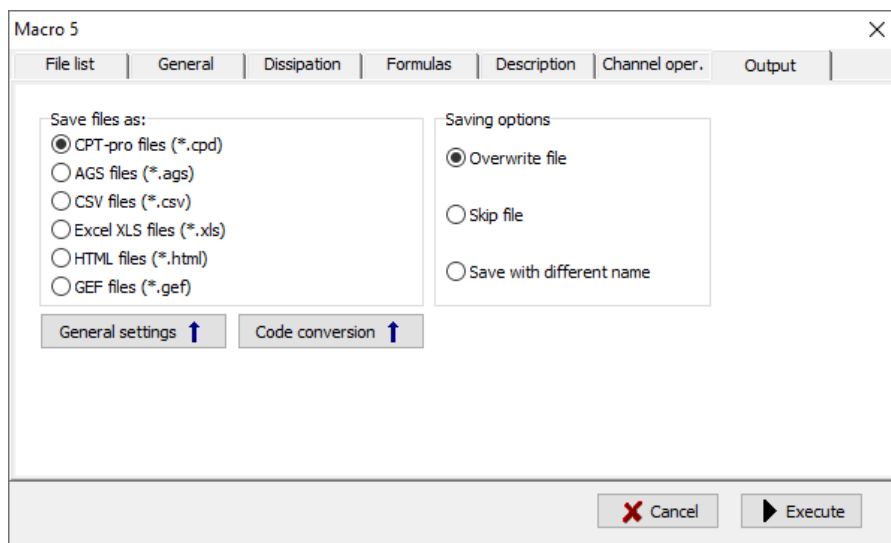


Fig. G-11. [Macro 5 / Output] window.

➔ Pressing [Execute] key causes execution of all operations set on **Macro 5** pages. Hence, actuate [Execute] function only after performing all settings on all **Macro 5** pages.

➔ Entry of channels containing sounding parameters and II order interpretation results into relevant *.CPD files occurs only with appropriately set channel selection in [Save channels] panel visible on [File] page selected after activating Format/Options function (see point H.4.3.).

➔ It is recommended to remove thin layers before executing **Macro 5**, however this slightly decreases accuracy of interpretation. Opposite sequence of these operation may come to calculation and presentation values of parameters for types of soil for which this calculation should not be performed.

G.6. Modification of predrilling depth. Macro 6.

The modification of the *predrilling depth* affects all recorded parameter values by assigning them to a different depth value and of course affects the interpretation results. **Macro 6** takes into account these

dependencies, although after changing the depth of the predrilling, all operations related to the classification and estimation of geotechnical parameters should be performed again.

Changing the depth of the borehole is performed after starting the **Macros / M6 - predrilling** function from the main menu. The value of new predrilling depth can be edited in window **[Predrilling]** – see Fig. G-12.

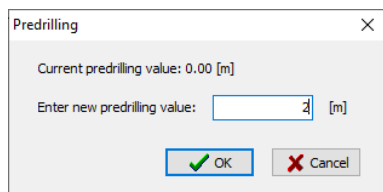


Fig. G-12. Macro 6. Edition of predrilling depth.

In case the change of the predrilling value concerns a file containing only measurement data, this change will be made immediately, the parameters will be assigned to the new depths. If, on the other hand, a change in predrilling occurs after the previous classification has been performed, the change will only occur after the new classification has been performed. In this case, the **[Warning]** window will appear with appropriate information - see

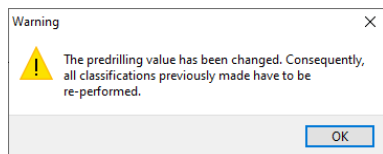


Fig. G-13. Macro 6. Warning window.

G.7. Batch modification of header data. Macro 7.

Macro 7 enables the serial entry of repeated header data for a set of selected *.CPD files. After running this macro, two panels are visible (see Fig. G-15). In the top panel, *.CPD files are selected to edit the header, and in the bottom panel - header fields are selected for editing.

The files are selected after clicking the **[Add files]** button, selecting the appropriate files and accepting with the **[Open]** button. The file selection operation can be repeated many times for different directories. To remove an incorrectly selected file from the list, select it and click the **[Remove selected files]** button. All selected files are deleted by clicking the **[Clear file list]** button.

After selecting files for serial editing of the header, edit the appropriate header fields. By clicking the **[Add header field]** button, a window will appear in which the header fields to be edited are selected by selecting the appropriate checkboxes. The list of these fields (see Fig. G-14) follows the list of **Favorite** fields of the header (see E.1 Fig. E-2).

After selecting the appropriate header fields and accepting it with the **[OK]** button, a table with the appropriate header data and fields for their edition appears in the top panel. Editing is done by entering the appropriate data in the **Values** column.

Add header elements

Header name

- ☒ Project name
- ☐ Project ID
- ☐ Project location name
- ☒ Project contractor
- ☒ Project engineer
- ☐ Client
- ☐ Start activity of project
- ☐ Client field
- Test general
 - ☐ Test name
 - ☐ Test ID
 - ☐ Test type
 - ☐ Type of penetration test
 - ☐ Pre-excavated depth
 - ☐ First layer density
 - ☐ Drilled ground water level
 - ☐ Drilled ground water level elevation
 - ☐ Ground water level
 - ☐ Ground water level elevation
 - ☐ Water depth (for offshore activities)
 - ☒ Company name
 - ☐ Investigation start date
- Test location
 - ☒ Test location name
 - ☒ Height system used
 - ☐ Z value

Cancel OK

In order to facilitate and speed up the entire operation of completing the header data, it is possible to select the file from which the header data will serve as a pattern for the remaining files. To do this, highlight selected file and click the **[Copy values from selected file]** button. After selecting such a template, the corresponding header fields can also be edited.

After clicking the **[Execute]** button, all selected header fields will be completed/changed in all selected *.CPD files according to the table **[Edit common header values]** and these files will be overwritten in the current locations.

Fig. G-14. Selection of header data for batch edition.

Edit common header values

Add files Copy values from selected file Remove selected files Clear file list

D:\CPTI pro all\CPTI files\AAAA demo\B41564.cpd
D:\CPTI pro all\CPTI files\AAAA demo\Cao18-5a.cpd
D:\CPTI pro all\CPTI files\AAAA demo\CP-3.cpd

Add header field Clear field list

Field description	Value	Unit
Project		
Project name	9968201	
Client	Von Stitz, AG	
Test general		
Type of penetration test	CPTU	
First layer density		kg/m ³
Ground water level		m
Company name	Geosoft sp. z o.o.	
Test location		
Height system used		
Z value		8848.00 m
Equipment		
Cone name	0	
Cone serial number		
Date of last calibration of sensors	18.03.2022	

Cancel Execute

Fig. G-15. Batch edition of header data.

H. GRAPHS/DIAGRAMS FORMATTING FUNCTIONS.

H.1. Setting the colors of the graphs.

CPT-pro provides the user with individual selection of colors, styles of lines (when black-and-white printer is used) and thickness of graphs/diagrams for the individual channels. Execution of **Format/Line settings** function causes appearance of [**Graph colors and styles**] window in which colors are assigned to graphs/diagrams in all the program channels and color of background is selected.

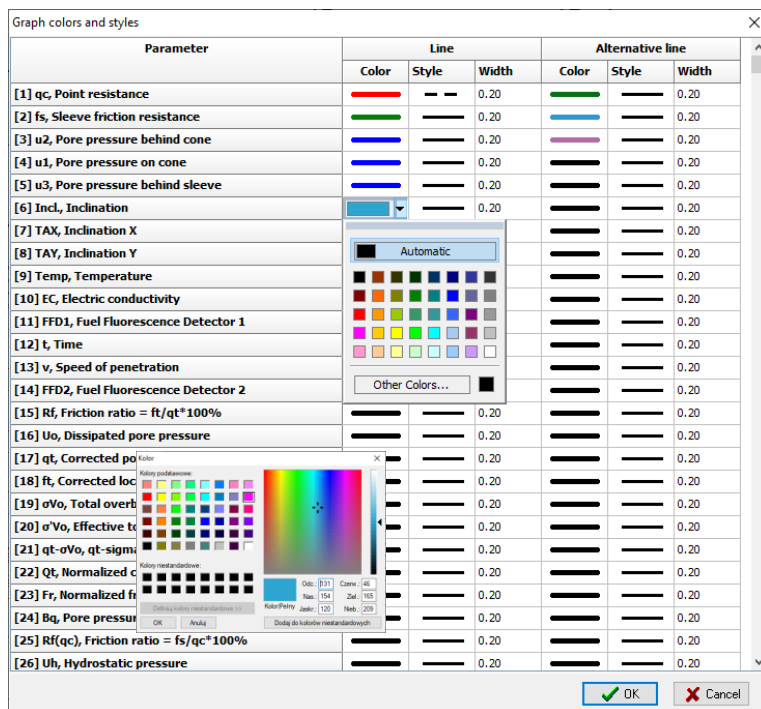


Fig. H-1. [**Graph colors and styles**] window.

The list of parameters in first column is sorted as selected in [**Parameters**] windows – see chapter H.2. To edit color and style of line highlight relevant cell and click the right part of it for opening color selection windows – see Fig. H-1.

To edit style of line highlight relevant cell and double click it for presenting available styles of line. Highlight selected line and move to another selection or click [OK] button.

Alternative lines for **dual log** (see chapter I.2) can be defined in the same way – see Fig. H-1.

H.2. Naming the parameters and setting the units.

Activation of **Format/Parameters and units** function causes appearance of [**Parameters**] window in which the following functions are realized:

- Naming parameters in the channels.
- Specifying the number of decimal places.
- Naming parameters in abbreviated form.
- Selecting the display unit

Parameters					
Nr	Channel name	Shortcut	Physical quantity	Display unit	Decimals
[1]	Point resistance	qc	Stress and pressure	Megapascal	2
[2]	Sleeve friction resistance	fs	Stress and pressure	Megapascal	3
[3]	Pore pressure behind cone	u2	Stress and pressure	Kilopascal	4
[4]	Pore pressure on cone	u1	Stress and pressure	Pound/square foot	3
[5]	Pore pressure behind sleeve	u3	Stress and pressure	Pound/square inch	3
[6]	Inclination	Ind.	Angle	Meter of water	1
[7]	Inclination X	TAX	Angle	Kip/square foot	3
[8]	Inclination Y	TAY	Angle	Kilogram/square centimeter	3
[9]	Temperature	Temp	Temperature	Ton (metric)/square meter	3
[10]	Electric conductivity	EC	Conductivity	Degree	2
[11]	Fuel Fluorescence Detector 1	FFD1	Reference	Degree	3
[12]	Time	t	Time	Celsius	3
[13]	Speed of penetration	v	Velocity	Siemens/meter	3
[14]	Fuel Fluorescence Detector 2	FFD2	Reference	Value	3
[15]	Friction ratio = $ft/qt \cdot 100\%$	Rf	Percent	Percent	2
[16]	Dissipated pore pressure	Uo	Stress and pressure	Megapascal	3
[17]	Corrected point resistance	qt	Stress and pressure	Megapascal	3
[18]	Corrected local friction	ft	Stress and pressure	Megapascal	3
[19]	Total overburden stress	σ_{Vo}	Stress and pressure	Megapascal	3
[20]	Effective total overburden stress	σ'_{Vo}	Stress and pressure	Megapascal	3
[21]	$qt - \sigma_{Vo}$	$qt - \sigma_{Vo}$	Stress and pressure	Megapascal	3
[22]	Normalized cone resistance	Qt	Reference	Value	3
[23]	Normalized friction ratio	Fr	Percent	Percent	3
[24]	Pore pressure parameter	Bq	Reference	Value	4
[25]	Friction ratio = $fs/qc \cdot 100\%$	Rf(qc)	Percent	Percent	3
[26]	Hydrostatic pressure	Uh	Stress and pressure	Megapascal	3
[27]	Friction ratio (NEN5140)	Rfd	Percent	Percent	3
[28]			No unit	None	3
[29]			No unit	None	3
[30]	Classification result	soil	No unit	None	0
[31]	Relative density	ID	Reference	Value	3

Fig. H-2. [**Parameters**] window.

→ Names of unit, abbreviated symbol and unit in channels with interpretation results are read out during interpretation and need not be additionally loaded.

→ The program saves the last configuration of [**Parameters**] window.


→ **Display Unit** has a special function, as it is used in logs, exported parameters, reports and options, as well as in CPT-CAD module. Thus, it is recommended to set **Display Unit** for all used parameters. To select Display unit scroll down the list by double click and choose relevant one.

→ All parameters that are results of own formulas option, have the unit defined in formula creation process.

→ The sequence of parameters can be changed by clicking the relevant cell in first row of table or selecting the sorting sequence from scrolled down list at bottom of [**Parameters**] window -

→ System channels (i.e. channels generated by system) can be hidden by highlighting checkbox [Hide system channels] -
 . In such case only channels generated by User with [Conditional formulas] function are visible.

H.3. Setting the horizontal scale.

Range of values function enables setting the horizontal scale in any selected channel by defining the maximum range of the parameter. After activating **Format/Parameter attributes** function, or clicking icon  (icon S on Fig. D-9) window [Parameter attributes] appears in which range of values for individual channels should be set.

→ The horizontal scale is defined by setting the minimum and maximum value of parameter using Display unit chosen in [Parameter attributes] window (see Fig. H-3).

→ Scale set for channel 3 (i.e. pore pressure u_2) is used also as pore pressure scale in dissipation graph.

Parameter name:	Display unit	Range:		Grid step:	Additional lines:				
		Min.:	Max.:		Values:	Color	Style	Width	Visible
[1] qc, Point resistance	MPa	0.00	10.00	2.000	2.000, 5.000, 10.000		—	0.10	<input checked="" type="checkbox"/>
[2] fs, Sleeve friction resistance	MPa	-0.10	0.50	0.100			0.10	<input checked="" type="checkbox"/>
[3] u_2 , Pore pressure behind cone	MPa	-0.50	2.00	0.5000			—	0.10	<input checked="" type="checkbox"/>
[4] u_1 , Pore pressure on cone	MPa	-0.50	2.00				—	0.10	<input checked="" type="checkbox"/>
[5] u_3 , Pore pressure behind sleeve	MPa	-0.50	2.00				—	0.10	<input checked="" type="checkbox"/>
[6] Incl., Inclination	°	0.00	40.00				—	0.10	<input checked="" type="checkbox"/>
[7] TAX, Inclination X	°	0.00	40.00				—	0.10	<input checked="" type="checkbox"/>
[8] TAY, Inclination Y	°	0.00	40.00				—	0.10	<input checked="" type="checkbox"/>
[9] Temp, Temperature	°C	-5.00	25.00				—	0.10	<input checked="" type="checkbox"/>
[10] EC, Electric conductivity	S/m	0.00	1.00				—	0.10	<input checked="" type="checkbox"/>
[11] FFD1, Fuel Fluorescence Detector 1		0.00	1.00				—	0.10	<input checked="" type="checkbox"/>
[12] t, Time	s	0.00	1.00				—	0.10	<input checked="" type="checkbox"/>
[13] v_p , Speed of penetration	mm/s	10.00	30.00				—	0.10	<input checked="" type="checkbox"/>
[14] FFD2, Fuel Fluorescence Detector 2		0.00	1.00				—	0.10	<input checked="" type="checkbox"/>
[15] Rf, Friction ratio = $f_t/q_t \cdot 100\%$	%	0.00	10.00				—	0.10	<input checked="" type="checkbox"/>
[16] U_o , Dissipated pore pressure	MPa	-0.50	2.00				—	0.10	<input checked="" type="checkbox"/>
[17] q_t , Corrected point resistance	MPa	0.00	50.00				—	0.10	<input checked="" type="checkbox"/>
[18] f_t , Corrected local friction	MPa	0.00	0.50				—	0.10	<input checked="" type="checkbox"/>
[19] σ_{Vo} , Total overburden stress	MPa	0.00	5.00				—	0.10	<input checked="" type="checkbox"/>
[20] σ'_{Vo} , Effective total overburden stress	MPa	0.00	5.00				—	0.10	<input checked="" type="checkbox"/>
[21] $q_t - \sigma_{Vo}$, $q_t - \sigma_{Vo}$	MPa	0.00	50.00				—	0.10	<input checked="" type="checkbox"/>
[22] Q_t , Normalized cone resistance		0.00	1000.00				—	0.10	<input checked="" type="checkbox"/>
[23] F_r , Normalized friction ratio	%	0.00	10.00				—	0.10	<input checked="" type="checkbox"/>

Horizontal line Draw addition lines to: End of graph ☒ OK ☐ Cancel

Fig. H-3. [Parameter attributes] window.

In [Minimum] column the minimum value should be defined (in most cases, the values of parameters are positive and in such a case “0” is recommended, however there are parameters that accept negative values, e.g. pore pressure u_2). In [Maximum] column - the maximum value of parameters.

In [Grid step] column define the distance (in appropriate units) between vertical grid lines.

In [*Additional lines*] column you can set the values of parameters presented on sounding sheet as vertical lines going through User defined values of parameter. These values should be edited in standard way with dot as decimal separator and comma as separator between them. Color, width and style of these lines can be set independently for each parameter. Highlighting [*Visible*] box causes the program to print lines on log.

The last settings of horizontal scale are saved in configuration files by the program after it is switched off and automatically reproduced after restart.

H.4. General settings.

Activation of *Format/Options* function gives access to additional formatting functions. These functions are grouped on three pages marked as:

- **General**
- **Graph**
- **File**

H.4.1. [*General*] page.

[*General*] page contains a number of functions formatting the sounding sheet such as vertical scale unit, horizontal grid, optional presentation of top and bottom axis and user's depth label.

Available on this page, in addition, is the box enabling activation/deactivation of soil bar update function after each change of data. Due to the fact that refreshing of soil bar requires performance of a number of time-consuming operations, in computers of lower capacity, it is recommended to perform operations on **CPT** data files with *Autoverify soil bar by each data operation* function deactivated.

Distance between charts is adjustable in edition field *Chart distance* – see Fig. H-4.

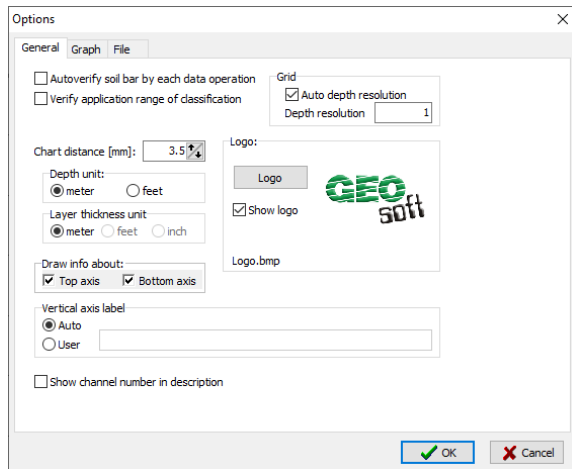


Fig. H-4. [*General*] page.

Setting the upper and bottom axis on graphs. The operator can set the upper (see Fig. H-5) and bottom (see Fig. H-6) axis on each chart independently by:

- Selection of parameter and unit in window **Graph layout** (see chapter D Fig. D-2 and Fig. D-9).
- Highlighting [**Top axis**] and/or [**Bottom axis**] checkbox. In this selection, the program enters axis with description (abbreviation of parameter name and unit) and tips (see Fig. H-5).

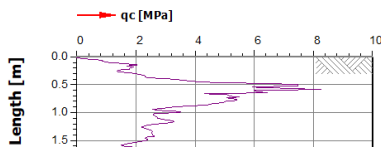


Fig. H-5. Upper axis description.

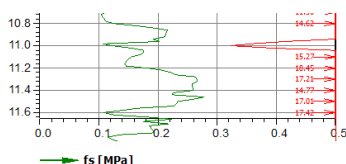


Fig. H-6. Bottom axis description.

Iteration number adjusts the number of iterations performed due to modification of selection of unit weight source. In general case 3 iterations are enough.

Edition window in **Vertical axis label** panel enables inserting user name of **Depth axis** (see Fig. H-5).

Setting the position of horizontal grid lines on graphs. The operator can set the optimum density of grid lines for a given range of sounding depth by:

- Highlighting [**Auto depth resolution**] box. In this setting, the program enters its own position of grid horizontal lines, optimized for the given length of CPT test.
- Entering own spacing between lines in [**Depth resolution**] box. Clicking this box causes it to pass to editing state. After entering own values, deactivating [**Auto depth resolution**] box and clicking <OK> button, grid horizontal lines appear on selected depths.

<Logo> button gives you possibility to input own logo on sounding sheet and choose format of graphic file. Most of standard graphic formats are available.

→ Logo can be inserted only to cell that is selected as [Logo] – see chapter D.3.1.

[**Graph**] page contains a number of functions formatting the graphic elements of a graph/diagram. It consists of three subpages.

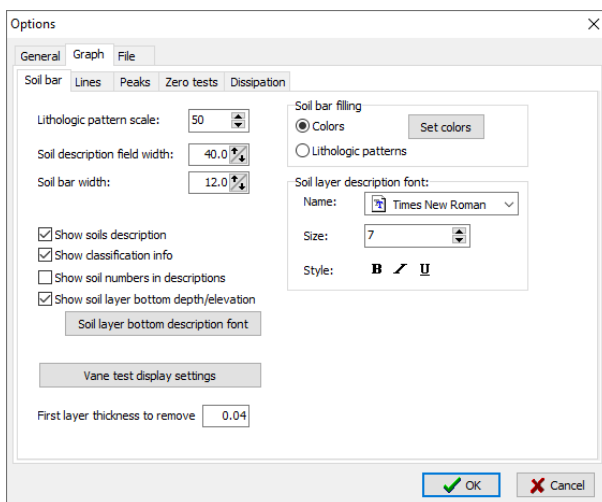


Fig. H-7. [Graph/Soil bar] page.

The following parameters and soil bar features are set on [Soil bar] page:

- **Pattern scale** in soil bar set in [Lithologic pattern scale] box by clicking symbol [▲] or [▼]. This scale is common to all hatches, but the proportion between them can be set in the [Soil attributes] window – see Fig. K-1
- Width of description field with soil type edition.
- Maximum thickness of first layer to remove.
- **Soil bar filling.** CPT-pro enables selecting the type of soil bar zone filling corresponding to assigned soil types – see chapter 0. The operator can choose between standard geological symbols or filling with different colors. Assigning a color to a specific type of soil is described precisely in chapter 0. The selection between colors and lithologic patterns can be done in [Soil bar filling] pane. The same selection can be done with use right click on any chart od log.
- Soil bar width (in 0.1 mm steps).
- Soil bar description font settings
 - Font type
 - Font size
 - Style.
- **Editing the names of soil types.** CPT-pro operates with names of soil types drawn directly from source material presenting the selected method of interpretation. The operator in justified cases can however change these names. Double clicking the box with the selected soil name causes it to move into *Edit State*. After writing the new names in the selected boxes and clicking <OK> button, the changes entered will be taken into account in the descriptions of soil types beside the soil bar.
- **Creating the broken line connecting the values of *in situ* pore pressure u_0 .** Due to the “nature” of pore pressure distribution test, the values of u_0 are defined only for several depths. For better visualization of the pore pressure graph, the facility of creating the broken line connecting the points of *in situ* pore pressure u_0 graph, has been introduced. Activation of this option is done by highlighting [Connect points on graph] box in [In situ pore pressure graph] panel.

- **Show/hide soil layer bottom description and description font settings** (see Fig. D-8).
- **Show/hide basic information about FVT tests related to CPT like depth/elevation and *vane shear strength* τ_v and description font settings¹⁰** (see Fig. D-8).

NOTE. Soil layer bottom description and FVT parameters are shown inside the geological profile. Therefore, the width of the profile and the appropriate fonts should be selected so as not to overlap each other – see Fig. D-8.

The following parameters and soil bar features are set on **[Graph/Lines]** page:

- Setting the line (width and color) drawn in case where values of parameters do not exist in loaded file.
- Type of presentation of *in situ* pore pressure values. As these values are not measured in continuous way (pore pressure dissipation tests or other system of measuring), values of *in situ* pore pressure exist only for few depth values and can be presented as broken line or separated points.
- Setting the line (width and color) of ground level.
- Setting the size and color of ground water level symbol.

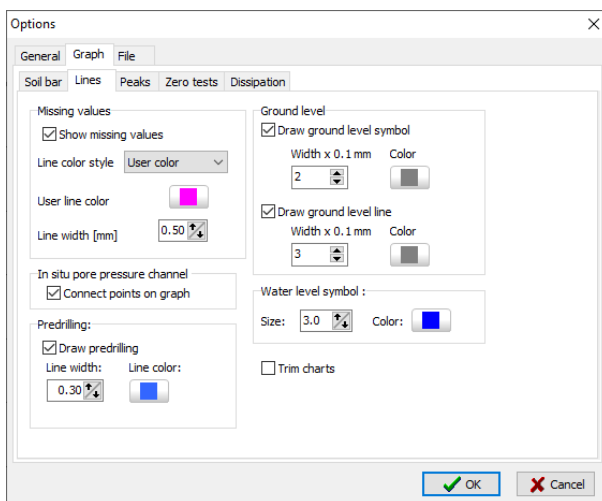


Fig. H-8. [Options/Graph/Lines] page.

¹⁰ The depth/elevation and shear strength τ_v values are directly read from the relevant *.VTF file containing the results of the FVT test interpretation performed with VANE-pro software.

[Options/Graph/Peaks] page. In case when values of parameters exceed horizontal scale (see chapter H.3) the info about missed values can be presented on graph. This option is activated by highlighting the checkbox [Show info about out of range] on [Peaks] page. In list below parameters can be chosen. Color of arrows and fonts can be set like color of graph or can be independently chosen by operator.

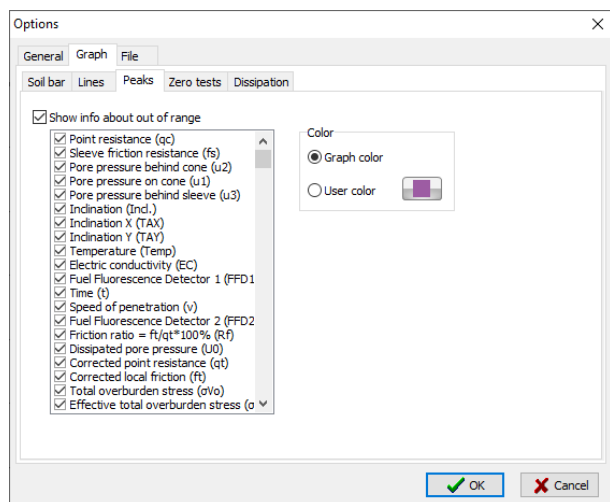


Fig. H-9.
[Options/Graph/Peaks] page.

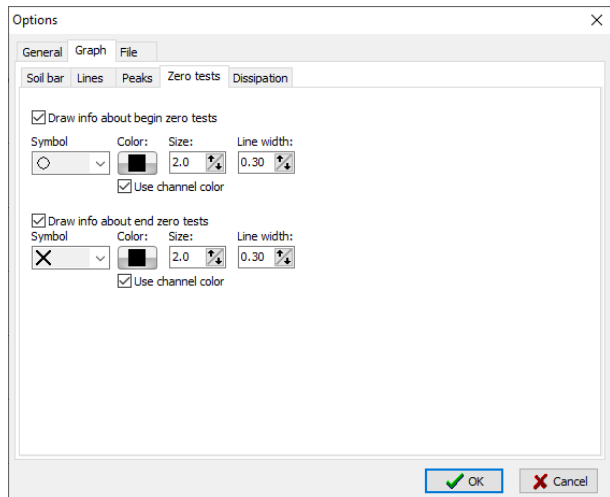


Fig. H-10. [Options/Graph/
Zero tests] window.

The symbols of initial and final zero test values can be plotted on CPT log. Basic settings i.e. selected graphic symbol, color, size and line width can be customized in [Options/Graph/Zero tests] window.

Basic settings of dissipation test report i.e. colors, widths and styles of lines that represent maximum value of pore pressure, times for X% dissipation and final dissipated value can be customized in **[Options/Graph/Dissipation]** window.

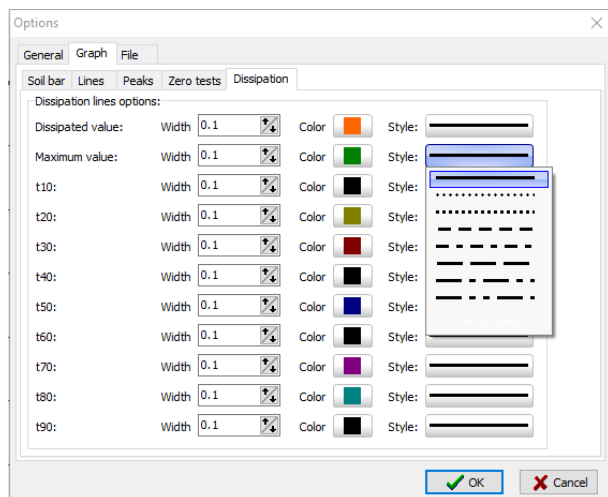


Fig. H-11.
[Options/Graph/Dissipation]
window.

[File] page enables maintaining the program configuration, i.e. settings performed and selection of data entered into *.CPD files.

- Highlighting **[Save configuration by exit]** box causes almost all settings entered to be written into **CPT-pro** configuration file, which will be automatically reproduced when restarting the program.
- **[Classification]** panel enables selecting the option of saving the result of soil type interpretation in the file characteristic for the selected method. Every method of soil type interpretation generates its own file with the interpretation result and having its characteristic extension *.h** (e.g. file classification according to Robertson '96 has the extension *.b01). Hence, the results of interpretation performed by different methods can be saved in separate files.
- **[Classification]** panel gives the following possibilities of saving classification data on exit:
 - [Save in CPT data file]
 - [Ask saving CPT file]
 - Do not save]
- **[Save channels]** panel enables the selection of channels that are to be saved in basic *.CPD file. Highlighting the small boxes causes saving of columns with values of selected channels in *.CPD file.

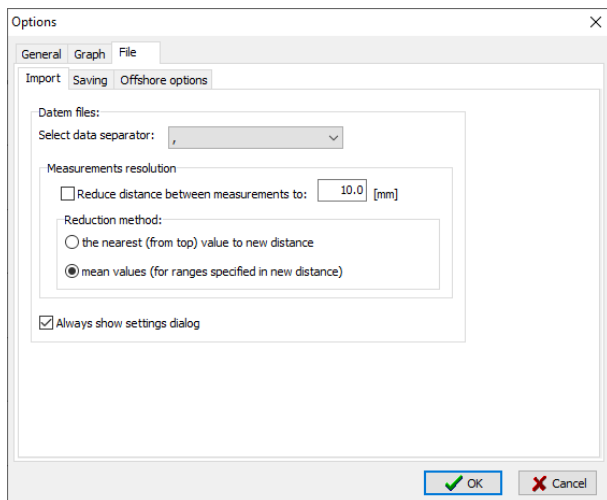


Fig. H-12. [File/Import] window.

Files generated by the **Datam**¹¹ CPT measurement system have a very high resolution - data is generated every 1 mm. This distance can be reduced by checking [**Reduce distance between measurement**] and setting the appropriate value.

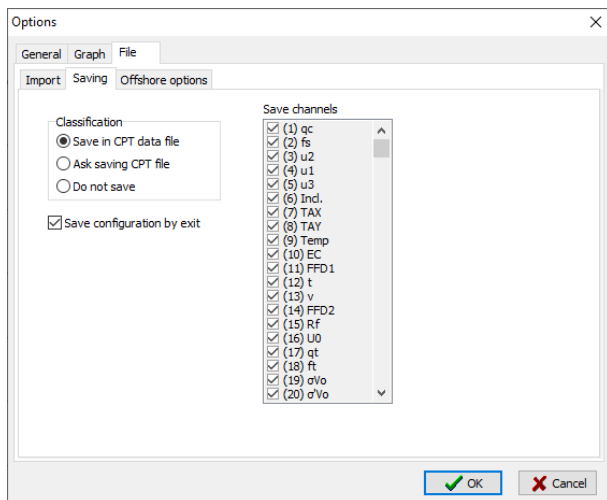


Fig. H-13. [Options/File/Saving] window.

¹¹ British manufacturer of offshore CPT equipment.

- If it is envisaged to execute geotechnical cross sections (available with CPT-CAD module), the results of soil type interpretation should be saved in *.CPD file.
- Absence of saved *.b** file disables the presentation of soil bar with soil classification results on the cross section.
- If it is planned to execute geotechnical cross sections, enter all the channels that are to be presented on the cross sections into *.CPD file. If a channel is not entered in *.CPD file, it cannot be presented on the cross section.
- During analysis of CPT data files, work channels are usually created in which intermediate results of analysis and copies of other channels are saved. Saving of all such channels in *.CPD file causes unnecessary overgrowth of *.CPD files created.

In offshore soundings, the parameter values depend on the place where the initial zero test is performed i.e. on desk, on seabed or in borehole bottom. The appropriate settings are made in the window shown on Fig. H-14.

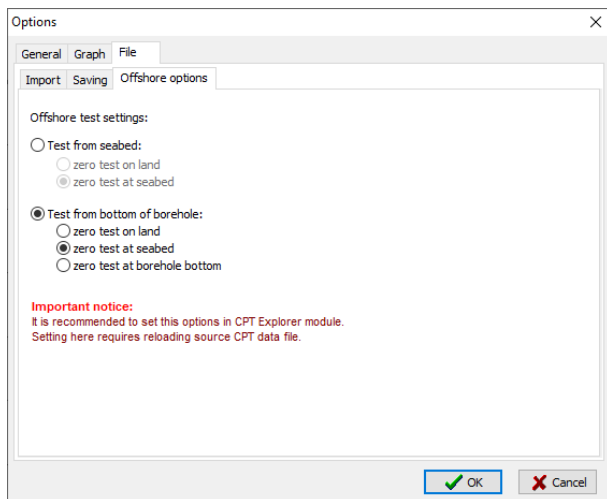


Fig. H-14. [File/Offshore options] window.

I. CONFIGURING THE GRAPHS.

I.1. Graph/CPT-pro format function.

Activation of **Graph/CPT-pro format** function causes opening of the sounding sheet configuration [**Graph settings**] window described in detail in chapter D.1. The window can also be opened by directly clicking icon [W] (see Fig. D-9) in the main menu of **Interpretation** module.

→ The content of header table is automatically filled on the base of header entries. To modify the content of any cell just double click it to put it in edition mode.

I.2. Dual log.

The **Dual log** option enables presentation of two different tests – **L** and **R** (left and right) - on the same page – see Fig. I-1. To activate that option and configure dual log (see Fig. I-1) run [**Graph/Dual log**] or click icon [Y] in the main menu of **Interpretation** module – see Fig. D-9.

Fig. I-1. [Dual log options] window.

All graphic objects, soil sticks and parameter graphs, are arranged in couples (see Fig. I-1). Each horizontal scale can be alternatively set as linear or logarithmic and – independently – as inverted. The number of couples of graphs can be defined by User and may vary between 1 and 5, however, as the

minimum width of graphs (excluding description of depth axis) is set as 2 cm, it may happen that some graphs do not find enough room in available area of chosen paper size. In case like that decrease the number of graphs and/or change the size of paper.

Soil sticks are independent i.e. User can select whether sticks and descriptions of soil layers should be shown independently for both tests, as well as can select classification method.

Dual log can be widely customized. User can not only decide about presentation of soil sticks and number of graphs, but also can select the fonts of soil type description and header data ([**Soil description font**] and [**Header font**] buttons), width of description, distance of graphs in each pairs, colors and styles of lines ([**Line settings**] button). The distance between pairs of graphs can be adjusted as well.

In case when some options of dual log should be used for single test, like for instance presentation of parameters in logarithmic scale, the test number can be selected in pane [**Select test number**].

Both, horizontal and vertical scales of graphs, are available directly from [**Dual log options**] window by pressing respectively [**Ranges**] and [**Scale**] buttons.

➔ [**Dual log**] option is designed to present all raw, derivative and interpreted parameters, as well as results of soil classification, so it works with *.CPD files only.

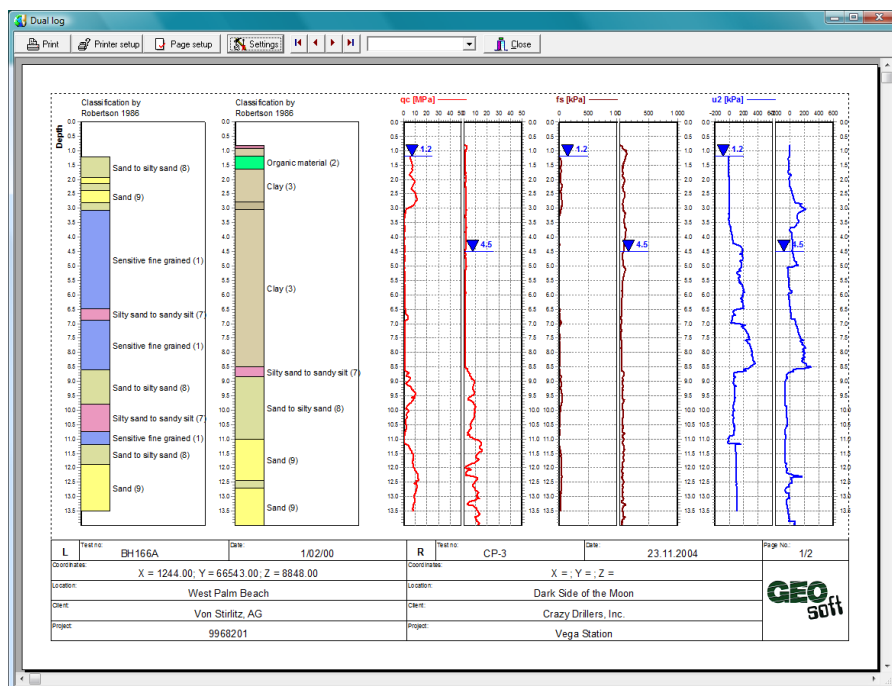


Fig. I-2. Dual log print preview.

I.3. Dissipation test graphs.

CPT-pro enables creating graphs of pore pressure dissipation tests (see Fig. I-4) on the basis of **CPT** data files. Activation of *Graph/Dissipation test* function or clicking the icon [Z] (see Fig. D-9) causes opening of [Select depth of dissipation] window (see Fig. I-3).

To select dissipation depths and calculated times T_{xx} check relevant checkboxes.

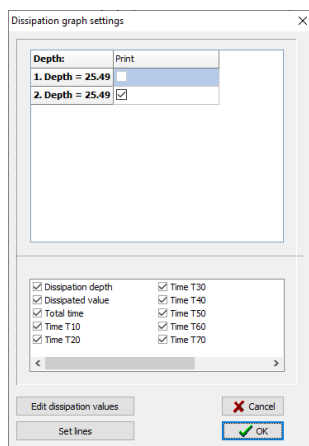


Fig. I-3. [Select depth of dissipation test] window.

Location:	Position: X: 5986293.00 m Y: 520184.00 m	Ground level: 0.00	Test no: C	Cone no: 3538
Project ID:	Client:	Date: 25/02/2014		Tip/sleeve area (mm ²): 10 / 150
Project: 13-1447-0183		Page: 1/1	Fig:	Area factor a/b: 0.590 / 0.016
		File: CPT13-70C.cpt		Pore pressure: U2

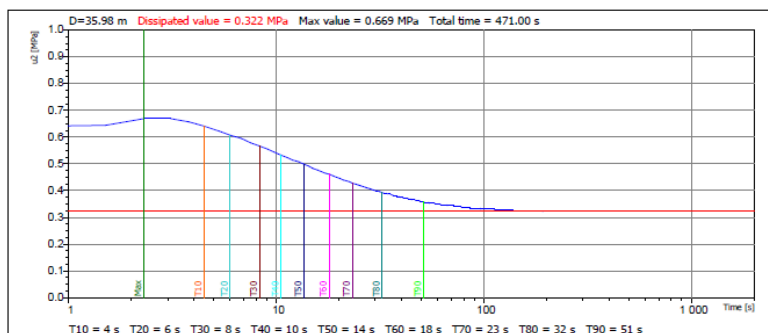
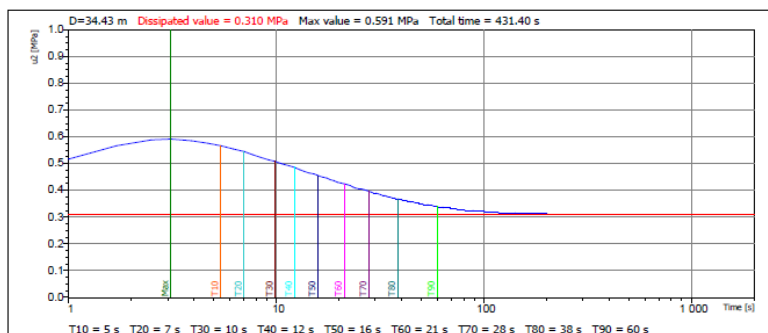
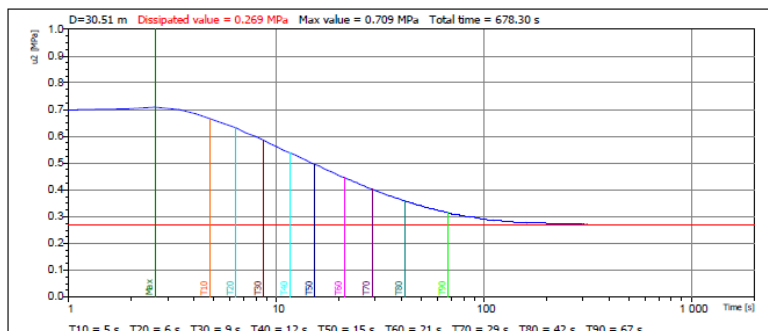


Fig. I-4. Dissipation test log.

I.4. Setting the vertical scale of graph.

The vertical scale is set in **CPT-pro** by setting the scale value 1:X in **[Scale]** window.

The function defining the depth range per page is described in detail in chapter D.3.2. Value of the vertical scale is defined in **[Scale]** window activated after selecting **Graph/Scale** function.

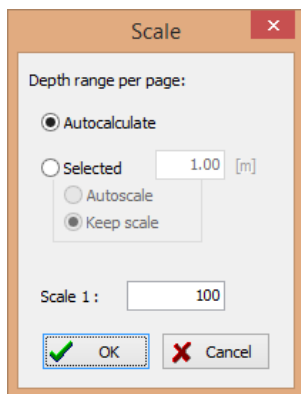


Fig. I-5. **[Scale]** window.

Activation of **[Keep scale]** box causes the depth on the graph to be presented precisely in the vertical scale selected, irrespective of setting of selected depth range per page.

* Value of the scale is defined by writing any positive whole number of maximum five digits (in an majority of applications, scale from 1:50 to 1:200 is used).

* Selected **[Autocalculate]** option generates graphs in chosen scale in whole available area (depending on margins and status (on/off) of header table).

[Scale] window can be opened directly from the main menu by clicking the inscription **[Scale 1:]** on the bar with icons, denoted in 0 by the letter **[T]**. Next is the scale selection window denoted in

by **[Scale 1:_]**. The most frequently encountered scales of type 1:10, 1:50, 1:100 etc., are available from scroll list activated by bar icon **[U]**. The scale is selected from the scale selection drop down box (by setting the cursor in it and a single click). Clicking the number defining the required scale causes automatic scaling of the graph to the selected value.

➔ **[Scale:]** box is not editable since **CPT-pro** constantly reads the current scale and automatically enters the corresponding number into this box.

➔ **[File:]** box is not editable since the program automatically places the name of the current *.CPD file.

I.5. Creating templates of sounding sheets.

CPT-pro enables creating templates of sounding sheets, i.e. it provides the possibility of setting such items of the graph/diagram as:

- * Number of graphic fields with graphs/diagrams;
- * Presence of soil bar on the sounding sheet;
- * Kind of parameters presented in the individual graphic fields;
- * Vertical and horizontal scales in the individual graphic fields;
- * Color, width and style of lines of individual graphs/diagram;
- * Full and abbreviated names of parameters presented.
- * Units of parameters presented.

After making all the settings, these templates can be saved on HD in the form of *.TEM files and read out again.

Creating interpretation templates is very simple. For this purpose, perform the following operations:

1. Enter any **CPT** data file.
2. Perform **interpretation of I** and/or **II order** in the scope envisaged for the template created according to the instruction described in chapter K.
3. Perform all the required settings of graphs/diagrams according to the above list.
4. Perform **Graph/Save as template** function.
5. Write the name of the template saved in the edit box (the extension is added automatically).
6. Click <**Save**> button.

Execution of the above sequence of instructions creates ***.TEM** file containing the complete setting of sounding sheet, in [**Template**] folder.

Loading templates can be done during loading the CPT data file directly from **Graph layout** window (Fig. D-2). It can be also carried out by executing **Graph/Load template** function. After executing this function, a standard **Windows** system window appears containing the corresponding folder, select the template (from the existing ***.TEM** files) and load it.

Quick selection of template can be activated by clicking the ▼ symbol next to icon [**W**] – see Fig. D-9.

→ If a ***.CPD** file is entered with interpretation results written and their scope is sufficient (i.e. the template created will not contain additional interpreted parameters) then it is not necessary to perform re-interpretation.

→ The program proposes saving the template created in [**Template**] directory created during installation. This setting should not be changed.

→ Templates can be used in Batch Printing procedure. It is possible to choose not only the CPT data files, but also as many templates as you need. CPT-pro will open each chosen data file, automatically load each chosen template and make printouts, step by step, in accordance with all of them.

I.6. Paging the graph/diagram.

If the vertical scale selected (with [**Keep scale**] box active (see chapter I.4) and the page size disable presentation of the whole graph/diagram on one page, **CPT-pro** automatically divides the graph/diagram into pages while maintaining the selected scale.

The page is changed just by scrolling down the page on screen.

→ Additionally entered objects, i.e. texts, ordinary broken lines and broken lines with filling are not page elements but screen elements. Hence, change of pages does not cause shifting of the objects executed and consequently after change of pages, they get located in an improper place.


→ If the sounding graph/diagram is located on several pages then each page should be fully supplemented with supplementary texts and broken lines before printout and saved in ***.WMF** and ***.EMF** graphic files.

J. SCREEN FUNCTIONS.

J.1. Data monitoring.

CPT-pro is provided with a procedure of reading out the values of selected parameters directly from the graphs on the screen and reading out the position of selected point (selected depth) on classification diagram (see chapter **K**).

Activation of reading out the values can be done by:

- ☐ Activating **Graph/Trace Graph** function or
- ☐ Clicking the icon with the loop  on graphs symbol denoted in Fig. D-9 with the letter [O].

After performing that, the mouse cursor changes from standard to **[+]**. Moving the pointer to the selected place on any graph/diagram visible on the screen and clicking the left button of the mouse causes creation of a horizontal red line determining the depth from which the values of parameters are read out. Simultaneously additional windows (Fig. J-1) with values of **Depth/Length** and selected parameters is generated.

To select another depth just click cursor in new position. To close tracking window – click once more relevant icon

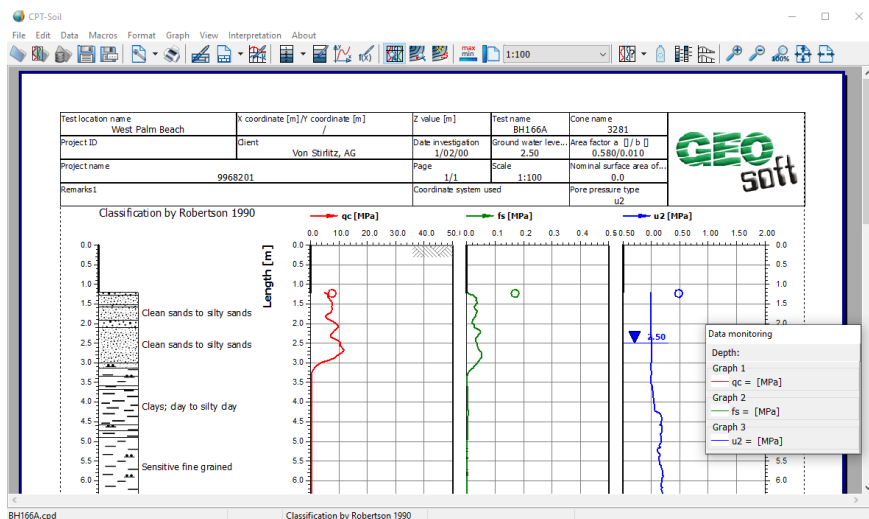


Fig. J-1. [Data monitoring] pane.

J.2. Setting the page size with sounding sheet on the screen.

The **Zoom in** and **Zoom out** functions built into **CPT-pro** provide the facility of considerably enlarging or adjust the image visible on the screen. The adjustment is done by clicking relevant icons i.e. **α**, **β**, **γ**, **δ** and **ε** - see Fig. D-9. Additionally, standard zoom function activated by **[CTRL + mouse wheel]** is implemented.

K. INTERPRETATION OF CPT SOUNDINGS.

One of the basic functions of **CPT-pro** is to perform interpretation of **CPT** soundings. The interpretation procedure is performed in two phases.

- In the first phase, interpretation of soil type occurs according to the selected method. For **CPT-pro** requirements, soil type interpretation methods are hereinafter called **I order interpretation methods**.
- In the second phase, interpretation in the scope of values of selected strength and physical characteristics occurs according to the indicated method. For **CPT-pro** requirements, selected strength and physical characteristics interpretation methods are hereinafter called **IInd order interpretation methods**.

IInd order interpretation methods are mostly not universal but are specified for selected soil types. Hence, before performing interpretation in the scope of selected strength and physical characteristics, separate the soil zones in which a selected **IInd order method** can be used, that is, **Ist order interpretation** should be performed.

Methods of **CPT** sounding interpretation, including formulae and graphs/diagrams have in majority been drawn with the knowledge and consent of the authors, directly from the monograph

Lunne, T., Robertson P.K. and Powell J.J.M.

Cone Penetration Testing in Geotechnical Practice.

Published by Blackie Academic & Professional 1997,

Reprinted by E & FN Spon 1997.

Short descriptions of all methods of interpretation are presented in chapter P.

→ **Ist** and **IInd** order interpretation methods have been selected from available global literature from the group of methods frequently applied, quoted and enjoying acknowledgement in geotechnical circles. The scope of applicability of these methods and their accuracy were not included in our analysis and therefore their utilization in solving definite geotechnical problems should be preceded by adequate geotechnical analysis and may be realized exclusively on the responsibility of the user of the program.

→ Each of the methods implemented is described in detail, giving the sources of publication. Any doubts regarding usage of selected methods and its accuracy should be discussed directly with the authors of the relevant publication.

K.1. Calculating the values of standard auxiliary and derivative parameters.

Interpretation of **CPT** soundings is very often based on additional auxiliary and derivative parameters, such as:

- * Total overburden stress σ_{v0} ,
- * Effective overburden stress σ'_{v0} ,
- * Corrected (for pore pressure effects) cone resistance $q_t = q_c + (1-a) \cdot u_2$,
- * Corrected (for pore pressure effects) local friction f_t ,
- * Friction ratio $R_f = f_t / q_t \cdot 100\%$,
- * Normalized cone resistance $Q_t = (q_t - \sigma_{v0}) / \sigma'_{v0}$,
- * Stress-normalized cone tip resistance $q_{t1} = q_t / (\sigma'_{v0} \cdot \sigma_{atm})^{0.5}$ ($\sigma_{atm} = 100 \text{ kPa}$)
- * Normalized friction ratio $F_r = f_t / (q_t - \sigma_{v0})$,

* Pore pressure parameter $B_q = (u - u_0) / (q_t - \sigma_{v0})$.

Once data file is loaded all listed above parameters are calculated automatically and saved into appropriately assigned channels from the range 15 – 29, 58 (see **Format/Parameters and units**).

→ Obtaining the above mentioned values of auxiliary and derivative parameters is very simple and can be performed at any time. Hence, it is recommended to enter the calculated values of these parameters into *.CPD files only when they form the subject of further analysis, particularly when further interpretation will be performed on the basis of their values according to methods not included in CPT-pro.

→ Selection of parameters entered into *.CPD file is done in **[Save channels]** panel visible in the window opened after executing **Format/Options** function and selecting the page with **[File]** marker.

K.2. Soil attributes.

A number of different soil characteristics and parameters may have influence on interpretation procedure of CPTU soundings and may directly occur in correlation equations. Some of them can be estimated on the base of CPTU parameters, however, a number of them cannot be estimated in this way and additional soil investigations are necessary. Such parameters that need additional estimations will be called **external parameters** in the rest of **CPT-pro** manual.

One of commonly used **external parameter** is empirical cone factor N_k , that is used for estimation of undrained shear strength S_u according to formula described in P.2.4. Another example is W_L – liquid limit used for estimation undrained shear strength S_u in fine-grained soils by Larsson - see P.2.10.

All currently used external parameters are presented and can be edited in window **[Soil attributes]** activated from menu **Interpretation** – see Fig. K-1.

The type of external parameter and interpretation method that uses it can be easily checked just by right click on parameter symbol/name.

→ **WARNING.** All external parameters saved initially in **[Soil attributes]** window should be treated only as initial approximation and should be replaced with relevant ones for correct interpretation.

Soil attributes														X
Classification:	No.	Soil description:	Soil type	Image	Color	Hatch	Scale	Unit weight [kN/m ³]	Nk	WL [%]	k	Poisson's ratio	ecv	
Robertson 1986	0	Unknown	Undefined				1.00	19.00	14	0.3	0.3	0.3	33	
Robertson 1990	1	Sensitive fine grained	Fine				1.00	17.50	14	0.3	0.3	0.3	33	
Robertson 1996 (b)	2	Organic material	Fine				1.30	12.50	14	0.3	0.3	0.3	33	
Robertson 2010	3	Clay	Fine				0.80	17.50	14	0.3	0.3	0.3	33	
Robertson 2016	4	Silty clay to clay	Fine				1.20	18.00	14	0.3	0.3	0.3	33	
Ph-8-04452	5	Clayey silt to silty clay	Fine				1.00	18.00	14	0.3	0.3	0.3	33	
GEOSOND	6	Sandy silt to clayey silt	Fine				1.00	18.00	14	0.3	0.3	0.3	33	
Meigh 1987	7	Silty sand to sandy silt	Transition				1.00	18.50	14	0.3	0.3	0.3	33	
Sennset 1989	8	Sand to silty sand	Coarse				1.00	19.00	14	0.3	0.3	0.3	33	
	9	Sand	Undefined				1.00	19.50	14	0.3	0.3	0.3	33	
	10	Gravelly sand to sand	Undefined				0.60	20.00	14	0.3	0.3	0.3	33	
	11	Very stiff fine grained	Fine				1.00	20.50	14	0.3	0.3	0.3	33	
	12	Sand to clayey sand	Coarse				1.00	19.00	14	0.3	0.3	0.3	33	
Reset display settings for all soils														OK

Fig. K-1. [Soil attributes] window.

Not only external parameter values can be edited in [*Soil attributes*] window but also colors and symbols used for presentation results of classification in sounding logs generated in **Interpretation** module and cross sections generated in **CPT-CAD**.

To edit color of soil type select the classification method by highlighting the relevant one and double click the cell with color. That operation activates standard Windows procedure (see Fig. K-3) for selection of color. To save selection just click [**OK**] buttons.

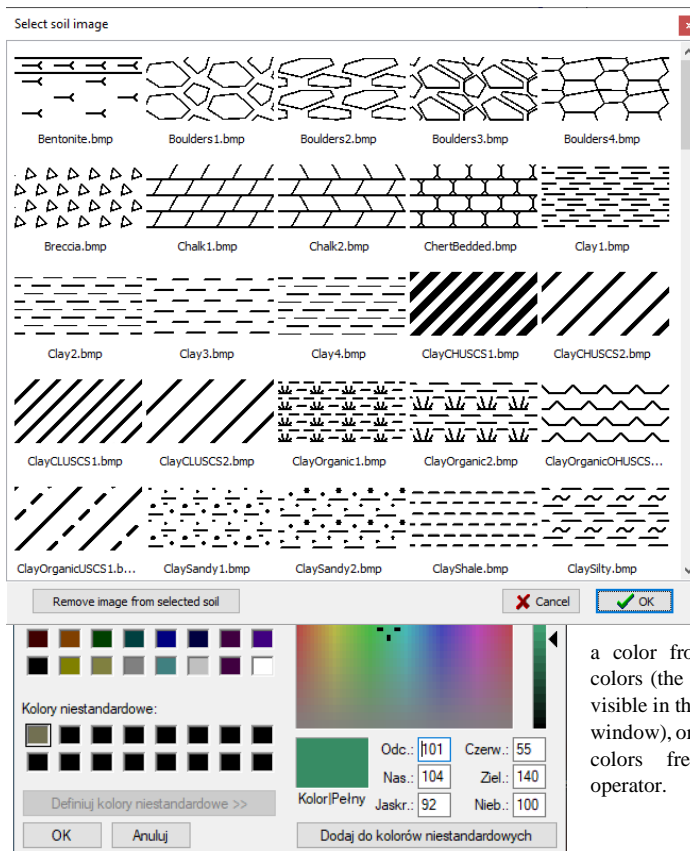
To edit graphic symbol select and double click the relevant cell with image. That operation opens the directory with all graphic symbols used in CPT-pro and generates all available symbols – see **Błąd! Nie można odnaleźć źródła odwołania..** The [*Scale*] column contains a pre-defined scale of the border defined individually for each soil. This scale can then be changed by specifying a global [*Lithologic pattern scale*] factor (Section H.4.2. Fig H.7), common to all soils. This scale also applies to hatches used in the CPT-CAD module.

The display style includes, in addition to the color and border used on the sounding log, the hatch style used in the CPT-CAD module to fill the soil bars. Selecting a hatch is the same as selecting a scarf - by double-clicking on the appropriate cell in the [*Hatch*] column and selecting the appropriate pattern in the [*Select soil image*] window that has just been created.

To change symbol just double click the relevant one and click any other cell in [*Select soil image*] window. All your selection will be saved in configuration files.

You may create own soil images using simple graphic software, for instance standard Windows **Paint**. The only limitation is size of image, which should be WxH = 240x120. Image should be saved in directory [**Images**] available on clicking **File/Tools/Open config directory**.

Fig. K-2. Soil geological patterns.



Color selection window.

In [Color] window, Windows system gives the facility of selecting a color from the group of basic colors (the corresponding palette is visible in the top left part of [Color] window), or a group of non-standard colors freely defined by the operator.

Edition of a color is realized by:

- * Highlighting the box in [Basic colors] panel.
- * Selection of the color from the color palette in the large square window by clicking the selected point.
- * Selection of color saturation by moving up/down with the mouse the black symbol [▲] located beside the vertical saturation bar.
- * Clicking [OK]

→ Color selection window is a standard Windows system window and all descriptions are in original language.

K.3. 1st order interpretation methods. Classification of soils.

1st order interpretation methods enable identification of soil types on the basis of **CPT** log. These methods are selected in [**Classification methods**] window opened by executing **Tools/Classification method** function or clicking the icon [K] – see Fig. D-9.

The following elements are available in [**Classification methods**] window (see Fig. K-4):

- [**Classification**] panel in which selection of the **1st order method** is realized,
- **Minimum layer thickness** setting
- Checkbox [**Calculate unit weight**] enabling calculation of unit weight based on implemented interpretation method (by Robertson 1986).
- 4 buttons:
 - ☐ <Info> activating the method description function.
 - ☐ <Load> causing loading of interpretation result in the scope of soil classification, performed earlier.
 - ☐ <New> causing activation and execution of soil type interpretation procedure (irrespective of whether the *.bXX file with soil type interpretation results was created earlier). <New> button automatically activates [**Draw soil type**] box in [**Graph settings**] panel. Activation of this box in turn causes creation of soil bar with classification result.
 - ☐ <Close> closing [**Classification methods**] window without executing any operation.

Quick selection of classification method is available by clicking the symbol ▼ next to icon [K].

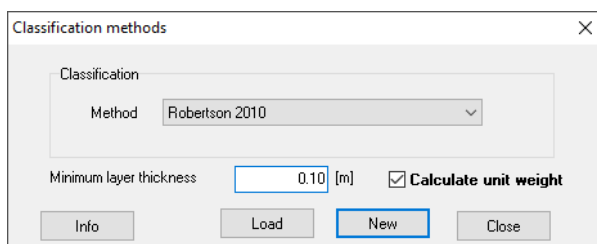


Fig. K-4. [**Classification methods**] window.

→ However it is possible to filter out thin layers in **Macro M3**, it is recommended to perform this operation directly after classification by setting the Minimum layer thickness in edition window (see Fig. K-4).

→ *.bXX file contains complete information on the results of interpretation performed. Name of file is identical as for main *.CPD file. The extension **bXX** is characteristic for the selected method. For example, if Robertson's method based on Rf (1986) is selected for **1st** order interpretation, files created with interpretation results will have the extension **b01**. If 1st order interpretation is performed according to Robertson's method based on Rf (1990), files created with interpretation results will have the extension **b02** etc.

If during earlier analysis classification result was not saved in relevant *.bXX file then the word "None" is visible in [**Method**] window. If *.bXX file was created earlier (and exists in the directory set during opening of *.CPD file), then the program automatically gets "set" to the method last selected.

Drop down of [**Classification**] panel box occurs by clicking symbol ▼ beside the box with the method name. The method is selected by clicking the mouse left button on the selected method.

After selecting the method and clicking <Info> button, the method window appears having the following information:

- Name of method.
- Original source and publication from which the method is quoted.
- Algebraic formula and/or the graph/diagram defining the selected method.
- Information on the scope of application of the selected method (optionally – if cited in the source materials).

The descriptions of all the methods currently implemented in **CPT-pro** are additionally presented in **Chapter P**.

Obtaining identification of soil types is realized in the sequence of the following operations:

1. Activate **Tools/Classification method** function (by clicking [**Tools**] in the main menu and [**Classification method**] in the newly opened menu).
2. Drop down the list of available classification methods by clicking symbol ▼.
3. Select the method by clicking the name of selected method with the mouse left button.
4. Click <New> button.

The soil bar with interpretation result regarding identification of soil types should appear beside the graphs/diagrams of selected parameters.

→ *Executing the interpretation of identification of soil types does not cause automatic saving of interpretation result in *.bxx file. If you wish to save the result of this interpretation into the file (e.g. to create geotechnical cross sections in Cross Section module), then:*

- *Activate Graph/Options function and select the page with [File] marker.*
- *Highlight [**Always save with CPT file**] or [**Ask saving CPT file**].*
- *Save actual CPT log as *.CPD file.*

Click **[Yes]** button when asking about saving classification.

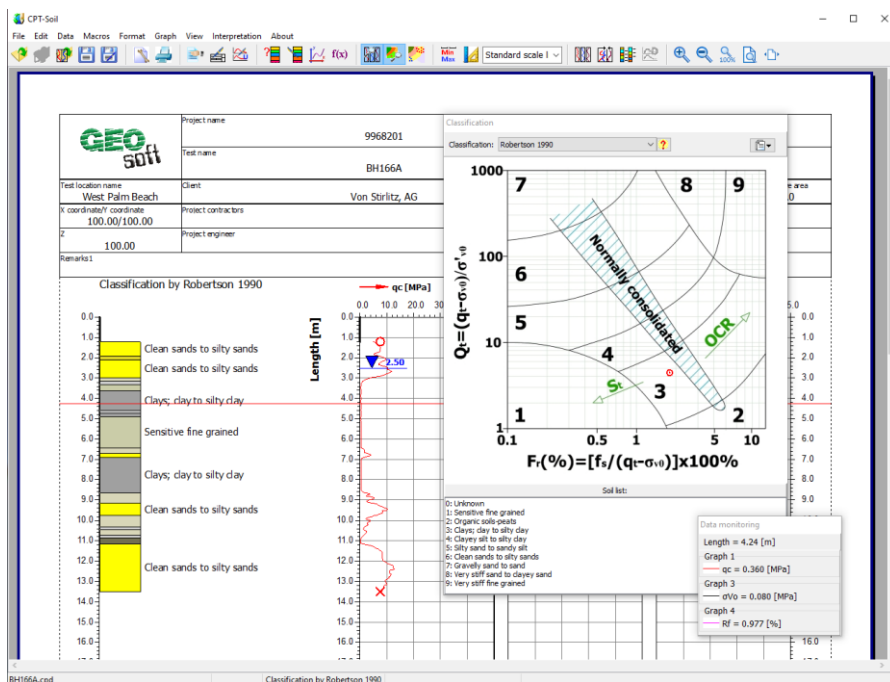




Fig. K-5. Results of classification (small red circle) on relevant classification diagram.

The result of classification and values of parameters can be also observed on classification diagram.

To activate this function click icons with symbol of loop on graphs marked with the letter **O** in Fig. D-9 and loop on classification diagram marked with **[P]**. Clicking left mouse button on any selected place of sounding graph activates “red line” on it and small red circle on classification diagram, showing the result of classification for chosen depth. Location of the red line (i.e. read out depth) can be changed by clicking mouse cross cursor in the newly selected place. To hide the diagram click icons **[O]** and **[P]** once more.

The result of classification presented on Robertson’s classification diagram can be also copied to clipboard and pasted to other software. Clicking the “copy icon”  on right upper corner of **[Classification]** window copies current classification result with chart to clipboard.

Clicking the chosen option makes copy of classification result, optionally with or without list of soil types. The **[Test number]** and **[Location]** are added automatically.

Despite of tracking results (single point) on classification diagram, the “cloud” with results of classification (Fig. K-6) can be plotted for entire test simultaneously. To check where are relevant results gradient of selected colors was implemented. To activate that option click **[Graph / Classification cloud]** or the icon  denoted as **[R]** on Fig. D-9

Few particular ranges of depth can be selected and highlighted by clicking [Set bands] button and filling parameters of selected layer. To mark selection on cloud check [Use color bands] checkbox.

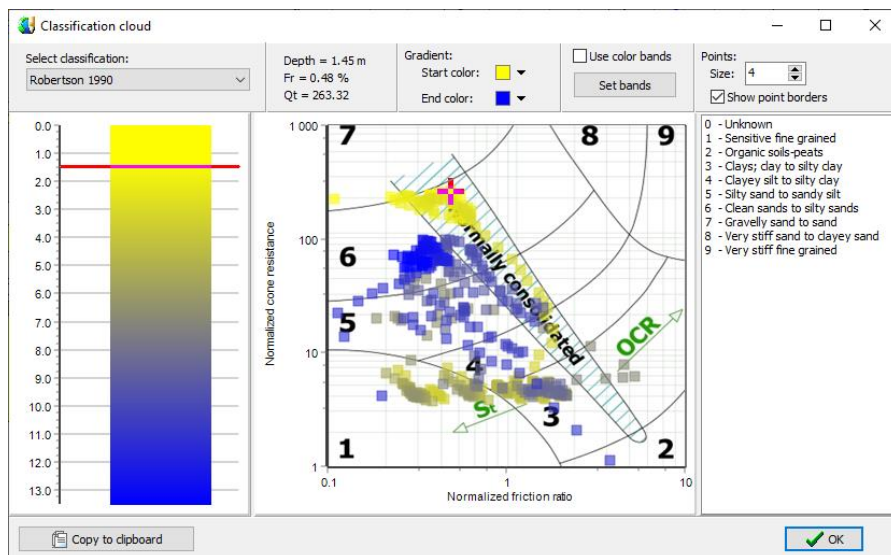


Fig. K-6. Cloud with results of classification.

Unit weight is a special parameter. It obviously depends on type of soil, on the other hand, most of classification and evaluation methods need overburden pressure on input, which is directly calculated from unit weight. To “break” this “closed circle”, there are implemented two methods of inserting unit weight:

1. Direct interpretation based on CPT results according to method published by **Lunne, Robertson, Powell**. In first step the Robertson's '86 classification is executed, as it directly depends on cone resistance q_c and friction ratio R_f only. After that, on base of **Table 5.2**, of that book, unit weight **UW** is evaluated and saved on channel **65**.
2. Estimation of the bulk weight of soil when loading a data file based on o the method described in [15] – see *References Section O*.
3. Estimation of the volumetric weight of soil in accordance with the values entered by the User in the [Soil attributes] window in the [Unit weight] column – see Fig. K-7. This option is implemented after selecting the [Custom] setting in the [Unit weight] window opened from the menu *Interpretation/Unit weight*.

→ After changing the Unit weight value, you need to reopen the file.

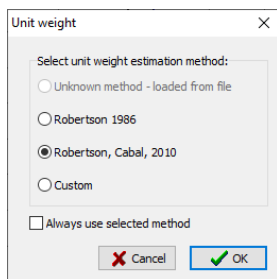


Fig. K-7. Window for selecting the method for estimating the volumetric weight of soil.

K.4. Entering a lithological profile from the GEO DB database.

The **CPT-pro** program allows you to enter a lithological profile from the **GEO DB** database and interpret geotechnical parameters based on this profile. To do this, you need to import a *.gdb file generated in the **GEO DB** database. The import procedure is available from the main menu **File / Import from GEO DB database** and from the **[Classification methods]** window – in this case, the classification from **GEO DB** is at the end of the list of implemented interpretation methods (Fig. K 8).

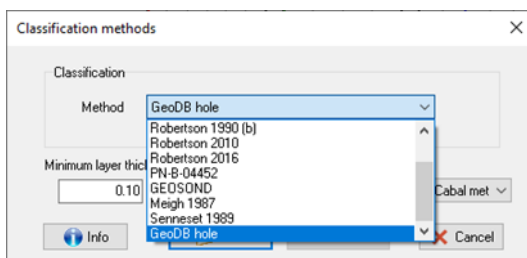


Fig. K-8. [Classification methods] window - classification from GEO DB.

K.5. Editing classification results.

Performing a first-order interpretation causes CPT-pro to generate an "internal" (i.e. existing only in RAM) data file with a set of results that contain information about the depth of the ceiling of each assigned layer and its thickness with a description of the type land (according to the selected interpretation method). The user can change the content of this information, among others: to better adapt the terminology to local conditions and requirements, or to adapt the classification results to the results of laboratory tests and other tests that may provide a more accurate description of the type of soil.

Editing the result of the **first-order** interpretation method is carried out directly on the sounding log by selecting the appropriate menu opened with the right mouse button on the edited layer (Fig. K-9) – see the last two items at the bottom of the list.

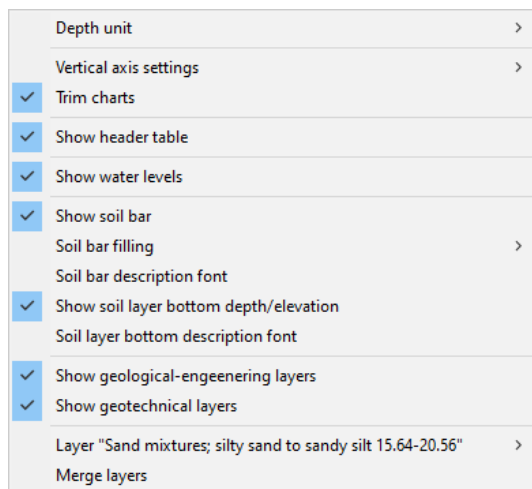


Fig. K-9. Menu for configuring the sounding card and editing classification results.

The penultimate item in the menu contains the soil type of the selected layer, its depth range and the > symbol opening another menu with editing functions of the selected layer - Fig. K-10.

The last item [**Merge layers**] on the menu activates the procedure of combining a layer package into one layer.

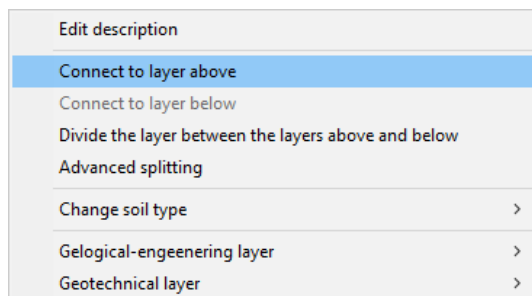


Fig. K-10. Editing functions of the selected layer.

Clicking the [**Edit description**] menu opens the [**Edit layer**] window - a window for basic editing of the selected layer – see Fig. K-11.

Edit layer

Layer above information:

Top: 7.48[m]
Bottom: 7.60[m]
Thickness: 0.12[m]
Soil type:
Silt mixtures; clayey silt to silty clay

Layer below information:

Top: 9.50[m]
Bottom: 9.72[m]
Thickness: 0.22[m]
Soil type:
Sands; clean sands to silty sands

Depth information

Top: Bottom: Thickness:

Soil type

Description

Show description:
☒ auto
☐ always
☐ never

Geological-engineering layer

Geotechnical layer

γ [kN/m ³]		N _k []		WL [%]		k []		v []		Φ_{cv} [°]		Soil type	
Def	Value	Def	Value	Def	Value	Def	Value	Def	Value	Def	Value	Def	Value
<input checked="" type="checkbox"/>	20	<input type="checkbox"/>	14	<input type="checkbox"/>	0.3	<input type="checkbox"/>	0.3	<input type="checkbox"/>	0.3	<input type="checkbox"/>	33	<input checked="" type="checkbox"/>	F

Fig. K-11. [Edit layer] window.

The upper part of the [Edit layer] window contains basic information about the layer above and below the edited layer.

Values of **External Parameters** can be edited. To come back to default values defined in [Soil attributes] window (Fig. K-20) check relevant checkbox in column [Def].

The scope of basic modification of the selected layer contains:

- **Editing the depth of the layer's ceiling** in the range up to [The ceiling of the layer above – 2 cm]
- **Editing the depth of the layer's floor** in the range up to [Floor of the layer below +2cm]
- **Select the soil type** according to the classification method used to generate the soil profile

NOTE – only soil with the selected classification method is available. When editing a profile from GEO DB, the soils occurring in a given borehole are available.

- **Changing the name of the selected soil**

NOTE – regardless of the changed name, the soil will have properties consistent with the selection in the Soil type box above

- **Show/hide the soil description** of the selected layer.

- **[auto]** means that the description appears if the font height of the description is smaller than the height of the layer on the sounding card
- **[always]** means the description appears regardless of the layer height on the sounding card
- **[never]** hides the soil type description
- Assignment of a geological-engineering layer number. The same function is performed directly in the layer editing menu window - Fig. K-10 after pressing the symbol >.
- Assignment of a geotechnical layer number. The same function is performed directly in the layer editing menu window - Fig. K-10 after pressing the symbol >.
- Edition of values of **External Parameters** that are assigned to the soil – see chapter K.7 and Fig. K-20.

In addition to basic layer modification, the **CPT-pro** program allows the following operations on layers:

- **[Connect to layer above]** - Connecting the selected layer to the layer above it. This operation results in the selected layer being merged with the layer above it and adopting all the attributes of the above layer into the new layer resulting from the merger.
- **[Connect to layer below]** - Connecting the selected layer to the layer below it. This operation results in the selected layer being merged with the layer below it and adopting all the attributes of the underlying layer into the new layer resulting from the merger.
- **[Divide the layer between the layers above and below]** - Separate the selected layer in equal parts between the layers above and below.
- **[Advanced splitting]** - Split the selected layer between the layers above it and lower. Clicking on this item in the menu opens a window **[Divide layer]** (Fig. K-13), in which, based on the visible graphs of selected parameters, you can divide the layers in any proportions by moving the division line with the mouse in the **up/down** direction. Additional information is provided by the location of the division point on the nomogram of the appropriate classification method.
- **[Change soil type]** – change soil type.
- **[Geological-engineering layer number]** – assigning a geological and engineering layer number to the selected layer. Assignment is made by clicking on the symbol > and selecting the appropriate number from the list.
- **[Geotechnical layer number]** – assigning a geotechnical layer number to the selected layer. Assignment is made by clicking on the symbol > and selecting the appropriate number from the list.

NOTE - divisions into geological-engineering layers and geotechnical layers are independent and may be different.

The lists of geological, engineering and geotechnical layer numbers are not closed and you can add new numbers in the boxes **[Geological-engineering symbols]** and **[Geotechnical symbols]** opened at any time after clicking on the appropriate menu.

The numbers of geological and engineering layers and geotechnical layers are optionally presented on sounding cards in the form of additional "bars" with descriptions next to the geological profile – see Fig. K-14.

<input checked="" type="radio"/> Not assigned
1a
1b
1c
11a
11b
11c
A1
A2
A3
B1
B2
B3
B4
C1
Add new symbol
Configure list

Fig. K-12. Assigning a geological-engineering or geotechnical layer number.

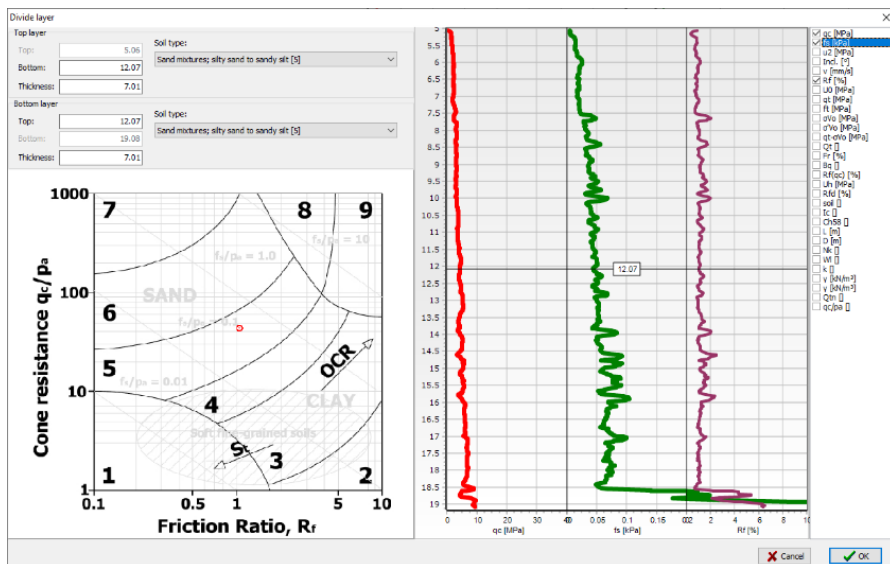


Fig. K-13. Window [Divide layer] – advanced layer splitting.

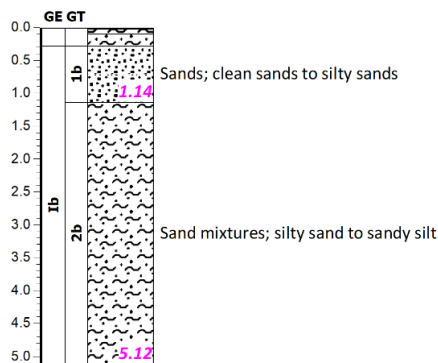


Fig. K-14. Presentation of Geotechnical and Geological-Engineering layers.

In the **[Divide layer]** window it is also possible to change the soil type in the layers resulting from the division. To do this, scroll down the **[Soil type]** lists and select the appropriate soil type.

NOTE. In CPD and XCPD files, information about the last active classification before saving the file is saved and this classification will be imported by CPT-CAD for creating sections. If a different classification should be included in the section for a given probing, the CPD/XCPD file should be reopened, the required classification selected/created, parameter estimates for this classification performed and changes saved. Saving is only possible to XCPD format.

K.6. Geological-engineering and geotechnical layers.

The CPT-pro program allows for grouping of separated lithological layers into geological-engineering (**GE**) layers and geotechnical (**GT**) layers. The divisions into **GE** and **GT** layers are independent of each other. As a rule, the boundary between adjacent **GE** and **GT** layers runs along one of the boundaries of lithological layers. If the classification method is changed after determining the **GE** and/or **GT** layers, the **GE** and **GT** layers defined earlier are eliminated.

The assignment of **GE** and **GT** layer numbers is performed directly on the sounding log. Right-clicking on the selected geological layer opens a context menu, in which the penultimate item at the bottom of the menu is the selected layer described by specifying the *type of soil, roof and floor*. Clicking on this layer opens another menu, which contains, among others, the items **[Geological-engineering layer]** and **[Geotechnical layer]**. Clicking on the appropriate item opens a list of **GE** or **GT** layer numbers, respectively, from which selection is made – see Fig. K-15. Editing existing **GE** and **GT** layer numbers can be done by clicking **[Configure list]** in the menu below the layer list or in the main menu **Interpretation/Layer symbols**.

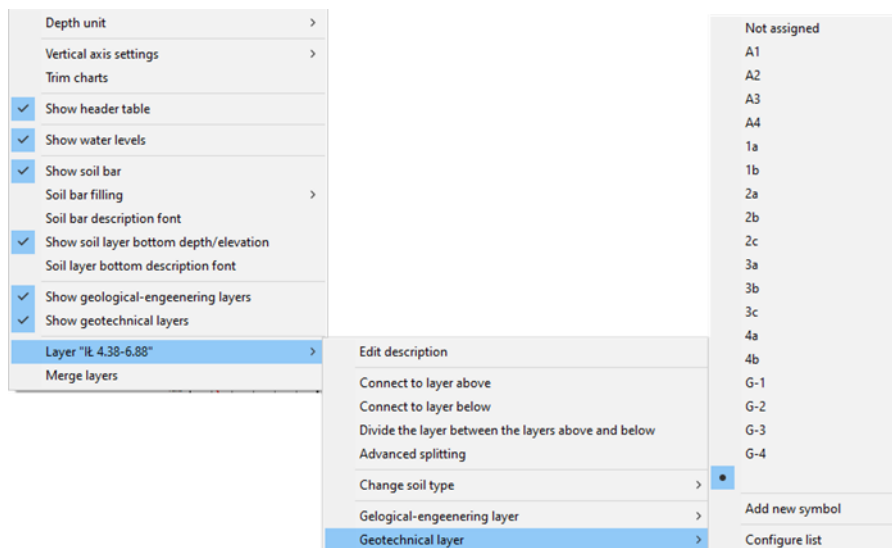


Fig. K-15. Assigning a geological-engineering or geotechnical layer number.

K.7. IInd order interpretation methods. Evaluations.

IInd order interpretation methods enable defining the values of selected strength and physical characteristics of soils on the basis of **CPT** log.

Almost all methods of estimating the values of geotechnical parameters, based on CPT parameters q_c , f_{ss} , u_2 and external parameters, take the form of correlation functions that link the values of the parameters sought with the CPT parameters. Most correlation functions apply only to a selected category of soil types. For example, the correlation that links the relative density of sandy soils I_D with CPT parameters applies only to sandy mixtures, while for cohesive soils this function obviously has some values but has no technical meaning.

In the **CPT-pro** program, there is a procedure that limits the use of correlation functions to selected soil types only. This type can be determined by selecting the soil number (each classification has its own soil numbers – see Fig. K-17, the **[Select soils]** window in the **Formula Editor** and the descriptions of classification methods – chapter P.1).

In many cases, correlation formulas apply to the entire soil category distinguished by grain size. The following categories have been distinguished in the CPT-pro program:

- Unknown soils (**Unknown**) – designated as **U**
- Fine soils (**Fine**) – designated as **F**
- Transitive soils (**Transitive** – see [17]) – designated as **T**
- Coarse soils (**Coarse**) – designated as **C**
- Gravely soils (**Gravely**) – designated as **G**

- Organic soils – designated as **O**

Type **F** soils include clayey and silty soils, type **T** soils include soils in the transition zone at the boundary of silty and fine sandy soils.

The division of soils into types designated by numbers is a more detailed and allows for better adjustment of the interpretation method to individual soil types. In many cases, however, the correlation function has a relatively broad application and can be used for the entire soil category, e.g. [**F**] or even [**F+T**].

An important application of the division into **U/F/T/C/O** (hereinafter referred to as **F/C**) categories is the interpretation of **CPT** soundings based on a classification profile from a source other than the classification interpreted in **CPT-pro**, e.g. based on a profile imported from the **GEO DB** database. In such a case, the borehole entered into **GEO DB** should have *soil type F/C* values entered. After exporting such a borehole to **CPT-pro**, the **F/C** layer characteristics are treated by the program as a distinguishing feature defining the application of the interpretation method to the soil of a given layer.

Selection of ***IInd order interpretation methods*** occurs in [**Evaluation**] window opened by executing **Tools/Evaluation** function.

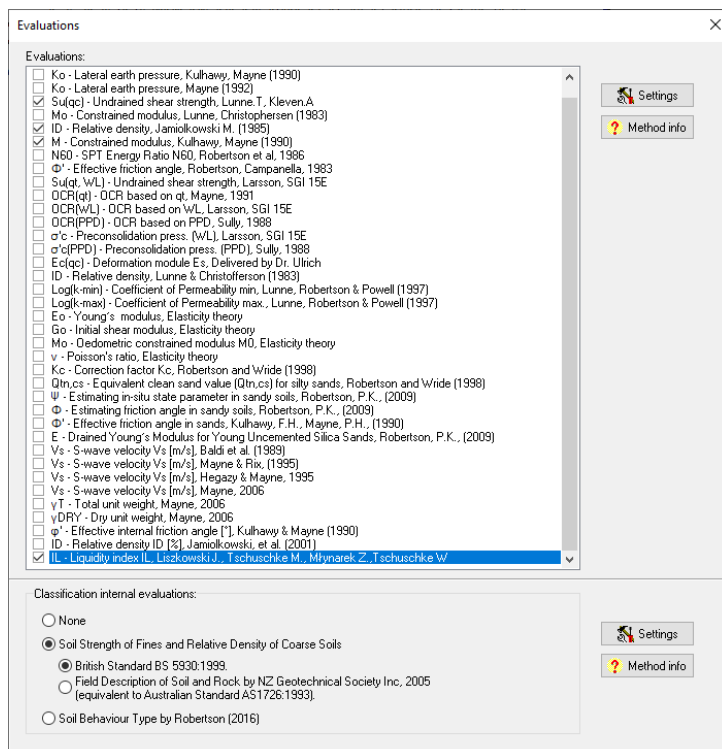


Fig. K-16. [**Evaluations**] window.

In the [Evaluations] window (Fig. K-16) the [Evaluations] and [Internal Classification evaluations] panels are available, in which the following functions are performed:

- Selection of **Evaluations** (more than one method can be selected) for performing interpretation of selected parameters. The method is selected by highlighting relevant checkbox on the left of the method description (after clicking the checkbox with the left button, [✓] symbol should appear).
- Selection of **Classification internal evaluation** (only one method can be selected) to activate additional description/evaluation of interpreted soil layers, like for instance [SAND loose], [SAND dense]. The method is selected (irrespective of the methods selected for performing interpretation) by highlighting the relevant radiobutton next to the name of the method.

Additionally there are included:

- <Settings> button activating [Evaluation options] window (Fig. K-17), used for external evaluations.
- <External parameters> (already announced in chapter 0) pane including two radiobuttons activating selected option of relation external parameter versus soil type or depth. Buttons [Set] open relevant [Evaluation parameters] window, used for entry values of external parameters (such like **Plasticity Limit** W_L etc.) required by some evaluation methods (Fig. K-17).
 - To add values of external parameters vs. type of soil click [Set] button next to [vs. Length] radiobutton.
- <Method info> button (activated after selecting any method for executing the description function) activating the method description function.
- <Settings> button activating [Settings] window (Fig. K-21) used for internal evaluations.

Note: Soil evaluation use: current classification method

Evaluated soil parameter	Symbol	Author	Soil numbers	Soil types	Calculate using	Channel
Relative density	ID	Lancelotta (1993)	[7,8,9]	[0]	soil types	31
Lateral earth pressure	Ko	Kulhawy, Hayne (1990)	[0,1,2,3,4,5,6,7,8,9,10]	[0,F]	soil types	32
Lateral earth pressure	Ko	Hayne (1992)	[7,8,9]	[0]	soil types	33
Undrained shear strength	Su(q)	Lambe, T, Klevens, A	[1,3,4]	[0]	soil numbers	34
Constrained modulus	Ho	Lambe, Christopherson	[7,8,9]	[0]	soil types if numbers are not set	35
Relative density	ID	Jamiołkowski H. (1985)	[7,8,9]	[0]	soil numbers	36
Constrained modulus	H	Kulhawy, Hayne (1990)	[1,2,3,4,5,6,7,8,9,10]	[0]	soil types if numbers are not set	37
SPT Energy Ratio N60	N60	Robertson et al. 1986	[1,2,3,4,5,6,7,8,9,10]	[0,F]	soil types if numbers are not set	38
Effective friction angle	φ'	Robertson, Campanella	[7,8,9]	[0]	soil types if numbers are not set	39
Undrained shear strength	Su(qt, WL)	Larsson, SG1 15E	[1,3,4]	[0]	soil types if numbers are not set	40
OCR based on qt	OCR(qt)	Hayne, 1991	[1,3,4]	[0]	soil types if numbers are not set	41
OCR based on WL	OCR(WL)	Larsson, SG1 15E	[1,3,4]	[0]	soil types if numbers are not set	42
OCR based on PPD	OCR(PPD)	Sully, 1988	[1,3,4]	[0]	soil types if numbers are not set	43
Preconsolidation press. (WL)	σ'c	Larsson, SG1 15E	[1,3,4]	[0]	soil types	44
Preconsolidation press. (PPD)	σ'c(PPD)	Sully, 1988	[1,3,4]	[0]	soil types	45

Warning: Soil types: type a soil type numbers, separated by ""
Example: 2,4,5

Soils for classification by Robertson 1986

- [0] Unknown
- [1] Sensitive fine grained
- [2] Organic material
- [3] Clay
- [4] Silty clay to clay
- [5] Clayey silt to silty clay
- [6] Sandy silt to clayey silt
- [7] Silty sand to sandy silt
- [8] Sand to silty sand
- [9] Sand
- [10] Gravely sand to sand
- [11] Very stiff fine grained
- [12] Sand to clayey sand

Cancel OK

Fig. K-17. [Evaluation options] window.

- Standard <OK> and <Cancel> buttons.

In the [Evaluation options] window for each interpretation method implemented in the program, it is specified for which **soil numbers** (column 4) and for which **soil types** (column 5) a given interpretation method is applicable. In **column 6**, the interpretation criterion priorities are set (Fig. K-17):

- Selection of soil by numbers
- Selection of soil by type F/C (Fig. K 15)
- Selection by numbers and if numbers do not exist, then by types F/C (e.g. according to the classification from GEO DB)

<input type="checkbox"/>	U
<input type="checkbox"/>	F
<input checked="" type="checkbox"/>	C
<input checked="" type="checkbox"/>	T
<input type="checkbox"/>	O

Fig. K-18. Selection of F/C type of soil.

soil types	▼
soil numbers	
soil types	
soil types if numbers are not set	

Fig. K-19. Criteria for selecting soil for interpretation.

Soil attributes													X
Classification:	No.	Soil description:	Soil type	Image	Color	Hatch	Scale	Unit weight [kN/m ³]	Nk	WL [%]	k	Poisson's ratio	ecv
Robertson 1986	0	Unknown	U				1.00	19.00	19	14	0.3	0.3	0.3
Robertson 1990	1	Sensitive fine grained	F				1.00	17.50	17.5	14	0.3	0.3	0.3
Robertson 1986 (b)	2	Organic material	T				1.30	12.50	12.5	14	0.3	0.3	0.3
Robertson 1990 (b)	3	Clay	F				0.80	17.50	17.5	14	0.3	0.3	0.3
Robertson 2010	4	Silty clay to clay	F				1.20	18.00	18	14	0.3	0.3	0.3
Robertson 2016	5	Clayey silt to silty clay	F				1.00	18.00	18	14	0.3	0.3	0.3
PN-B-04452	6	Sandy silt to clayey silt	T				1.00	18.00	18	14	0.3	0.3	0.3
MEGH 1987	7	Silty sand to sandy silt	T				1.00	18.50	18.5	14	0.3	0.3	0.3
SENNESET 1989	8	Sand to silty sand	T				1.00	19.00	19	14	0.3	0.3	0.3
	9	Sand	C				1.00	19.50	19.5	14	0.3	0.3	0.3
	10	Gravelly sand to sand	C				0.60	20.00	20	14	0.3	0.3	0.3
	11	Very stiff fine grained	C				1.00	20.50	20.5	14	0.3	0.3	0.3
	12	Sand to clayey sand	T				1.00	19.00	19	14	0.3	0.3	0.3

Reset display settings for all soils

OK

Fig. K-20. [Soil attributes] window with edition of external parameters.

K.7.1. British standard evaluation

Settings

Current interpretation: Robertson 1986

Select classification to configure settings: Robertson 1986

Granular soils:

Granular soils: 7,8,9,10

Descriptions:

Long	Short
Very Loose	VL
Loose	L
Medium Dense	MD
Dense	D
Very Dense	VD

Cohesive soils:

Cohesive soils: 3,4,5,6

- ☐ 0 - Unknown
- ☐ 1 - Sensitive fine grained
- ☐ 2 - Organic material
- ☒ 3 - Clay
- ☒ 4 - Silty clay to clay
- ☒ 5 - Clayey silt to silty clay
- ☒ 6 - Sandy silt to clayey silt
- ☐ 7 - Silty sand to sandy silt

Descriptions:

Long	Short
Very Soft	VSo
Soft	So
Firm	F
Stiff	St
Very stiff	VSt

Description:

☒ Long Width: 50.0

☐ Short Width: 45.0

☒ Use smooth values

Range of smoothing, $k = 1$

Destination channel: 71

Minimum layer thickness: 0.20 [m]

Cancel OK

Fig. K-21. British Standard BS 5930: 1999 settings.

The **British Standard BS 5930** interpretation method is a specific method that intervenes in the description of the soil type by providing information on its condition – the degree of compaction ID for sandy soils and a descriptive assessment of the shear strength for cohesive soils.

→ As **British Standard** evaluation method may create extra thin layers inside layers being the result of classification, there is implemented additional filtering option. To remove these thin layers set Minimum layer thickness in edition window of British Standard Settings window (Fig. K-21). This value should be smaller or equal to layers removed after classification.

→ To set values of external parameters (Fig. K-11, Fig. K-20) chose soil description system (connected with classification system) by highlighting appropriate classification method. After that click one of edition fields on right side and edit the value. Use mouse cursor or arrow keys to move to another edition field. Clicking question mark icon over the columns opens list with the list of methods, which use chosen external parameter. Clicking the name of method opens its description.

→ Just to avoid missing of updating external parameters (which can vary for different areas), highlighting checkbox with evaluation method using external parameters shows **[Warning]** window.

K.8. Program configuration in the scope of II^{nd} order interpretation methods.

II^{nd} order interpretation methods are generally adapted to certain selected soils. In certain cases, the scope of applicability of the selected method is wide, it is limited exclusively to a few soil types. CPT-pro enables precise stating of soil type in which the selected II^{nd} order method can be used.

→ **I^{st} order interpretation methods** performing classification usually have their own terminology. Hence, before performing II^{nd} order interpretation, perform I^{st} order interpretation in which the individual soil type zone will be separated, and define the range of applicability of selected II^{nd} order interpretation methods.

Selection of II^{nd} order method and defining the range of their applicability is done in [Evaluation options] window (Fig. K-9.) opened by activating **Tools/Evaluation** function and then highlighting the selected method (see K.2.) and clicking <Options> button.

The table with columns marked as follows, is available in [Evaluation options] window:

- * **Evaluated soil parameter** – with full name of parameter
- * **Symbol** – with standard symbol (if there is any)
- * **Author** – with name (names) of author (authors) of source paper
- * **Soil types** – with numbers of soil types in accordance with the selected I^{st} order interpretation method
- * **Channels** – with number of the channel in which the interpretation result is entered
- * **F/C** – with information whether the selected method is applied to fine soils or to coarse soils.

The first three columns and [Channels] column contain only the information read out from the file having the operation subprogram of the given method and are not editable. The column **Soil types** is editable. That columns become editable after double-clicking the edit field with the mouse left button. Filling the field contents in [Soil types] columns should be in accordance with the directions provided in the bottom section of [Evaluation options] window.

Clicking <OK> button causes acceptance in the current program configuration of the entries made in [Evaluation options] window and closing of this window.

→ The numbers entered into [Soil types] column result in interpretation of the selected parameter only in the areas (in depth ranges) in which the selected I^{st} order interpretation method indicated existence of soil types corresponding to the numbers entered.

→ The scope of applicability of the individual methods proposed in CPT-pro (i.e. soil types visible in [Evaluation options] window in [Soil types] column – see above) should be verified and eventually corrected by the user.

→ The settings entered into [Evaluation options] window are saved by the program in the configuration file. The next start of CPT-pro causes reading of these settings and their entry into the current configuration.

K.9. Conditional formulas (option).

CPT-pro gives possibility to enter own conditional interpretation formulas, which may include few different equations, defined for selected soil types and for defined ranges of selected parameter. Most of standard mathematical functions are available.

After clicking [Interpretation/ Conditional formulas] a [Formula Editor] window appears (Fig. K-22), in which you can create your own interpretation formulas. Due to the fact that interpretation

formulas can contain applicability conditions (e.g. type of soil to which the formula can be applied), formulas created in CPT-pro are called **conditional formulas**.

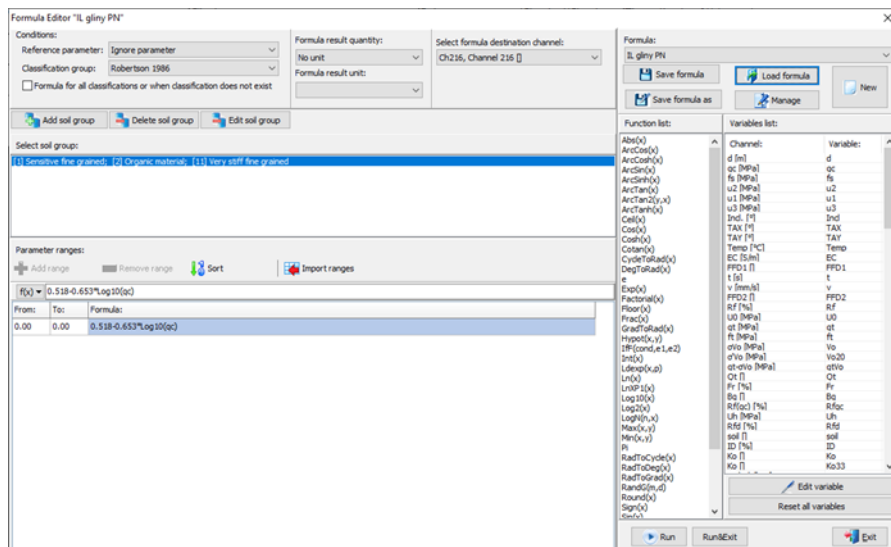


Fig. K-22. [Formula Editor] window.

Creating formulas is done in the following order:

1. Defining the scope of applicability of the method.
2. Defining the reference parameter, the values of which affect the form of correlation equations - if the method requires defining such a parameter, then in the [Conditions] panel, select the appropriate parameter from the drop-down list. If the method does not require such a parameter, leave the **Ignore parameter** setting.
3. Select the first-order interpretation method (classification) from the drop-down list, for which the soils in which the method is to be applied will be selected. For the selected method, click the [Add soil group] button and select the soils for which the method is to be applied. After accepting the selection, the selected soils should appear in the [Select soil group] panel. In this way, you can create several soil groups. If the method being created is to work for all soils, then select the [Formula for all classifications or when classification does not exist] checkbox.
4. Select the selected soil group and in the [Parameter ranges] panel enter the **From-To** range of the reference parameter (if one has been defined) and the appropriate correlation equation for the selected soil group. The names of the functions in the correlation equation must be consistent with the format presented in the [Function list] column. The function argument must be entered exactly as it appears in the [Variable] column.
5. Select the unit group appropriate for the interpreted parameter by expanding the list in the [Formula result quantity] panel. If the parameter is dimensionless, leave [No unit].

6. For the selected unit group, select the unit specified in the correlation formula from the **[Formula result unit]** list.
7. In the **[Select formula destination channel]** panel, select the channel to which the result of the formula operation is to be saved. Since CPT-pro allows the creation of a very large number of user channels (400), it is recommended to assign "permanently" channel numbers for parameters defined in User formulas. Selecting **[First available]** and clicking **<Next>** opens the **[Define new parameter]** window, where you can set the parameter attributes, such as parameter name, abbreviation, minimum, maximum, units, grid, graph color and line thickness – see Fig. K 19. Clicking the **[Finish]** button will assign the selected attributes to the parameter.

Fig. K-23. **[Define new parameter]** window.

8. The parameter defined above can be saved. To do this, click the **[Save formula as]** button, enter your own formula name and click **<OK>**.

→ All formulas must keep the same format as on **[Function list]**, otherwise formula will not be accepted and error message will be generated.

→ You can just drag-and-drop a function from list to Formula cell, however, complex functions $f(g(x))$ should be typed.

→ To type the exponentiation (a^b) use symbol ^ from keyboard.

A correctly defined and saved **Formula** can be loaded at any time by selecting the appropriate parameter name from the **[Formula]** drop-down list and clicking the **<Load>** button. The loaded formula can be edited. After editing, click the **[Save formula]** button to save the changes under the old formula name, or **[Save formula as]** to save the formula under a new name. Clicking **[Run & Exit]** executes the formula and goes to the main window of the **Interpretation** module. Clicking **[Run]** executes the formula and remains in the **[Formula Editor]** window.

Formula management can be performed in the [**Formulas**] window activated by clicking the [**Manage**] button.

In this window, the following operations can be performed:

- Changing the order in the formula list – by selecting formulas and clicking the [**Move up**] and [**Move down**] buttons
- Changing the name of the formula
- Copying the formula
- Importing the formula
- Deleting the formula

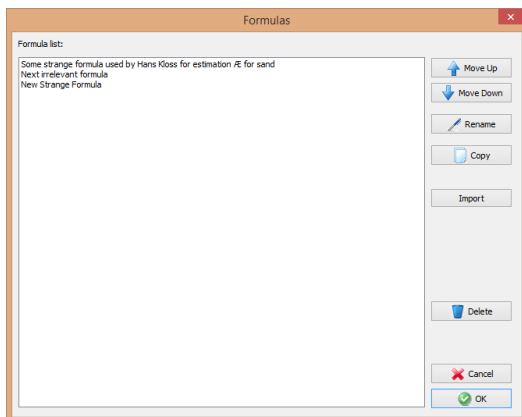


Fig. K-24. Formulas window with managing tools.

K.10. Saving interpretation results to an XCPD file.

The interpretation result containing the performed classifications and estimates of geotechnical parameters can be saved to a file in CPD, XCPD or XCPDX format. Along with the recording of the values of individual channels, information about the most recently used classification method is saved in the file.

When saving, it should be noted that the estimation of some parameters is closely related to the classification performed before this estimation (e.g. the degree of compaction of ID depends on the indication of sandy soil zones). Therefore, if after the execution of formulas calculating some parameters, the classification method changes, it may happen that the parameter estimates will not be consistent with the open classification. For example, the degree of compaction of sandy soils ID may have values in clay zones.

K.11. Characteristic values of geotechnical parameters.

According to **Eurocode 7**, the characteristic value of a geotechnical parameter is a conservative estimate of the soil property associated with the occurrence of a specific limit state, taking into account information on the statistical distribution of this parameter, uncertainties related to the estimation method (including the number of estimates) and the dispersion of the obtained results.

Eurocode 7 clearly indicates that the characteristic value should be determined as a 5% quantile of the probability distribution of this parameter. However, according to a number of opinions, such an estimate does not take into account the natural variability of soil properties, which, when added to the randomness of the method for determining the parameter value, often leads to a very large overestimation of the parameter variability and, as a result, to excessively low values obtained directly from the 5% quantile method.

Therefore, the **CPT-pro** program uses a number of methods for estimating characteristic parameter values, which can then be assigned to individual lithological layers or to defined geological-engineering layers (GE) or geotechnical layers (GT). Depending on the purpose of the study, the distribution of test holes, the quality of the equipment used for the study, etc., the user should select the appropriate method.

Taking into account the fact that in some circumstances¹² the 5% quantile should be used and in others the 95% quantile, the following procedures have been implemented in the **CPT-pro** program to estimate the characteristic values of geotechnical parameters:

- The sample **mean value** $m(X)$ of parameter X calculated from the available designations tests¹³
- According to the **Polish Standard PN-81/B-03020**: [*mean value from the sample – standard deviation from the population* $m(X)-\sigma(X)$]
- According to **Schneider method** – [*sample mean value – half of the sample standard deviation* $m(X)-s(X)/2$]
- According to **Schneider method** – [*sample mean value + half of the sample standard deviation* $m(X)+s(X)/2$]
- [*sample mean value – sample standard deviation* $m(X)-s(X)$]
- [*sample mean value + sample standard deviation* $m(X)+s(X)$]
- According to Eurocode 7 – [*5% quantile of the probability distribution of variable* $X = \mu(X)-1.645\sigma(X)$]
- According to Eurocode 7 – [*95% quantile of the probability distribution of variable* $X = \mu(X)+1.645\sigma(X)$]
- First quarter¹⁴ method - [$(m(X) + X_{min})/2$] (where X_{min} – minimum value of the sample)
- Fourth quarter method - [$(m(X) + X_{max})/2$] (where X_{max} – maximum value of the sample)

Characteristic values of parameters can be estimated according to the above statistics within the interpreted lithological layers and defined geological-engineering layers and geotechnical layers.

In the case of determining characteristic values of parameters for individual lithological layers, statistical calculations apply to a single borehole and each lithological layer separated in it.

In the case of determining characteristic values for geological-engineering layers and geotechnical layers, statistical calculations apply to the selected probe package and the logical sum of all layers of a given type in all selected boreholes.

¹² The principle is to adopt safer values

¹³ That is, values interpreted at registered individual depths of CPT test

¹⁴ The *first/fourth quarter* method is not based on statistics and has no mathematical support. It is an easy-to-use approximate method used in some countries.

NOTE. It may happen that in the defined geological-engineering or geotechnical layer X there are lithological layers for which the value of a given parameter is not calculated - for example, if in a sandy layer classified as geotechnical layer X there is a small cohesive interbedding of the I_D parameter (degree of compaction), then in this cohesive interbedding the I_D value is not calculated and for this cohesive zone the I_D assumes the value None. When calculating the characteristic value of I_D for the entire layer X, the values from the clay interbedding are not taken into account and the result of the calculations applies only to the sandy zones included in X.

Clicking the [**Characteristic values**] item in the [**Interpretation**] menu opens the [**Characteristic values**] window (Fig. K-25), which defines the method of calculating the characteristic parameter values.

The [**Add files**] button opens a standard Windows window, where CPD/XCPD files for calculations are selected. After selecting the files, their list with access paths appears in the left-hand panel.

In the middle panel, the type of layers and individual layers for which calculations will be performed are selected:

- Geological-engineering layers
- Geotechnical layers
- Lithological layers

For geological-engineering layers and geotechnical layers, it is possible to estimate characteristic values jointly for a package of selected soundings, whereas for lithological layers, the estimation of characteristic values is carried out individually for each layer in one selected borehole.

The right-hand panel contains a list of all available channels with parameters, from which, after checking the appropriate checkboxes, those for which characteristic values for the appropriate layers will be calculated are selected.

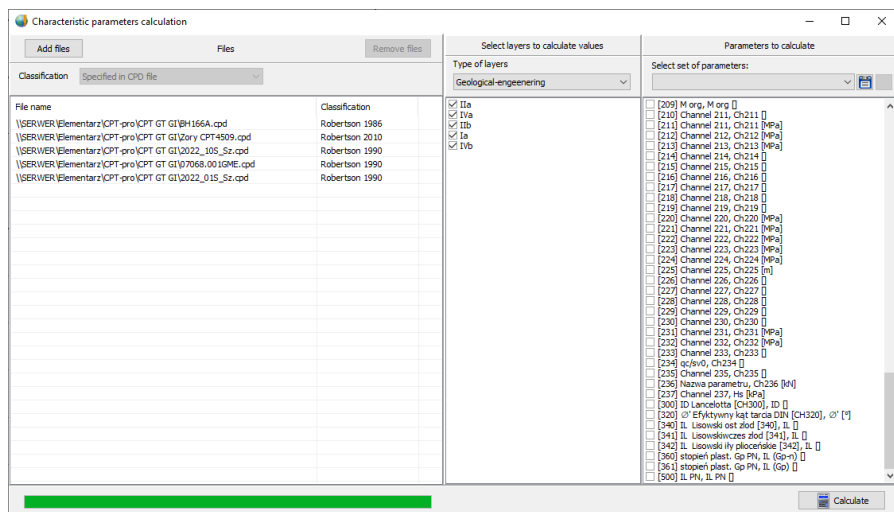


Fig. K-25. Characteristic value calculation configuration window.

After selecting the appropriate parameters and clicking the [**Calculate**] button, a table is generated with a list of selected geological-engineering or geotechnical layers and the calculation results – see Fig. K-27 and Fig. K-26:

- A. The values of basic statistics regarding the sounding parameters:
- Mean value **m(X)**
 - Sample standard deviation **s**
 - Population standard deviation **σ**
 - Coefficient of variation **V** ($=s/m(X)$)
- B. Calculated characteristic values of selected parameters. These values are calculated in accordance with all implemented methods and should be selected in the further analysis and design phase, outside the CPT-pro program.

The complete table with calculation results can be exported in its entirety to **XLS** (Excel) format, where it can be further edited.

Sand to silty sand	Parameter name	Mean value μ	Value acc. Schneider ($\mu-s/2$)	Value acc. PN-81/B-03020 ($\mu-o$)	Value acc. Eurocode 7 ($\mu-1.645\sigma$)	Value acc. Schneider ($\mu+5s/2$)
	[1] Point resistance, q_c [MPa]	6.67	6.26	5.87	5.35	7.08
	[2] Sleeve friction resistance, f_s [kPa]	28.667	23.801	19.098	12.927	33.533
	[31] Relative density, ID [%]	73.9	72.2	70.5	68.4	75.6
	[39] Effective friction angle, ϕ' [°]	44.86	44.48	44.12	43.64	45.24
Sand	Parameter name	Mean value μ	Value acc. Schneider ($\mu-s/2$)	Value acc. PN-81/B-03020 ($\mu-o$)	Value acc. Eurocode 7 ($\mu-1.645\sigma$)	Value acc. Schneider ($\mu+5s/2$)
	[1] Point resistance, q_c [MPa]	8.82	8.48	8.16	7.74	9.17
	[2] Sleeve friction resistance, f_s [kPa]	28.000	24.056	20.517	15.690	31.944
	[31] Relative density, ID [%]	79.6	78.5	77.5	76.2	80.6
	[39] Effective friction angle, ϕ' [°]	44.87	44.73	44.60	44.43	45.01
Sand to silty sand	Parameter name	Mean value μ	Value acc. Schneider ($\mu-s/2$)	Value acc. PN-81/B-03020 ($\mu-o$)	Value acc. Eurocode 7 ($\mu-1.645\sigma$)	Value acc. Schneider ($\mu+5s/2$)
	[1] Point resistance, q_c [MPa]	7.75	7.47	7.22	6.88	8.02
	[2] Sleeve friction resistance, f_s [kPa]	43.333	40.833	38.619	35.579	45.833
	[31] Relative density, ID [%]	75.0	73.9	72.9	71.5	76.1
	[39] Effective friction angle, ϕ' [°]	43.84	43.64	43.45	43.20	44.05

Fig. K-27. Fragment of the table with the results of calculations of characteristic values for

IIa	Parameter name	Mean value μ	Value acc. Schneider ($\mu-s/2$)	Value acc. PN-81/B-03020 ($\mu-o$)	Value acc. Eurocode 7 ($\mu-1.645\sigma$)	Value acc. Schneider ($\mu+5s/2$)
	[1] Point resistance, q_c [MPa]	28.14	23.03	17.96	11.40	33.25
	[2] Sleeve friction resistance, f_s [kPa]	244.104	193.445	143.227	78.160	294.764
	[31] Relative density, ID [%]	81.6	80.2	78.8	76.9	83.1
	[39] Effective friction angle, ϕ' [°]	44.69	44.46	44.25	43.96	44.92
IVa	Parameter name	Mean value μ	Value acc. Schneider ($\mu-s/2$)	Value acc. PN-81/B-03020 ($\mu-o$)	Value acc. Eurocode 7 ($\mu-1.645\sigma$)	Value acc. Schneider ($\mu+5s/2$)
	[1] Point resistance, q_c [MPa]	3.90	2.51	1.13	-0.67	5.29
	[2] Sleeve friction resistance, f_s [kPa]	74.721	41.779	8.855	-33.628	107.663
	[31] Relative density, ID [%]	33.2	28.3	23.5	17.2	38.1
	[39] Effective friction angle, ϕ' [°]	34.19	31.15	28.12	24.20	37.22
IIb	Parameter name	Mean value μ	Value acc. Schneider ($\mu-s/2$)	Value acc. PN-81/B-03020 ($\mu-o$)	Value acc. Eurocode 7 ($\mu-1.645\sigma$)	Value acc. Schneider ($\mu+5s/2$)
	[1] Point resistance, q_c [MPa]	7.37	5.70	4.04	1.89	9.03
	[2] Sleeve friction resistance, f_s [kPa]	78.734	76.734	74.734	72.734	80.734

Fig. K-26. Fragment of the table with the results of calculations of characteristic values for geological-engineering layers.


L. GEO DB MODULE.

L.1. General description of *Geo DB* module.

Geo DB provides you with geological, geotechnical, geophysical and geo-environmental data management for subsurface projects. The software enables effective data collection, quick access to data and instant generation of reports and logs. All data is stored in the database. Versions based on MS Access, MS SQL Express Server and MS SQL Server are available.

Due to different soil description systems and properties in different countries, *Geo DB* allows for the input of data in different standards. The USCS, ISO 14688-1, ISO 14689-1¹⁵ and PN-B-02480 standards as well as tools for introducing new User standards are implemented in the *Geo DB* database.

Geo DB can be a fully multilingual program. For each table and list implemented in *Geo DB*, the software allows you to enter all entries in different languages. In the base version, Polish and English were implemented and tools for translating all entries into any language were added. So ultimately, assuming all data has been entered into the *Geo DB* tables, lists and database, **the final printout of the hole logs and reports can be obtained in any standard and in any selected language**. If an item does not have a translation, the default entry is automatically entered.

All the repeatedly used information entered into the database is compiled in appropriate tables and their introduction consists in opening the appropriate list by double clicking the value of parameter and selecting the appropriate entry from this list - Fig. L-1. All lists and tables implemented in *Geo DB* can be edited by User by clicking symbol .

WARNING. After adding an incorrect parameter to the list, it is possible to delete it. However, it is not recommended to delete parameters from the lists added earlier, because if such a parameter is deleted, all previous values with this parameter will be deleted, and in some cases errors in the program operation may occur.




[-] Equipment			
Equipment name	Georg 220		
Equipment operator	Don Diego de la Vega		
[-] Test circumstances			
Method of backfilling the hole	Cement mixture	▼	
	<div> None Excavated material Bentonite Cement mixture Concrete Clay </div>		

Fig. L-1. Parameter with scrolled down list of possible entries.

All information about holes entered into the database is grouped into structures named *projects*. The most important data sets and the relationships between them are shown in diagram in the Fig. L-3.

¹⁵ The Polish version of the ISO standards may differ slightly from the corresponding standards in other EU countries, so it is recommended to verify and possibly correct the soil tables after installing the program.

The **Geo DB** database allows you to enter additional user profiles regardless of the geological profile. For example, it is possible to introduce an additional vertical division into zones with different pollution, different geotechnical properties, etc.

Due to the necessity to provide the possibility of entering header data from various standards, the number of possible header fields is about hundred, of which there are usually a dozen or so in continuous use. For effective selection and input of data, the possibility of adding selected fields to **Favorites** and showing only those added to **Favorites** on the selection lists has been implemented. The favorites list is fully User controlled and can be changed at any time.

The same mechanism for selecting favorites has been implemented in other parts of the program, in which, due to the large number of possible items, it was necessary to limit the selection lists. Access to the **Favorites** selection lists is marked in the program by the symbol ★.

Select header elements

Field description	Selected
<input type="checkbox"/> Own coordinate system	<input type="checkbox"/>
<input type="checkbox"/> Own reference level	<input type="checkbox"/>
<input type="checkbox"/> Fixed horizontal level	<input type="checkbox"/>
<input type="checkbox"/> Highway, railway or dike cone	<input checked="" type="checkbox"/>
<input type="checkbox"/> Mileage	<input checked="" type="checkbox"/>
<input type="checkbox"/> Method of determination of the zid	<input type="checkbox"/>
<input type="checkbox"/> Method of determination of the xyid	<input type="checkbox"/>
<input type="checkbox"/> Orientation x axis inclination	<input type="checkbox"/>
<input type="checkbox"/> Measurer horizontal location	<input type="checkbox"/>
<input type="checkbox"/> Date measurement horizontal location	<input type="checkbox"/>
<input type="checkbox"/> Measurer vertical location	<input type="checkbox"/>
<input type="checkbox"/> Date measurement vertical location	<input type="checkbox"/>
<input type="checkbox"/> Reference system and location	<input type="checkbox"/>
<input type="checkbox"/> Conducted transformation coordinates	<input type="checkbox"/>
<input type="checkbox"/> Angle between positive x and north	<input type="checkbox"/>
<input type="checkbox"/> National Grid Easting of location	<input type="checkbox"/>
<input type="checkbox"/> National Grid Northing of location	<input type="checkbox"/>
<input type="checkbox"/> National Grid referencing system used	<input type="checkbox"/>
<input type="checkbox"/> Test location remarks	<input type="checkbox"/>
<input checked="" type="checkbox"/> Equipment	
<input type="checkbox"/> Equipment name	<input checked="" type="checkbox"/>
<input type="checkbox"/> Equipment operator	<input checked="" type="checkbox"/>
<input type="checkbox"/> Injection	<input type="checkbox"/>
<input checked="" type="checkbox"/> Test circumstances	
<input type="checkbox"/> Depth of penetration and possible causes of any interruptions (like dissipation test) x	<input type="checkbox"/>
<input type="checkbox"/> Method of backfilling the hole	<input checked="" type="checkbox"/>
<input type="checkbox"/> Back filling from	<input type="checkbox"/>
<input type="checkbox"/> Back filling to	<input type="checkbox"/>

Select all header fields

☒ OK ☒ Cancel

Fig. L-2. Hole header content.

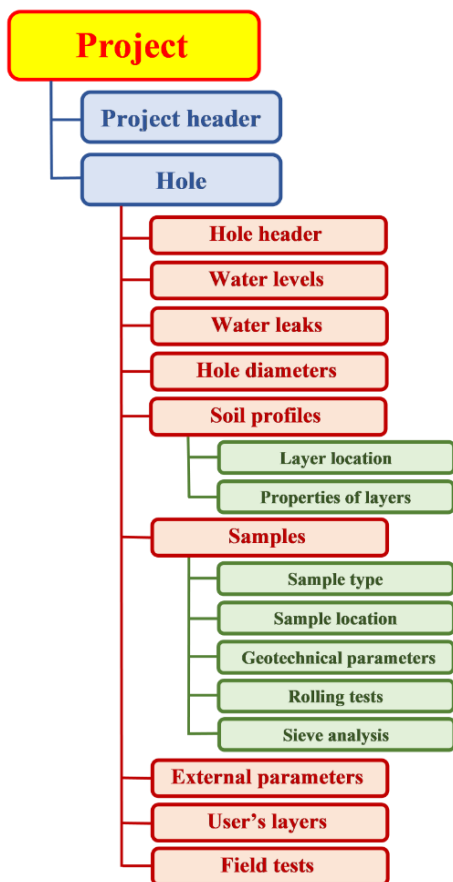


Fig. L-3. General structure of Geo DB database.

The main *Geo DB* window contains five main panels – see Fig. L-4. On the left - a panel with *header data of the hole* (Fig. L-5) and pane for entering *water levels*¹⁶, *water leaks* and *hole diameters* – see Fig. L-6, in the central part - a pane with *layer management* and *list of layers* (Fig. L-9) created in a selected or newly introduced hole, and on the right - a pane for entering *soil names with admixtures* (Fig. L-10) and pane for entering layer characteristics (Fig. L-11).

Both the table with header data and the table with layer characteristics have the *[Favorites]* mechanism implemented, so the content of the main window can be reduced only to the items selected

¹⁶ Many pairs of water level drilled/stabilized can be entered with dates of measurement

by the User. Also, the list of soils in the [Soil] pane in the center of the main window can be reduced to the items selected for [Favorites].

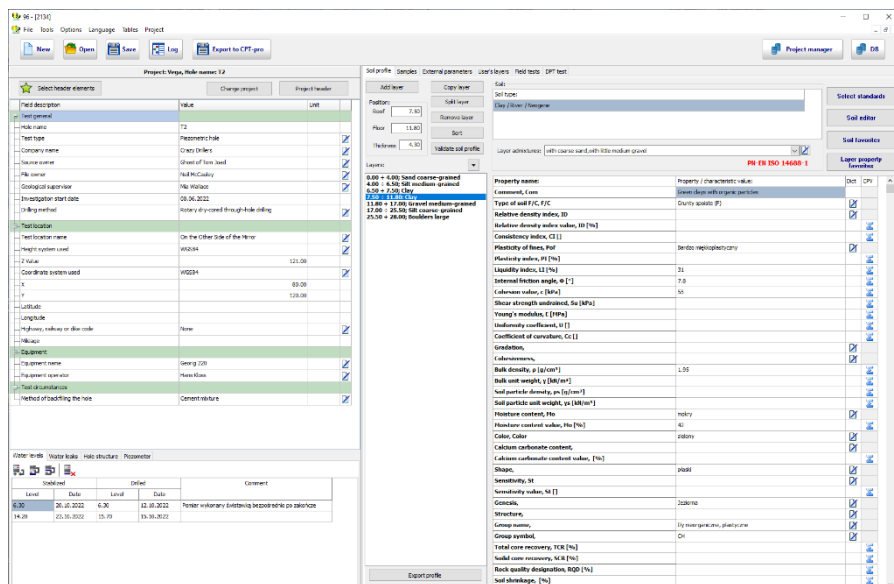


Fig. L-4. Main window of GEO DB software.

Select header elements

Change project

Edit project header

Field description	Value	Unit	
Test general			
Test name	W3REBRETWERQ		
Test type	Piezometric hole		
Drilled ground water level		3.00	
Ground water level (stabilized)		2.00	
End depth of penetration test		13.00	
Company name	Geosoft sp. z o.o.		
Source owner	None		
File owner	None		
Geological supervisor	Bartholomeo		
Investigation start date	03.03.2022		
Drilling method	Rotary core drilling		

Fig. L-5. Pane with header data. Only ones selected for Favorites are shown.

Stabilized		Drilled		Comment
Level	Date	Level	Date	
6.30	20.10.2022	6.30	12.10.2022	Measurement taken with a whistle immediately after drilling
14.20	22.10.2022	15.70	15.10.2022	

Fig. L-6. Pane for entering water levels, water leaks, hole structure and piezometers.

Pipe length [m]		Filters			
Inner	Outer	Top [m]	Bottom [m]	Type	Description
44.40	1.10	32	38	Brass mesh filter	Any comment about filter

Initial water level [m] 17.80 Sensor depth [m]

Comment:
Here you can add any comment

Delete piezometer Measurements

Fig. L-7. Piezometer data and measurements input window.

The **Geo DB** program allows for entering the basic characteristics of the piezometer construction and piezometric measurements in the form of **[Date / Water level / Comment]** – see Fig. L-7.

The measurement entry window is activated by pressing the **[Measurements]** button – see Fig. L-8.

Piezometer measurements

Initial water level: 17.80[m] Kinner pipe length: 44.40[m] Outer pipe length: 1.10[m]

Date/time	Water level [m]	Comment
01.07.2024 17:50	17.50	
04.07.2024 17:51	17.70	
07.07.2024 17:51	18.20	
10.07.2024 17:52	17.90	
15.07.2024 17:52:00	17.70	

lipiec 2024

pon.	wt.	śr.	czw.	pt.	sob.	niedz.
24	25	26	27	28	29	30
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	1	2	3	4

Dzień: 15.07.2024

Cancel OK

Fig. L-8. Entering piezometric data.

The central panel contains a list of entered layers and tools for managing this list.

Add layer Copy layer

Position:

Roof 0.00

Floor 4.00

Thickness 4.00

Split layer

Remove layer

Sort

Validate soil profile

Layers:

0.00 ÷ 4.00: Sand coarse-grained

4.00 ÷ 6.50: Silt medium-grained

6.50 ÷ 7.50: Clay

7.50 ÷ 11.80: Clay

11.80 ÷ 17.00: Gravel medium-grained

17.00 ÷ 25.50: Silt coarse-grained

25.50 ÷ 28.00: Boulders large

Fig. L-9. Layer list and layer management in the central panel.

The right panel contains a window for entering soil types for defined layers, together with tools related to soil types - see Fig. L-10, and a window for entering properties of defined layers – see Fig. L-11.

Fig. L-10. Layer content for currently selected layer. The current standard for the classification of soil in red.

Property name:	Property / characteristic value:	Dict	CPV
Comment, Com	Yellow sands with gravel and cobbles, however but it could be		
Type of soil, F/C	Coarse		
Relative density, ID	Medium dense		
Relative density index value, ID [%]	None		
Shrinkage limit, SL [%]	Very loose		
Plastic limit, PL [%]	Loose		
Liquid limit, LL [%]	Medium dense		
Consistency index, CI []	Dense		
Plasticity of fines, PoF	Very dense		
Plasticity index, IP [%]			
Liquidity index, LI [%]			
Internal friction angle, Φ [°]	32		
Cohesion value, c [kPa]	58		
Shear strength undrained, Suu [kPa]			

Fig. L-11. Soil properties table (part) with scrolled down Relative density list.

L.2. Soil characteristics stored in the database.

The **Geo DB** program allows you to save practically all soil characteristics, which are used in engineering practice, and a whole range of geological information, into the database. It is possible to input raw data from boreholes, laboratory and field tests, and data resulting from the interpretation of raw data, such as stratification, lithology, genesis, chronostratigraphy, water levels, geotechnical parameters and much more.

The list of laboratory and field tests, the results of which can be entered into the database, is practically unlimited. In addition to a number of introduced tests, **Geo DB** allows you to define your own parameters by specifying the name of the test, the unit of the parameter and its values.

The results of the laboratory tests are linked to the samples and the samples to the boreholes, which makes it possible to quickly link the test results to the location in the field.

L.2.1. Soil table.

Each soil type relevant for each selected standard can (but does not have to) be saved with own

- genesis
- chronostratigraphy
- display style (representing color and pattern on soil stick in log and cross-section)
- main, second, third and fourth components
- name in implemented languages (in case when a soil name has no translation, a default name is automatically entered)

The **Geo DB** database contains pre-filled land tables for the standards listed under L.1. Editing these tables is possible after running the **Tables / Soils** function from the main menu. Each entry in the soil table can be changed, and it is also possible to add your own soil types by clicking the **[Add soil]** button.

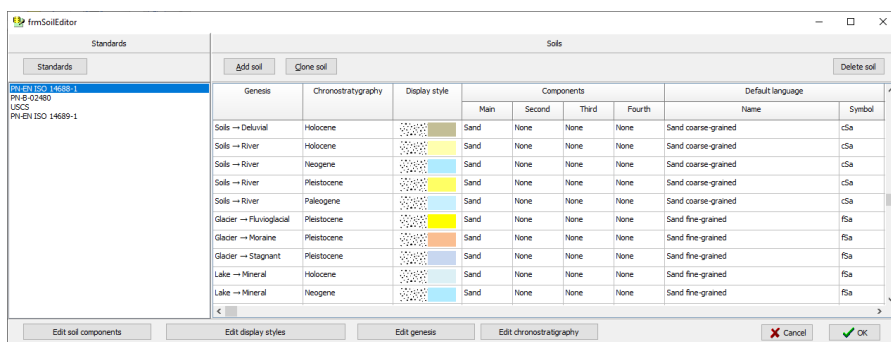


Fig. L-12. Soil table with genesis, chronostratigraphy and components.

L.2.2. Edition of soil components.

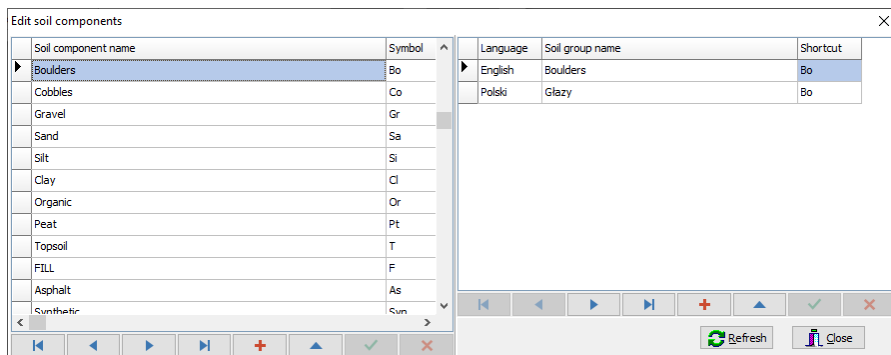


Fig. L-13. Soil components table.

To edit soil components (Fig. L-13) click **[Edit soil components]** button on window with soil table - Fig. L-12. To add own soil components click button with **+** symbol and fill relevant cells. The default name of component should be edited in left pane and relevant translations in right one.

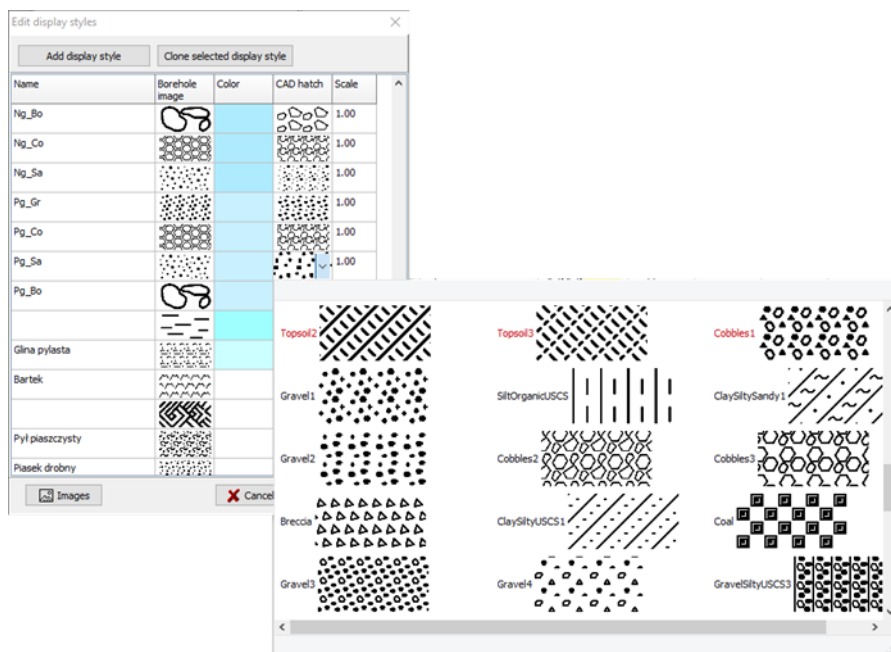


Fig. L-14. *[Edit display style] window with scrolled down hatch patterns.*

L.2.3. Edition of display styles.

For each soil the display style consist of the bitmap pattern, color¹⁷ and hatch that are used for representation the soil on borehole log and cross section. Editing and adding new styles are performed in the **[Edit display styles]** window.

- To edit name of existed style just double click relevant name in **[Name]** column and edit own text.
- To change the pattern double click the relevant pattern and the select the one from window with patterns already existed in database. The hatch is changed in the same way.
- To add new pattern to database (BMP 240x120 graphic file)
 - click **[Images]** button to open **[Image management]** window
 - click **[Load]** button in **[Image management]** window
 - Select the relevant file from any directory in your computer and double click it

¹⁷ Colors implemented in soil table for PN-EN ISO 14688-1 and PN-EN ISO 14688-1 standards are the same as recommended in [11].

- Click **[Add]** button in **[Image management]** window
- To change the color in **[Color]** column click the relevant cell and select the color
- To add new display style click **[Add display style]** (Fig. L-12)

After clicking **[Add display style]** button, another line with display styles is added. A description of the ground should be added in it and the appropriate pattern and color should be selected.

The **[Scale]** column contains the initial values of the pattern scale, both for the BMP format used to fill in the borehole log and for the hatch used in the CPT-CAD program to fill the borehole profile. This value is determined individually for each soil. In the CPT-CAD module, hatch scales can be changed using a factor **[Hatch scale [%]]**, common to all soils.

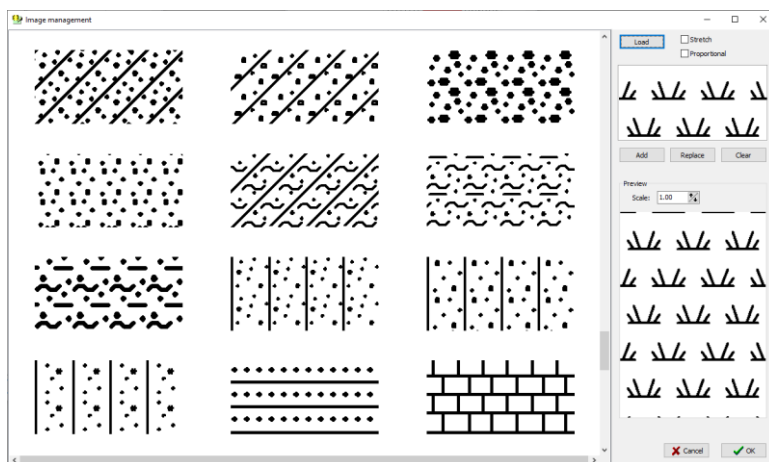


Fig. L-15. **[Image management]** window.

L.2.4. Edition of genesis and chronostratigraphy.

The chrono and genesis tables are filled in according to geological knowledge and their editing is not recommended. **At this point, it should be noted that genesis and chronostratigraphy are properties of a given type of soil¹⁸.** Regardless of such attribution of these properties, genesis and chronostratigraphy can also be ascribed to properties of specific geological strata.

¹⁸ National implementations of the requirements of the *Eurocode standards* usually require that the chronostratigraphy and genesis should be specified in the soil description

L.3. Entering data into the database.

L.3.1. New project and edition of project data. Project manager.

The **Geo DB** program allows you to group holes into the so-called *projects* according to criteria specified by the user. Usually, such a criterion is the purpose of the holes or their location. Each hole can be assigned to one project, but it is possible to use the holes in another project, e.g. when creating a geotechnical section or map.

To run **Project manager** click **Project/Manage** function from main menu. In the [**Project manager**] window, edit existed project data or click [**Add project**] button to generate new project. As with other data, the project header also uses the **Favorites** mechanism. To change the contents of the *favorites* list, click the **Tables/Favorites/Project header** function

The screenshot shows the 'Project manager' window. On the left, there is a list of projects: 'Project X-15', 'Vega', 'Bridge over the Odra river', 'Dark Side of the Moon', 'Somewhere Between Highway 61 & 49', and 'Jeden'. The 'Somewhere Between Highway 61 & 49' project is selected. On the right, there is a form for editing project data. The form has a table with columns: 'Field description', 'Value', 'Unit', and a checkbox. The data is as follows:

Field description	Value	Unit	
Project location name	La hacienda de los de la Vega		<input checked="" type="checkbox"/>
Project location ID			<input checked="" type="checkbox"/>
Country of project			<input checked="" type="checkbox"/>
Land of project	Florida		<input checked="" type="checkbox"/>
Province of project	Zabrze		<input checked="" type="checkbox"/>
County of project	Dade		<input checked="" type="checkbox"/>
City / town of project	Wroclaw		<input checked="" type="checkbox"/>
Project contractor			
Project engineer	don Diego de la Vega		<input checked="" type="checkbox"/>
Client	Geosoft sp. z o.o.		<input checked="" type="checkbox"/>

Below the table, there is a section for 'Additional holes' with columns: 'Hole name', 'Hole ID', 'Project name', and 'Project ID'. At the bottom of the window, there are buttons: 'Add project', 'Delete project', 'Save project content', and 'Close'.

Fig. L-16. Project manager window.

When creating a new *project*, only entering its name is mandatory. All other *project header* elements can be introduced in any other phase.

L.3.2. New hole wizard.

The implemented wizard is started automatically after clicking the **[New]** button. At this stage you can choose one of the existing **projects** (see Fig. L-17) or go to editing a new one by clicking **[Quick project creation]** button.

Selected project informations	
Field description	Value
Project name	Vega
Project ID	
Project location name	La hacienda de los de la Vega
Project location ID	
Country of project	
Land of project	Florida
Province of project	Dade
County of project	Hialeah
City / town of project	Miami Beach
Streetname of project	
Postal code of project	
Project comment	
Project contractor	NASA Inc.
Project engineer	don Diego de la Vega
Client	Geosoft sp. z o.o.
Start activity of project	25.06.2022
End activity of project	
Client field	

Fig. L-17. New hole wizard - selection of project.

After selecting the appropriate project, click **[Next]** to proceed to the phase of **entering the hole header data** (Fig. L-19) of the hole into the database. The name of the borehole must be entered and the remaining header data can be completed at any time. Almost all text data can be entered by selecting from the appropriate lists¹⁹ (see L.1). Numerical data is entered by entering the appropriate number with a *dot* as a decimal separator.


Fields included in a hole header can be:


- text
- numeric (including date)
- logical (yes/no)

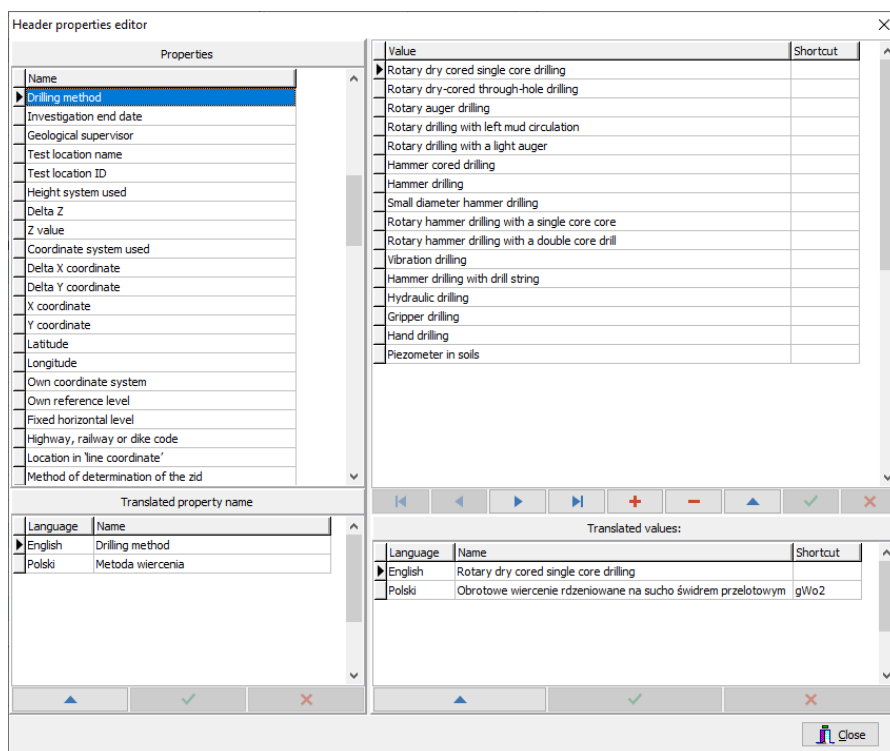
Text values can be entered by User “from the keyboard” or selected from previously generated lists²⁰ (tables). As a general rule, all repeatable text fields can be entered by selecting from an appropriate list, and only unique fields (e.g. hole name, comment etc.) can be entered by directly editing the appropriate text. Dates are entered by selecting from the calendar scrolled down in the appropriate field.

¹⁹ After installing the program, some lists, such as location name, client etc. they are empty and during the use of the program they should be gradually filled up according to the User's needs

²⁰ Also called dictionaries

To enter a date, click the appropriate integral in the Value column and then the calendar icon .

Quick access to the appropriate lists is provided by clicking the  icon. The lists (tables) from which repetitive text values of header fields are selected have the structure shown in Fig. L-18.



Header properties editor

Properties

Name
▶ Drilling method
Investigation end date
Geological supervisor
Test location name
Test location ID
Height system used
Delta Z
Z value
Coordinate system used
Delta X coordinate
Delta Y coordinate
X coordinate
Y coordinate
Latitude
Longitude
Own coordinate system
Own reference level
Fixed horizontal level
Highway, railway or dike code
Location in 'line coordinate'
Method of determination of the zid

Translated property name

Language	Name
▶ English	Drilling method
Polski	Metoda wiercenia

Value

Value	Shortcut
▶ Rotary dry cored single core drilling	
Rotary dry-cored through-hole drilling	
Rotary auger drilling	
Rotary drilling with left mud circulation	
Rotary drilling with a light auger	
Hammer cored drilling	
Hammer drilling	
Small diameter hammer drilling	
Rotary hammer drilling with a single core core	
Rotary hammer drilling with a double core drill	
Vibration drilling	
Hammer drilling with drill string	
Hydraulic drilling	
Gripper drilling	
Hand drilling	
Piezometer in soils	

Translated values:

Language	Name	Shortcut
▶ English	Rotary dry cored single core drilling	
Polski	Obrótowe wiercenie rdzeniowane na sucho świdrem przelotowym	gWo2

Close

Fig. L-18. Table with text header values.

The upper left field contains the names of the header fields, the lower left field contains translations of names into individual languages, the upper right field contains dictionary values and the lower right field contains translations of dictionary values. For numeric data, the fields on the right are blank.

Entering header data is done in the [**Hole header**] window by inserting appropriate values in individual cells.

It is possible to enter only the name of the hole and proceed to the next phases. All other header data (except the hole name) can be completed or edited at any time.

After entering the header data of the hole, go to the **layer input phase** (Fig. L-20) by clicking the [**Next**] button – see Fig. L-19.

Create new hole wizard

Hole header

Fill hole header values

Field description	Value	Unit	
Test general			
Test name	J23		
Test type			<input checked="" type="checkbox"/>
Company name			<input checked="" type="checkbox"/>
Source owner			<input checked="" type="checkbox"/>
File owner			<input checked="" type="checkbox"/>
Geological supervisor			<input checked="" type="checkbox"/>
Investigation start date			
Drilling method			<input checked="" type="checkbox"/>
Test location			
Test location name			<input checked="" type="checkbox"/>
Height system used			<input checked="" type="checkbox"/>
Z value			
Coordinate system used			<input checked="" type="checkbox"/>
X coordinate			
Y coordinate			
Latitude			
Longitude			

Go to layers page to enable layers view

< Back Next > Cancel Skip wizard ☐ Don't show again

Fig. L-19. New hole wizard - hole header edition.

Create new hole wizard

Layers

Add or edit hole layer

Layer position

Roof

Floor

Thickness

Soil:

Soil type:

Layer admixtures: ☒ Standards **PH-EN ISO 14688-1**

Property name:	Property value:	CPV
Comment		
Type of soil		<input checked="" type="checkbox"/>
Relative density		<input checked="" type="checkbox"/>
Relative density index value		
Shrinkage limit		
Plastic limit		
Liquid limit		
Consistency index		
Plasticity of fines		<input checked="" type="checkbox"/>
Plasticity index		
Liquidity index		

Layer list

Delete selected layer

< Back Add layer Finish Cancel Skip wizard ☐ Don't show again

Fig. L-20. New hole wizard - layers properties edition.

In the first step of introducing layer characteristics, select the standards according to which the soil type will be defined. by clicking the **[Standards]** button. Clicking this button opens the **[Hole standards manager]** window, in which the standards already in use are presented. To add another standard, click the **[Add standard]** button, select the relevant standard and click **[OK]**. It is possible to introduce soils simultaneously according to two or more standards.

In the next step, expand the lists in the **[Soil type]** panel and select the proper soil names for the selected standards. If necessary, select the admixtures after expanding the **[Add mixtures]** list. The last necessary step for adding a layer is to give its floor in depth units. The characteristics listed below on the right may be added at this stage or at any time thereafter. To add another layer, click the **[Add layer]** button and repeat the above operations. To finish entering layers, click the **[Finish]** button.

The entered borehole with layers is saved to the database after clicking the **[Save]** button in the upper left corner of the screen.

NOTE. The Project cannot be deleted from the database if at least one borehole is assigned to it. It is not recommended to delete projects, but if for important reasons a Project has to be deleted from the database, it is necessary to delete all the holes assigned to it first. The project name and its other characteristics may be modified at any time without restriction.

It is also possible to insert a borehole without the use of a wizard. To do this, click the **[Skip wizard]** button, select a project from the list in the **[Select project]** window (see Fig. L-21), click **[OK]** and enter the hole header data and characteristics as described above. The same window can be opened by clicking **[Change project]** button.

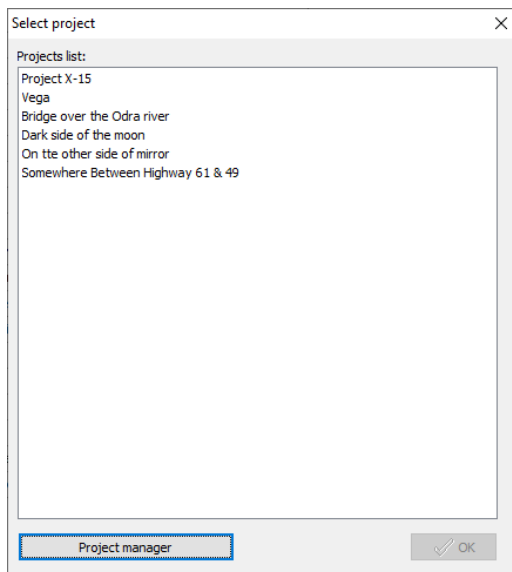


Fig. L-21. Project selection window.

L.3.3. Editing a borehole entered into the database.

To edit or complete the characteristics of the opening entered into the database, click the [*Open*] button in the upper left corner of main window, select the project from the [*Select project*] drop-down list to which the required borehole is assigned and then select the relevant borehole name from the list displayed.

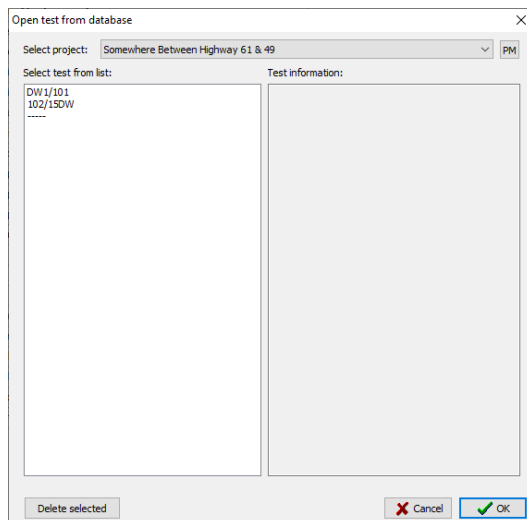


Fig. L-22. Selection of borehole from database.

L.4. Additional data entered into the Geo DB database.

The *Geo DB* software also allows you to enter into the database information about geotechnical tests performed in the field and in the laboratory, as well as the resulting geotechnical parameters and additional separated zones. It is also possible to enter field test results and other external parameters, e.g. from standards or other studies.

Geotechnical parameters can be linked to the collected soil samples (see Fig. L-26) or they can be the properties of the layers directly entered to the database – see chapter L.4.8.

The *Geo DB* program also allows you to enter into the database information about parameters not related to samples or soil layers, e.g. resulting from measurements of sensors installed in the ground (e.g. pore pressure measurements) etc.

L.4.1. Geotechnical parameters.

Geo DB has an extensive list of commonly used geotechnical parameters, both those with numerical values and those whose values are texts. Definitions and attributes of all implemented parameters and tools for editing new ones are included in the [*Parameter editor*] window (see Fig. L-23) opened after running *Tables / Parameters / Definitions*.

The definition of each parameter includes:

- Name
- Shortcut
- Type (number, list, list array)
- Physical quantity
- Display unit
- Precision
- Minimum
- Maximum
- Grid step
- Symbol (graphic pattern on graphs)
- Color
- Line width (on printouts)
- Line style
- Line color
- Line visible (yes/no)
- Usable for (Layers / Samples / Externals)

The screenshot shows the 'Parameter editor' window with a table of parameters. The table has columns for Name, Shortcut, Type, Physical quantity, Display unit, Precision, Minimum, Maximum, Grid step, Symbol, Color, Line width, Line color, Line style, Line visible, and Usable for. The parameters listed include Soil type, Top, Floor, Comment, Type of soil, Relative density, Relative density index value, Shrinkage limit, Plastic limit, Liquid limit, Consistency index, Plasticity of fines, Plasticity index, Liquidity index, Internal friction angle, Effective internal friction angle, Cohesion value, Effective cohesion value, Shear strength undrained, Shear strength drained, Young's small-strain modulus, Young's modulus, Poisson's ratio, Shear small-strain modulus, Shear modulus, and Octoedric small-strain constrained modulus. Each parameter has its corresponding settings filled in the table.

General settings		Physical quantity		Display settings												Usable for
Name	Shortcut	Type		Display unit	Precision	Minimum	Maximum	Grid step	Symbol	Color	Line width	Line color	Line style	Line visible		
Soil type	Soil	List array														
Top	Top	Number	Length	m	2	0.00	100.00		○	0.10					Layers	
Floor	Floor	Number	Length	m	2	0.00	100.00		○	0.10					Layers	
Comment	Com	Text													Layers	
Type of soil	P/C	List													Layers	
Relative density	RD	List													Layers	
Relative density index value	RD	Number	Percent	%	2	0.00	100.00		○	0.10					Layers, Samples, Externals	
Shrinkage limit	SL	Number	Percent	%	2	0.00	100.00		○	0.10					Layers, Samples, Externals	
Plastic limit	PL	Number	Percent	%	2	0.00	100.00		○	0.10					Layers, Samples, Externals	
Liquid limit	LL	Number	Percent	%	2	0.00	100.00		○	0.10					Layers, Samples, Externals	
Consistency index	CI	Number	Reference		1	-100.00	100.00		○	0.10					Layers, Samples, Externals	
Plasticity of fines	IpF	List													Layers	
Plasticity index	IP	Number	Percent	%	2	0.00	100.00		○	0.10					Layers, Samples, Externals	
Liquidity index	LI	Number	Percent	%	2	0.00	100.00		○	0.60					Layers, Samples, Externals	
Internal friction angle	φ	Number	Angle	°	2	0.00	90.00		○	0.10					Layers, Samples, Externals	
Effective internal friction angle	φ'	Number	Angle	°	2	0.00	90.00		○	0.10					Layers, Samples, Externals	
Cohesion value	c	Number	Stress and pressure	kPa	2	0.00	100.00		○	0.10					Layers, Samples, Externals	
Effective cohesion value	c'	Number	Stress and pressure	kPa	1	0.00	1000.00		○	0.10					Layers, Samples, Externals	
Shear strength undrained	Su	Number	Stress and pressure	kPa	1	0.00	200.00		○	0.10					Layers, Samples, Externals	
Shear strength drained	Sud	Number	Stress and pressure	kPa	1	0.00	1000.00		○	0.10					Layers, Samples, Externals	
Young's small-strain modulus	Ea	Number	Stress and pressure	MPa	2	0.00	100.00		○	0.10					Layers, Samples, Externals	
Young's modulus	E	Number	Stress and pressure	MPa	2	0.00	100.00		○	0.10					Layers, Samples, Externals	
Poisson's ratio	ν	Number	Reference		2	0.00	1.00		○	0.10					Layers, Samples, Externals	
Shear small-strain modulus	G0	Number	Stress and pressure	MPa	2	0.00	100.00		○	0.10					Layers, Samples, Externals	
Shear modulus	G	Number	Stress and pressure	MPa	2	0.00	100.00		○	0.10					Layers, Samples, Externals	
Octoedric small-strain constrained modulus	Mo	Number	Stress and pressure	MPa	2	0.00	100.00		○	0.10					Layers, Samples, Externals	

Fig. L-23. Definitions of geotechnical parameters.

General settings			Physical quantity	
Name	Shortcut	Type		Display unit
Liquidity index	LI	Number	Percent	%
Internal friction angle	Φ	Number	Angle	°
Effective internal friction angle	Φ'	Number	Angle	°
Cohesion value	c	Number	Stress and pressure	kPa
Effective cohesion value	c'	Number	Stress and pressure	kPa
Shear strength undrained	Suu	Number	Stress and pressure	lb/ft ²
Shear strength drained	Sud	Number	Stress and pressure	lb/ft ²
Young's small-strain modulus	Eo	Number	Stress and pressure	kgf/cm ²
Young modulus	E	Number	Stress and pressure	t/m ²

Fig. L-24. Selected parameter attributes with scrolled down list of display units.

L.4.2. Soil samples.

Information about soil samples and the values of the laboratory tests performed on these samples can be entered into the database in the [Samples] tab in the central panel – see Fig. L-25. The basic characteristics of the samples are the depth of sampling and the type of sample. The depth is entered by editing the appropriate number in column [Value] (Fig. L-25) and the sample type is selected from the drop-down list. This list can be extended with other types at any time.

Soil profile	Samples	External parameters	User's layers	Field tests	DPT test																																
Samples: Add sample Delete sample <input checked="" type="checkbox"/> Copy parameter list from previous sample																																					
<div> <div> Disturbed, 1.00[m] Undisturbed sample, 1.20[m] Disturbed, 2.00[m] Undisturbed sample, 3.00[m] Disturbed, 4.00[m] Disturbed, 5.00[m] Disturbed, 6.00[m] Undisturbed sample, 6.91[m] Undisturbed sample, 6.92[m] Undisturbed sample, 6.93[m] Undisturbed sample, 6.94[m] Undisturbed sample, 6.95[m] Undisturbed sample, 6.98[m] Disturbed, 7.00[m] Disturbed, 8.00[m] Disturbed, 9.00[m] Disturbed, 10.00[m] Undisturbed sample, 12.30[m] Undisturbed sample, 14.50[m] Bag sample, 15.30[m] Split-spoon sample, 16.20[m] Undisturbed sample, 16.80[m] </div> <table border="1"> <thead> <tr> <th>Field description</th> <th>Value</th> <th>Unit</th> <th></th> </tr> </thead> <tbody> <tr> <td colspan="4">General</td> </tr> <tr> <td>Type of sample</td> <td>Undisturbed sample</td> <td></td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>Depth of sample</td> <td>3.00</td> <td></td> <td></td> </tr> <tr> <td>Thickness of sample</td> <td>1.00</td> <td></td> <td></td> </tr> <tr> <td>Sampler type</td> <td>Piston sampler</td> <td></td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>Date of sampling</td> <td>08.11.2022</td> <td></td> <td></td> </tr> <tr> <td>Laboratory weight of sample</td> <td>1.65</td> <td></td> <td></td> </tr> </tbody> </table> </div>						Field description	Value	Unit		General				Type of sample	Undisturbed sample		<input checked="" type="checkbox"/>	Depth of sample	3.00			Thickness of sample	1.00			Sampler type	Piston sampler		<input checked="" type="checkbox"/>	Date of sampling	08.11.2022			Laboratory weight of sample	1.65		
Field description	Value	Unit																																			
General																																					
Type of sample	Undisturbed sample		<input checked="" type="checkbox"/>																																		
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Sampler type	Piston sampler		<input checked="" type="checkbox"/>																																		
Date of sampling	08.11.2022																																				
Laboratory weight of sample	1.65																																				
Geotechnical parameters: Add parameters Delete selected parameter																																					
<table border="1"> <thead> <tr> <th>Name:</th> <th>Value:</th> </tr> </thead> <tbody> <tr> <td>Internal friction angle, Φ [°]</td> <td>25.8</td> </tr> <tr> <td>Cohesion value, c [kPa]</td> <td>44.6</td> </tr> <tr> <td>Total core recovery, TCR [%]</td> <td>48</td> </tr> <tr> <td>Shear strength undrained, Suu [kPa]</td> <td>144</td> </tr> </tbody> </table>						Name:	Value:	Internal friction angle, Φ [°]	25.8	Cohesion value, c [kPa]	44.6	Total core recovery, TCR [%]	48	Shear strength undrained, Suu [kPa]	144																						
Name:	Value:																																				
Internal friction angle, Φ [°]	25.8																																				
Cohesion value, c [kPa]	44.6																																				
Total core recovery, TCR [%]	48																																				
Shear strength undrained, Suu [kPa]	144																																				

Fig. L-25. Entering samples and lab test values to database.

L.4.2.1. Adding geotechnical parameters to samples.

Geotechnical parameters obtained as a result of sample testing are selected after pressing the [Add parameters] button located under the sample header by checking the appropriate checkbox – see Fig. L-26. The text values of the header fields in the [Value] column are selected from drop-down lists, activated by slow²¹ double clicking the appropriate cell. Numerical values of header description are entered from the keyboard.

²¹ Quick double click activated edition of parameter list

The numerical values of the parameters are entered from the keyboard in the **[Value]** column, taking into account the currently selected display unit, visible in the **[Name:]** column.

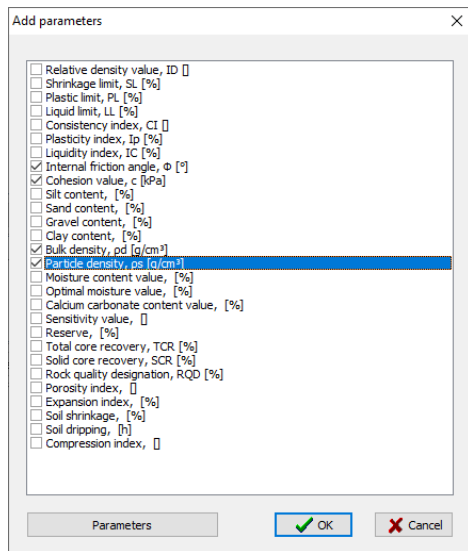


Fig. L-26. Geotechnical parameters linked to soil samples.

Most geotechnical parameters have the form (**depth,value**). The list of introduced parameters to **Geo DB** is presented in Fig. L-26. If necessary, the User can add additional parameters of this form to the system by pressing **tables / parameters / definitions** from the main menu.

In addition to these base characteristics (**depth,value**), the samples may be associated with non-geotechnical parameter values, such as a roll test or sieve analysis. A widely used laboratory test of soil is sieve analysis, during which the amount of soil remaining on sieves with a precisely defined mesh clearance is determined. The number of sieves and the mesh size of the sieves vary between countries and laboratories, **Geo DB** also enables the introduction of its own sieve system.

L.4.2.2. Rolling tests.

The rolling test is a simple test that allows for an approximate determination of the cohesiveness of the soil. The test result is the number of rolls made on a hand-formed ball of soil with a diameter of approximately 7 mm, until the subsequent rolls begin to fall apart during rolling. The test result is the number of successful rollings on one ball of soil.

Rolling test results are entered in the **[Rolling test]** panel. Any number of roller test results can be entered for each soil sample. The first and next lines with the test result are added after pressing the **[Add]** button.

L.4.2.3. Particle size analysis.

A commonly used laboratory test for soil samples is *sieve analysis*, which basically involves sifting a soil sample through a column of sieves of a specific size and measuring the residue on each of them. Due to the fact that sieve sizes are standardized and there are a number of different standards, the **Geo DB** program allows you to introduce several different sets and individually select one of them for each sample.

A. Adding sieve analysis data.

Clicking the **[Add new sieve analysis]** button creates a tab with the following items (**Błąd! Nie można odnaleźć źródła odwołania.**):

- Sieve standard selection list
- Sample weight entry window
- Pan weight entry window
- Current information about the total % of the entered soil weights on the sieves
- Table with soil weights on individual sieves
- **[Report]** button

Sieve name:	Size [mm]:	Value [%]:	Weight [g]
40	40.000	5.60	56.00
1 in	25.000	3.80	38.00
20	20.000	4.50	45.00
18	18.000	6.50	65.00
14	14.000	12.40	124.00
0.265 in	6.700	8.80	88.00
4.5	4.500	5.60	56.00
3.15	3.150	5.80	58.00
No. 10	2.000	9.80	98.00
No. 14	1.400	4.50	45.00
No. 18	1.000	1.50	15.00
No. 35	0.500	5.50	55.00
No. 60	0.250	3.50	35.00
No. 120	0.125	5.20	52.00
No. 230	0.063	1.20	12.00
No. 270	0.053	1.50	15.00
No. 325	0.045	2.50	25.00
No. 400	0.038	3.50	35.00
No. 450	0.032	1.50	15.00
No. 500	0.025	0.80	8.00
No. 635	0.020	0.30	3.00

Fig. L-27. Entering sieve analysis data.

Adding a new set of sieves is done in the **[Definition of sieve sets]** window (Fig. L-28) opened by pressing the icon next to the **[Sieve set]** selection list (Fig. L-27).

Geo DB has already implemented sieve sets according to standards:

- PN-B-04481
- PN-EN 933-1
- ISO 565/3310-1 / ASTM E11

- US Standard

As in many other cases, within each set of sieves it is possible to select specific sieves as ***Favorites***. This selection is made by checking the appropriate checkbox in the window [***Definition of sieve sets***].

Adding a new set of sieves is done by pressing the **+** icon.

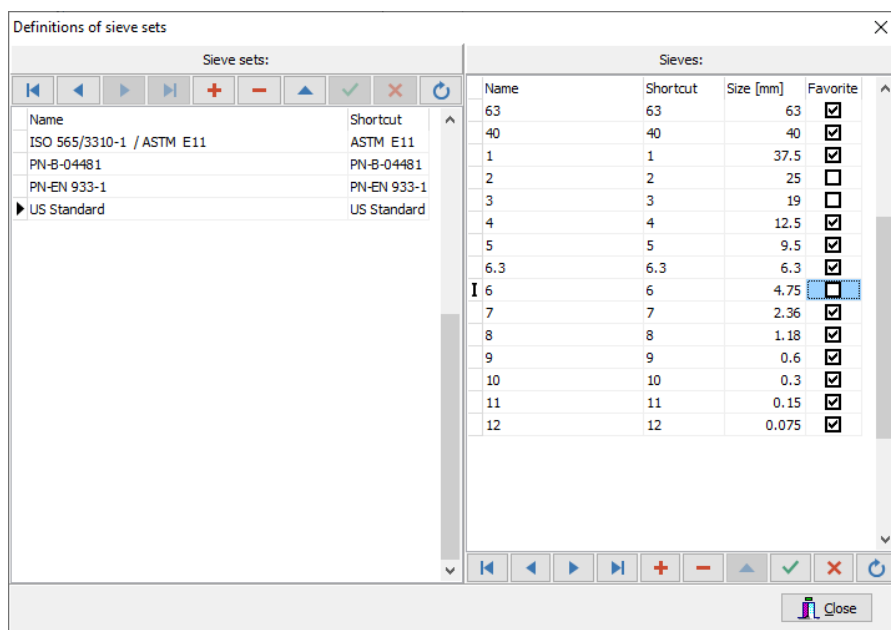


Fig. L-28. Definition of sieve sets.

WARNING. It is not recommended to delete and edit a set of sieves for which sieve analysis data has been entered. Such an operation may delete the entered data and, in some situations, may generate a program error.

B. Sieve analysis report.

The sieve analysis report is generated after pressing the [**Report**] button in the appropriate tab. For each tab, the [**Report**] button generates a report specific to the *sieve standard* selected in the tab and the set of entered data. The report consists of three main panels:

- Header table
- Grain size chart
- Table containing
 - The content of individual fractions in numerical form
 - Histograms of fraction distribution
 - Detailed histogram for all subfractions
 - Common histogram for main fractions (clay, silt, sand, gravel)
 - Quantiles for individual grain sizes D10, D20...D90
 - Calculated grain size parameters
 - Grain uniformity index **C_u**
 - Grain curvature index **C_c**
 - Percentage of clay fraction **I** [%]

The window with a preview of the sieve analysis report (Fig. L-29) contains in the upper part the name of the analysis (in accordance with the name of the tab dedicated to a given analysis), a drop-down list with available soil classification standards (according to which histograms and calculated shares of individual fractions will be generated), and the [**Print**] button activating the printing procedure.

The selection of a classification standard results in the boundaries between individual soil fractions consistent with this classification standard being plotted on the grain size chart and the appropriate histogram configuration.

The classification standards and sieve set standards are independent of each other. Individual fields in the report header table have the same functionality as fields in the hole card header table (see section L.4.9).

The header table automatically retrieves data from the **Project** and **Hole** headers, as well as additional data that is entered in the sieve analysis form.

The grain size chart additionally contains vertical lines separating individual fractions (generated individually for each classification standard implemented in **Geo DB**), descriptions of individual fractions and subfractions, a vertical grid consistent with the set of sieves used in a given analysis, and a standard horizontal grid.

The horizontal axis of the chart is on a logarithmic scale and the vertical axis is on a linear scale.

The bottom table of the report contains the following information and objects:

- A numerical summary of the percentage of individual fractions and sub-fractions
- Histograms of the percentage of individual fractions and subfractions
- Quantiles for individual grain sizes D10, D20...D90
- Grain uniformity index **C_u**
- Grain curvature index **C_c**
- Percentage of clay fraction **I** [%]

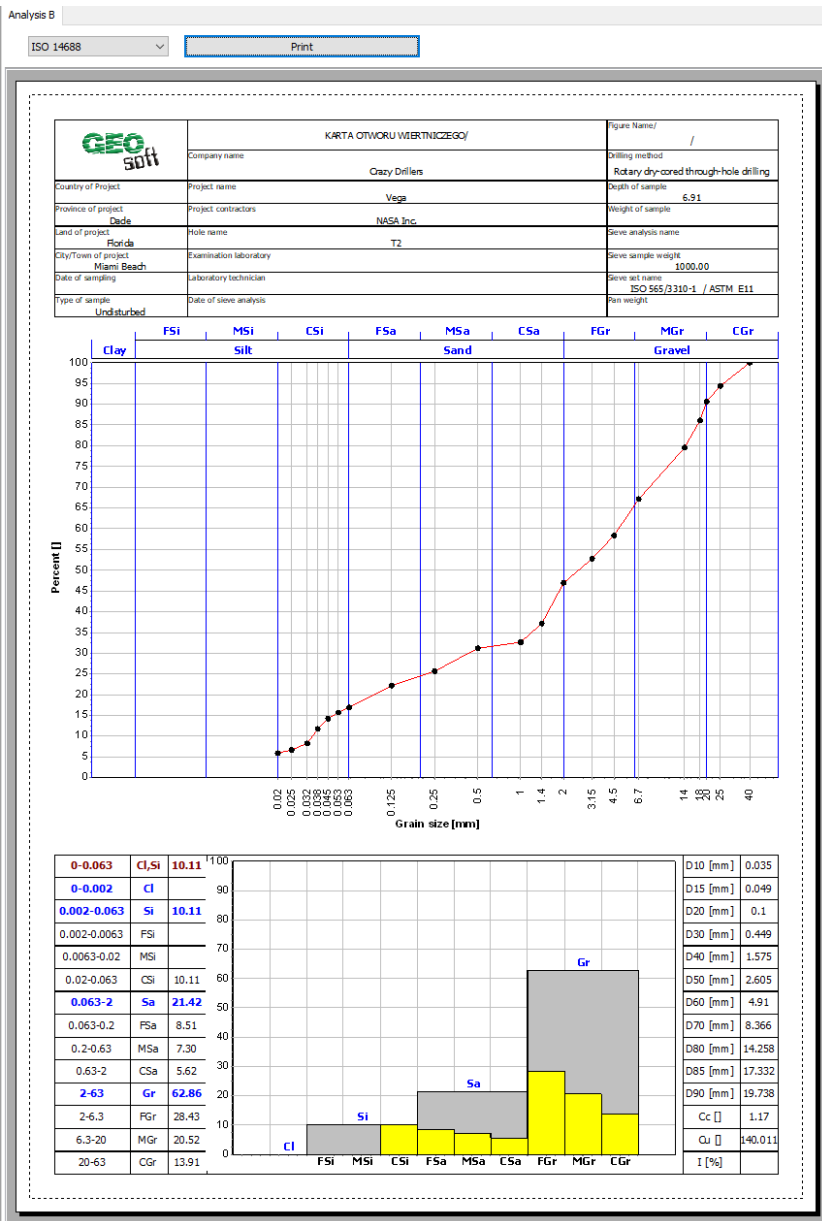


Fig. L-29. Sieve analysis report window.

L.4.3. External parameters.

In addition to the geotechnical parameters resulting from laboratory tests and related to soil samples, it is possible to enter into the database the values of parameters not related to the samples, such as those measured by sensors inserted into the ground (temperature, pH, pore pressure in situ, etc.), taken from existing standards or measured in field tests. These parameters are called external parameters in *Geo DB* and can be entered on the [External parameters] tab in the central panel.

The list of external parameters is the same as the list of parameters linked to samples, but you can customize the list using the *Favorites* mechanism.

The external parameter is selected and added by:

- selecting the [External parameters] tab
- clicking the [Add] button
- selecting the parameter from the drop-down list
- accepting the selection by clicking the [OK] button.

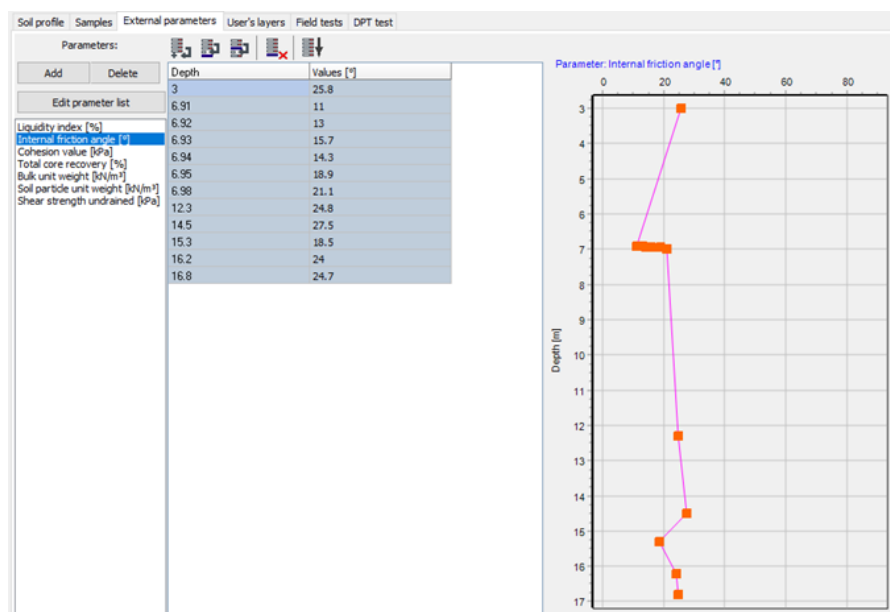


Fig. L-30. Entering the values of external parameters.

Clicking the [Add] button opens a window with a drop-down list (Fig. L-31), from which the appropriate parameter can be selected.

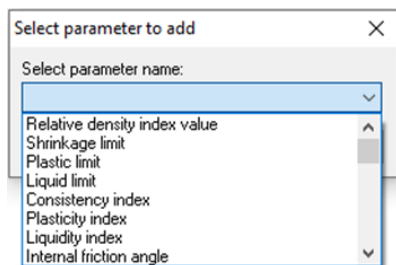



Fig. L-31. Adding a new external parameter.

Entering the parameter value is done by:

- adding a value row by clicking the  icon
- entering the depth value and parameter value in the appropriate cells.

To add additional values repeat the above procedure. When entering the values of external parameters, a graph of the parameter as a function of depth is generated in parallel to check the correctness of the input – see Fig. L-30. External parameter plots can be displayed on borehole cards along with other properties.

The list of **external parameters** is the same as the list of parameters associated with samples, but can be shortened by using the **Favorites** mechanism described earlier.

Graphs of **external parameter** values can be presented on the borehole log together with other properties and can be presented on cross-sections generated in CPT-CAD module as well.

External parameters may come from various sources²² that are not fully (i.e. with specific header and raw data) entered into the **Geo DB** database, such as field test results, standards, publications, etc.

ATTENTION.

1. The external parameters have the form (**depth,value**). When adding parameters from field tests, this structure is natural, but when adding parameters from other studies or standards, it is usually not possible to specify the **depth**. In such a case, the depth should be any value within the range appropriate for the layer to which the parameter applies.
2. Providing a depth value consistent with the soil layer to which the external parameter applies is important because the values of external parameters are taken into account to estimate the characteristic values of parameters for the layers.

²² Field test results can also be entered into the database in the [Field tests] tab. The [External parameters] tab is intended mainly for entering results from standards, other studies, etc.

L.4.4. User's layers.

In addition to geological and geotechnical soil profiles, it is possible to enter the so-called **User profiles** into the **Geo DB** database, which may contain additional information, e.g. soil suitability for piling, the presence of contaminated layers, etc.

User profiles are added in the **[User's layers]** tab. Adding a profile is done by adding another row with the **[Add row]** button, editing the slab and floor of the layer and selecting the **Soil type** from the drop-down list – see Fig. L-32. This list can be freely edited after clicking the **[Edit user layers list]** button. User's layers can be displayed on borehole cards along with other properties.

Soil profile	Samples	External parameters	User's layers	Field tests
Add row	Delete row	Sort	Validate	Edit user layers list
Show current soil profile				
User's layers I	User's layers II	User's layers III		
Roof	Floor	Type		
3	6	Soil to exchange		
6	11	Weak soil		
11	16	Soil with the relevant load-bearing capacity of the pile		
		Soil to exchange		
		Reinforced soil		
		Weak soil		
		Soil with the relevant load-bearing capacity of the pile		

Fig. L-32. Adding User's layers.





L.4.5. Field tests.

Geo DB software allows you to enter the results of field tests such as **Field Vane Test (FVT)**, **Menard Pressuremeter Test**, **Pore pressure measurements** etc. into the database.

It is assumed that the **[Field tests]** tab registers only those tests for which only general data is available, i.e. location (or more precisely the name of the hole in the **Geo DB** database with which the test can be associated), measurement results (**depth, value**) and possibly the results of the interpretation of geotechnical parameters, also in the form (**depth, value**). For example - the **FVT** field test in borehole T2, for which the interpreted values of undrained shear strength τ and cohesion c are known. This situation often occurs when using various studies and papers that do not contain source data but only final results.

If complete source data regarding the field test and possibly header data of this test are available²³, e.g. dynamic **DPT** soundings, in such cases it is recommended to use the tab dedicated to a specific test (see chapter L.4.6), where a full interpretation can be performed and an appropriate documentation (report, sounding log).

L.4.5.1. Field test data entry.

Field test data is entered in the **[Field tests]** tab in the central panel of the main window. After clicking this tab, a panel opens with icons   visible. The first one  opens the window for adding field tests (Fig. M 30) and the second one  gives access to editing the list of field tests. Field tests are added by checking the appropriate checkbox.

²³ CPTU static soundings and FVT tests are analyzed and interpreted in detail in CPT-pro and VANE-pro. Selected results can be imported into Geo DB.

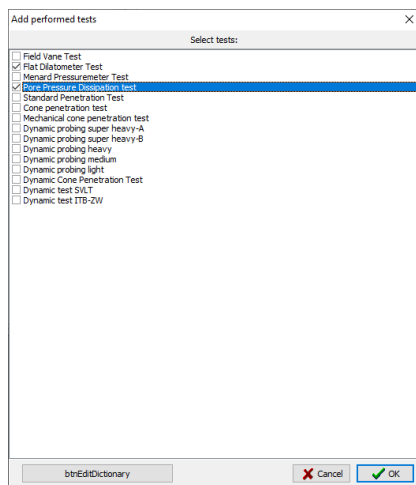


Fig. L-33. Adding field tests.

After accepting the selection of field tests, tabs dedicated to the selected tests, the [Add parameters] button opening the window for adding parameters, and three panels appear:

- List of selected parameters for a given test with comments about the parameters
- Table with values as a function of depth and comments on individual measurements
- Graph of the selected parameter

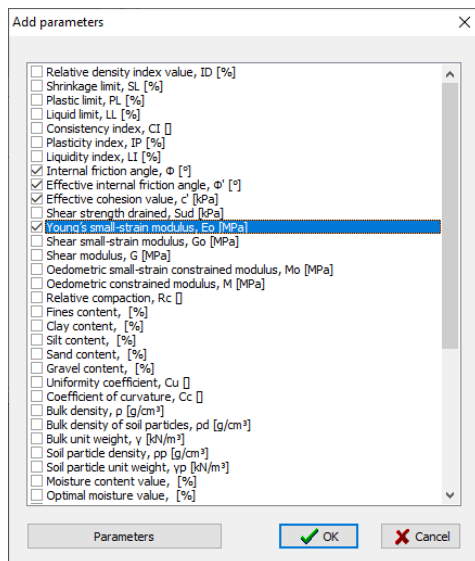


Fig. L-34. Adding parameters interpreted from field tests

Clicking the [Add parameters] button opens a window for selecting geotechnical parameters for the selected field test (=selected tab) – see Fig. L-34. The parameters are selected by checking the appropriate checkbox.

After accepting the selection of parameters in the [Add parameters] window, the field test panel is supplemented with tabs for selected tests, a list of selected tests, a table with parameter values for individual depths and a graph of the selected parameter as a function of depth - Fig. L-35.

Charts of selected parameters are refreshed on an ongoing basis when entering the value of each parameter and are used to continuously check the correctness of the input. Parameter attributes on the chart such as color, symbol, line connecting points, etc. are defined in the [Parameter editor] window – see chapter L.4.1 and Fig. L-23.

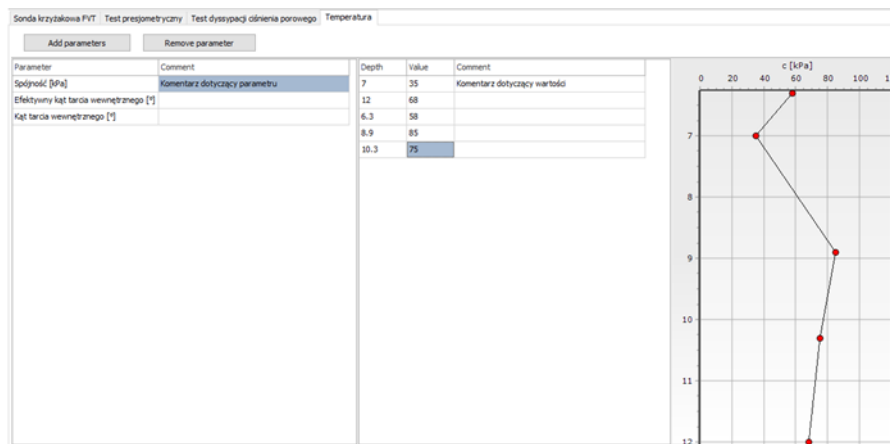


Fig. L-35. Entering Field Test data.

Charts of parameter values from field tests and their interpretation, entered in the [Field tests] tab, can be included in the borehole log and in cross-sections made in the **CPT-CAD** module.

L.4.6. Dynamic Penetration Tests (DPT).

The **Geo DB** program allows you to enter and interpret the results of **Dynamic Penetration Tests**:

- DCPT
- DPL
- DPM
- DPH
- DPSH
- SLVT
- ITB-ZW

The basic characteristics of these tests are available in the generally available literature. For control and ease of selection, they are listed next to the **DPT test type** selection list – see Fig. L-36.

L.4.6.1. Entering DPT test results.

DPT test results are entered in the [**DPT test**] tab. After clicking the [**Add DPT test**] button (Fig. L-36), the [**DPT test type**] selection list is activated, from which the appropriate test type should be selected. At the same time the [**Add DPT test**] button changes its function to [**Remove DPT test**] (Fig. L-37) and the [**Measurements**] panel (Fig. L-38) appears, in which N_x^{24} values and **Torque**²⁵ values are entered (number of blows per successive X cm) for individual sounding intervals with a thickness of X cm, specified in the relevant standard for a given type of sounding.

→ **NOTE.** *Selecting the wrong test may result in inappropriate interpretation methods and incorrect interpretation results.*

Fig. L-36. Buttons and list settings before entering DPT

²⁴ The X value for most DPT tests is 10 [cm], for DCPT it is 15 [cm] and for DPSH it can be 10 [cm] or 20 [cm].

²⁵ When performing the DPT, it is recommended to rotate the rod with the registration of the maximum torque. Some DPT standards (SLVT and ITB-ZW) assume driving a vane into the ground and performing the FVT test in cohesive soils to estimate shear strength.

Fig. L-37. Buttons and content after entering DPT test.

Number	Blows count per distance
1	1.00
2	2.00
3	4.00
4	4.50
5	5.00
6	5.50
7	6.00
8	7.00

Depth	Torque [Nm]
1.8	35
2.9	45
4.2	72
6.2	48
8.1	55

Fig. L-38. [Measurements] panels.

The following functions have been used to speed up the N_X data entry procedure in the [*Blow count per distance*] column.

- clicking the [**Enter**] key - accepting the last entered N_X numbers
- clicking on the ↓ arrow key - accepts the last entered N_X numbers and creates another line for N_X data entry.

The icons in the [*Measurements*] panel are used to:

- add another row at the end of the list
- add another row above the selected row
- add another row below the selected row
- and delete the selected row.

While entering the data from the DPT test, a graph of the entered parameters (number of blows per X cm N_X and torque **T**) is drawn on an ongoing basis to control the correctness of entering the data (Fig. L-40).

L.4.6.2. Interpretation of DPT test results.

Dynamic soundings are mainly used to estimate the basic characteristics of sandy soils, such as the *relative density index* I_D , *internal friction angle* Φ , *oedometric module* M and others. However, the *CBR* (*California Bearing Ratio*) parameter, which is also defined for cohesive soils, can be interpreted based on the DPT results and appropriate correlation functions. In the world literature, one can find correlations

linking the results of the DPT test with other parameters specific to cohesive soils, but their accuracy and thus their usefulness are limited. *Eurocode 7* [3, 13] includes correlation equations to estimate the I_D from DPL and DPH soundings.

Geo DB allows for continuous interpretation of DPT soundings, in which the value of the interpreted parameter is estimated for each interval with a thickness of X , and additionally - estimates of the characteristic values of parameters for the layers defined in the [*Soil profile*] tab and corrected during the interpretation procedure.

The following can be used as a basis for estimating the characteristic value of a parameter:

- μ (mean value)
- $\mu-s/2$ (mean value - 1/2 of the sample standard deviation (**Schneider H.R.**))
- $\mu-\sigma$ (mean value - standard deviation from the population (**PN-B-04452:2002**))
- $\mu-1.645*\sigma$ (mean value -1.645 σ of the population standard deviation (**Eurocode 7**))

After selecting the type of DPT test, the selection lists for the method of estimating the characteristic values and the method of interpretation become active (Fig. L-39). Selecting a DPT test type limits the interpretation method selection list to those that are specified for that DPT test type.

Fig. L-39 Selection of the basis for estimation of characteristic values and selection of the method of interpretation.

→ **NOTE.** The estimation of the characteristic values is based in the first phase on the estimation of the characteristic values of N_x and in the second phase on imposition an appropriate correlation function on this value. The reverse order would give incorrect results due to the non-linear (usually logarithmic) nature of the correlation functions.

After clicking the [**Save results**] button, the calculated density characteristic values are automatically saved (here as **Relative density index value, I_D**) as a property of the corresponding layer.

→ **NOTE.** Each method in the list of interpretation methods has, among other things, contained information on which layer property the calculated characteristic values should be saved.

L.4.7. Interpretation of vane test results (only for SLVT and ITB-ZW).

SLVT and ITB-ZW type soundings consist in driving a vane into the ground (similarly as in other methods) and making rotations with a torque measurement T in cohesive soils. These values are then recalculated according to standard formulas for shear strength τ [kPa]. In the case of several such shears in a given layer, the characteristic value of the τ parameter is calculated and automatically saved as a property of the appropriate layer after clicking the [Save results] button.

Soil profile | Samples | External parameters | User's layers | Field tests | DPT test

Remove DPT test

DPT test type:
 DPL

Estimation of characteristic N_x value based on:

Interpretation method:

Selected test type information
 Measurement distance: 10.00
 Hammer weight: 10.00
 Height of fall: 500.00
 Anvil diameter: 100.00
 Anvil weight: 6.00
 Cone base area A: 10.00
 Cone angle: 90.00
 Base diameter new: 35.70

Measurements type:
 ☐ centimeters per blow
 ☒ blow count per measurement distance

Rod length [m]
 1

Details Save results

Measurements

Number	Blows count per distance
1	1.00
2	1.00
3	1.00
4	1.00
5	4.00
6	4.00
7	3.00
8	3.00

Torque measurements
 Panel 21

Depth	Torque [Nm]
1.20	22.00
2.80	26.00
3.90	29.00
4.60	28.00
5.50	22.00
6.50	35.00
7.40	38.00
8.50	45.00
10.00	38.00
11.80	36.00

DPT Measurements
 Blow count per distance

Torque measurements
 Torque [Nm]

Fig. L-40. Complete form for entering DPT test results.

L.4.8. Characteristic values of geotechnical parameters.

The characteristic value of geotechnical parameter X_k can be defined as the best estimate of unknown statistical mean of parameter in the soil layer [18].

Characteristic values of parameters can be calculated:

- Individually for each layer in a single borehole
- Jointly for those layers in the borehole that have the same *geotechnical layer number*
- Jointly for the selected group of boreholes and those layers that have the same *geotechnical layer number*

The **GEO DB** program has built-in procedures for determining the characteristic values of parameters based on:

- Values determined in laboratory tests of samples
- External values determined in field tests or defined in some standards
- Values determined jointly in laboratory, field tests or defined in standards

According to Eurocode 7, the characteristic value X_k of geotechnical parameter X should be determined as a **five percent quantile** from the probability distribution of this parameter. Assuming that the parameter X is a random variable with a normal distribution, the following formula for the characteristic value is obtained:

$$X_k = \mu(X) - 1.645\sigma(X) = \mu(X)(1 - 1.645V(X))$$

where $\mu(X)$, $\sigma(X)$ and $V(X)$ denote respectively: population mean value, population standard deviation and the coefficient of variation of the random variable X .

The above definition has certain shortcomings, the most important of which are

- The need to determine/estimate the mean value and standard deviation from the population based on usually a small number of studies.
- Inability to take into account the natural variability of soil characteristics, which, with a small number of tests, generates an "excessively" high value of the variability coefficient and, consequently, an excessively low value of the characteristic parameter.
- Such "pure" statistical approach should be used for sufficiently large data sets ($N = 30$).

Some solution to these problems is the proposal given by Schneider [18]:

$$X_k = m(X) - 0.5s(X)$$

where $m(X)$ and $s(X)$ denote respectively: *sample mean value* of parameter X and *sample standard deviation* of the random variable X .

In Schneider's approach [18], the statistical approach can be used from the number of test values $n \geq 13$ and the obtained result will be as conservative as according to Eurocode 7, however for $n > 10$ results could be acceptable.

Using the similar reasoning as in [18], an analogous formula can be given, which will give statistically analogous results as above, but the drawback of this estimate will be the excessively conservative (i.e. unreasonably pessimistic) values of the characteristic parameter. That formula can be used for the number of tests values $n \geq 5$.

$$X_k = m(X) - s(X)$$

Statistically correct use of this method is possible from sample size $n \geq 5$, but the result is an excessively conservative estimate of characteristic parameters.

Another attempt to solve the problem of excessive underestimation of characteristic parameter values is the so-called 3-sigma rule - proposed by Duncan [], in which the standard deviation in the population was estimated as

$$\sigma(X) = \frac{1}{6} (X_{\max} - X_{\min})$$

The adoption of such an estimation, justified by the fact that in the case of a normal distribution of variable X , the probability that it will take values differing from the mean μ by more than 3σ , is very low. The adoption of such an assumption allows the use of the same characteristic value estimate as in Eurocode 7, i.e.

$$X_k = \mu(X) - 1.645\sigma(X) = \mu(X)(1 - 1.645V(X))$$

L.4.8.1. Calculation procedures used to estimate the values of characteristic parameters.

➔ *NOTE. Geo DB does not check the size of statistical sample before performing statistical calculations, but only checks the possibility of calculating the standard deviation, which is possible for test number ≥ 2 . In the case of a single test, this test value is assigned as the value of the characteristic parameter.*

➔ *NOTE. Standard deviation from the sample and population are similar for a large number of tests, but for a small number of tests they may differ significantly.*

Taking into account the fact that for safety reasons the 5% quantile should be used in some circumstances and the 95% quantile in others (depending on which version gives more secure values), the following calculation methods have been introduced:

- i. Mean value $m(X)$ of parameter X calculated from available test results
- ii. According to *Polish standard PN-81/B-03020* : [**sample mean – population standard deviation $m(X)-\sigma(X)$**]
- iii. According to Schneider's method – [**sample mean - half of the sample standard deviation $m(X)-s(X)/2$**]
- iv. According to Schneider's method – [**sample mean + half of the sample standard deviation $m(X)+s(X)/2$**]
- v. [**sample mean - sample standard deviation $m(X)-s(X)$**]
- vi. [**sample mean + sample standard deviation $m(X)+s(X)$**]
- vii. According to Eurocode 7 – [**5% quantile from the parameter probability distribution = $\mu(X)-1.645\sigma(X)$**]
- viii. According to Eurocode 7 – [**95% quantile from the parameter probability distribution = $\mu(X)+1.645\sigma(X)$**]
- ix. First quarter method²⁶ - [**$(m(X) + X_{\min})/2$**] (where X_{\min} – minimum value from sample)
- x. Fourth quarter method - [**$(m(X) + X_{\max})/2$**] (where X_{\max} – maximum value from sample)


L.4.8.2. Characteristic values determined individually for each layer in borehole.

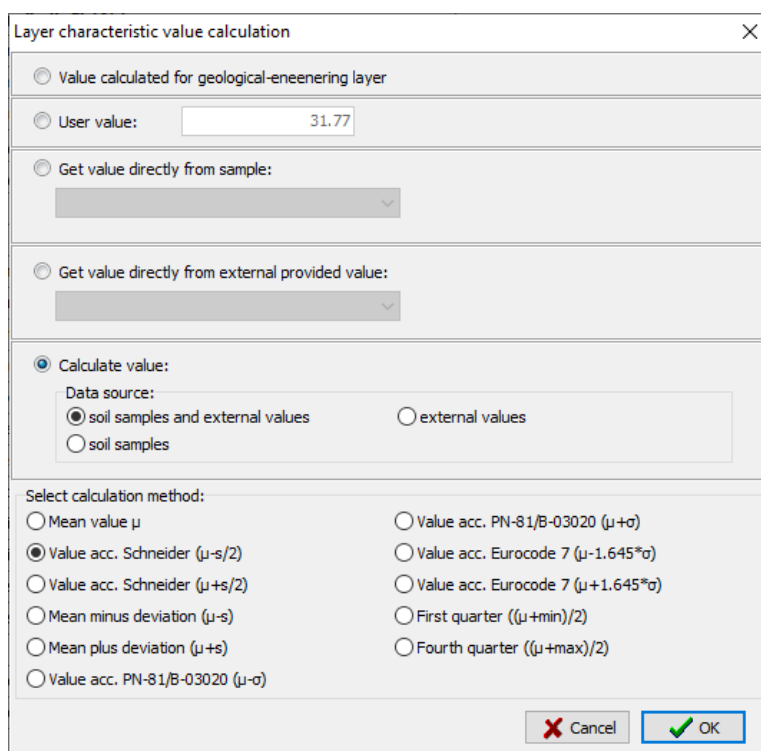
Characteristic values of parameters can be determined based on:

²⁶ The *first/fourth quarter method* is not based on statistics and has no mathematical background. It is an easy-to-use approximate method used in some countries.

- User's estimate
- The value determined in the examination of the indicated sample
- Value determined in the indicated external source (particularly in standards)
- Statistical calculations (see above)

To calculate the characteristic values of a parameter for a selected layer:

- Select the layer in the central panel in the [**Soil profile**] tab.
- Left-click on the icon  in the CPV column in the right panel corresponding to the selected parameter. This operation will open a window for selecting the data source and calculation method – see Fig. L-41.
- Select the data source for calculations (*samples + external parameters*, *samples*, *external parameters*) and the calculation method in the above-mentioned selection box.
- Click [OK] to perform calculations and enter the result to Property / characteristic value column.



Layer characteristic value calculation

☐ Value calculated for geological-engineering layer

☐ User value:

☐ Get value directly from sample:

☐ Get value directly from external provided value:

☒ Calculate value:

Data source:

☒ soil samples and external values ☐ external values

☐ soil samples

Select calculation method:

☐ Mean value μ ☐ Value acc. PN-81/B-03020 ($\mu + \sigma$)

☒ Value acc. Schneider ($\mu - s/2$) ☐ Value acc. Eurocode 7 ($\mu - 1.645 \cdot \sigma$)

☐ Value acc. Schneider ($\mu + s/2$) ☐ Value acc. Eurocode 7 ($\mu + 1.645 \cdot \sigma$)

☐ Mean minus deviation ($\mu - s$) ☐ First quarter ($(\mu + \min)/2$)

☐ Mean plus deviation ($\mu + s$) ☐ Fourth quarter ($(\mu + \max)/2$)



☐ Value acc. PN-81/B-03020 ($\mu - \sigma$)

Fig. L-41. Calculation of characteristic value of parameters.

L.4.8.3. Joint determination of the values of characteristic parameters for geotechnical layers in a group of boreholes.

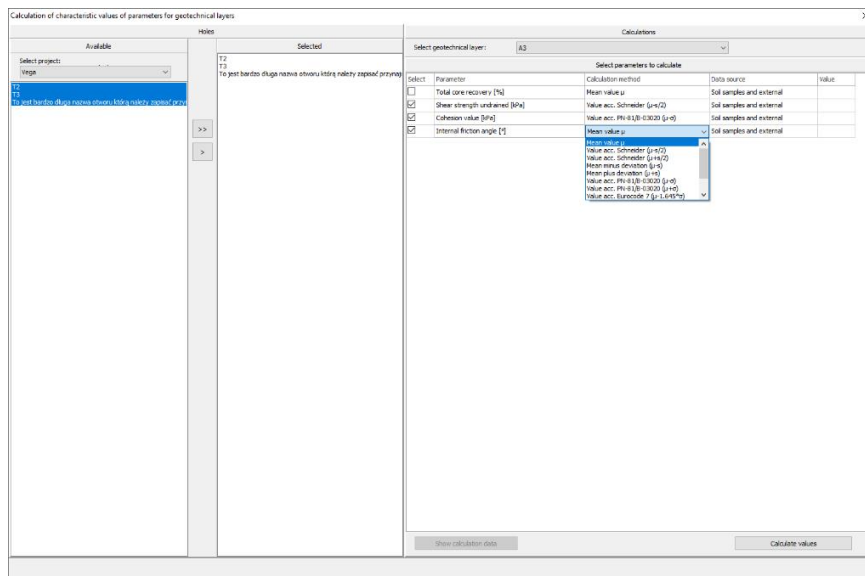
It happens that a group of boreholes or single one contains layers with similar properties, which may be marked with the same common **geotechnical layer number**. In such a case, it is possible to jointly perform appropriate statistical calculations on parameters derived from tests of such similar layers for all holes included in the group.

The procedure of collective calculation of characteristic values for geotechnical layers in a selected group of holes is performed after running the **Tools / Calculation of characteristic values for geotechnical layers** function in window [Calculation of characteristic values for geotechnical layers] see Fig. L-42.


This window consists of three panels. In the left panel, select the project and select holes for the hole group. Clicking the  icon inserts the selected hole into the hole group selected in the center panel. To select all holes from a given project, click the icon .

The following functions are implemented in the right panel:

- selecting the geotechnical layer number - by expanding the [Select geotechnical layer] list and selecting the appropriate layer
- Selecting a parameter to estimate the characteristic value - by checking the appropriate checkbox
- Selecting a calculation method from the drop-down list
- Selection of the data source for statistical calculations (soil samples tests, external parameters, both).



Calculation of characteristic values of parameters for geotechnical layers

Select projects: 
 Available:
 T2
 T3
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 T6
 T7
 T8
 T9
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Calculations				
Select geotechnical layer:		A3		
Select parameters to calculate				
Select	Parameter	Calculation method	Data source	Value
<input type="checkbox"/>	Total core recovery [%]	Mean value μ	Soil samples and external	
<input type="checkbox"/>	Shear strength undrained [kPa]	Value acc. Schneider ($\mu-s/2$)	Soil samples and external	
<input type="checkbox"/>	Cohesion value [kPa]	Value acc. Eurocode 7 ($\mu-1.645\sigma$)	Soil samples and external	
<input type="checkbox"/>	Internal friction angle [°]	Mean value μ	Soil samples and external	

Mean value μ
 Value acc. Schneider ($\mu-s/2$)
 Value acc. Schneider ($\mu+s/2$)
 Mean minus deviation ($\mu-s$)
 Mean plus deviation ($\mu+s$)
 Value acc. PN-81/B-03020 ($\mu-\sigma$)
 Value acc. PN-81/B-03020 ($\mu+\sigma$)
 Value acc. Eurocode 7 ($\mu-1.645\sigma$)

Fig. L-43. Selection of method of calculation characteristic values of parameters.

After setting all the above-mentioned fields, click the [**Calculate values**] button to receive the results. In this phase, the results (*characteristic values*) are not yet entered into the database and are only used for a preliminary assessment of their correctness.

If the results appear to be correct, click the [**Save**] button to save the results as **characteristic parameter values** for all selected holes and for the selected geotechnical layer.

These results are visible in the [**Property / characteristic values**] column - see Fig. L-4 and Fig. L-5. Like other layer properties, characteristic parameters can be presented on the borehole log and on cross-sections made in CPT-CAD.

It may happen that the selected geotechnical layer number does not appear in all selected holes. In this case, the characteristic value of the parameter is only saved in holes that contain the selected geotechnical layer.

The above procedure can be performed especially for a single hole in a group containing geotechnical layers marked with the same number.

More details about the calculations will be available after clicking the [**Show calculation data**] button – see Fig. L-44.

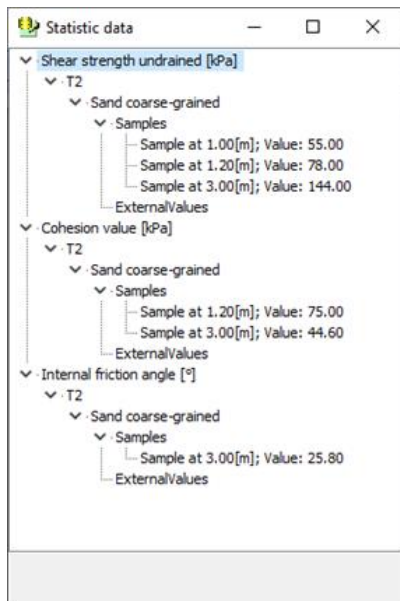


Fig. L-44. Details on statistical calculations.


The above procedure regarding *characteristic values* can be performed in particular for one hole in which there are layers with a common geotechnical layer number.

Characteristic parameter values appear for each hole selected for the group in the table with layer properties, in the [**Property / characteristic values**] column – see Fig. L-4 and Fig. L-11.

It may happen that the characteristic value of a parameter is the value specified in some standard²⁷. In such a case, enter this value as the value of an external parameter and then select it by selecting the [**Get value directly from external provided value**] option, see Fig. L-41.

➔ **NOTE.** Setting the statistical method to determine characteristic values is an individual feature of each geotechnical parameter. The methods set during the last calculations are proposed by the program for subsequent calculations according to the same schema as was (perhaps) introduced in window Fig. L-41. Changing the method in the window Fig. L-42 results in a selection in the window Fig. L-41 and vice versa.

L.4.9. Borehole log.

The **GEO DB** program enables automatic generation of a borehole card for the currently open borehole and in accordance with the previously made settings. The borehole log window (Fig. L-45) is opened with a button  on the main **GEO DB** window.

²⁷ Eurocode 7 allows this procedure

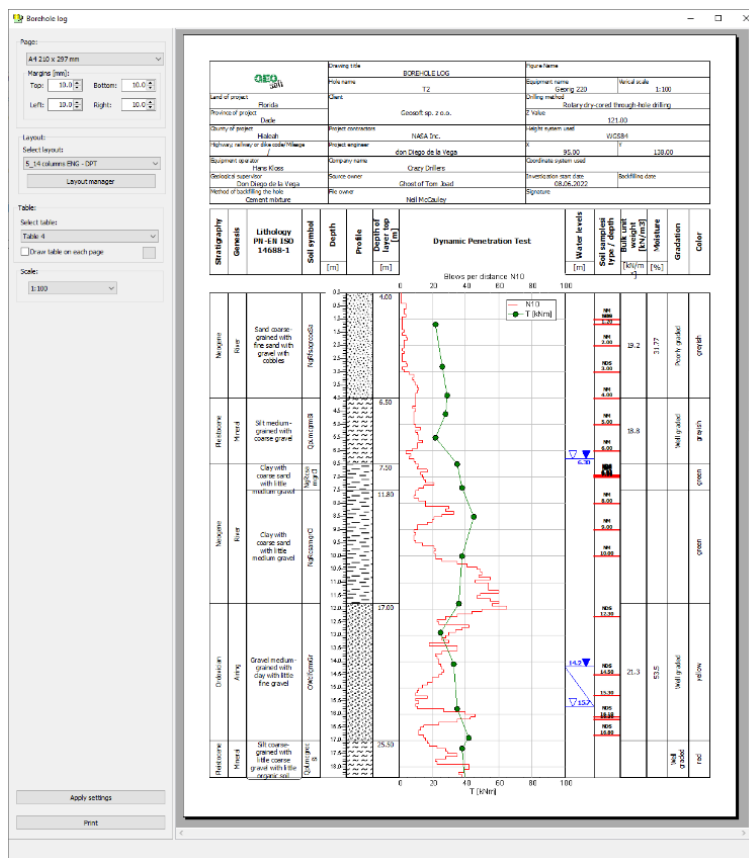


Fig. L-45. Borehole log configuration window.

The left part of the window contains the basic configuration settings of the borehole log:

- Page settings (size, margins)
- Drop-down list with available *main table* layouts
- Button opening the *Layout manager*
- Drop-down list with *header table* patterns
- Scale settings
- Buttons for accepting [*Apply settings*] and [*Print*] settings.

The main feature of the hole card window is the exact *borehole card preview*. That preview is active, which means that you can make certain settings directly there.

The borehole log consists of a **header table** containing selected variables from the **project header** and **hole header**, and a **main table** containing a freely selected set of information regarding the currently selected hole. The header table fields may also contain elements related to the hole log itself, such as logo, vertical scale, page number, etc.

Configuring a borehole card layout involves selecting the previously configured **header table** and **main table** patterns.

The header table is fully customizable. The user has at his disposal a number of pre-configured tables with various numbers of cells²⁸, in which the content can be freely set.

Double-clicking with the left mouse button on any cell of the header table opens the edit window for this table field - Fig. L-46.

The left panel of the header field edit pane contains settings for the **header data source**. The central and right panels contain tools for editing **the content** of a given field.

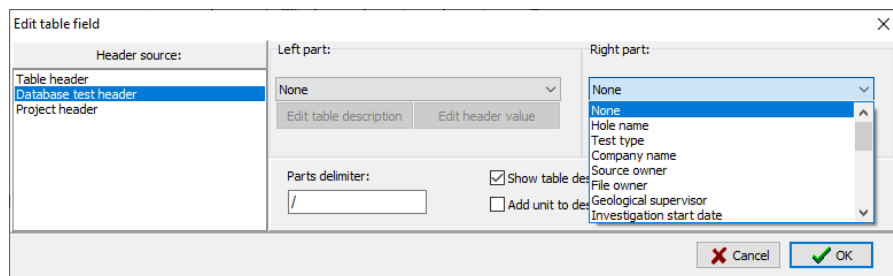


Fig. L-46. Edycja pola tabelki nagłówkowej.

In each field of the header table, two variables can be entered, separated by a selected separator (**Parts delimiter**). The variable on the left is set in the central panel, and the variable on the right is set in the right panel. The choice of separator and the settings for **showing/hiding** the table and options for showing units are located in the lower part of the window. Leaving the value [**None**] in the right panel results in only one variable in a given field in the header table.

The main table consists of columns containing information about the currently selected hole and fields with descriptions of the contents of individual columns. The vertical division of the columns is consistent with layers specified in the hole and is presented in the declared vertical scale. Descriptions of the column contents are incorporated into the main table template. Column content descriptions are incorporated into the master table layout.

²⁸ Geosoft can create an additional header table format with any number of rows and columns

The main table template manager (Fig. L-47) activated by the [*Layout manager*] button consists of four panels.

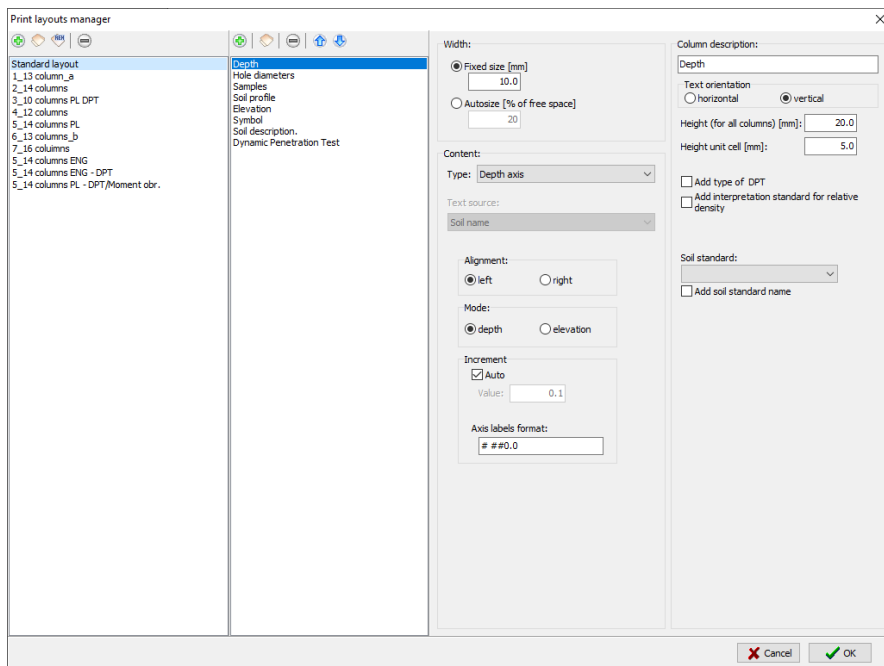


Fig. L-47. Borehole log layout manager.

Panel 1

- Selecting and marking a layout
- Creating a new **main table** with any selected number of columns
- Copying an existing table template and saving it under a new name
- Changing the name of the **main table** template
- Delete **main table** template

Panel 2

- Selecting and marking the template column
- Adding a new column to an existing layout
- Delete the selected column from the layout
- Changing the content of individual columns
- Changing the order of columns in the selected layout

Panel 3

- Geometric settings of individual columns
- Content settings for individual columns
- Justification settings in columns
- Selecting the vertical scale type (*depth/elevation*)
- Configure vertical scale of columns

Panel 4

- Editing the column description in the [*Column description*] window
- Column description orientation settings (vertical/horizontal)
- Cell size settings with column descriptions
- DPT test settings
 - Show/hide the test type
 - Show/hide information about the interpretation method
- Selection of soil classification standard
- Show/hide information about the soil classification standard

Due to the various types of information and ways of presenting them, the following types of columns are implemented in **Geo DB**:

- Depth axis
- Soil profile
- Text
- Water levels
- Soil samples
- Leaks
- Charts

As the program develops, it is possible to add additional types of columns.

Double-clicking the left mouse button on any column of the main table opens the edit window for this column - Fig. L-49.

The permanent elements of this window are:

- Column size settings (width or autoscale)
- Column content selection window
- Drop-down list with selection of information source in the column
- Column description editing window
- Description text inclination setting window
- Checkbox settings for showing/hiding information about the DPT test
- Checkbox settings for showing/hiding information about the DPT test interpretation method
- Soil classification standard selection window

The variable elements of the column edit pane depend on the currently selected column type and contain settings specific to this type.

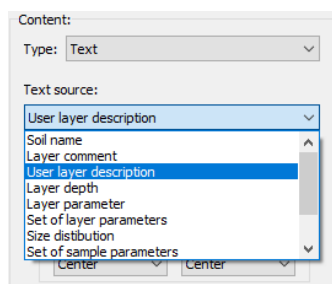


Fig. L-48. Source of data for [Text] column.

Selecting the **Text** column type allows you to enter any layer property into this column.

Fig. L-49. Column settings window.

L.4.10. Exporting borehole data to the CPT-pro program.

The **GEO DB** program allows you to export basic borehole data to the **CPT-pro** program in order to interpret **CPT** soundings based on the lithological profile registered in the **GEO DB** database.

Exporting this data includes, among others, basic information from the *Project* and *Borehole* headers, information about layers, including:

- Soil type
- Soil type F/C
- Roof and floor of the layer
- Display style - color, hatching

The *soil type F/C* is particularly important because it is the main criterion for the possibility of using a given interpretation method to estimate the values of geotechnical parameters.

L.5. Export of CPT sounding interpretation results to IFC file.

Export to format **IFC**²⁹ (**Industry Foundation Classes**) a single borehole data set or a package of data sets assigned to the **Project** provides compliance with **BIM** (**Building Information Modeling**) technology, allows for effective sharing of information between different programs and their archiving.

A 3D graphic representation of all selected boreholes is exported to the **IFC** file with an alternative division into lithological or geological-engineering or geotechnical layers and the properties of all layers, including the values of geotechnical parameters.

Geo DB allows you to choose the type of graphic representation. The following are available.

- Closed shell
- Extruded area
- Solid swept disc

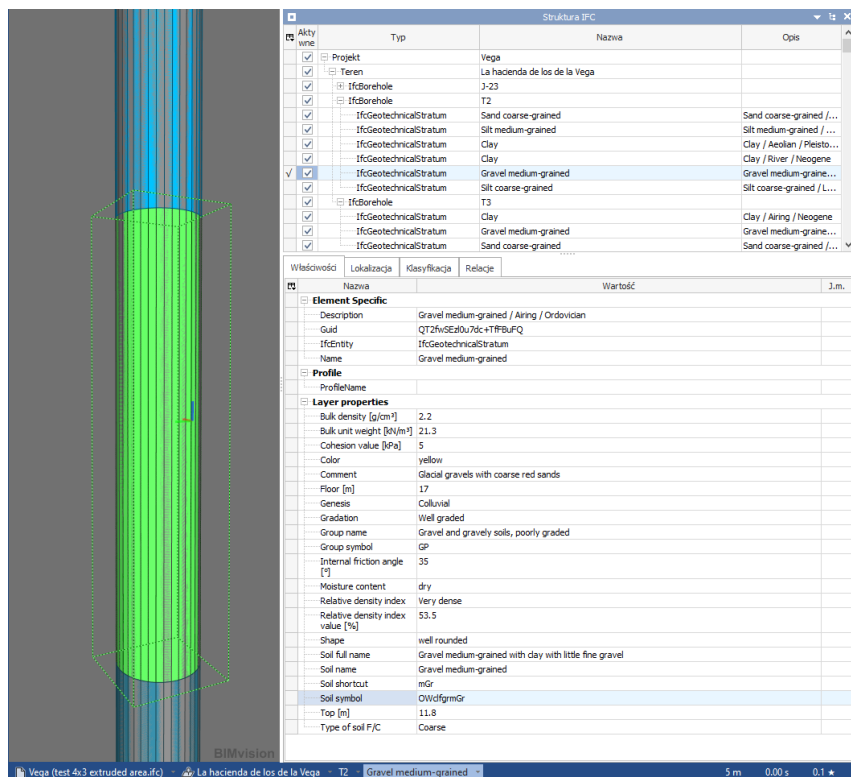


Fig. L-50. Graphical representation of CPT sounding and selected layer properties.

²⁹ Free tools such as **BIMvision** or **BIMcollab** are sufficient to view **IFC** files. **IFC** files in the **2x3** version can also be opened in **ZW CAD**.

The graphic representation selected for export should take into account the capabilities and limitations of the program in which the **IFC** file will be opened. There is no problem with **IFC viewers** such as **BIMvision**, which are constantly updated and have a wide range of compatible graphic representations.

After selecting the selected layer, a window with a list of properties of this layer appears next to the graphic representation of soundings – see Fig. L-50 and Fig. L-51.

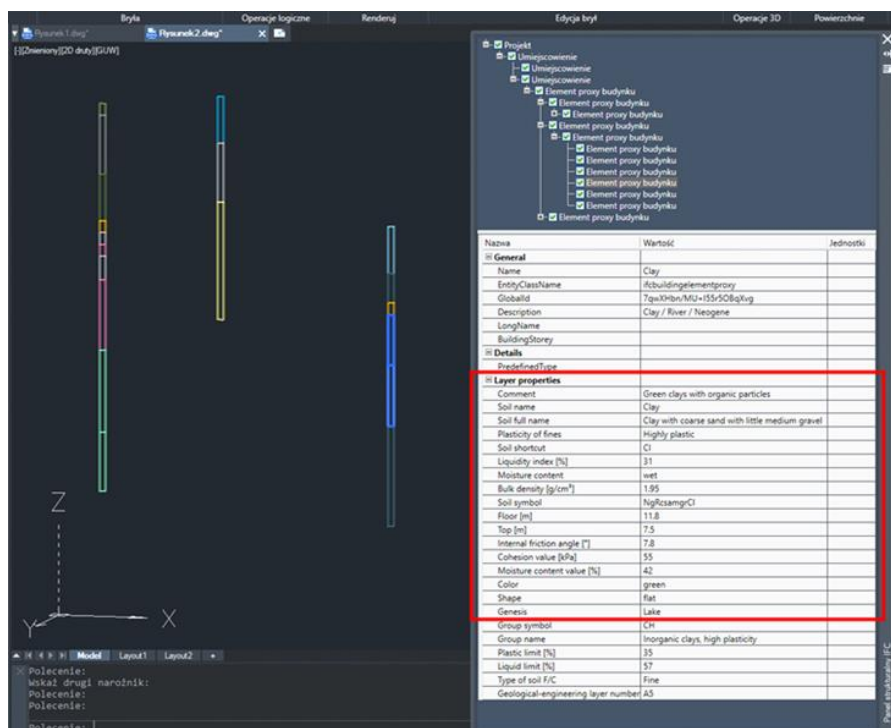


Fig. L-51. IFC file opened in ZW CAD.

L.5.1. Exporting a *Project* to IFC format.

The **Geo DB** program allows you to export all properties of all boreholes contained in any selected **Project** to IFC format in **2x3**, **4** or **4x3** format versions. Clicking the **Export to IFC file format** item in the **Project** menu opens the [Select Project] window in which you select the **Project** for export – see Fig. L-52.

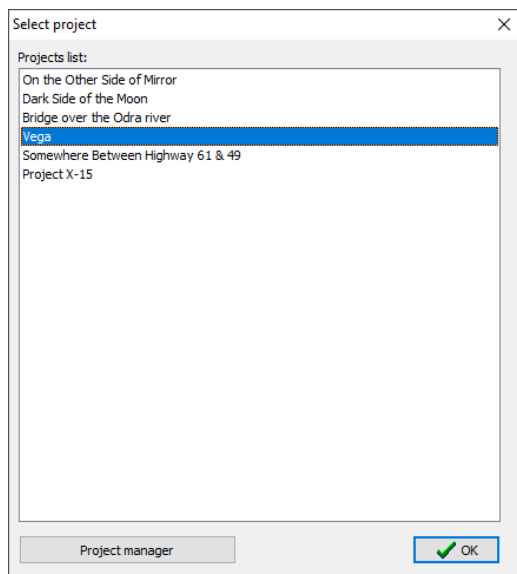


Fig. L-52. Selecting the *Project* to export to IFC file.

Selecting the **Project** and clicking the OK button opens the [IFC Export] window (), where the export configuration takes place.

In this window the IFC file format and the type of graphic representation³⁰ should be selected and accepted by clicking [OK]. After that, a standard Windows window appears, in which the directory where the IFC file is to be saved should be selected.

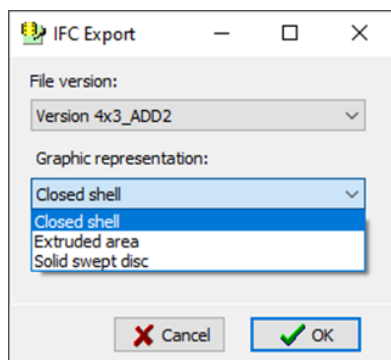


Fig. L-53. IFC export configuration. Expanded list of available graphical representations.

³⁰ The IFC file format version and graphic representation type should be selected based on the ability to open the IFC file in other programs. Some programs, such as **BIMvision**, open basically all current IFC formats and most graphic representations, but many programs only open older **2x3** versions and selected graphic representations.

M. CPT-CAD MODULE

M.1. General description of *CPT-CAD* module.

CPT-CAD has implemented all functions of former modules **Cross Section** and **Map Extended**. Additionally, due to implemented CAD type vector graphics, there is a number of extra options included. Data for creating cross-sectional features may come from the interpretation of CPT soundings (conducted in the **Interpretation** module) and/or from records in the **Geo DB** database.

The crucial functions of *CPT-CAD* are:

- Edition of vector maps and drawings saved in DWG (ver. 2004) and DXF (ver. 2004) formats.
- Creation customer's own vector maps, which can be exported to DXF or DWG files.
- Drawing cross-sections with inserted following objects:
 - Soil sticks with results of classification interpreted from CPT soundings or saved in Geo DB database
 - Hole names
 - Dimensions (distance between holes, elevation of top of layer etc.)
 - Descriptions of soil types derived from the interpretation of CPT soundings or from the **Geo DB** database
 - Layer properties, text and numbers based on entries in **Geo DB**
 - Graphs of parameters interpreted in the Interpretation module and/or entered into the **Geo DB** database
 - Graphic objects created by the user using implemented CAD graphics
 - Raster objects and blocks
- Saving cross-sections and maps in *.CPTCAD format, which preserves the entire cross-section structure and allows subsequent editing
- Saving cross-sections and maps in DWG/DXF formats, enabling subsequent graphic editing (without access to basic information regarding holes and soundings)

NOTE

→ *CPT files expected to be used in CPT-CAD module should have co-ordinates X, Y and Z, and should be saved in *.CPD format, which is native format of CPT-pro and includes all native parameters and results of interpretation.*

M.2. Maps and CAD graphics.

M.2.1. Graphic tools.

CPT-CAD module has implemented advanced CAD type vector graphics, which allows to edit DWG and DXF files. Own graphics can be generated in CAD window, activated from **Main** menu by clicking [**CAD Graphics**].

Most of graphic functions used in CAD type software (like *Autocad* etc.) are implemented in *CPT-CAD* module and are available from menu and icons.

All functions of graphic module are shown below on screen shots from menu - see Fig. M-4 ÷ Fig. M-7

Most of functions are available directly on main CAD window under relevant icons – see Fig. M-8.

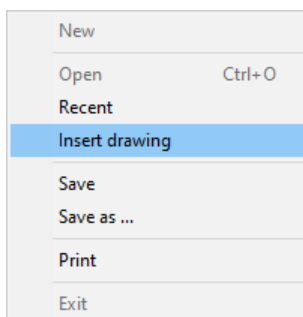


Fig. M-2. Menu File.

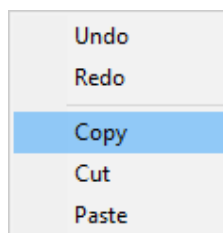


Fig. M-1. Menu Edit.

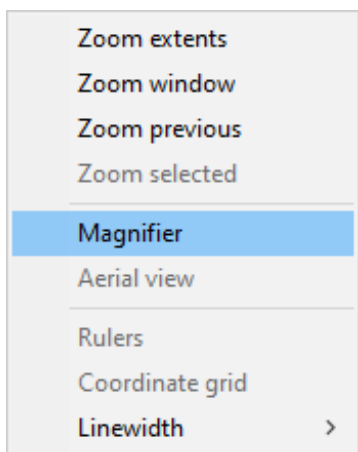


Fig. M-3. Menu View.

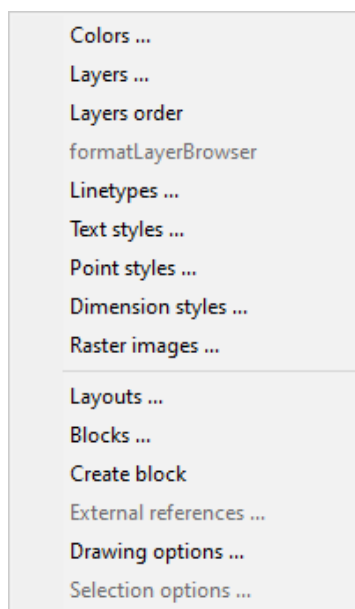


Fig. M-4. Menu Format.

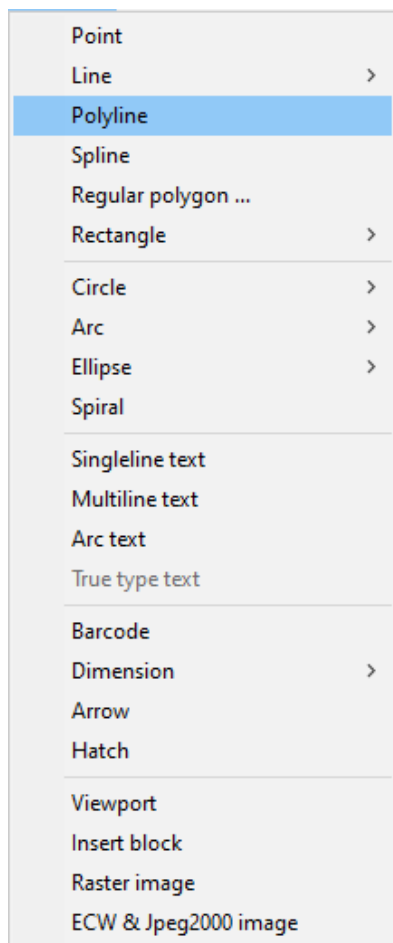


Fig. M-6. Menu Graphics.

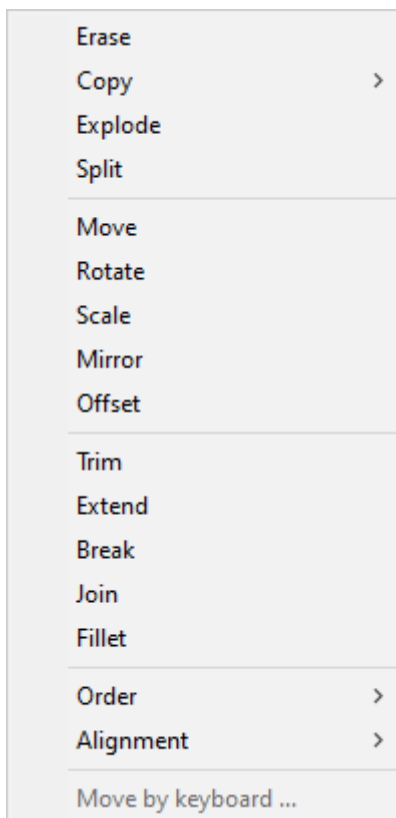


Fig. M-5. Menu Modify.

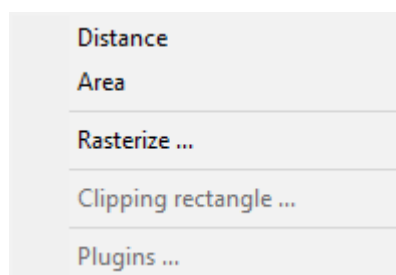


Fig. M-7. Menu Tools.

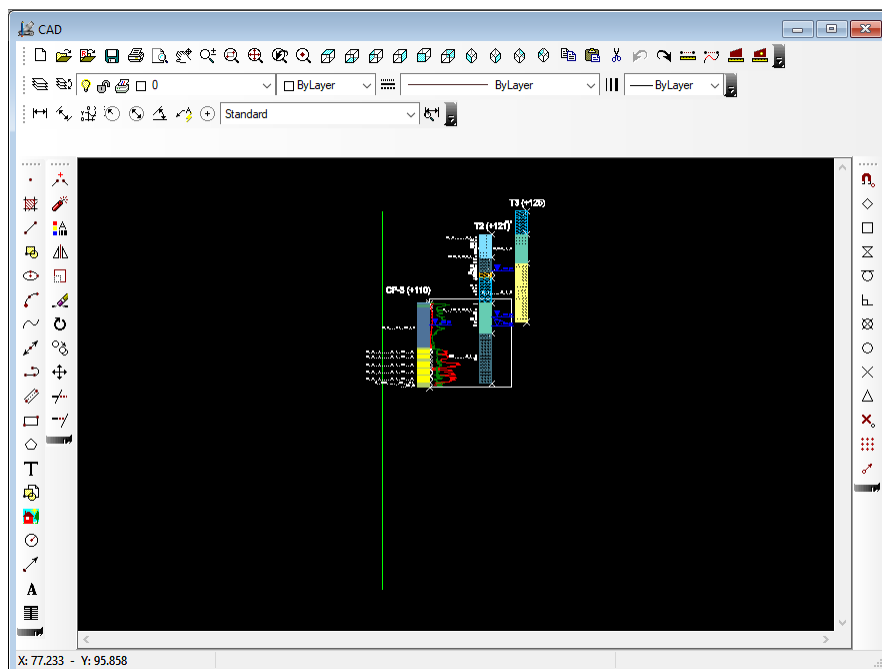


Fig. M-8. CAD drawing window.

Icons on right side of screen are used to select the snap options (Fig. M-8), which are widely used in generation of own drawings and particularly in drawings of geological layers – see chapter N.3.

→The **CPT-CAD** module has implemented a number of graphic functions similar to **AutoCAD** and **MicroStation** packages. The user's interface, operation, nomenclature of program functionalities, as well as structure and laminar structure of created drawings are also standard like in other CAD type software. Therefore, it is recommended to supplement this **Operating Instructions** with detailed instructions or a monograph related to **AutoCAD** or **MicroStation**.

→Elementary practice in use of **AutoCAD** and **MicroStation**-like programs, makes using **CPT-CAD** graphic functions easy and natural.

M.2.2. Maps.

CPT-CAD module, due to implemented advanced graphic options, is the perfect tool for creation own maps with locations of selected CPT tests and boreholes (see below section 0), as well as any objects that are expected to be included on map (existed and projected roads, buildings etc.). Import of DWG and DXF files allows to insert existed CAD maps as background.

Map with locations of CPT test and boreholes (saved in GEO DB) can be automatically generated during the cross-section setup and generation phase.– see section 0.

M.3. Cross sections.

CPT-CAD module executes geotechnical cross sections based on results of interpretations of **CPT** soundings saved in relevant files and/or CPT soundings saved in CPT database and/or soil profiles saved in geological database of **GEO DB** module. Implemented **CAD** type graphics and procedures implemented in **CPT-CAD** enables automatic generation of the following elements:

- Soil sticks (automatically generated from selected *.CPD and *.B** files) being results of classification and interpretation procedure executed in **Interpretation** module and/or saved in Geo DB database, equipped with:
 - Color or hatch fillings consistent with the pattern assigned to individual soils in the **Interpretation** module and in **Geo DB**
 - Description of soil type for layers
 - Properties of layers registered in **Geo DB**, both text and numerical, including the values of characteristic parameters calculated in **Geo DB**
 - Elevations of selected layers
 - Distances between holes
 - Graphs of freely selected CPT parameters, native or interpreted (optionally generated)
 - Graphs of parameters registered in **Geo DB**

In addition, advanced graphic tools included in the **CPT-CAD** module allow you to enter your own graphic objects, such as layer boundaries, geological structures, engineering objects on the ground surface, etc. Available include:

- Graphic objects generated by operator with use of advanced CAD type graphics, like line, polyline, spline curve, circle, ellipse, arc, hatch, dimensions etc..
- Raster images that can be resized and added to complete the section (photos of existed buildings etc.) just by standard **copy / paste** procedure.
- DWG or DXF projects of objects generated in other CAD type and located in section area to complete view of section.
- Text descriptions. Multiline texts, font, size, color, inclination and location are fully controlled by operator.

The CPT-CAD module allows you to create cross-sections with different horizontal and vertical scales. This effect is achieved by declaring the proportions between the horizontal and vertical scales and then selecting the appropriate print scale.

M.3.1. Creation of cross-sections.

The generation of cross-sections consists of the following phases:

1. Initial selection of CPT tests and boreholes.
2. Section configuration, including the selection of the type of section line and its precise definition. Available types of sections and section lines:
 - a. **Projection** onto the selected polyline. The distance between the holes on cross-section are proportional to the distances between the projections of soundings on the section line. A polyline may consist of a single segment or multiple segments.
 - b. **Point-to-point** cross section. The distance between the holes on cross-section are proportional to the real distances between soundings.
 - c. **Road cross-section**. The distance between the holes on cross-section are proportional to the road distances (=mileage) between soundings along the road.

3. Drawing polyline for cross-section type **a**
4. Selection of rate **horizontal to vertical scale**.
5. Final selection of CPT tests and boreholes.
6. Drawing of base cross-section with soil sticks and water symbols.
7. Complementing the base cross-section with objects generated automatically based on CPT soundings and entries in the GEO DB database:
 - a. CPT parameter plots
 - b. Symbols of samples taken from boreholes
 - c. Texts containing, among others: soil type and layer properties
8. Supplementation with your own text and graphic objects using CAD graphic tools included in the CPT-CAD module based on the user's experience and knowledge

M.3.1.1.1. Phase 1. Selection of CPT tests and boreholes.

To select holes saved in the Geo DB and CPT tests for cross-sections, click Holes list in the Main menu. In the [Hole selection] window, go to the [Database holes] tab and select the appropriate Project – see Fig. M-9. All holes assigned to the selected Project will be placed on the list of selected holes in the central panel of this window. Holes can be added individually by checking the appropriate checkboxes, or together – by clicking the [Add all available holes] button. It is possible to add holes from several different Projects. Selected holes appear in the left panel.

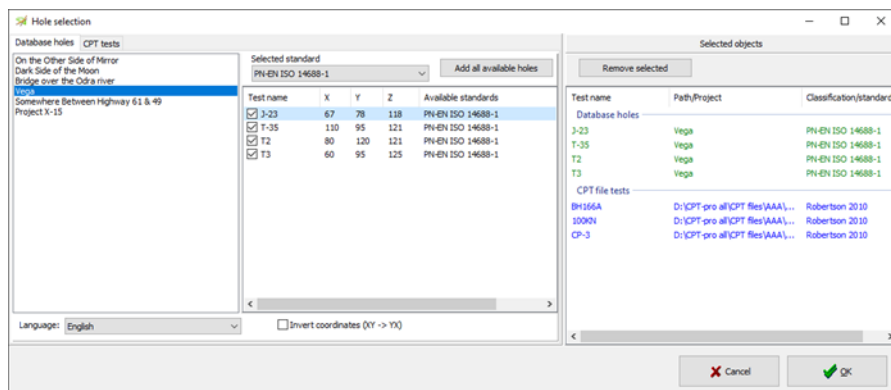


Fig. M-9. Selection of boreholes from Geo DB database. [Database holes] tab.

To select **CPT** tests for the section:

Click the [CPT tests] tab

Select the directory in the left pane that contains the appropriate **CPD/XCPD** files and their associated *.B** (see Fig. M-10). All selected probes should appear in the right pane – see Fig. M-10.

Check the appropriate checkboxes next to the CPT file names

To select all files in a given directory click [Add all CPT tests] button.

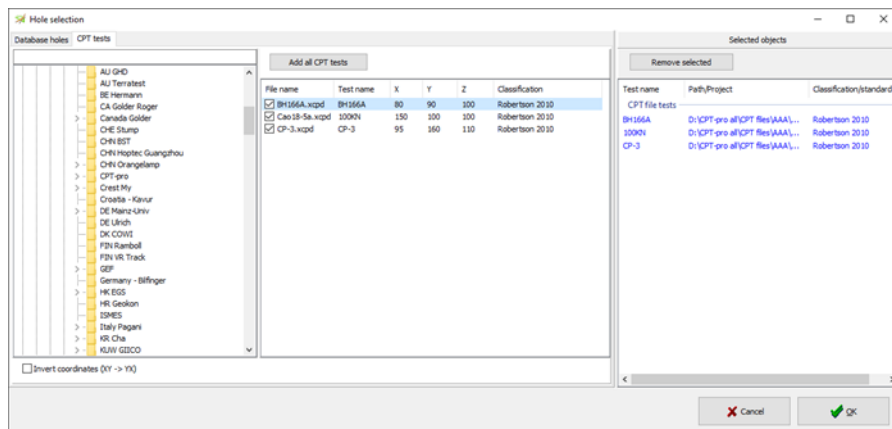


Fig. M-10. CPT tests selection window. [CPT tests] tab.

- **NOTE.** Only the checkboxes for probes containing all **X**, **Y** and **Z** coordinates and the classification result are active
- CPT files can be selected from different directories.
- *.CPD files with CPT sounding interpretation results should be saved in the same directory as *.B** files with classification results.
- CPD/XCPD files should contain X, Y and Z coordinates.

After selecting all holes, click the [OK] button to proceed to **Phase 2**.

M.3.1.2. Phase 2. General cross-section configuration and map with location of holes.

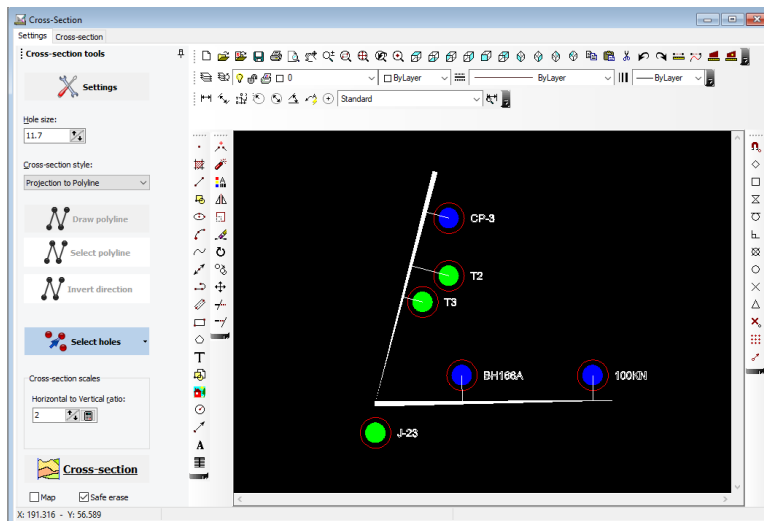
The main configuration parameters of section are:

1. Type of section line:
 - b. Projection polyline on which selected holes are projected.
 - c. Point-to-point polyline i.e. line from hole to hole, which is defined by selection of holes one by one. The sequence of selection is important as it defines the course of line and sequence of holes on cross-section.
 - d. Cross-section along the road, in which the distances between holes on section are generated on the base of mileage.
2. Vertical unit, which is usually the same as unit used in co-ordinate system and on map.
3. Horizontal to vertical unit ratio, which defines the reduction of the horizontal length of section.

The map generated in *phase 2* can be supplemented by adding any CAD objects using standard functions available after clicking the appropriate icons (see Fig. M-11). The size of hole symbols, size of description of hole names and the offset may be configured in [*Cross-section settings*] window – see Fig. M-12. To open this window click [*Settings*] button.

The map with all added objects may be saved as DWG or DXF file.

Cross-section configuration window (Fig. M-11) consists of two panels. The left one contains the buttons and editing boxes used to configure the cross-section, the right one displays the map with the locations of points and the cross-section line.



*Fig. M-11. Cross-section configuration window with [Projection to polyline] selected and finally selected holes. The triangle/line shows direction of section.
Blue points represent CPT tests and green ones – boreholes from Geo DB.*

The basic steps related to the cross-section configuration should be performed from top to bottom in the left pane:

1. Adding descriptions and adjusting the size of hole symbols and descriptions for easier selection of holes – see Fig. M-12. To activate this option click [*Settings*] button.
2. Selection of type of cross-section line.
3. Drawing projection line for projection onto straight line and polyline (Points **1.a** and **1.b** – see above).
4. Final selection of CPT tests and boreholes on map in right panel activated by pressing the [*Select*] button.
5. Determining the ratio of the horizontal scale to the vertical. For example, if the final vertical scale of the printout is **1: 200** and the horizontal scale is **1: 500**, the appropriate ratio is **2.5**.

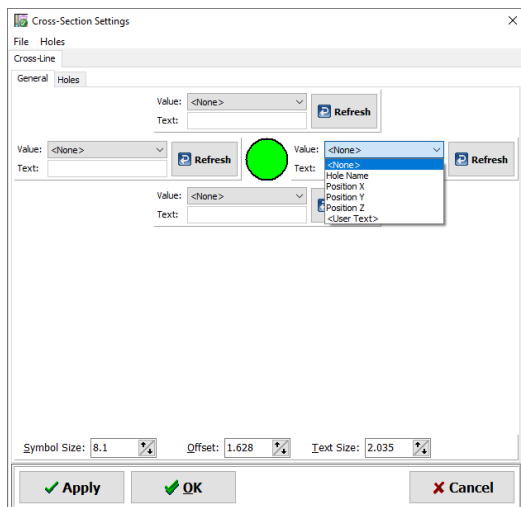


Fig. M-12. Configuring the map with holes. Adding descriptions to hole symbols.

Creating a cross-section starts from definition of cross-section line. To define section line scroll down the [**Cross-section style**] box and select the relevant one.

The following section lines are available:

1. **Polyline** – can be defined in the standard way using the mouse. The point selected first is the start of the section and will be displayed to the left of the section. Selected points are perpendicularly projected onto the section line. The order of selecting points does not affect the section.
2. **Point-to-point polyline**. The line is defined by selecting successive points. The order of selecting points affects the section.
3. **Cross-section along the road**. It is a point-to-point cross-sectional line except that the distance between the points is according to the mileage along the road, not the distance on the map

NOTE

➔ Once [**Projection to Polyline**] is selected the button [**Draw polyline**] appears. To enter own polyline click this button and enter polyline in standard way with mouse.

➔ Polyline sections are presented not as dashes but as elongated triangles, clearly indicating the direction of the section.

➔ Once polyline is completed after right click and [**Enter**], the [**Draw polyline**] button becomes inactive, while the [**Select**] button becomes active.

The **Polyline** section line may be defined by pasting a line copied from another file³¹ and snapping the ends of the automatically generated cross-section line to the ends of the pasted line. To paste that “external” line on map with hole symbols open relevant DWG/DXF file in [CAD Graphic]³² window (see Fig. M-13), copy it and paste to [Settings] window in standard way using the copy/paste icons. Pasted line will keep its original coordinates.

NOTE ➔ Once cross-section line and holes are selected and accepted by clicking [Cross-section] button the cross section line cannot be modified.

The last element of the configuration of the geological cross-section is the determination of the ratio of the horizontal to vertical scale. That can be defined by editing the **Horizontal to Vertical ratio**. For example, if you plan a horizontal scale on a 1: 500 printout and a vertical scale of 1: 200 then the ratio of these scales is $500/200 = 2.5$ and this number 2.5 should be entered.

The **Horizontal to Vertical ratio** i.e. reduction of horizontal length of section can be defined just by editing the relevant number or by modifying it by clicking the arrows up and down.

The map generated in the phase of defining the cross-section line and selecting the holes for the cross-section can be used to create a **map with the location of the holes** against the background of the terrain map. This map can be created using the additional [CAD Graphic] window from the **Main / CAD Graphics** menu – see Fig. M-13.

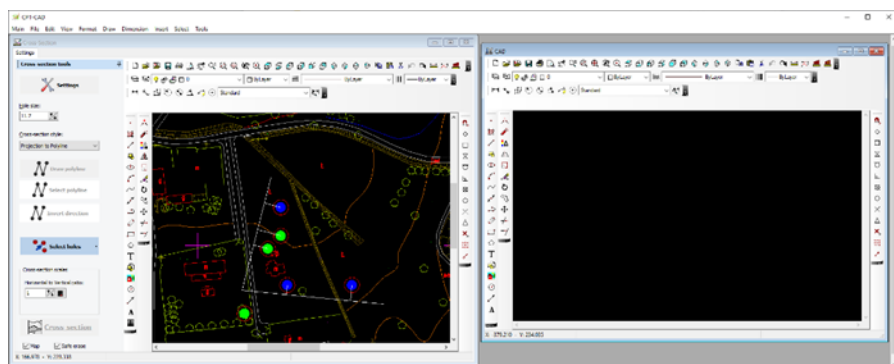



Fig. M-13. Main CPT-CAD window with open section configuration window and extra CAD graphics window.

To do this, perform the following actions in the given order:

1. Open separate **CAD Graphic** window – as shown on Fig. M-13.
2. Open own terrain map in that CAD window
3. Open the layer list in window with location of selected holes for section with the  icon and unlock the **Holes** layer with the location of holes – see Fig. M-14,

³¹ DWG or DXF formats are available

³² Available from **Main** menu – see right window on Fig. M-13

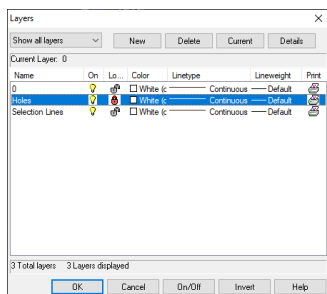




Fig. M-14. Layers in cross-section configuration window.

4. Select holes with descriptions and optional section lines, copy them to the clipboard and paste them in the **CAD Graphics** window using standard icons  .
5. Save the received terrain map with holes and cross-sectional lines in DXF/DWG format for further work.

It is possible to open the terrain map directly in the section line definition window, but due to possible different text styles in CPT-CAD and in the file with your own terrain map, hole descriptions may not be displayed correctly.

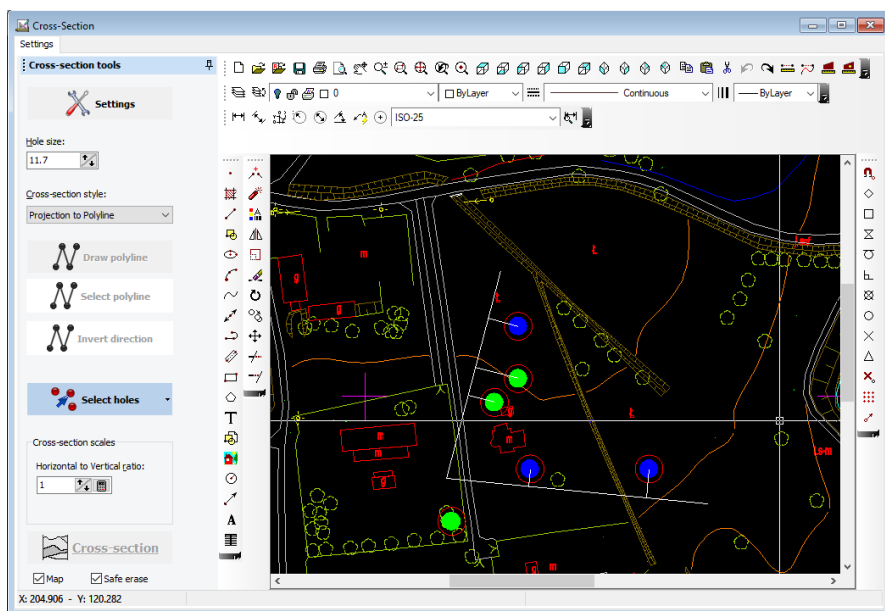


Fig. M-15. Location of holes against the terrain map.

NOTE. The terrain map must be saved in the same coordinate system as the coordinates of the soundings and boreholes.

M.3.1.3. Phase 3. Final selection of CPT tests and boreholes. Raw cross-section generation.

To finally select holes to cross-section click [**Select**] button and click relevant hole symbols on map. Each hole that was selected is marked with line connecting the centre of hole and projection line. In case when hole was selected by mistake, just click right mouse button on hole and select [**Remove Hole**] from context menu.

NOTE.

➔ When projecting onto a straight line, this line has a defined start and end. The start of the line is on the bottom left of the screen and the end is on the right side of the top. Moving the beginning and end of this line across the screen does not change the original function of these points, i.e. the beginning will always be the beginning, regardless of the location after the shift.

➔ When projecting onto a polyline, the beginning of the section is determined by the order of selecting polyline vertices. The same relationship applies to the road cross-section.

➔ In a point-to-point section, the first selected hole defines the beginning of the section. The order of the points is according to the order in which they were selected.

➔ The beginning of the section is on the left side of the section and the printout. These points are represented by green lines in the section except point-to-point section.

The beginning and the end of projection line, as well as vertices of polyline, are presented on cross section as green vertical lines. Additionally, the horizontal co-ordinate of mouse cursor is calculated on basis of left green line (beginning of section), so projection line should be precisely defined.

In case when **Point-to-point line** was selected, the map with holes looks in the same way, however there are no extra objects generated except of holes and its names. The selection procedure is very similar i.e. clicking [**Select**] button and clicking the selected holes in relevant sequence one by one. First selected hole is placed as a first on left side of generated section and next ones in sequence of selection. Removing the irrelevant hole from the selection is the same as in *projection line section* i.e. by clicking [**Remove Hole**] on context menu generated on right click.

If the **By road co-ordinates** cross-section line is selected, the cross-section is generated similarly to the **Point-to-point-line** cross-sections, but with the difference that the distances between the holes are proportional to the mileage read from the CPT files or the Geo DB database.

The vector map (*.DWG, *.DXF) may be inserted as a background before, during or after the final selection of holes. That option may be particularly valuable when **projection line** is selected, due to possible correlation between location of **projection line** and objects on map.

Click [**Cross Section**] button to go to the next phase, i.e. to generate a raw section (Fig. M-16) and complete it in next phases with all the required objects.

In the basic version of the cross-section, the following elements are automatically generated:

- start and end of the section line (external green lines)
- the vertices of polyline (internal green lines)
- geological profiles filled with colors or patterns
- symbols of water levels with elevations
- names of holes above the profiles
- distances between holes
- cross-section dimensions
- horizontal grid
- vertical axes

Fig. M-16. Raw cross-section.

Each of these elements is on its own CAD layer and may be the subject of further editing. Each layer can be turned on/off as needed, just like in standard CAD programs. The window with the generated cross-section contains menus and icons with available CAD graphics functions and the tabs [*Cross-section*], [*Layers*], [*Samples*] and [*Data*]. Each of these tabs contains additional settings and functions.

The [Cross-section] tab contains the [Safe erase] checkbox and [Cross-section settings], [Generate layer positions] and [Hide non-user layers] buttons.

The [**Layers**] tab contains profile width settings:

- Profile width – the width of soil stick on printout in mm
- Hook point selection³³
- Value **Hatch scale [%]** (the scale factor of geological patterns) used for filling the soil stick
- Checkboxes:
 - **Layer texts** – to show/hide layer descriptions
 - **Visible** – to show/hide soil sticks with descriptions.
 - **Use color for hatch** – to use hatch in relevant soil color
 - **Fill hole background** – to insert white background behind the hatch.

The [*Samples*] tab shows location of soil samples associated with holes.

The **[Data]** tab contains the field for definition the horizontal size of field with CPT graphs, hook point for that graphs and checkbox for eventual hiding the CPT graphs.

³³ The soil stick with colors/patterns may be plotted on left or right side of the vertical line representing the position of hole. Hook point (**Left**) places the soil stick to the left of that line.

All objects created automatically by the program are placed on their own separate layers. For the clarity of the final drawing and the efficiency of editing, it is recommended to create your own objects complementing the cross-sections, also on your own dedicated layers – see Fig. M-17.

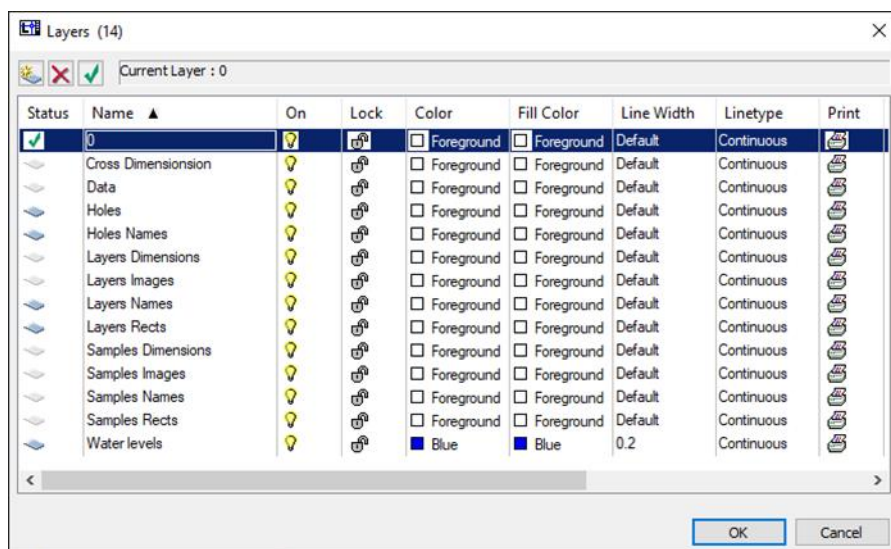


Fig. M-17. Layers created automatically by the program during the cross-section generation phase.

M.3.1.4. Phase 4. Final completion of the cross-section.

Basic section settings, such as annotation distances from objects, font sizes, description field width, geological profile bar width, and field size for parameter plots are available in the [**Cross-Section Settings**] window - Fig. M-18 in tab [**Cross-Section**] at the bottom of the window. To open that settings window click [**Cross-section settings**] button.

The screenshot shows the 'Cross-Section Settings' dialog box with the 'Cross' tab selected. The 'General' sub-tab is active, displaying settings for 'Holes' and 'Cross-Section Scales'. The 'Style' is set to 'Projection to Polyline'. Under 'Cross-Section Scales', 'Vertical Unit' is 'Meters [m]' and 'Horizontal to Vertical Ratio' is '1'. The 'Hole' section includes 'Hole Name Offset' (1), 'Hole Layers' (Size: 2, Hook Point: Left, Layer Name Width: 7.5, Min layer thickness: 0.5, Layer Name Text Height: 0.4, Layer Name Offset: 0.5, Layer Dimensions Offset: 0.25), and 'Hole Data' (Size: 4, Hook Point: Right). The 'Cross-Section' section includes 'Holes Dimensions Offset' (2), 'All Holes Dimensions Offset' (4), and 'Cross Dimensions Offset' (4). The 'Hole Samples' section includes 'Hole Samples Size' (0.666666), 'Hook Point' (Right), 'Layer Name Width' (7.346), 'Layer Name Offset' (0.167), and 'Layer Dimensions Offset' (0.084). At the bottom, there are buttons for 'Clear Layer descriptions', 'Edit Layer descriptions', and 'Generate Layer descriptions', followed by 'Apply', 'OK', and 'Cancel' buttons.

Fig. M-18. Cross-Section Settings window.

A. Adding CPT parameter charts.

To add plots of CPT parameters, both native and interpreted, right-click on any selected layer of the soil profile derived from the CPT sounding and click **[View hole]** in the appearing menu. As a result of this operation, a window will appear containing a list of channels available in the appropriate sounding file and a bar with a soil profile. Selecting the appropriate checkboxes displays the appropriate charts next to the bar – see Fig. M-19.

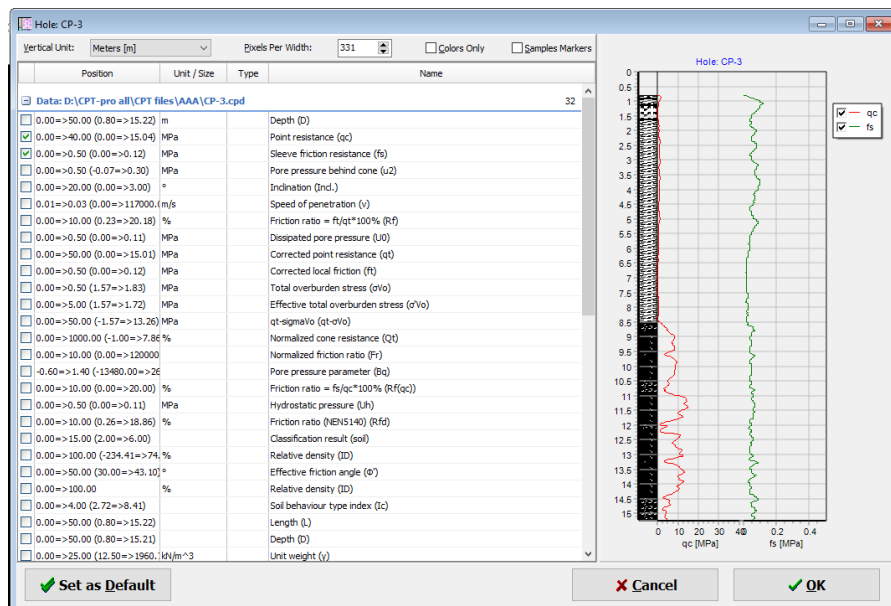


Fig. M-19. Content of selected CPT file.

Clicking the **[OK]** button will display the selected graphs in the cross-section next to the selected soil bar. Clicking the **[Set as default]** button displays the selected graphs next to each soil bar associated with the own CPT sounding.

Chart line attributes, i.e. color, thickness and line style, are taken from the CPT-pro program settings. The height of the CPT parameter graph field results from the length of CPT test. The width of this field is set in the **[Data]** tab in the **[Field size]** – see Fig. M-18.

B. Adding layer description.

Hole profiles can be supplemented with layer descriptions. For profiles derived from the interpretation of CPT soundings, the layer descriptions include the names of soil types. For profiles from the Geo DB database, the descriptions may contain name of soil type and any selected layer characteristics, both numerical and textual.

NOTE. → The name is not generated for a layer whose cross-section height is lower than the font height.

Adding and editing layer descriptions is done using the [**Clear Layer descriptions**], [**Edit Layer descriptions**] and [**Generate Layer descriptions**] buttons, available at the bottom of the [**Cross-section settings**] - see Fig. M-18.

Clicking the [**Clear Layer Names**] button deletes all previously entered descriptions.

The [**Edit layer descriptions**] button opens the [**Edit display parameter list**] description editing window – see Fig. M-20. There are three buttons in this window:

[**Add**] - opens the layer properties selection window [**Parameter settings**] - see Fig. M-21.

[**Edit**] - allows you to change the settings for a previously selected layer property.

[**Delete**] - allows you to delete the selected layer property from the list.

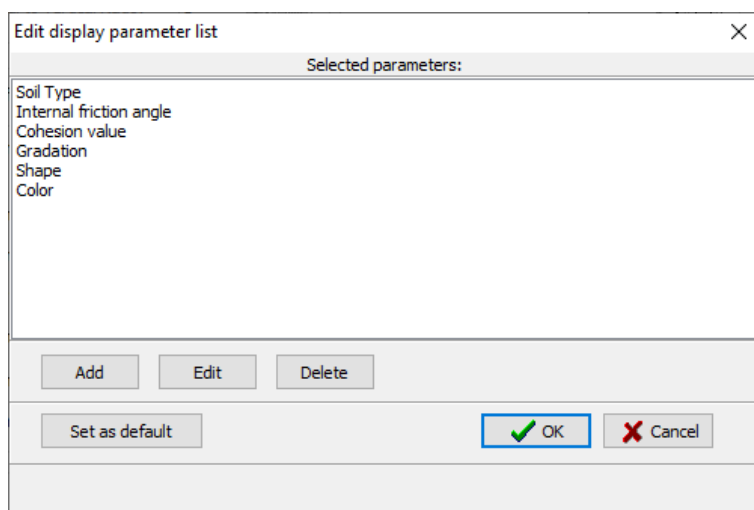


Fig. M-20. [**Edit display parameter list**] window.

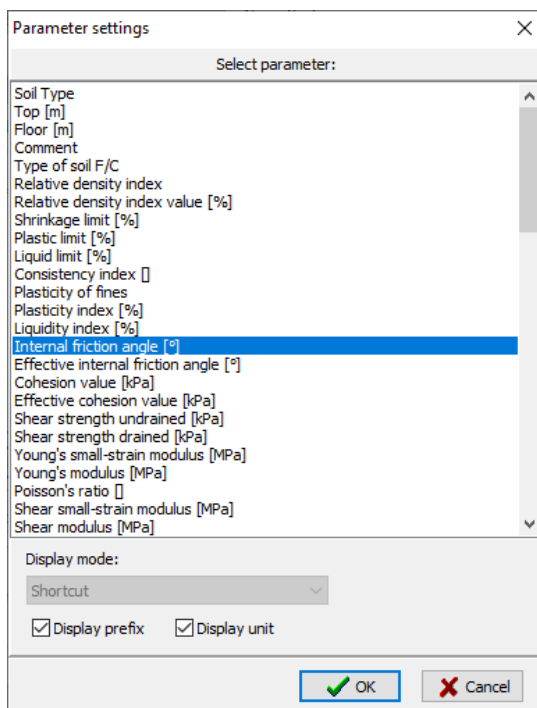


Fig. M-21. [Parameter settings] window. Selection of layer properties for layer description.

Each element of the layer description may be given in full or in abbreviated form. Additionally, numerical parameters may contain a prefix and a display unit in the description – see Fig. M-22.

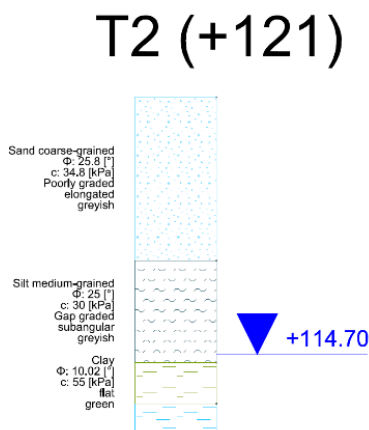


Fig. M-22. Layer description on cross-section.

C. Adding dimensions to cross-section.

The following objects can be added to cross-section from menu available from right click on any soil stick (see Fig. M-23) separately for each soil stick:

- Layer description individually for selected layer and selected hole
- Layer positions i.e. elevations of roof, bottom and center
- Layer thickness

The same objects can be added jointly for all holes in the cross-section after clicking the [**Generate layer position**] button according to the settings in the [**Generate layer position**] window – see Fig. M-24.

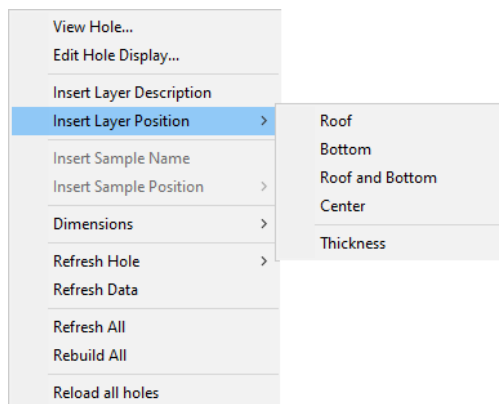


Fig. M-23. Menu available by right clicking on any soil stick.

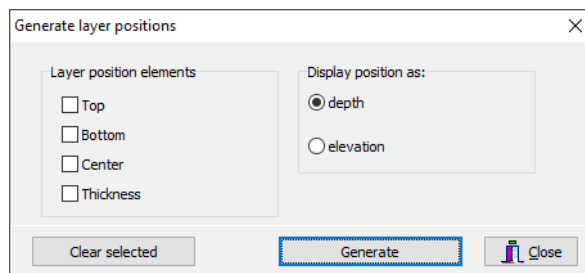


Fig. M-24. Common layer position settings.

The above-described menu also contains functions **View hole** (Fig. M-19) and **Edit hole display** (Fig. M-18) discussed earlier and additional functions to refresh the content of the section.

Additionally, selected holes or the whole cross-section can be reloaded from the same menu if changes have been made to CPT files or records in the database.

D. Adding own graphic and text objects.

In addition to a number of objects generated on the basis of information contained in CPT files and the Geo DB database, the program allows you to insert your own graphic and text objects into the cross-section.

1. Layers, geological structures etc. which cannot be generated automatically and must be drawn by Operator on basis of not only the soil profiles and CPT parameters but also on basis of geological knowledge and experience of User. All typical CAD graphic tools can be used to obtain high quality detailed interpretation of geological structure
2. Top and bottom of geological/geotechnical layer can be generated just by drawing relevant polylines (function activated by clicking icon **b** – see Fig. M-25) going through top and bottom of layers on soil stick and estimated level between holes. The co-ordinate **X** (shown in left down corner) represents the distance from the beginning of section line and position of cursor, co-ordinate **Y** represents the elevation, so it is possible to precisely draw the layer borders as well as a ground level surface.

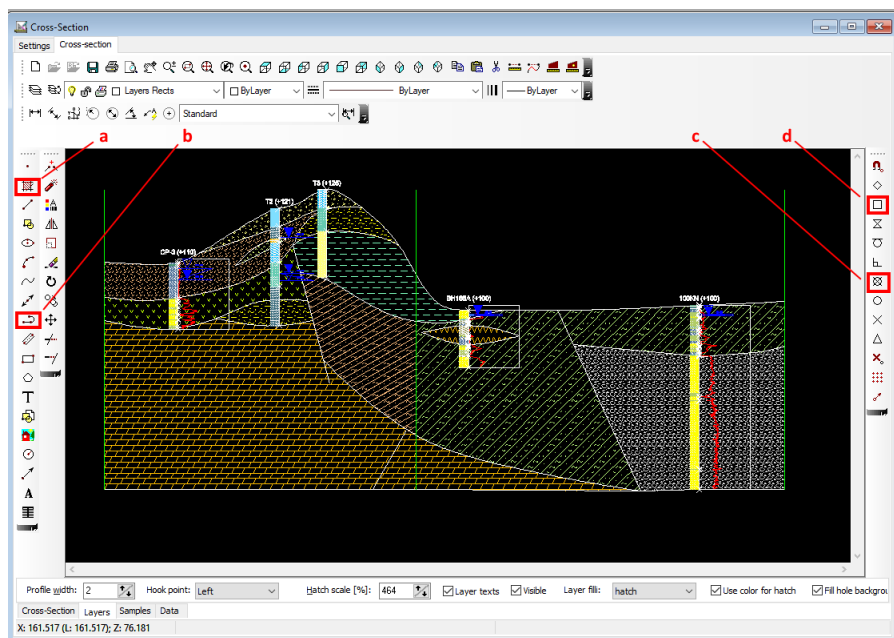


Fig. M-25. Cross section in edition phase.

As both lines should go through defined points on soil stick, it is recommended to use snap functions – see [*Snap to Grip*] – icon **d** on Fig. M-25 and [*Snap to Node*] - icon **c** on Fig. M-25.

The scale of hatches added when editing a cross-section can be determined while adding them and freely changed by editing in the [*Properties*] window. However, the scale of hatches filling the borehole profiles can be changed by setting the [*Hatch scale [%]*] factor, common to all holes and all types of soil.

The initial value of that hatch scale and, consequently, the proportions between their scales are determined:

- For profiles derived from the interpretation of CPT soundings - in the [*Soil attributes*] window – see Fig. K-1
- For profiles from the **Geo DB** database - in the [*Edit display styles*] window – see Fig. L-12.

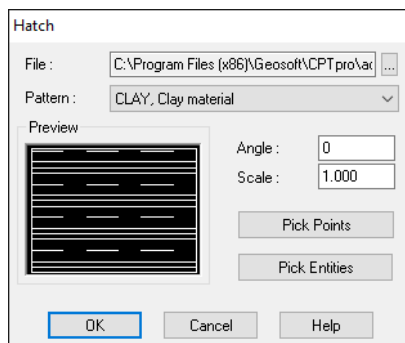


Fig. M-26. Hatch configuration window.

It is recommended to create lines separating geological layers and other lines defining areas intended for the introduction of hatches on layers specially created for these purposes. When creating hatches, other layers except those that define the areas to be hatched should be disabled.

In general - for the clarity of the drawing and ease of editing, it is recommended to create User objects on specially created and dedicated layers.

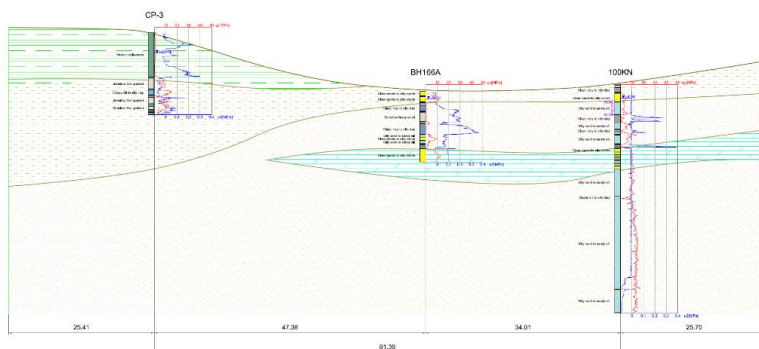


Fig. M-27. Cross-section with added graphs and dimensions.

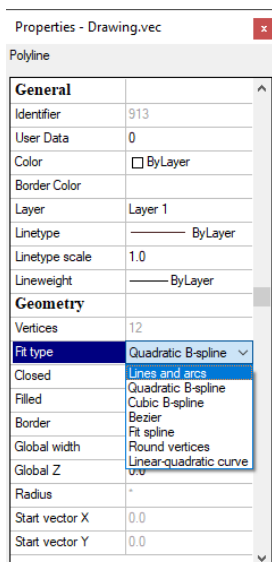


Fig. M-28. Properties of the selected polyline with expanded line rounding options.

All lines and other graphic objects may be edited and have their properties modified at any time, by highlighting, right clicking and selecting [**Properties**] from the context menu – see Fig. M-28. Scrolling down the property in right column allows to select the required one.

It may happen that areas enclosed by polylines are no longer closed after rounding and the hatch cannot be generated. In such a case, each connection of separate polylines should be checked and closed.

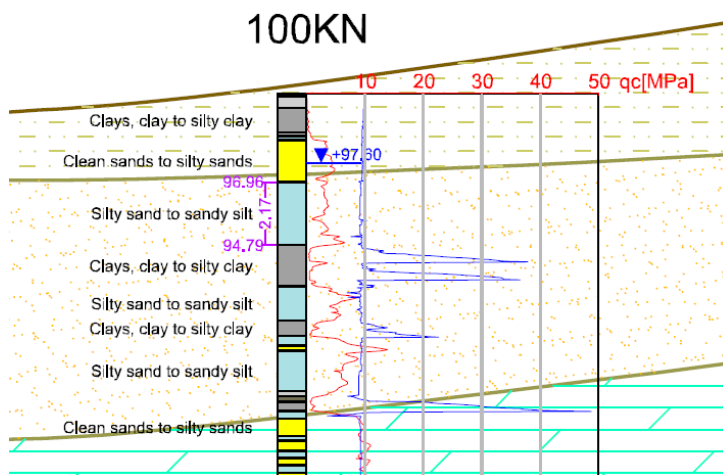


Fig. M-29. Cross section with added objects.

M.3.2. Saving cross-section.

Sections can be saved as DWG/DXF graphic files in which connections to the database and files are lost and only the graphic part can be edited, or as fully editable files in which connections to the database and files are preserved. The latter files have the extension ***.cptcad**.

To save the cross-section in a DWG/DXF file, click the icon in the cross-section window, select the format in the save window and click the **[Save]** button.

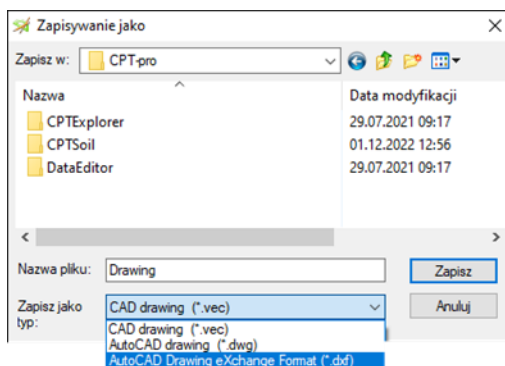
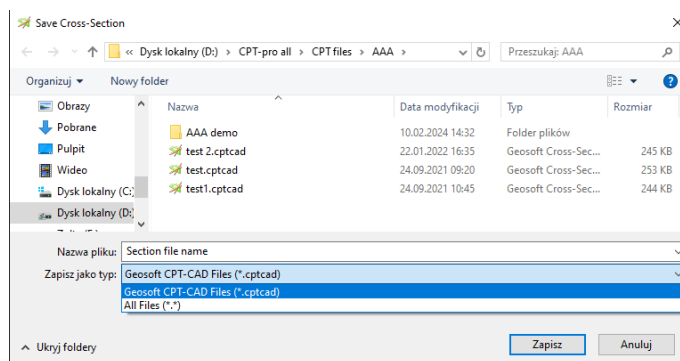


Fig. M-30. Saving cross-section as graphic file DWG/DXF.

To save the cross-section in a fully editable ***.cptcad** file, go to the **[Settings]** tab where the cross-section is defined, then go to the **[Cross-section]** menu and click **[Save file]** menu. Select **Geosoft CPT-CAD Files** format, enter the name of file and click **[Save]** button.

The file ***.cptcad** can be open and fully edited any time.



*Fig. M-31. Saving cross-section as editable *.cptcad file.*

N. SEISMIC MODULE (SCPT).

N.1. General description and running *Seismic* module.

Seismic module allows User to filter, interpret and analyze data files generated in seismic test as well as generate report with results of analysis. The results (velocities for depth intervals) can be presented as sounding logs, including the graph of function *velocity vs. depth* in selected vertical scale and header table with standard descriptions (date, hole name, site etc.) and company logo. The results can be also saved in **CSV** file and easily imported to *Interpretation* module of *CPT-pro* or another software for further analysis. Particularly interesting and valuable is transfer of results of seismic analysis to *CPT-pro*, due to common presentation of seismic and CPTU data as well as using *Formula Editor* implemented in that software to calculate values of geotechnical parameters on base of values of velocity of seismic waves.

Seismic is designed as a one of modules of *CPT-pro* package, however, it is also available as a fully independent application.

The universal procedures implemented in the *SC* can be used not only for files generated in SCPT test but also for other ones like SDMT (seismic dilatometer) etc. tests, in which the seismic wave characteristics are saved (value vs. time).

Once you run *Seismic* module the main window with open data selection window appears (see Fig. N-1).

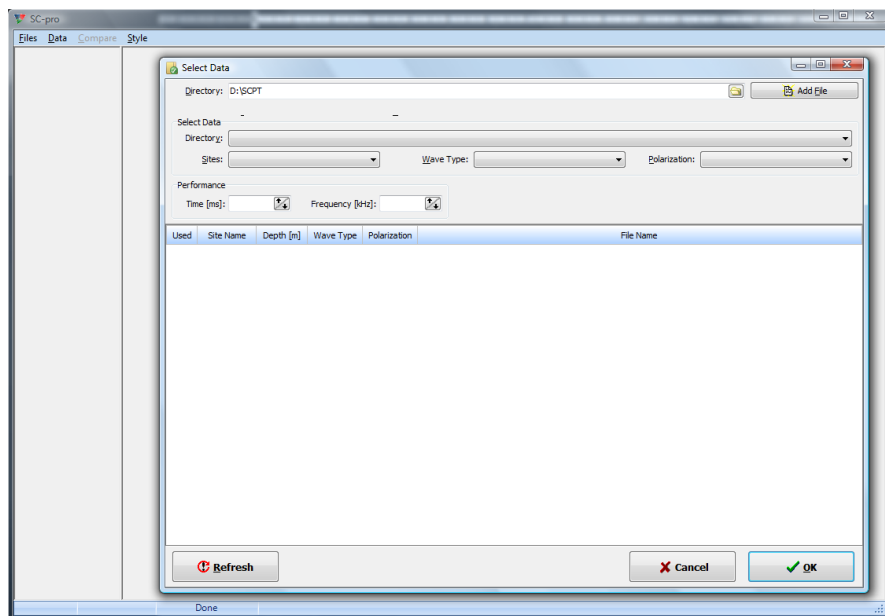




Fig. N-1. Main window of *SC* module with data selection window. Automatically opened *Select Data* one.

To search for relevant data files click the icon  at the end of directory field on top of **Select Data** window and use standard Windows browser (which appears automatically). Once you select the directory with seismic data files and accept that, the table with basic characteristics of data files, like *Site Name*, *Wave Type*, *Polarization* and *File Name*, is filled (see Fig. N-2). Additionally, there is included column of checkboxes described as **[Used]** to select the files that should be considered in further analysis (checked) and omitted (unchecked). As usually only the data files generated in one hole and characterizing the same wave type are analysed simultaneously, the selection of data files can be limited to ones generated in selected hole/site, representing the same **Wave Type** and having the same **Polarization**. To select the **hole**, **Wave Type** and **Polarization** click the  symbol at the end of relevant selection field.

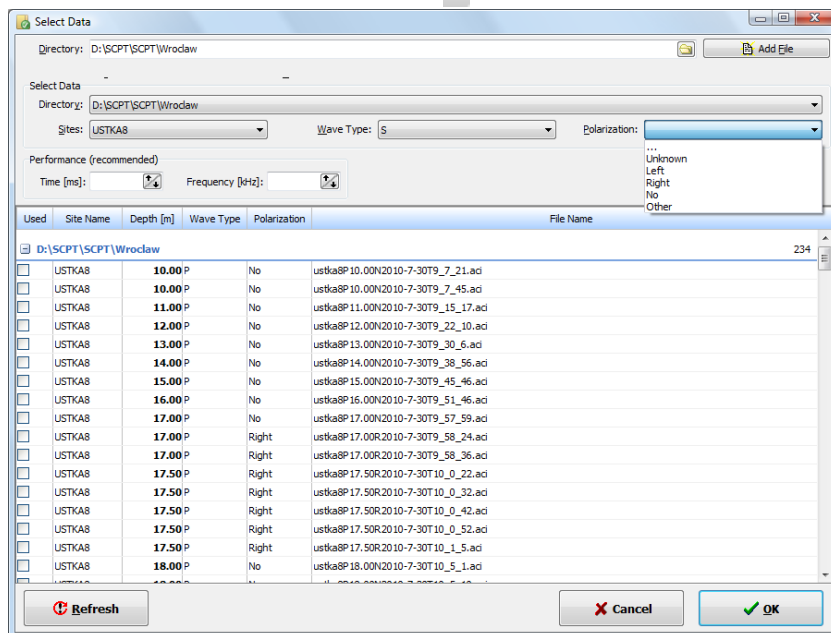


Fig. N-2. [Select Data] window with list of selected files and Wave Type list scrolled down.

Clicking [OK] button will start procedure of loading all selected files. In first phase of loading all selected files are open and relevant thumbnails on left margin are generated. In second phase, each loaded file is analysed, the structure and completion of data are checked and finally – each data set is transformed to variable system to have it ready for filtering and analysis. The status of second phase is shown on status bar as a value of type **13/104**, which means that total number of selected file is 104 and file #13 is being analysed – see Fig. N-3.

The files in second phase are analysed in sequence defined by name, however, you can select any of file and double click relevant thumbnail to have it analysed with priority.

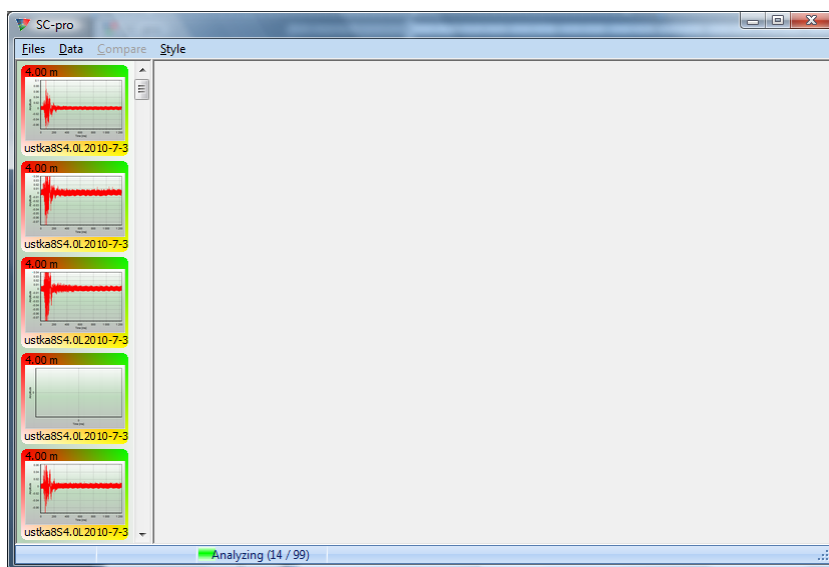


Fig. N-3. Main window of SC module with thumbnails of loaded data files.

The seismic wave detected and saved by seismic sensors (accelerometers or geophones) is a sum of “main” wave generated on surface (by sledge hammer, piston blows etc.) and many different components treated as noisy, generated by engines, machines, construction site objects etc. and usually looks like on Fig. N-4.

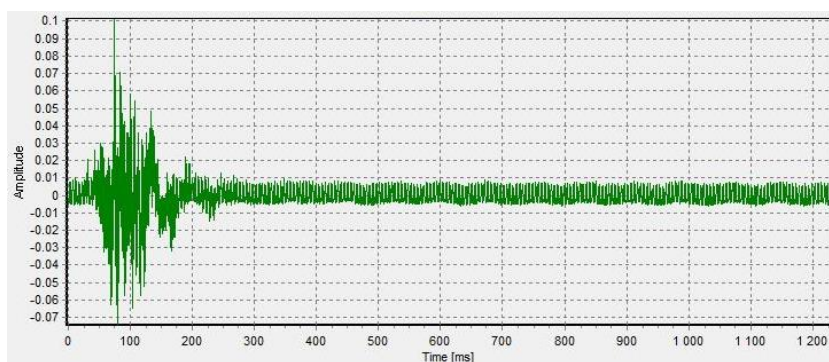


Fig. N-4. Raw seismic data record.

Applying filtering procedures and removing noise and signals generated by irrelevant sources allows to extract the part of spectrum that represents the generated impulse on surface (see example on Fig. N-5) and can be used to estimate the soil properties in further analysis.

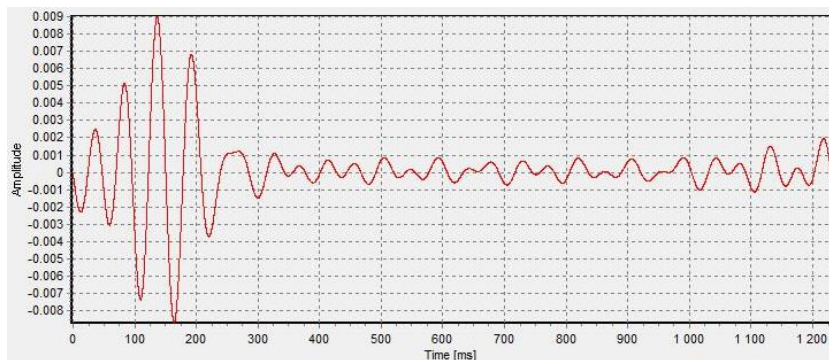


Fig. N-5. Filtered seismic data (the same record as on Fig. N-4).







N.1.1. Filtering seismic data.

The filtering procedures implemented in **SC** software, based on advanced mathematical procedures, allow to cut off any part of spectrum of registered waves.

To select the seismic data for filtering and analysis double click the relevant thumbnail on left margin. Within a while the data are loaded and shown on graph – see Fig. N-6. Upper graph [**Amplitude vs. time**] shows the values of amplitude. Both axes, vertical and horizontal, are linear and have automatically adjusted minimum and maximum according to values of amplitude and time. Time unit (default unit is millisecond) can be modified in **Graphs' Unit / Time** selection pane.

Lower graph shows spectrum of registered wave and generated filters. The horizontal axis – **Frequency** - can be presented in linear scale or logarithmic one. However, the logarithmic scale is strongly recommended for defining filter settings.

To set the filter the following icons, located at the pane in left bottom corner, are used:

-  to add new filter
-  to remove selected filter
-  to apply filter settings to selected data set
-  to cancel filter settings
-  to save filter settings
-  to load filter settings

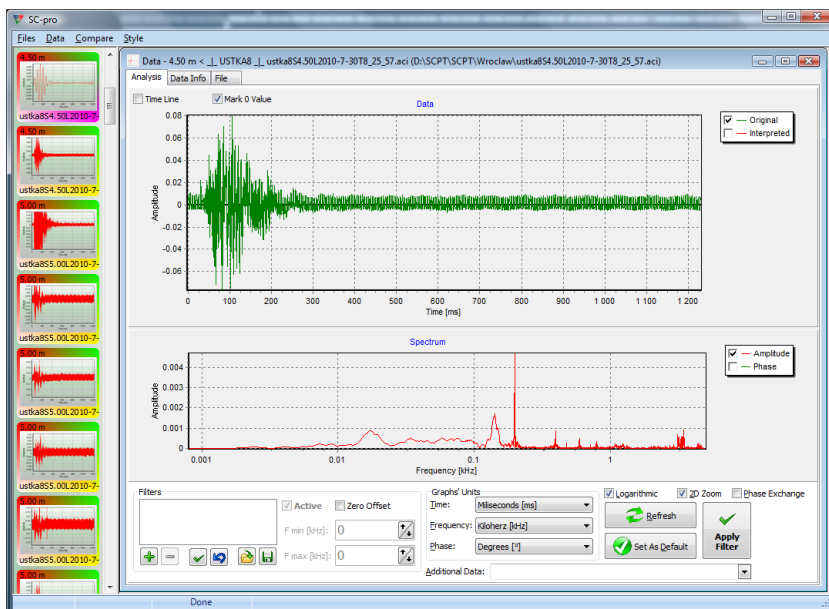



Fig. N-6. Loaded raw seismic data. Amplitude vs. Time on upper graph and spectrum on lower one.

Once you click  icon, the coloured area that represents the filter appears on lower graph. At the same time the filter settings F_{min} and F_{max} i.e. values of minimum and maximum of range are presented in small edition windows next to filter settings icons – see Fig. N-7.

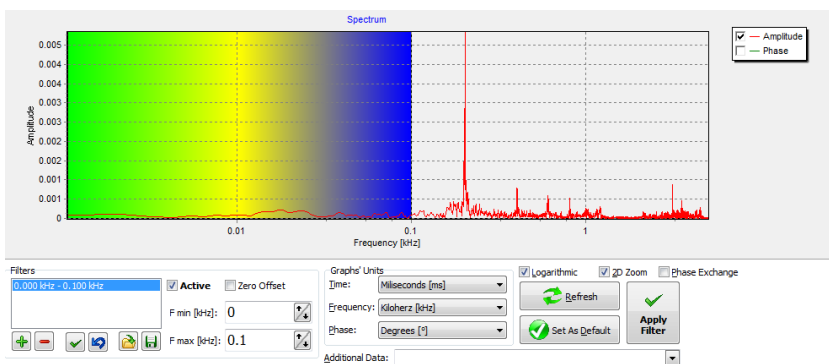



Fig. N-7. Generated filter.

The values of minimum and maximum are set as 0 and 0.1 kHz, however, they can be easily adjusted to required values just by edition of F_{\min} and F_{\max} values or dragging the borders of generated filter area by mouse with left click. To check the result of applied filters click icon  or **[Apply filter]** button.

→ Only active range of frequency (highlighted on Fig. N-8) is used for further analysis and whole range outside of that is omitted.

→ If additional part of spectrum should be considered, the next relevant filter can be generated. The number of filters is unlimited.

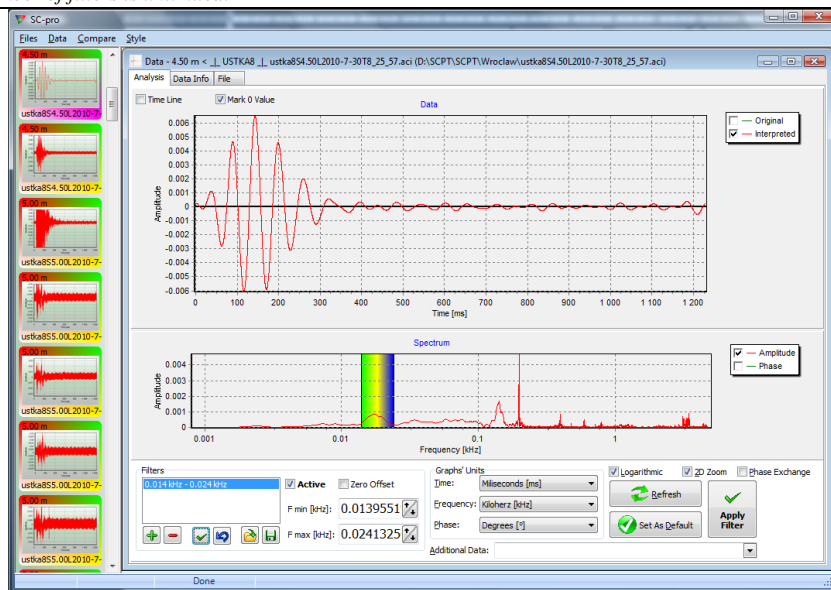



Fig. N-8. Generated and customized filter in bottom pane. Filtered wave in upper one.

To apply the generated filters to all selected data files click **[Set as default]** button. Once you click it, the relevant calculations are executed for all selected data sets and results are shown on thumbnails on left margin.

To save filter settings for further analysis (next holes) click  icon and execute standard Windows operations.

N.1.2. Comparison of waves and determination of velocity.

It may happen that more than few different waves are generated for each depth. That is correct procedure, as sometimes different waves should be considered for different depth ranges. Additionally,

the filters used in field data acquisition software are quite simple and cannot be a base for good selection of waves for further analysis. Though, all recorded waves should be analyzed.

The main goal of analysis of seismic tests is determination of velocity of seismic waves for User defined depth ranges. It is usually done by comparison of waves registered on different depth and determination of difference of time necessary to reach each depth of test by wave.

Usually seismic tests are performed after each half meter. The shorter distance between tests may generate problems in comparison of waves due to very small difference of time. The longer distance makes the description of soil properties too general, however in some circumstances one meter distance may be sufficient.

To start the procedure of comparison of waves and determination the sought difference of time, click the **[Compare]** option in main menu and select **[Compare data]**. **Compare** window (see Fig. N-9) in which files to compare can be selected, consists of four sub-windows marked with relevant bookmarks. The main one - **[Settings]** window - allows to select the waves to compare from scrolled down lists **[Data 1]** and **[Data 2]**. The sequence of files on lists is the same as on thumbnails on left margin, so the selection of files is quite easy.

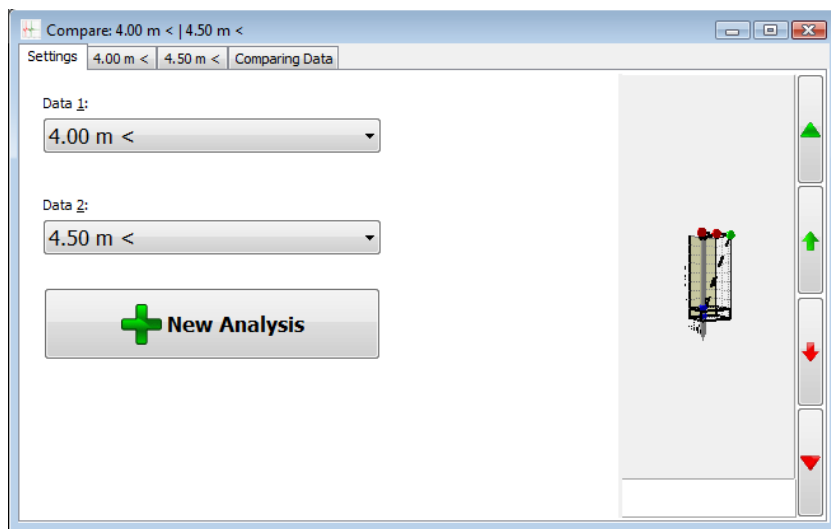



Fig. N-9. [Compare] window.

To select graphs to compare scroll down the lists in **[Data 1]** and **[Data 2]** windows and highlight the relevant ones.

Once the data files are selected you can go directly to **[Comparing data]** bookmark and see the result of comparison (see Fig. N-10). To zoom the selected area use the same procedure as in most of CAD programs i.e. click left mouse button in left upper corner of zoomed area and drag it to its right bottom corner. The result of zooming is shown on Fig. N-11. To move the zoomed area click right button and move it to selected place (see result on Fig. N-13).

The same window is used for determining the difference between time of reaching the **depth 1** and **depth 2**. To do that place the mouse cursor on bottom axis (cursor should change to ) and move the axis in relevant direction to have good overlap of waves – see Fig. N-13. Sometimes the significant difference of amplitude may make comparison difficult. To handle with such problem you can adjust the amplitude of one wave by clicking the green and red arrows on right side.

Once the waves overlap, the time difference appears in [Data shift] window and calculated speed of wave is shown in [Speed] one. To save the result (velocity of wave for selected depth range) click [Register button]. Repeat the same procedure for each depth range and relevant couples of waves. Both selected waves are also shown together on bookmarks marked with the depth of tests.

To go to the next couple of waves click [New Analysis] button. The wave that was considered previously as second one (in **Data 2** window) and selected by acceptance the velocity (=clicking [Register] button) is moved to **Data 1** window. At the same time the next wave from next depth is suggested in **Data 2** one.

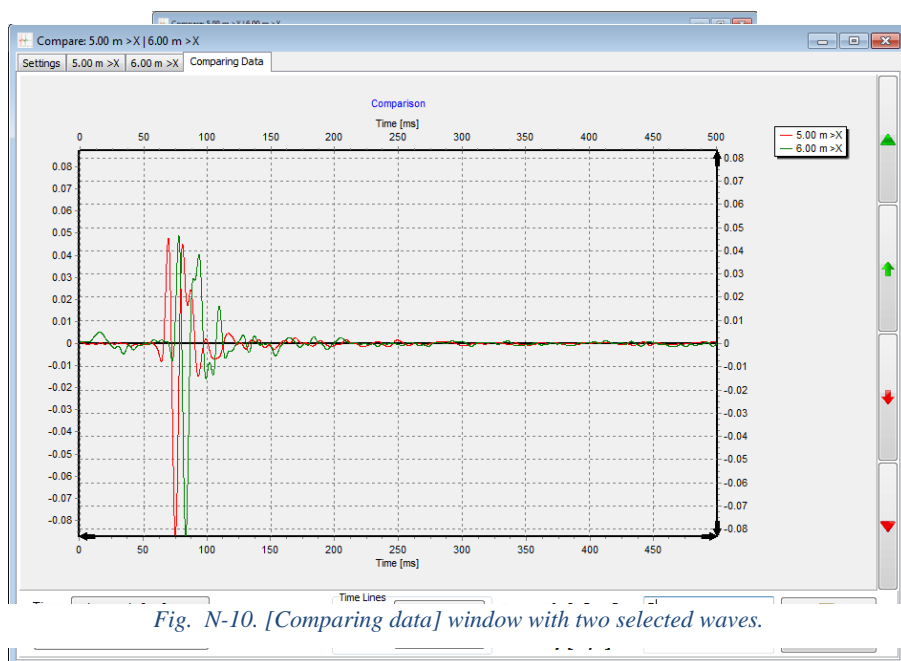


Fig. N-11. [Comparing data] window. Zoom of selected area.

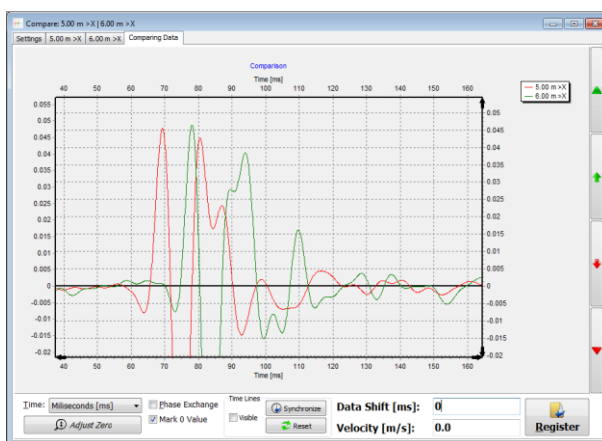


Fig. N-12. [Comparing data] window. Graphs in initial position. Data Shift = 0.

Implemented option [Move] allows to move with right click bottom green graph together with bottom axis to position where characteristic and relevant points of both graphs are overlapped. It is assumed that the “time distance” estimated in this way is equal to time difference between relevant arrival times.

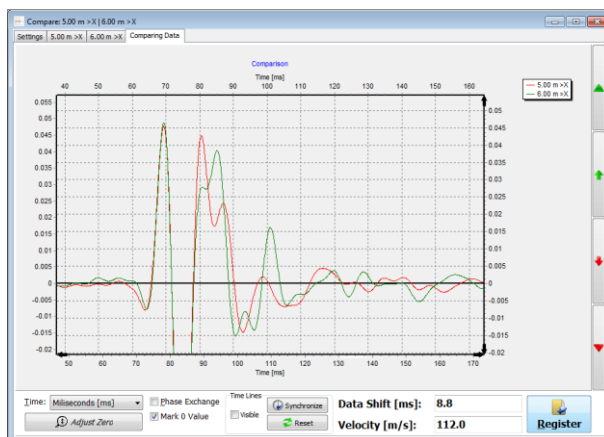


Fig. N-13. [Comparing data] window and overlap of waves.

Using the same **[Move]** procedure you can move bottom axis and relevant (lower) graph to position, where characteristic points of graphs overlap. That gives the difference of time and allows to calculate the velocity of seismic wave between two points where seismic waves were detected. Calculated time difference 8,8 ms and velocity of wave 112.0 m/s are presented in bottom pane. Once the velocity and time difference are accepted, click the **[Register]** button to save them for further analysis.

N.1.3. Results of analysis.

The values of velocity that were accepted and saved by pressing **[Register]** button, may happen that two or more values for some depth ranges, can be graphically presented on chart activated from main menu by clicking **Compare** and **Result** (see Fig. N-14).

All values of velocity that were registered are shown as blue thin lines. To finally select the values of velocity go to **[Analyses]** bookmark (see Fig. N-15), double click selected depth range, scroll down the list of values by clicking black triangle on right and highlight the relevant value. All selected values of velocity are shown in **[Speed view]** window as red thick graph (Fig. N-14).

➔ Values of velocity selected in Analysis window (Fig. 15) can exported to *.SCSPD file and added to *.CPD file for further analysis (only in version 5.57 or higher of CPT-pro). See C.4.3.

All objects shown in **[Speed view]** window i.e. all registered values of velocity (blue lines), finally selected values (red graph) and red points that define red graph can be switched on and off just by checking the checkboxes in legend.

The units of depth and velocity can be freely selected by scrolling down the relevant lists and highlighting the relevant values.

All waves considered in calculations of velocity can be shown together on multi chart graph in **[MultiChart]** bookmark. The selection of waves can be done by checking the checkboxes in legend.

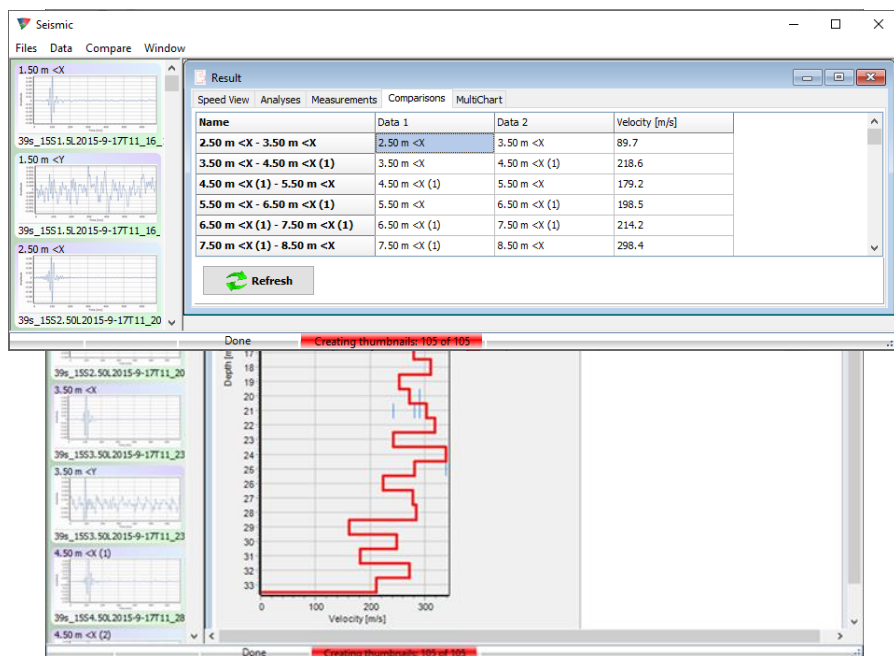


Fig. N-14. Graph of velocity vs. depth.

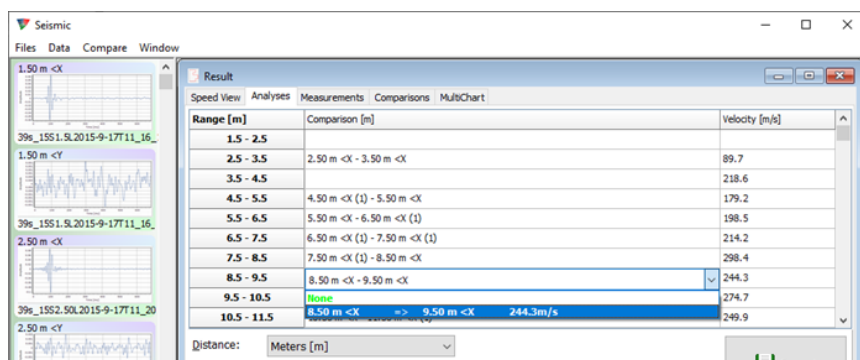


Fig. N-16. [Comparisons] window with final values of wave velocity.

Fig. N-15. Final selection of interpreted velocity.

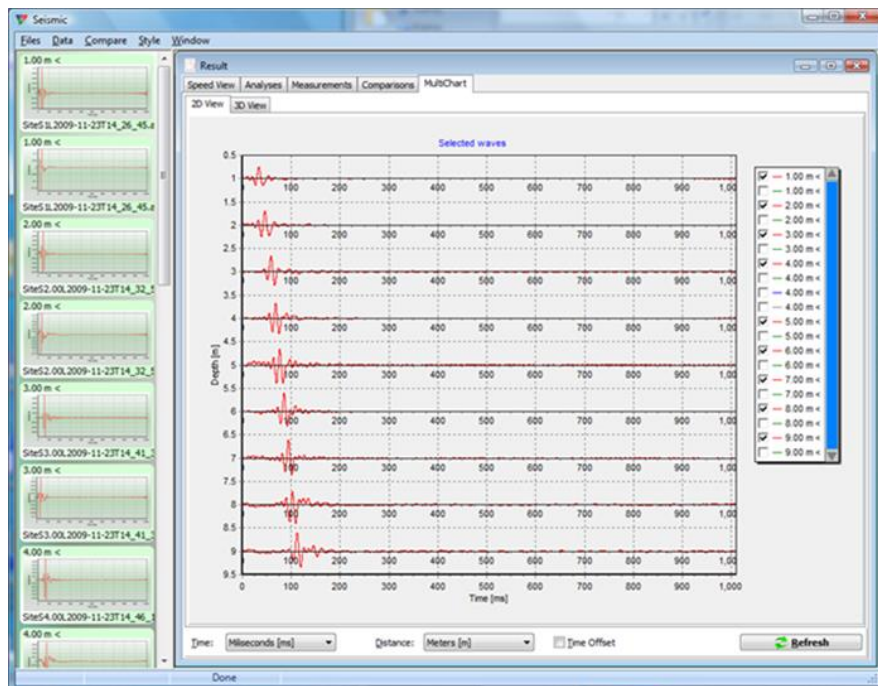


Fig. N-17. Multichart window with seismic waves.

N.2. Reporting.

N.2.1. General description of Log Editor.

The **Log Editor** implemented in **Seismic-pro** software allows User to generate high quality complete reports. It is equipped with number of tools standard for advanced text editors that allows not only to generate graphs with results of seismic analysis but also complete reports with texts formatted in advanced manner.

All functions are included in four bookmarks:

- Main Tools
- Insert
- Page Layout

- View

All functions implemented in **Log Editor** are available just by clicking the relevant button and

Fig. N-18. [Main tools] functions.

work in standard way like in other advanced text editors.

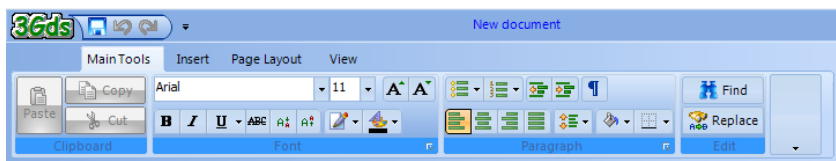
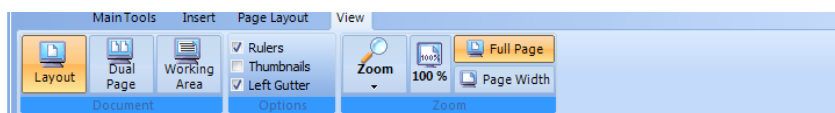


Fig. N-21. [View] functions.



N.2.2. Generation of reports.

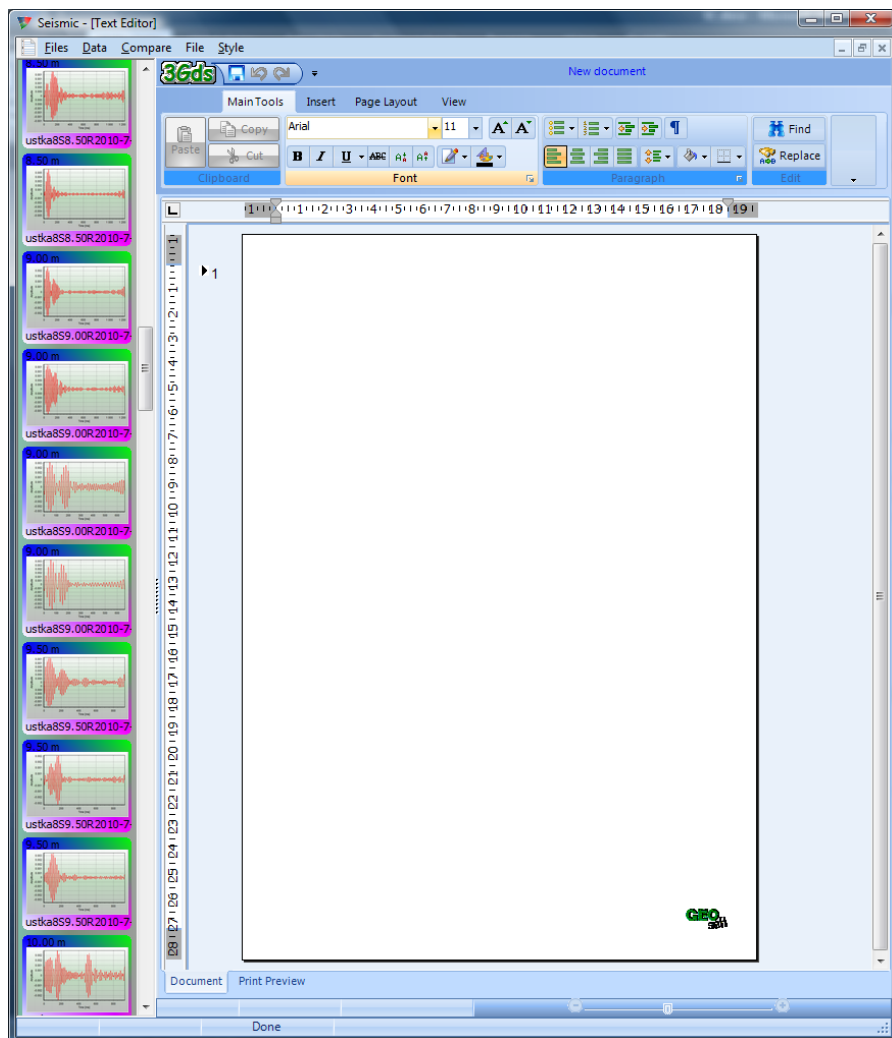


Fig. N-22. Editor window for edition of reports. Full view.

It is assumed that all results of seismic analysis, intermediate and final ones, can be easily included in report, so the **Log Editor** is actually an advanced text editor equipped with a number of additional functions necessary to include results of analysis.

To run **Log Editor** click [**Files**] in main menu and [**Editor**].

N.2.3. Header table.

The standard element of almost all logs is header table that includes general information regarding seismic tests like hole name, date, location, co-ordinates, project name etc. Usually the header table has included logo of contractor and/or some graphic elements.

To generate header table place mouse cursor in relevant row of the page, click left button, go to [**Insert**] bookmark, click [**Table**] button and highlight with left mouse button the relevant area (number of rows and columns). The width of cells can be adjusted just by mouse (with left click). The height is automatically adjusted due to text written in that cell or inserted graphic object.

To combine cells vertically highlight the relevant cells, click right button and select relevant function from menu.

To insert text to cells click in selected one and just type it on keyboard. All standard formatting tools, like font, alignment, color, bold, italic, upper and lower index and many others are available and work like in other text editors.


Test type: Seismic, 3-axial	Complementary tests: CPTU	Date: 2011-04-23	Supervisor: Max Otto von Stirlitz	Hole no.: X-15	
Sensor type: accelerometer	Location: Dark side of the Moon	Co-ordinates: X=2247639.35 Y=3488745.57 Z=8848.23	Drill company: GEOSOFT	Client: Hassling of Elgin	

Fig. N-23. Example of header table.

→ It is recommended to generate “blank” table with logo and all standard texts like “Test type” “Date”, “Hole no.” etc. and save it as 3Gds document (see chapter N.2.6). The same document can be open, filled with texts relevant to presented seismic test and saved with new name. That operation allows to save time in process of generating next reports and use “template” of header table many times.

N.2.4. Graphs.

All graphs generated in seismic analysis, concerning the selected waves and final ones, can be easily included in report. To copy graph to report just click right button outside of chart below the legend and click appeared [**Copy Graph**] button. To paste graph in log click left button to select row on page of log, click right button and finally click [**Paste Graph**] option in context menu.

→ Only the [**Paste Graph**] option inserts selected graph in log. The option [**Paste**] is used exactly like [**CTRL + V**] to insert texts or graphics copied previously.

All graphs are inserted in log not as a simple graphics but as a complete graphs with many customizable attributes. To customize graph click right button on graph and select the option **Edit Graph** from menu (see Fig. N-24).

The size of graphs can be easily adjusted with mouse just by clicking it and moving one of black squares on border of graph (**Fig. O-26**), exactly in the same way like adjusting the size of graphics in text editors. Additionally, graphs that have structure [**Depth vs. value**] can be presented in vertical scale of type **1:X**. To set that scale click [**Scale**] option (**Fig. O-25**) and follow instructions next to that figure.

The main attributes of graphs can be customized by clicking the option [**Edit Graph**] – see Fig. N-27.

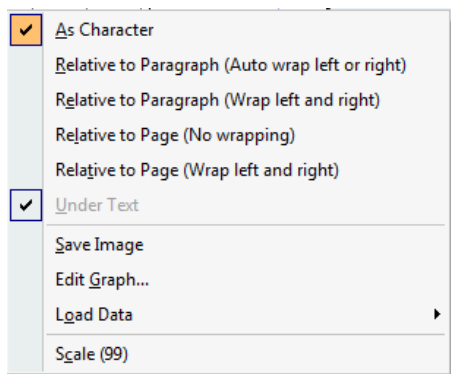


Fig. N-24. Graph customizing menu (the [Load Data] function is reserved for future applications). The lower option [Scale] is visible only when graph has structure [Depth vs. value]. In case of all other graphs that option does not appear.

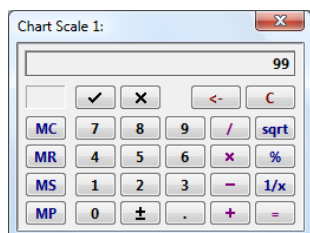


Fig. N-25. Scale setting option. To set the vertical scale just type it and accept by clicking ☒ button.

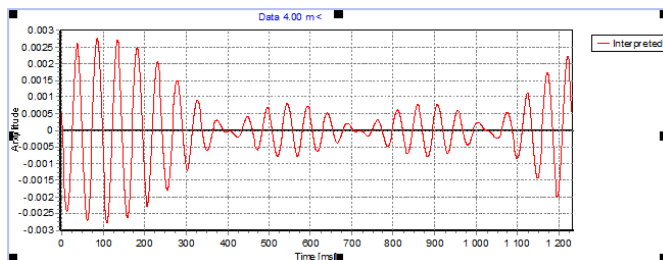


Fig. N-26. Selected graph with black square points used to set the size of graph by mouse like size of graphics in MS Word editor.

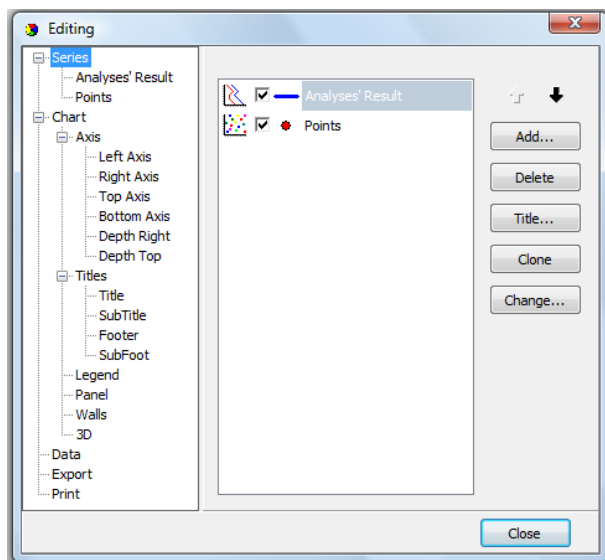


Fig. N-27. Graph editing window.

All functions are gathered in few groups. The commonly used are options related to graph lines (color, thickness) available after highlighting the relevant series name (*Analyses Result* on example on left) and options related to axis like scales, ranges, ticks, grids etc. available after highlighting [*Left Axis*] and [*Bottom Axis*] options.

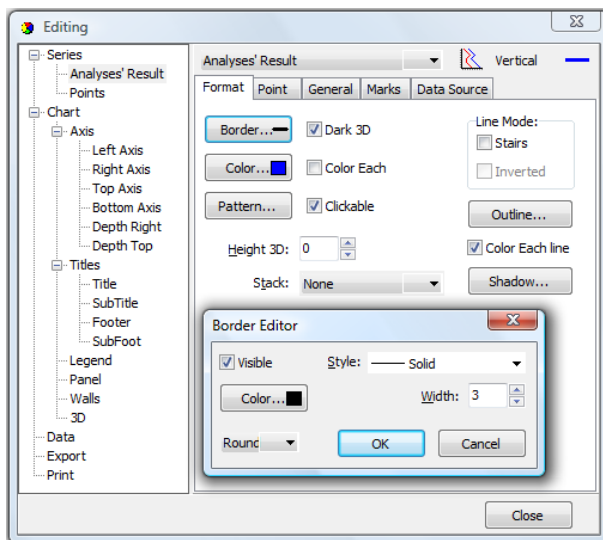


Fig. N-28. Graph line settings options with open Border Editor.

The thickness of line is available as [**Width**] after clicking [**Border**] button. The color of line can be edited by clicking [**Color**] button and selection from standard color matrix.

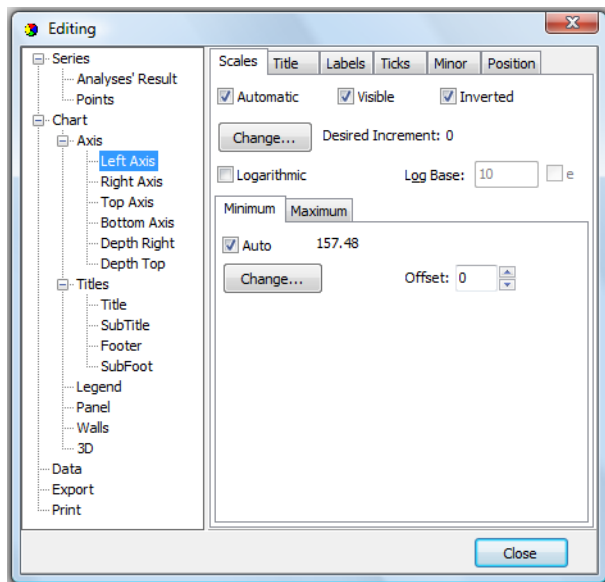


Fig. N-29. Left axis attribute settings window with open [Scales] bookmark.

The minimum and maximum are defined usually automatically due to minimum and maximum of values. To change it select the relevant bookmark ([*Minimum*] or [*Maximum*]), uncheck [*Auto*] checkbox, click [*Change*] button and set relevant values.

Exactly the same procedure can be applied to each other axis.

NOTE. The left axis is the same as vertical axis, the bottom one is equal to horizontal axis.

In the same window the titles, ticks and grids can be customized.

N.2.5. Texts.

The **Log Editor** has implemented a number of advanced editing functions that allow to generate high quality reports. All standard editing functions like:

- Font type
- Font size
- Font color
- Upper and bottom index
- Alignment
- Spacing
- Frames
- Bold, italics and underline
- Columns
- Header and footer
- And many others

are available and work like in other advanced text editors (see Fig. N-18, Fig. N-19, Fig. N-20 and Fig. N-21). Additionally, there are included such options like [*Shapes*] including lines, arrows, block arrows and simple shapes. The implemented *Copy/Paste* and *Insert* functions allows to include any graphics and *Symbol* in edited text.

Thus, **Log editor** can be used not only to generate logs of seismic soundings but also all standard text documents.

N.2.6. Saving of reports.

All reports and logs generated in **Log Editor** can be saved as a fully editable files of **3Gds** format as well as text formats DOC, RTF and PDF.

Files saved in 3Gds format can be fully edited, including edition and customizing all inserted graphs, however, the files saved in DOC, RTF and PDF formats can only text have editable. All included graphs are treated just as a graphics and only size can be modified.

Printing option uses standard Windows procedure, so all printers that can be installed under Windows system can be used.

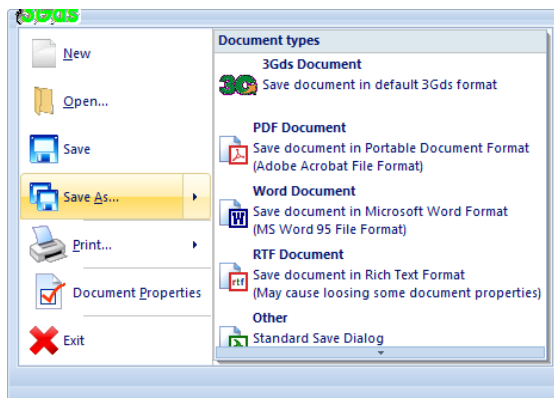


Fig. N-30. Saving options.

N.3. Saving of projects.

As analysis of All selection settings, selected files, interpretation settings, interpretation results and report (partial or completed) that concern all SCPT tests conducted in selected hole, can be saved in **Projects**. The main purposes of that function are:

1. Possibility of stopping analysis any time and continuing after loading the project (complete analysis of all tests in considered hole may take several hours or days).
2. Saving complete analysis to come back for next investigations.

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16. Robertson, P.K.

Cone penetration test (CPT)-based soil behavior type (SBT) classification system – an update.

Canadian Geotechnical Journal. 2016.

17. Robertson, P.K., Cabal, K.L.

Estimating soil unit weight from CPT.

Gregg Drilling & Testing Inc., Signal Hill, California, USA.

18. Schneider H.R.

Definition and determination of characteristic soil properties..

Proceedings XII International Conference on Soil Mechanics and Geotechnical Engineering.
Hamburg, Balkema, Rotterdam. 1997.

P. INTERPRETATION METHODS.

P.1. 1st order interpretation methods.

P.1.1. Soil classification method based on R_f and q_t . Robertson 1986.

Source paper.

Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J.

Use of piezometer cone data.

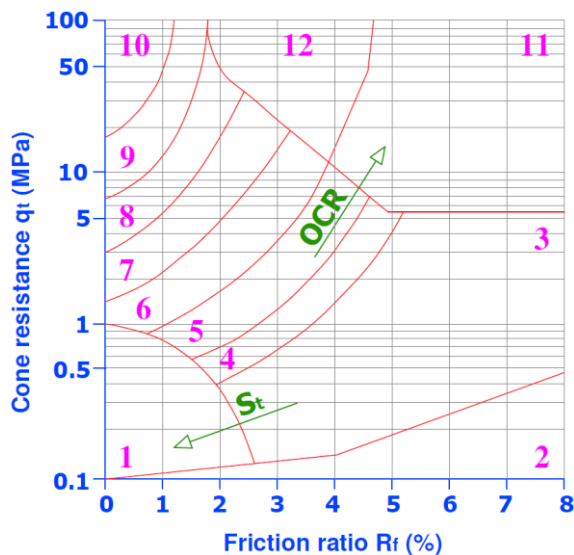
Proceedings of the *ASCE Specialty Conference In Situ '86: Use of In Situ Tests in Geotechnical Engineering*. ASCE. 1986.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.



Classification system from CPTU data (quoted after Lunne, Robertson and Powell, 1997).

Zone	Soil Behavior Type	Zone	Soil Behavior Type
1	Sensitive fine grained	7	Silty sand to sandy silt
2	Organic material	8	Sand to silty sand
3	Clay	9	Sand
4	Silty clay to clay	10	Gravelly sand to sand
5	Clayey silt to silty clay	11	Very stiff fine grained *
6	Sandy silt to clayey silt	12	Sand to clayey sand *

* Overconsolidated or cemented.

P.1.2. Soil classification method based on Q_t and F_r . Robertson 1990.

Source paper.

Robertson, P.K.

Soil classification using the cone penetration test.

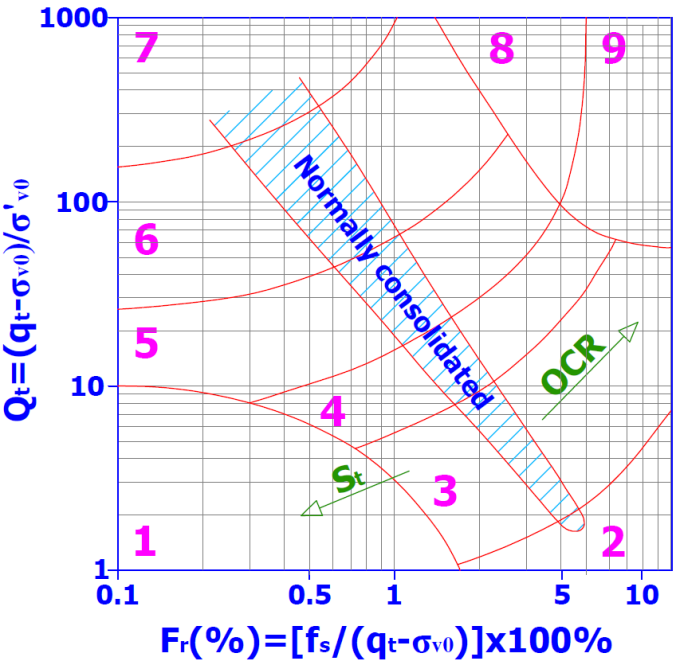
Canadian Geotechnical Journal. 1990.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.



Classification system
from CPTU data
(quoted after Lunne,
Robertson and
Powell, 1997).

Zone	Soil Behavior Type	Zone	Soil Behavior Type
1	Sensitive, fine grained	6	Sands; clean sand to silty sand
2	Organic soils-peats	7	Gravely sand to sand
3	Clays; clay to silty clay	8	Very stiff sand to clayey sand
4	Silt mixtures; clayey silt to silty clay	9	Very stiff fine grained
5	Sand mixtures; silty sand to sandy silt		

P.1.3. Soil classification method based on B_q and q_t . Robertson 1986.

Source paper.

Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J.

Use of piezometer cone data.

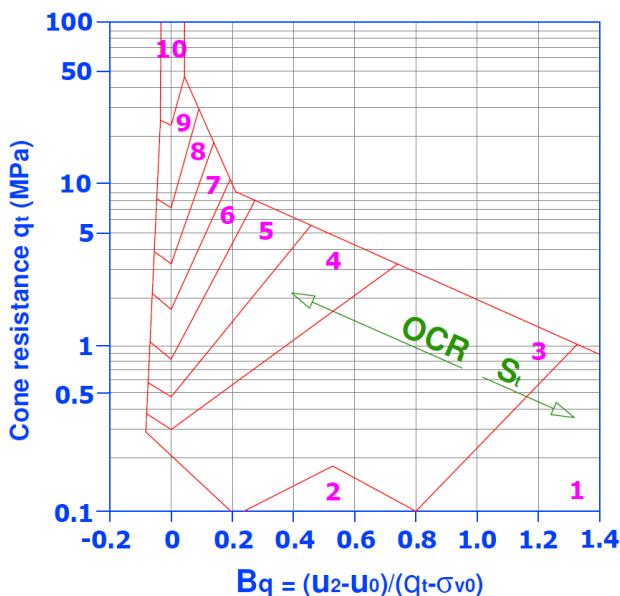
Proceedings of the *ASCE Specialty Conference In Situ '86: Use of In Situ Tests in Geotechnical Engineering*. ASCE. 1986.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.



Classification system from CPTU data (quoted after Lunne, Robertson and Powell, 1997).

Zone	Soil Behavior Type	Zone	Soil Behavior Type
1	Sensitive fine grained	7	Silty sand to silty clay
2	Organic material	8	Sand to silty sand
3	Clay	9	Sand
4	Silty clay to clay	10	Gravely sand to sand
5	Clayey silt to silty clay	11	Very stiff fine grained *
6	Sandy silt to clayey silt	12	Sand to clayey sand *

* Overconsolidated or cemented

P.1.4. Soil classification method based on Q_t and B_q . Robertson 1990.

Source paper.

Robertson, P.K.

Soil classification using the cone penetration test.

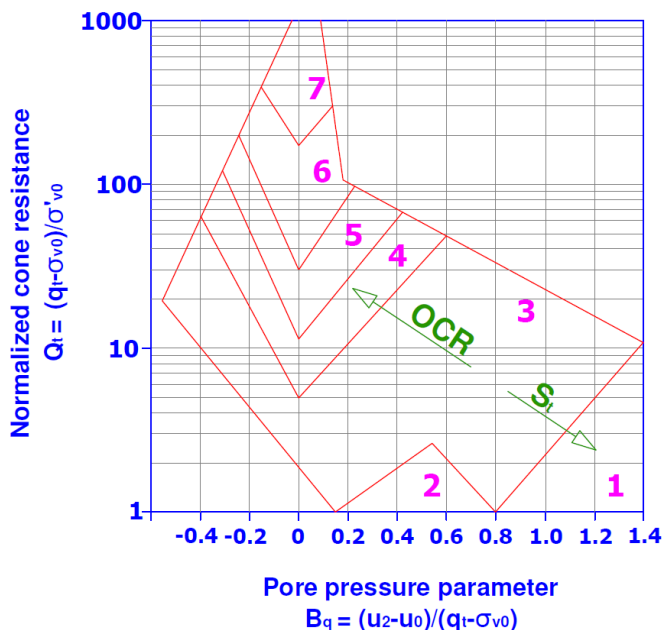
Canadian Geotechnical Journal. 1990.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.



Classification system from CPTU data (quoted after Lunne, Robertson and Powell, 1997).

Zone	Soil Behavior Type	Zone	Soil Behavior Type
1	Sensitive, fine grained	6	Sands; clean sand to silty sand
2	Organic soils-peats	7	Gravely sand to sand
3	Clays; clay to silty clay	8	Very stiff sand to clayey sand
4	Silt mixtures; clayey silt to silty clay	9	Very stiff fine grained
5	Sand mixtures; silty sand to sandy silt		

P.1.5. Soil classification method by Robertson 2010. Dimensionless SBT chart.

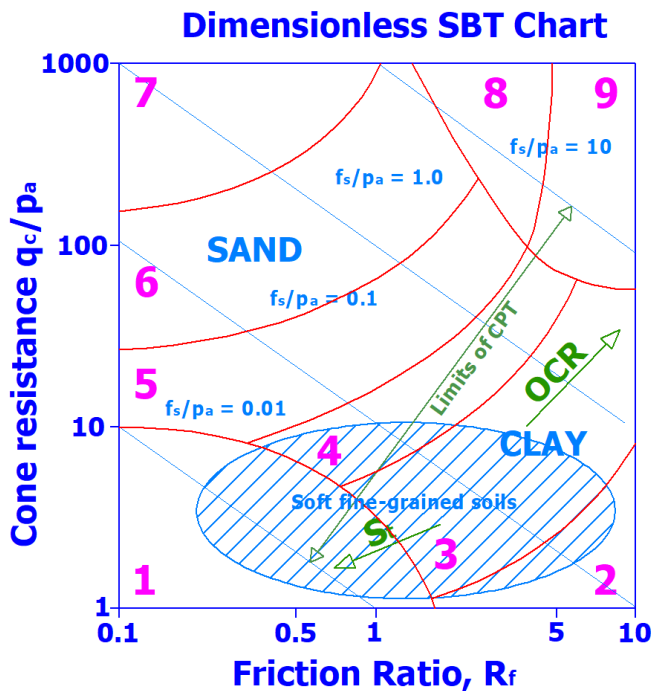
Source paper.

Robertson, P.K.

Soil behavior type from the CPT: an update.

2nd International Symposium on Cone Penetration Testing, CPT'10.

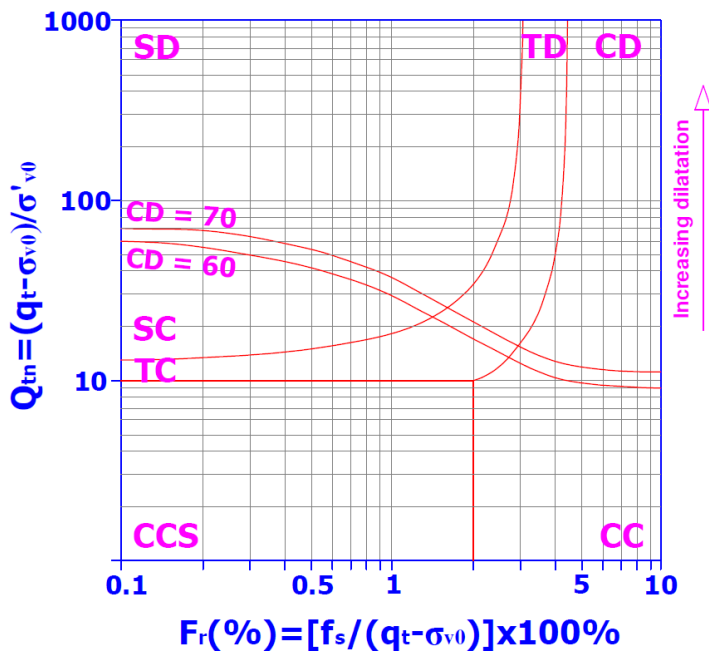
Huntington Beach, CA, USA.



Zone	Soil Behavior Type (SBT)	Zone	Soil Behavior Type (SBT)
1	Sensitive, fine grained	6	Sands; clean sands to silty sands
2	Clay – organic soil	7	Dense sand to gravelly sand
3	Clays; clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures; clayey silt to silty clay	9	Stiff fine grained
5	Sand mixtures; silty sand to sandy silt		

Robertson, P.K.

Canadian Geotechnical Journal. 2016.



- 1: CCS Clay-like - Contractive-Sensitive
- 2: CC Clay-like - Contractive
- 3: CD Clay-like - Dilative
- 4: TC Transitional - Contractive
- 5: TD Transitional - Dilative
- 6: SC Sand-like - Contractive
- 7: SD Sand-like - Dilative

$$CD = (Q_{tn} - 11)(1 + 0.06F_r)^{17}$$

$$I_B = \frac{100(Q_{tn} + 10)}{70 + Q_{tn} + F_r}$$

P.1.7. Soil classification method by Polish Norm PN-B-04452:2002.

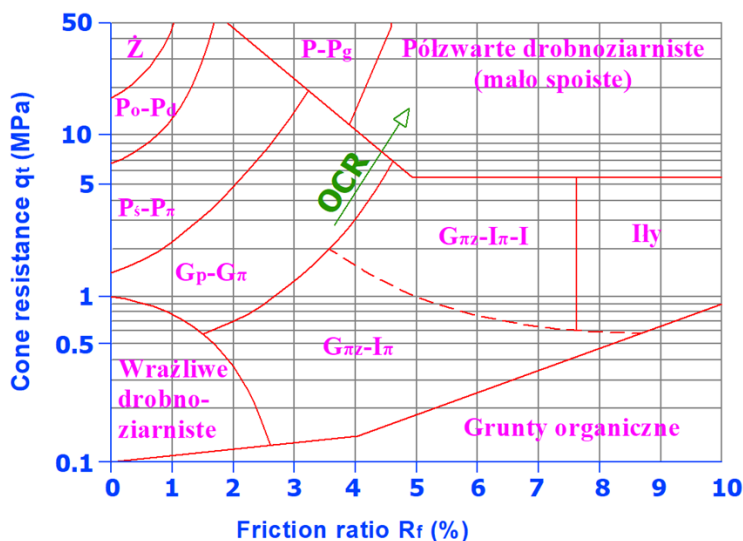
Polska Norma PN-B-04452:2002.

Adaptacja nomogramu P.K. Robertsona (1986) na podstawie:

Młynarek, Z., Tschusche W., Wierzbicki J.

Klasyfikacja gruntów podłoża budowlanego metodą statycznego sondowania.

XI Krajowa Konferencja Mechaniki Gruntów i Fundamentowania. Geotechnika w budownictwie i transporcie. PG Gdańsk, 1997.



P.1.8. Soil classification method by Eurocode 7, German implementation.

Also quoted in:

Karl Josef Witt

Grundbau-Taschenbuch. Teil 1: Geotechnische Grundlagen.

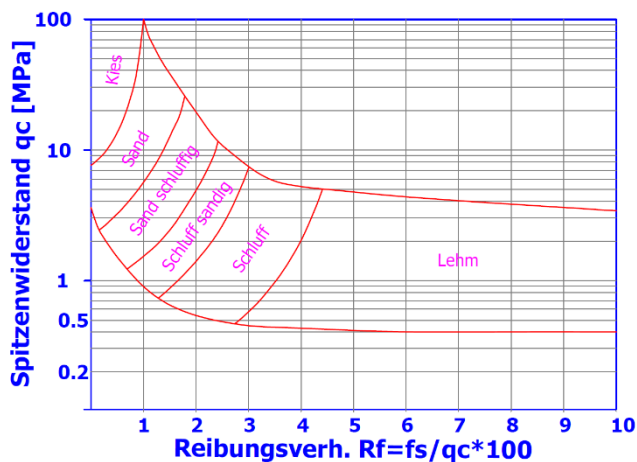
Ernst & Sohn (2008).

Dr.-Ing. Bernd Schuppener

Eurocode 7 – Geotechnical design – Part 2 Ground investigation and testing

Federal Waterways Engineering and Research Institute, Karlsruhe, Germany

Classification system from CPTU data.

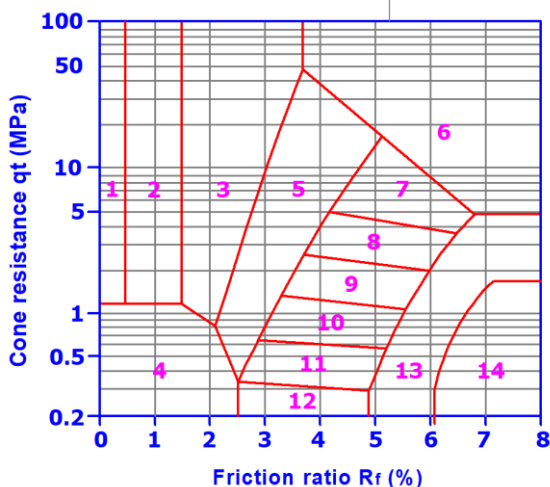


P.1.9. Soil classification method based on British adaptation of classification system of Meigh (1987).

Source paper: Meigh, A.C., *Cone Penetration Testing - Methods and Interpretation*
CIRIA, Butterworths, 1987

Quoted in:

CONE PENETRATION TESTING (CPT). *"Simplified Description of the Use and Design Methods for CPTs in Ground Engineering"*. FUGRO, 2004.



Zone	Soil Behavior Type	Unit weight [kN/m ³]	Zone	Soil Behavior Type	Unit weight [kN/m ³]
1	Coarse grained SAND	20	8	Insensitive, inorganic VERY STIFF CLAY	18
2	SAND	19.5	9	Insensitive, inorganic STIFF CLAY	18
3	Silty SAND	19	10	Insensitive, inorganic FIRM CLAY	17.5
4	Very silty SAND	18.5	11	Insensitive, inorganic SOFT CLAY	17.5
5	Sandy CLAY	18	12	Insensitive, inorganic VERY SOFT CLAY	17.5
6	Clay, Silt & Sand MIXTURES	18	13	ORGANIC CLAY	15
7	Insensitive, inorganic HARD CLAY	18	14	PEAT	12.5

P.1.10. Soil classification method by Senneset & Janbu.

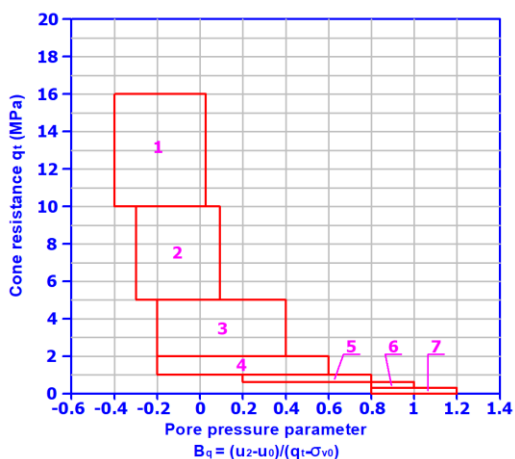
Source paper: Senneset K., Janbu N. (1985), STP 883, ASTM, Philadelphia, 41-54.

Also quoted in:

Chaney K., Demars R.

Strength testing of marine sediments: laboratory and in-situ measurements ...

American Society for Testing and Materials, 1985.



Zone	Soil Behavior Type	Zone	Soil Behavior Type
1	Hard stiff soil (OC)	5	Fine SILT, medium CLAY
2	Dense SAND	6	Soft CLAY
3	Loose SAND	7	Very soft CLAY
4	Stiff CLAY		

P.2. IInd order interpretation methods.

P.2.1. Relative Density ID in normally consolidated, relatively evengraded sands.

Source paper.

Lancelotta, R. (1983).

Analisi di Affidabilità in Ingegneria Geotecnica.

Atti Istituto Scienza Costruzioni. No. 125. Politecnico di Torino.

Also quoted in:

Larsson, R. (1985).

The CPT test. Equipment – testing – evaluation. An in situ method for determination of stratigraphy and properties in soil profiles.

Swedish Geotechnical Institute. Information 15E.

Formula (quoted after Larsson, 1995) :

$$I_D = -131 + 66 * \log_{10} \frac{q_T}{(\sigma'_{v0})^{0.5}}, (\%)$$

P.2.2. Coefficient of lateral stresses K_0 in fine-grained soils.

Source paper.

Kulhawy, F.H., Mayne, P.H. (1990).

Manual on estimating soil properties for foundation design.

Electric Power Research Institute, 1990.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.

Formula (quoted after Lunne, Robertson and Powell, 1997) :

$$K_0 = 0.1 * \left(\frac{q_t - \sigma_{v0}}{\sigma'_{v0}} \right)$$

P.2.3. Coefficient of lateral stress K_0 in coarse-grained soils.

Source paper.

Mayne, P. (1992).

Tentative method for estimating σ_{h0} from qc data in sands.

Proceedings of the International Symposium on Calibration Chamber Testing, Potsdam, New York, 1991.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.

Formula (quoted after Lunne, Robertson and Powell, 1997) :

$$K_0 = 0.35 * OCR^{0.65}$$

P.2.4. Undrained shear strength s_u in normally consolidated marine clays.

Source paper.

Lunne, T., Kleven, A. (1981).

Role of CPT in North Sea foundation engineering.

Session at the ASCE National Convention: Cone Penetration Testing and Materials, S. Louis. ASCE.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.

Formula (quoted after Lunne, Robertson and Powell, 1997) :

$$s_u = \frac{q_c - \sigma_{v0}}{N_k}$$

➔ Cone factor N_k varies between 11 and 19 with an average value 15 (Lunne, Kleven. 1981).

Kjekstad (1978) obtained average value $N_k=17$ for non-fissured overconsolidated clays (quoted after Lunne, T., Robertson P.K. and Powell J.J.M. 1997).

P.2.5. Constrained Modulus M_0 in normally consolidated sands.

Source paper.

Lunne T., Christoffersen H.P. (1985).

Interpretation of Cone Penetrometer Data for Offshore Sands.

Norwegian Geotechnical Institute, 1985. Publication No. 156.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.

Formula (quoted after Lunne, Robertson and Powell, 1997) :

$M_0 = 4 q_c$	for	$q_c < 10 \text{ MPa}$
$M_0 = 2 q_c + 20 \text{ (MPa)}$	for	$10 \text{ MPa} < q_c < 50 \text{ MPa}$
$M_0 = 120 \text{ MPa}$	for	$50 \text{ MPa} < q_c$

P.2.6. Relative Density I_D in normally consolidated, uncemented sands.

Source paper.

Jamiolkowski, M. et al. (1985).

New developments in field and laboratory testing of soils.

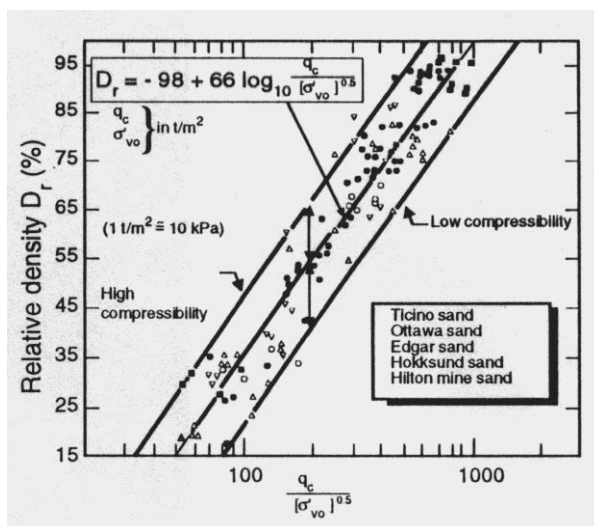
State of the art report. Proc. Of the 11th International Conference On Soil Mechanics and Foundation Engineering. A.A. Balkema.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.



Formula:

$$I_D = -98 + 66 * \log_{10} \frac{q_c}{(\sigma'_{v0})^{0.5}}, (%)$$

Drawing and formula quoted after Lunne, Robertson and Powell, 1997.

P.2.7. Constrained Modulus M in fine-grained soils.

Source paper.

Kulhawy, F.H., Mayne, P.H. (1990).

Manual on estimating soil properties for foundation design.

Electric Power Research Institute, 1990.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.

Formula (quoted after Lunne, Robertson and Powell, 1997) :

$$M = 8.25 * (q_t - \sigma_{v0})$$

P.2.8. SPT Energy Ratio N_{60} .

Source paper.

Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig J. (1986).

Use of piezometer cone data.

Proc. of the ASCE Speciality Conference In Situ '86: Use of In Situ Tests in Geotechnical Engineering. ASCE.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.

➔ According to Lunne, Robertson and Powell suggestion, for fine grained soil correlation SPT-CPT is applied to q_t and for coarse-grained soil correlation is applied to q_c .

Soil classification and SPT Energy Ratios. (after Lunne, Robertson and Powell 1997).

Zone	Soil behavior type (after Robertson 1986)	$(q_t/p_a)/N_{60}$	Zone	Soil behavior type (after Robertson 1986)	$(q_t/p_a)/N_{60}$
1	Sensitive, fine grained	2.0	7	Silty sand to sandy silt	3.0
2	Organic material	1.0	8	Sand to silty sand	4.0
3	Clay	1.0	9	Sand	5.0
4	Silty clay to clay	1.5	10	Gravelly sand to sand	6.0
5	Clayey silt to silty clay	2.0	11	Very stiff fine grained	1.0
6	Sandy silt to clayey silt	2.5	12	Sand to clayey sand	2.0

p_a – reference stress of 100 kPa.

P.2.9. Effective friction angle Φ' in sands (Robertson, Campanella).

Source paper.

Robertson, P.K., Campanella, R.G. (1983).

Interpretation of cone penetrometer test: Part I: Sand.

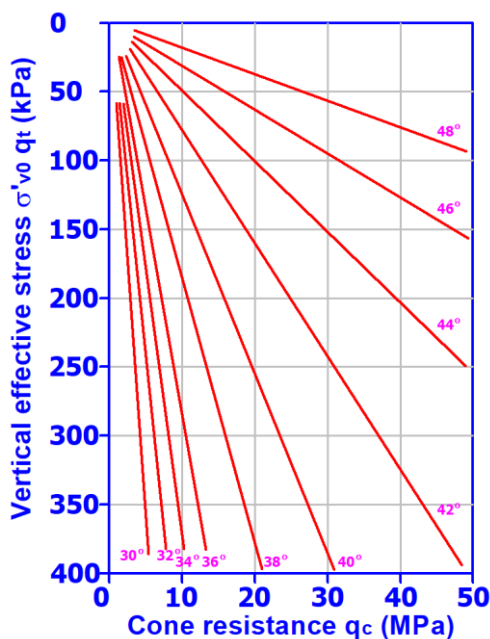
Canadian Geotechnical Journal, 20(4).

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.



Relationship between σ'_{vo} , q_c and Φ' in uncemented, moderately incompressible, predominately silica sands.

Quoted after Lunne, Robertson and Powell, 1997.

P.2.10. Undrained shear strength s_u in fine-grained soils.

Source paper.

Rolf Larsson

The CPT test. Equipment – testing – evaluation. Information 15E.

Swedish Geotechnical Institute, 1995.

Formula (quoted after Larsson) :

$$s_u = \frac{q_T - \sigma_{v0}}{13.4 + 6.65W_L}$$

W_L – liquid limit

P.2.11. Overconsolidation ratio OCR.

Source paper.

Mayne P.W. (1991).

Determination of OCR in clays by piezocone tests using cavity expansion and critical state concepts.

Soils and Foundations, 31(2).

Also quoted in

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.

Formula (quoted after Lunne, Robertson and Powell, 1997) :

$$OCR = k \frac{q_t - \sigma_{v0}}{\sigma'_{v0}}$$

with an average value of $k = 0.3$ with a range of 0.2 to 0.5.

Higher values of k are recommended in aged heavily overconsolidated clays (Powel, 1988 – quoted after Lunne *et al.*).

P.2.12. Overconsolidation ratio OCR.

Source paper.

Rolf Larsson

The CPT test. Equipment – testing – evaluation. Information 15E.

Swedish Geotechnical Institute, 1995.

Formula (quoted after Larsson) :

$$\log OCR = 0.167 \frac{q_T - u_2}{\sigma'_{v0} (5.0W_L - 0.6)} - 0.05$$

W_L – liquid limit

P.2.13. Overconsolidation ratio OCR.

Source paper.

Sully J.P., Campanella R.G., Robertson P.K. (1988)

Overconsolidation ratio of clays from penetration pore water pressures.

Journal of Geotechnical Engineering, ASCE, 114(2)

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.

Formula (quoted after Lunne, Robertson and Powell, 1997) :

$$OCR = 0.66 + 1.43 \frac{u_1 - u_2}{u_0}$$

Where u_1 is pore pressure measured on tip of cone.

P.2.14. Overconsolidation pressure σ'_c .

Source paper.

Rolf Larsson

The CPT test. Equipment – testing – evaluation. Information 15E.

Swedish Geotechnical Institute, 1995.

Formula (quoted after Larsson) :

$$\log OCR = 0.167 \frac{q_T - u_2}{\sigma'_{v0} (5.0W_L - 0.6)} - 0.05$$

$$\sigma'_c = OCR * \sigma'_{v0}$$

W_L – liquid limit

P.2.15. Overconsolidation Pressure based on PPD ($= (u_1 - u_2)/u_0$).

Source paper.

Sully J.P., Campanella R.G., Robertson P.K. (1988)

Overconsolidation ratio of clays from penetration pore water pressures.

Journal of Geotechnical Engineering, ASCE, 114(2)

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.

Formula (quoted after Lunne, Robertson and Powell, 1997) :

$$OCR = 0.66 + 1.43 \frac{u_1 - u_2}{u_0}$$

$$\sigma'_c = OCR * \sigma'_{v0}$$

P.2.16. Soil Density and Strength Descriptive Terms. British Standard.

Source paper.

British Standard BS 5930:1999. Code of practice for investigation.

Section 6. Paragraph 41.3.2.

P.2.17. Soil Density and Soil Strength Descriptive Terms. New Zealand and Australian Standards.

Source paper.

Field Description of Soil and Rock.

NZ Geotechnical Society, Inc. December 2005

and

Australian Standard AS1726:1993

Descriptive Term	Undrained Shear Strength (kPa)	Diagnostic Features
Very soft	< 12	Easily exudes between fingers when squeezed
Soft	12 – 25	Easily indented by fingers
Firm	25 – 50	Indented by strong finger pressure and can be indented by thumb pressure
Stiff	50 – 100	Cannot be indented by thumb pressure
Very stiff	100 – 200	Can be indented by thumb nail
Hard	200 –	Difficult to indent by thumb nail

NOTE. *NZ Standard* defines range S_u at **200 – 500** for *Hard* soils, whereas *Australian AS1726:1993* at **> 200**.

Descriptive Term	Density Index I_D
Very dense	> 85
Dense	65 – 85
Medium dense	35 – 65
Loose	15 – 35
Very loose	< 15

P.2.18. Soil behavior type index I_c .

Source paper:

Robertson P.K. (1990).

Soil classification using the cone penetration test.

Canadian Geotechnical Journal.

Also quoted in:

Lunne, T., Robertson P.K. and Powell J.J.M. (1997).

Cone Penetration Testing in Geotechnical Practice.

Blackie Academic & Professional.

$$I_c = ((3.47 - \log Q_t)^2 + (\log F_r + 1.22)^2)^{0.5}$$

Where:

Q_t is the normalized cone penetration resistance, dimensionless

F_r is the normalized friction ratio, in percent

P.2.19. Young's Modulus E_0 .

$$E_0 = 2 \rho V_s^2 (1+\nu)$$

Where:

V_s - *S wave* velocity

ρ - mass density of soil

ν - Poisson's ratio

P.2.20. Initial Shear Modulus G_0 .

$$G_0 = \rho V_s^2$$

Where:

V_s - *S wave* velocity

ρ - mass density of soil

P.2.21. Oedometric constrained modulus M_0

Source – **Elasticity Theory**

$$M_0 = \rho V_p^2$$

Where:

V_p - *P wave* velocity

ρ - mass density of soil

P.2.22. Poisson's ratio

Source – **Elasticity Theory**

$$\nu = \frac{k^2 - 2}{2k^2 - 2}$$

Where:

$$k = \left(\frac{V_p}{V_s} \right)^2$$

V_p - *P wave* velocity

V_s - *S wave* velocity

P.2.23. Normalized cone parameter Q_{tn} to evaluate soil liquefaction.

Source papers:

Robertson, P.K. and Wride, C.E., (1998).

Evaluating cyclic liquefaction potential using the cone penetration test.
Canadian Geotechnical Journal.

Jefferies, M.G. and Been, K., (2006).

Soil Liquefaction – A critical state approach.
Taylor & Francis, ISBN 0-419-16170-8.

Robertson, P.K., (2009).

CPT interpretation – a unified approach.
Canadian Geotechnical Journal.

Robertson, P.K., (2010).

Estimating in-situ state parameter and friction angle in sandy soils from CPT.
2nd International Symposium on Cone Penetration Testing, Huntington Beach, CA, USA,
May 2010

Q_{tn} = normalized cone parameter to evaluate soil liquefaction (for clean sands)

$Q_{tn,cs}$ = normalized cone parameter to evaluate soil liquefaction for silty sands corrected to equivalent clean sand value

I_c = Soil Behavior Type (SBT)

n = stress exponent that varies with SBT (Robertson and Wride, 1998)

$$n = 0.381 (I_c) + 0.05 (\sigma'_{v0}/p_a) - 0.15$$

K_c = correction factor that is a function of grain characteristics (combined influence of fines content, mineralogy and plasticity) of the soil

$$\text{if } I_c \leq 1.64 \quad K_c = 1.0$$

$$\text{if } I_c > 1.64 \quad K_c = 0.403 I_c^4 - 5.581 I_c^3 - 21.63 I_c^2 + 33.75 I_c - 17.88$$

$$(1) \quad Q_{tn} = [(q_t - \sigma_{v0})/p_a] (p_a/\sigma'_{v0})^n$$

$$(2) \quad Q_{tn,cs} = K_c Q_{tn}$$

P.2.24. State parameter Ψ .

Source paper:

Robertson, P.K., (2010).

Estimating in-situ state parameter and friction angle in sandy soils from CPT.

2nd International Symposium on Cone Penetration Testing, Huntington Beach, CA, USA, May 2010

$Q_{tn,cs}$ = normalized cone parameter to evaluate soil liquefaction for silty sands corrected to equivalent clean sand value, calculated as in P.2.23.

Ψ = the state parameter defined as difference between current void ratio and the void ratio at critical state at the same mean effective stress.

$$\Psi = 0.56 - 0.33 \log Q_{tn,cs}$$

P.2.25. Peak friction angle Φ for sands.

Source paper:

Jefferies, M.G. and Been, K., (2006).

Soil Liquefaction – A critical state approach.

Taylor & Francis, ISBN 0-419-16170-8.

Also quoted in

Robertson, P.K., (2010).

Estimating in-situ state parameter and friction angle in sandy soils from CPT.

2nd International Symposium on Cone Penetration Testing, Huntington Beach, CA, USA, May 2010

Φ_{cv} = constant volume (or critical state) friction angle depending on mineralogy (Bolton, 1986), typically about 33 degrees for quartz sands but can be as high as 40 degrees for feldspathic sand. Assumed $\Phi_{cv} = 33$ [deg].

Ψ = the state parameter defined as difference between current void ratio and the void ratio at critical state at the same mean effective stress, calculated as in P.2.24.

$$\Phi = \Phi_{cv} - 48 \Psi$$

P.2.26. Peak friction angle Φ for sands (based on Jefferies and Bean 2006).

– see P.2.25.

Source paper:

Robertson, P.K., (2010).

Estimating in-situ state parameter and friction angle in sandy soils from CPT.

2nd International Symposium on Cone Penetration Testing, Huntington Beach, CA, USA, May 2010

Φ_{cv} = constant volume (or critical state) friction angle depending on mineralogy (Bolton, 1986), typically about 33 degrees for quartz sands but can be as high as 40 degrees for felspathic sand. Assumed $\Phi_{cv} = 33$ [deg].

Ψ = the state parameter defined as difference between current void ratio and the void ratio at critical state at the same mean effective stress, calculated as in P.2.24.

$$\Phi = \Phi_{cv} + 15.84 [\log Q_{tn,cs}] - 26.88$$

P.2.27. Effective friction angle Φ' in sands (Kulhawy, Mayne).

Source paper:

Kulhawy, F.H., Mayne, P.H.,

Manual on estimating soil properties for foundation design.

Report EL-6800 Electric Power Research Institute, EPRI, August 1990.

Also quoted in:

Robertson P.K., Cabal K.L.

Guide to Cone Penetration Testing. For Geotechnical Engineering. 6th Edition.

Gregg Drilling and Testing, Inc. 2015.

$$\Phi' = 17.6 + 11 \log (Q_{tn})$$

P.2.28. Drained Young's modulus for young uncemented silica sands.

Source paper:

Robertson P.K., Cabal K.L.

Guide to Cone Penetration Testing. For Geotechnical Engineering. 6th Edition.

Gregg Drilling and Testing, Inc. 2015.

$$E = 0.015 [10^{(0.55E + 1.68)}] (q_t - \sigma_{v0})$$

P.2.29. Density index I_D in sands based on the results of the DPT (Dynamic Penetration Test). EN 1997-2:2007.

Source paper:

EN 1997-2:2007. Eurocode 7 - Geotechnical design - Part 2: Ground investigation and testing. Annex G.

Poorly-graded sand ($C_u \leq 3$) above groundwater

$$I_D = 0.15 + 0.260 \log N_{10L} \quad (\text{DPL})$$

$$I_D = 0.10 + 0.435 \log N_{10H} \quad (\text{DPH})$$

Poorly-graded sand ($C_u \leq 3$) below groundwater

$$I_D = 0.21 + 0.230 \log N_{10L} \quad (\text{DPL})$$

$$I_D = 0.23 + 0.380 \log N_{10H} \quad (\text{DPH})$$

Well-graded sand-gravel ($6 \leq C_u$) above groundwater

$$I_D = 0.14 + 0.550 \log N_{10H} \quad (\text{DPH}).$$

P.2.30. Density index I_D in sands based on the results of the DPT (Dynamic Penetration Test). PN-B-04452:2002

Source paper:

PN-B-04452:2002

DPL

$C_u > 3$, for the range (**water level – 2m; water level +1m**) N_{10L} increases by 50%

$$ID = 0.429 * \log N_{10Lcor} + 0.071$$

DPM

$C_u > 3$, for the range (**water level – 2m; water level +1m**) N_{10M} increases by 50%

$$ID = 0.431 * \log N_{10Mcor} + 0.176$$

DPH

for the range (**water level – 2m; water level +1m**) N_{10H} increases by 50%

$$ID = 0.441 * \log N_{10Hcor} + 0.271$$

DPSH-B

for the range (**water level – 2m; water level +1m**) N_{10SB} increases by 50%

$$ID = 0.441 * \log N_{10SBcor} + 0.196$$

**P.2.31. Oedometer modulus based on the results of the DPT
(Dynamic Penetration Test).**

Source paper:

EN 1997-2:2007. Eurocode 7 - Geotechnical design - Part 2: Ground investigation and testing. Annex G.

$$M_{OED} = w_1 p_a \left(\frac{\sigma'_v + 0.5 \Delta \sigma'_v}{p_a} \right)^{w_2}$$

Gdzie

w_1 – stiffness coefficient

poorly graded sands ($C_U \leq 3$) above groundwater

$w_1 = 214 \log N_{10L} + 71$ (DPL, $4 \leq N_{10L} \leq 50$)

$w_1 = 249 \log N_{10H} + 161$ (DPH, $3 \leq N_{10H} \leq 10$)

low-plasticity clays ($0.75 \leq I_C \leq 1.30$) above groundwater

$w_1 = 4N_{10L} + 30$ (DPL, $6 \leq N_{10L} \leq 19$)

$w_1 = 6N_{10H} + 50$ (DPH, $3 \leq N_{10H} \leq 13$)

w_2 – stiffness coefficient

sands $C_U \leq 3$ $w_2 = 0.5$

low-plasticity clays $I_P \leq 10$ & $w_L \leq 35$ $w_2 = 0.6$

σ'_v – overburden effective stress

$\Delta \sigma'_v$ – overburden effective stress from extra load

p_a – atmospheric pressure

I_P – plasticity index

I_C – consistency index

w_L – liquid limit

P.2.32. Shear wave velocity V_s in sands

Source paper:

Baldi, G., R. Bellotti, V.N. Ghionna, M. Jamiolkowski, and D.C.F. LoPresti
Modulus of Sands From CPTs and DMTs.

Proceedings, 12th International Conference on Soil Mechanics & Foundation Engineering, Vol. 1,
 Rio de Janeiro, 1989, Balkema, Rotterdam.

Also quoted in:

Mayne, P.W.

Final Report NCHRP Project 20-05, Cone Penetration Testing State-of-Practice

Transportation Research Board, Synthesis Study, Washington, DC 20001, 2007

$$V_s \text{ (m/s)} = 277 (q_t)^{0.13} (\sigma'_{vo})^{0.27}$$

P.2.33. Shear wave velocity V_s in clays

Source paper:

Mayne, P.W. and G.J. Rix,

Correlations Between Shear Wave Velocity and Cone Tip Resistance in Clays

Soils & Foundations, Vol. 35, No. 2, 1995.

Also quoted in:

Mayne, P.W.

Final Report NCHRP Project 20-05, Cone Penetration Testing State-of-Practice

Transportation Research Board, Synthesis Study, Washington, DC 20001, 2007

$$V_s \text{ (m/s)} = 1.75 (q_t)^{0.627}$$

P.2.34. Shear wave velocity V_s in all soils

Source paper:

Hegazy, Y.A. and P.W. Mayne

Statistical Correlations Between V_s and CPT Data for Different Soil Types

Proceedings, Symposium on Cone Penetration Testing, Vol. 2, Swedish Geotechnical Society, Linköping, 1995, pp. 173-178.

Also quoted in:

Mayne, P.W.

Final Report NCHRP Project 20-05, Cone Penetration Testing State-of-Practice

Transportation Research Board, Synthesis Study, Washington, DC 20001, 2007

$$V_s \text{ (m/s)} = [10.1 \cdot \log q_t - 11.4]^{1.67} [f_s/q_t \cdot 100]^{0.3}$$

q_t i f_s [kPa]

P.2.35. Shear wave velocity V_s in saturated all soils

Source paper:

Mayne, P.W.

The 2nd James K. Mitchell Lecture: Undisturbed Sand Strength from Seismic Cone Tests

Geomechanics & Geoengineering, Vol. 1, No. 4, Taylor & Francis Group, London, 2006

Also quoted in:

Mayne, P.W.

Final Report NCHRP Project 20-05, Cone Penetration Testing State-of-Practice

Transportation Research Board, Synthesis Study, Washington, DC 20001, 2007

$$V_s \text{ (m/s)} = 118.8 \log (f_s) + 18.5$$

f_s [kPa]

P.2.36. Total unit weight γ_T in saturated all soils

Source paper:

Mayne, P.W.

The 2nd James K. Mitchell Lecture: Undisturbed Sand Strength from Seismic Cone Tests

Geomechanics & Geoengineering, Vol. 1, No. 4, Taylor & Francis Group, London, 2006

Also quoted in:

Mayne, P.W.

Final Report NCHRP Project 20-05, Cone Penetration Testing State-of-Practice

Transportation Research Board, Synthesis Study, Washington, DC 20001, 2007

$$\gamma_T \text{ (kN/m}^3\text{)} = 8.32 \log V_s \text{ (m/s)} - 1.61 \log z$$

z – depth in (m)

P.2.37. Dry unit weight γ_{DRY} in sand

Source paper:

Mayne, P.W.

In-Situ Test Calibrations for Evaluating Soil Parameters

Overview Paper, Characterization & Engineering Properties of Natural Soils II, (Proc. Singapore Workshop), Taylor & Francis Group, London, 2006.

Also quoted in:

Mayne, P.W.

Final Report NCHRP Project 20-05, Cone Penetration Testing State-of-Practice

Transportation Research Board, Synthesis Study, Washington, DC 20001, 2007

$$\gamma_{\text{DRY}} \text{ (kN/m}^3\text{)} = 1.89 \log(q_{t1}) + 11.8$$

P.2.38. Effective friction angle Φ' in sands

Source paper:

Kulhawy, F.H. and P.W. Mayne

Manual on Estimating Soil Properties for Foundation Design

Report EPRI EL-6800, Electric Power Research Institute, Palo Alto, 1990

Also quoted in:

Mayne, P.W.

Final Report NCHRP Project 20-05, Cone Penetration Testing State-of-Practice

Transportation Research Board, Synthesis Study, Washington, DC 20001, 2007

$$\phi' (^{\circ}) = 17.6 + 11.0 \log (q_{t1})$$

P.2.39. Relative density I_D in sands

Source paper:

Jamiolkowski, M., D.C.F. LoPresti, and M. Manassero

Evaluation of Relative Density and Shear Strength of Sands from Cone Penetration Test and Flat Dilatometer Test

Soil Behavior and Soft Ground Construction (GSP 119), ASCE, Reston, Virginia, 2001

Also quoted in:

Mayne, P.W.

Final Report NCHRP Project 20-05, Cone Penetration Testing State-of-Practice

Transportation Research Board, Synthesis Study, Washington, DC 20001, 2007

$$I_D (\%) = 100 [0.268 \ln(q_{t1}) - 0.675]$$

P.2.40. Liquidity index I_L

Source paper:

Młynarek, Z., Wierzbicki, J., Stefaniak, K.*Wykorzystanie metody CPTU do oceny zmian ciężaru objętościowego gruntów w podłożu*

Inżynieria Morska i Geotechnika, 2019

$$I_L = X(A - B \ln(q_n)) + Y(C q_n^D)$$

Where the coefficients X, Y, A, B, C i D are respectively:

Solifluction clays Gliny soliflukcyjne	X=1, Y=0, A=0.271, B=0.147, C=1, D=1
Clays of the last glaciation Gliny ostatniego zlodowacenia	X=1, Y=0, A=0.310, B=0.216, C=1, D=1
Clays of earlier glaciations Gliny wcześniejszych zlodowaceń	X=1, Y=0, A=0.375, B=0.254, C=1, D=1
Pliocene clays Iły plioceńskie	X=0, Y=1, A=1, B=1, C=0.059, D= -1.89
Glacial sandy clays Lodowcowe gliny piaszczyste	X=0, Y=1, A=1, B=1, C=0.571, D= -1.44