Dynamic Probing

1 Dynamic Probing

Software used for Dynamic Penetration Tests, that is the reading, recording, interpretation, storage and the management of any type of penetrometer including new or custom equipment and of in borehole SPT readings.

Dynamic Probing provides functions for the archiving of readings by site and for automatic calculation of the real energy transmitted, including correction for warp and the correlation coefficient with SPT (standard reference tests for geomechanic calculations and geotechnic correlations).
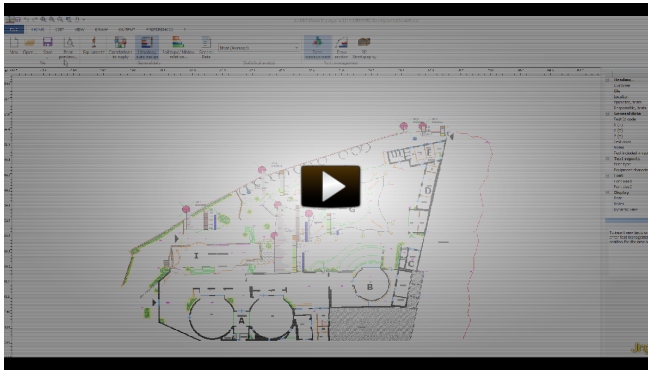
Processing the tests for the computation of bearing capacity of shallow foundations using numerous methods, for the calculation of various geometries (Strip Footings, Mat foundations, Spread footings, etc.) and related settlements, the verification of driven piles and the definition of the liquefaction potential of soils subject to seismic forces. The graphics of the stratigraphic columns can be exported in Slope, LoadCap, MP (Piles and Micropiles); in particular, for the last two applications, are also exported the geotechnical parameters as results of the processing.

Processing of data is instantaneous, deriving the values of Ndp & Rd and immediately generating a graphic display. In addition, the software proposes discrete layer boundaries and enables bitmaps or colors to be assigned for lithologic coding.

EQUIPMENTS
The software has a database of commonly used test equipments:
• Borro
• DIN 4
• DPM (DL030 10) (Medium)
• DPM (DL030 16) (Medium)
• DPA
• DPL (Light)
• DPSH (Dynamic Probing Super Heavy)

- SCPT (Standard Cone Penetration Test)
- SPT (Standard Penetration Test)
- DPSH TG 63-X PAGANI
- SCPT TG 63-X PAGANI
- DPM (DL 030 SUNDA)
- RAYMOND
- PENNY 30
- Geo Deep Drill (DPH50, DPSH63-73)
- Nordmeyer (LMSR-X model)

User equipment: Any type of custom equipement can be added *

* Any other type of equipment may be added and/or removed to those precoded. For each new equipment added the correlation coefficient is calculated automatically.

For the calculation of N60, N1,60 are required: CE (energy correction factor), Cn (overburden correction factor), Cr (rod length correction factor which depends on the total length of the drill rod), Cb (bore-hole diameter correction factor and its is set according to the selected diameter from the drop down list), Cs (liner correction factor).

EXPORT EQUIPEMENT ARCHIVE
The list of equipments can be exported in xml or txt format and imported in installation locations other than the local PC.

DATA INPUT AND LAYER MANAGEMENT
Dynamic Probing features a clear and straightforward processing of readings obtained on site.

DATA ENTRY
As the user enters the number of blows for each penetration step, the sampler bit coefficient, reduced, and non reduced as well as dynamic resistance on the layer are calculated; also a bar diagram for the number of blows and a graphic representation of the progress of dynamic resistance are shown.

LAYER MANAGEMENT
Even more simple is the definition of the layers: the user can define the stratigraphy (layer depth and lithological characterization) numerically or graphically as the software allows the interactivity between the dialog boxes.

READINGS PROCESSING
Dynamic Probing features a clear and straightforward processing of readings obtained on site.
New readings may be inserted at any point, assigning the cartesian position coordinates (X and Y), the initial depth (Z), the final depth, the ground water table

depth if any, as well as the date. For each site an indefinite number of readings may be recorded and the correlations suggested developed. Each reading is easily identified visually thanks to the legend and display graphics of dynamic resistance and number of blows.

CORRELATIONS

The geotechnic parameters of particular significance for terrain characterization may be indicated by the user. The litho logic cases that originate the numerous correlations accompanying the program, enable the user to characterize an extensive variety of terrains. The user is further provided with tools to select for use those correlations judged to most nearly reflect to the litho types actually encountered. The parameters that are the outcome of the computation are:

Cohesive terrains

• Undrained cohesion (*Terzaghi-Peck, SUNDA (1983)-Benassi Vannelli, Sanglerat, TERZAGHI & PECK (1948), U.S.D.M.S.M., Schmertmann (1975), Fletcher (1965), Houston (1960), Shioi – Fukui (1982), Begemann, De Beer, Robertson (1983))*
• Oedometric modulus *(Stroud e Butler (1975), Vesic (1970), Trofimenkov (1974), Mitchell e Gardner, Buisman-Sanglerat)*
• Young's modulus *(Schultze-Menzenbach, D'Appollonia ed altri 1983)*
• Unit volume weight *(Meyerhof ed altri)*
• Others

Cohesionless soils

• Relative density *(Gibbs & Holtz (1957), Meyerhof (1957), Skempton (1986), Schultze & Menzenbach (1961))*
• Friction angle *(Peck-Hanson-Thornburn-Meyerhof (1956), Meyerhof (1956), Sowers (1961), Malcev (1964), Meyerhof (1965), Schmertmann (1977), Mitchell & Katti (1981), Shioi-Fukuni (1982), Japanese National Railway, De Mello, Owasaki & Iwasaki)*
• Oedometric modulus *(Buisman-Sanglerat, Begemann (1974), Farrent (1963), Menzenbach e Malcev)*
• Young's modulus *(Terzaghi, Schmertmann (1978), Schultze-Menzenbach, D'Appollonia ed altri (1970), Bowles (1982))*
• Poisson's modulus *(A.G.I.)*
• Shear deformation modulus *(Ohsaki & Iwasaki, Robertson and Campanella (1983))*
• Weight by unit volume *(Meyerhof ed altri)*
• Classification *(A.G.I.)*
• Shear wave velocity
• Liquefactive potential *(Seed (1979))*
• Ko modulus *(Navfac (1971-1982))*
• Others

New correlations for: N60, N160,   Modulus oedometric stress-dipendent in according: EC7, DIN 4094-3

COMPUTATION

For each sampling, based on the user selected soil type (Cohesive or Non cohesive), computation is performed layer by layer. Thereafter for each layer the parameters of all the proposed correlation parameters are calculated, particularly highlighting the ones favored by the user.

For each layer, the number of blows, depth, the correlation applied and the calculated geotechnic parameter value may be exported.

EXPORT OF RESULTS

The results are exported in tabular and graphical format. For each test is created a table where are inserted the results of the tests chosen previously by the user preceded by the identification data of the test (order number, date, etc.) and by the characteristics of the equipement used, as well as the data related to the site (project title, location, engineer, etc.). The tables can be associated with the graphs of the number of blows and of the dynamic resistance. It is also available the possibility to build the stratigraphic column corresponding to each test.

BEARING CAPACITY AND LIQUEFACTION

Dynamic Probing calculates the bearing capacity and settlement of surface foundations utilizing a number of methods and additionally calculates the liquefaction potential of non coherent layers.

SECTIONS IN DYNAMIC PROBING

Dynamic Probing enables the automatic generation sections from test data using the 'Sections' module. A command enables the selection of those tests on which the generation of the sections is based and to open the new application. (The same procedure can be used from the GeoStru program 'Static Probing'; the counterpart of Dynamic Probing for Static penetrometers).

The Sections module is actually a stand alone section editor within, which sections can be created. Further it enables an import of stratigraphic columns originating from the GeoStru programs 'Stratigrapher'.

'Sections' is interfaced with GeoStru program Slope,such that the sections generated can be read as input by this program in order to perform an analysis of their stability.

3D SECTIONS

For a minimum of three tests, Dynamic Probing is able to perform the three-dimensional reconstruction of the stratigraphy.

1.1 Equipment

This window may be used to select an instrument in the list of the ones in the database, review its characteristics, add those of a new one or remove an existing one. The window may be reached from the *Home > General Data* menu of. Click on one equipment from the list to select it for use or for editing.

To delete an instrument, right click the name. This enables the *Delete* function.

To add a new instrument, right click the root (*Equipment* at the top of the list*)*. This enables the *New* function that opens a blank window in which the new characteristics may be entered. The characteristics to be entered, usually provided by the supplier, are:

Type	Equipment Name.
Step	Cone penetration distance increment in cm (10/20/30).
Hammer weight	Weight of the hammer
Flight	Length of hammer flight
Tip area	Area of cone
Rod length	Select from drop down list the length of rods used.
Rod weight	Weight of rod in kg per meter length.
Passive mass	Combined mass of hammer port and strike head in kg. (Mass excluding hammer).
Depth first rod joint	Depth of first rod joint with the next one in
Specific blow energy	Is calculated by the program as data of new equipment is entered.
Correlation Coeff. with Nspt	Coefficient of correlation with standard test. This varies with effective depth. Usually is used that of second meter. Select from drop down list lower down in the window.
Coating/Slurries	Select Yes/No.

Drilling system efficiency

Standardization of NSPT

The different equipment types introduce variability factors in the value of NSPT therefore is needed a correction to report the number of blows N to the energy efficiency of the driving system. Generally all researchers refer to an efficiency of 60% (N60).

The efficiency of the device is identified as follows:

$$ERi = (Ei/E^*) \text{ in \%}$$

where:

Ei = Energy of the first compression wave produced by the impact of the hammer it is a loss of energy due to the transformation of the kinetic energy of the hammer into compression wave in the rods.

E^* = Nominal kinetic energy of a hammer (free-fall energy of the hammer) of mass/weight equal to 63.5 kg in free fall from a height of 0.76 m (equal to 474 Joule).

The value of Ei is obtained, among many theories, even with the method of the compression wave integration. *(F. Cestari, par. 5.3.8.5 – "Prove Geotecniche in Sito").*

Skempton (1986) summarized the values obtained with the most commonly used devices in the world, getting the efficiency ERi as a product of two terms:

$$ERi = ERv \,´\, hd$$

where:

ERv = velocity energy ratio equal to Eh/E* with Eh hammer (transferable) energy in base of hammer impact velocity and hd dynamic efficiency that depends on the dimensions of the hammer, driving system and rods.

In the table below are shown the results of a series of measurements:

	Release			Hammer system			ER_i: %
	Type	Cathead	ER_v: %	Hammer	Anvil weight: kg	η_d	
Waterways Experiment Station	Trip	—	100	Vicksburg	0	0·83	83
Japan	Tombi	—	100	Donut	2	0·78	78
Japan	Slip-rope (2 turns)	Small	83	Donut	2	0·78	65
USA	Slip-rope (2 turns)	Large	70	Safety	2·5	0·79	55
UK	Slip-rope (1 turn)	Small	85	Old standard	3	0·71	60
USA	Slip-rope (2 turns)	Large	70	Donut	≈ 12	0·64	45
UK	Trip	—	100	Pilcon	19	0·60	60

Energy ratios and dynamic efficiency
(Skempton, A.W. (1986) – Géotechnique 36, No. 3, 425 - 447)

Correlation coefficient assigned

Check if the user wants to use a correlation coefficient different from the one automatically calculated by the program.

> **N.B.** The program calculates the energy ratio (Coefficient of correlation with N_{SPT}) by methods proposed by Pasqualini 1983 - Meyerhof 1956 - Desai 1968 - Borowczyk - Frankowsky 1981.

> **Note:** For the equipment *DPSH TG 63 200 MEARDI PAGANI (with 73 kg hammer)* have been made a series of tests to determine experimentally the correlation coefficient, according to which the coefficient 1.66 is certainly applicable to the gravel and gravel with sand and you get to 2. On average it was set at 1.8.

1.2   Correlations to apply

The program contains a data base of methodologies and data to correlate the observed soil properties to the more significant geotechnical parameters that characterize soils.

For each parameter type a number of different authors may be selected (see Geotechnical correlations). By default the program uses a set of correlations but with expert, or local knowledge, or for explorative aims these can be altered.

To see or alter the selected set open the "*Correlations to apply*" window (*Home > General Data* menu).

The window has a tab for cohesive and one for cohesionless soils and within each parameter, evaluation can occur according to different authors.

This choice is not tied to an individual test, but applies to the evaluation process as follows:

1. When a test is processed (Process not Reprocess) for the first time, the selections made in "*Correlations to apply*" are used AND the set is recorded with the test.
2. If later the test is again processed (not Reprocessed) the stored set is used again, not the "*Correlations to apply*" set that may have changed in the intervening time.
3. After processing, it is possible to alter the correlation authors for specific layers. When this is done the alteration is incorporated in the set associated with the layer and will be reused on subsequent process commands.

In this way it is possible to refine the parameter set for each test.

Alterations to the operative correlations relevant for other tests need not be rolled back if the original test must be re evaluated, say consequent upon an alteration to the stratigraphy.

If however it is required to start again with a different set of authors, then the Reprocess command should be used. This command operates as if Process command was being used for the first time. i.e. the set of selected authors is used and that set is stored with the test overwriting any previous set.

Results of correlations for cohesionless terrains are certainly more reliable than those for cohesive ones as these latter ones are influenced by drainage to a greater extent, while the rapid test occurs in saturated state with consequent lesser reliability. In any case the in situ dynamic test enables a more reliable parameterisation of cohesionless loose terrain that does not permit undisturbed sampling.
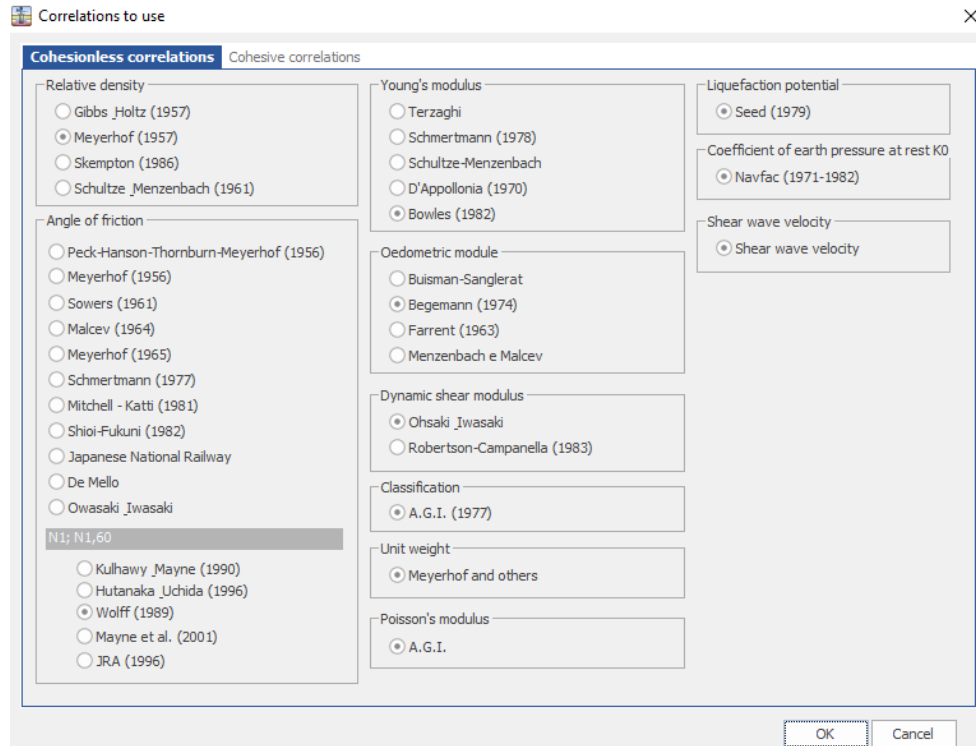
1.3   N60 - N1,60

Computation of N1, 60

The most recent empirical correlations of N_{SPT}, relative density and angle of shearing resistance of granular are calculated using the penetration resistance in terms of N60 ($N_{SPT}=N_{60}$ according to Cestari, 1996) or of $N_{1,60}$, normalized value at a geostatic vertical pressure of 1 bar by applying the coefficient CN (Liao and Withman 1986).

$$N_{60}=NSPT*CE$$

N60: Value of corrected N_{SPT} for an efficiency of 60% (**according to Cestari N60=NSPT**)

$$CE=ER/60$$

The energies of the different systems vary from 45% to 98%

$$N_{1,60}= N_{SPT}*CE*CN*CR*CB*CS$$

$$CN=(Pa/\sigma'v)1/2 \text{ Liao and Withman (1986)}$$
pa=atmospheric pressure = 98.1

$$CN=2/(1+\sigma'v/100) \text{ Skempton (1986) Fine sands}$$

CN=3/(2+σ'v/100) Skempton (1986) Coarse sands

Normalization at an effective stress of 100 Kpa (1 Kg/cm^2)

CN: Overburden correction factor
CE: Energy correction factor
CR: Rod length correction factor
CB: Bore-hole diameter correction factor
CS: Liner correction factor
ER: Hammer energy transfer ratio according to ASTM D-4633-86

CN in practical application cannot exceed 2 and preferably not exceed 1.5. The correction of CN is applied only for the computation of relative density and angle of shearing resistance, and is not applied to the computation of the undrained parameters and deformation parameters.

RELATIVE DENSITY

$$Dr=(N_{1,60}/A)1/2 \qquad \textit{Skempton (1986)}$$

A: variable constant between 55-65 from fine sands to coarse sands.

The parameter A is expressed according to *Cubrinowski and Ishihara (1999-2000)* as a function of the difference between the maximum and minimum void ratio.

$$A=9/(e_{max}-e_{min})1.7$$

The variation fields of (emax-emin) are taken from Das et al. (2012) for clean sands and silty sands, while for gravel reference can be made to data reported by *Jamiokowakj and Lo Presti (2003)*

$$e_{max}-e_{min}=0.19-0.29$$

ANGLE OF SHEARING RESISTANCE
The most used correlations in the last years, as reported NCHRP (2010) are:

φ'=54-27.6034*exp(-0.014*$N_{1,60}$)   Kulhawy & Mayne (1990)

φ'=(20*$N_{1,60}$)0.5+20   [for $N_{1,60}$=3.5-30] Hutanaka & Uchida (196)

φ'=27.1+0.3*$N_{1,60}$-0.00053*$N_{1,60}$ Wolff (1989)

φ'=(15.4*$N_{1,60}$)0.5+20   Mayne et al. (2001)

$$\varphi'=(15*N_{1,60})0.5+15 \qquad\qquad [\text{for} \qquad N_{1,60}>5$$
$$\varphi<45] \ \text{JRA (1996)}$$

An interpolating correlation of the average values of φ is defined with the following equation:

$$\varphi=20.1* N_{1,60}0.2$$

Recently *Brown and Hettirachchi (2008)* use more precautionary values for the angle of shearing resistance compared with the previous ones that can be assimilated approximately to the constant volume friction angle that is to the shearing resistance in critical conditions in correspondence of which further deformations occur without volume variation:

$$\varphi'=0.3818*\tan^{-1}(24.525*N_{60}/\sigma')$$

TO PERFORM THE COMPUTATION OF N60, N1,60:

1.4   Correspondence soil type/number blows

A table giving the standard relation between the number of blows and the soil type being traversed for cohesive, cohesionless and granular cohesive soils is enclosed in the program, in *Home >General Data* menu.

The user may amend the values in the table and indeed the description. It is also intended that the user may alter the color assigned to the specific soil types.

It should be noted however that any changes made operate globally and are not restricted to the particular project.

As data is entered in test entry window, the user can discern the soil layer discontinuities and define layer boundaries and assign cohesion characteristic.

If it is desired, the program can then automatically assign the soil types to the layers using ("*Lithology auto assign command*", in the same menu).
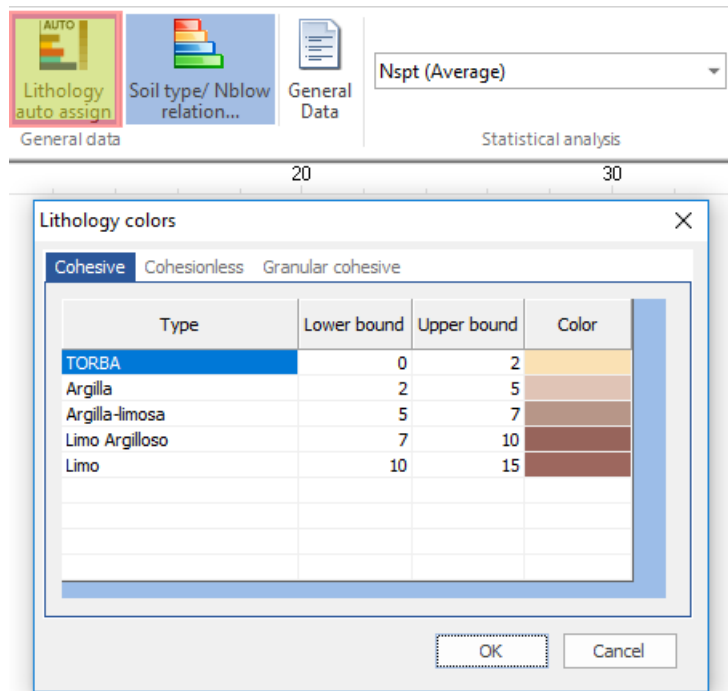
1.5   General data

Allows the user to assign the general data for the header (Customer, Site, Location, Operator and Manager for the test, Order code and certificates to attach). The safety factor for the pressure on the layer (between 20 and 22, a safety coefficient equal to 20 corresponds to a coefficient equal to 4 of shallow foundations).

» By inserting the location in the format: xxxx street, city, state, country, will be detected automatically the work area. Alternatively, the user can assign the coordinates in decimal degrees in the WGS84 system.
The localization system requires an internet connection.

1.6   Statistical analysis

Enables statistical processing of numerical data in Dynamic Probing using in the calculation of layer's representative values a value less than or greater than the arithmetic average of the layer, and the possible values ? are:

- **Average:** Arithmetic average of the number of blows on the layer (Default).

- **Minimum:** Minimum value of number of blows on the layer.

- **Maximum value:** Maximum value of number of blows on the layer.

- **Minimum average:** Arithmetic average of values below the average, of number of blows on the layer.

- **Average + deviation:** Average incremented by average deviation.

- **Average – deviation:** Average decreased by average deviation.

- **Normal distribution R.N.C.** - see Characteristic parameters

- **Normal distribution R.C.** - see Characteristic parameters

1.7   Oedometric modulus stress dependent

G.3 Example of establishing the stress-dependent oedometer modulus from DP results

(1) This is an example of the derivation of the vertical stress dependent oedometer settlement modulus (E_{oed}), frequently recommended for settlement calculation of spread foundations, defined as follows:

$$E_{oed} = w_1\, p_a \left(\frac{\sigma'_v + 0,5\, \Delta\sigma'_v}{p_a} \right)^{w_2}$$

where

w_1 is the stiffness coefficient;

w_2 is the stiffness exponent;
       for sands with a uniformity coefficient $C_U \leq 3$: $w_2 = 0,5$;
       for clays of low plasticity ($I_p \leq 10$; $w_L \leq 35$): $w_2 = 0,6$;

σ'_v is the effective vertical stress at the base of the foundation or at any depth below it due to overburden of the soil;

$\Delta\sigma'_v$ is the effective vertical stress caused by the structure at the base of the foundation or at any depth below it;

p_a is the atmospheric pressure;

I_p is the plasticity index;

w_L is the liquid limit.

(2) Values for the stiffness coefficient (w_1) can be derived from DP tests using for example the following equations, depending on the soil type:

poorly-graded sands ($C_U \leq 3$) above groundwater

$$w_1 = 214\, \lg N_{10L} + 71 \quad (\text{DPL; range of validity: } 4 \leq N_{10L} \leq 50)$$

$$w_1 = 249\, \lg N_{10H} + 161 \quad (\text{DPH; range of validity: } 3 \leq N_{10H} \leq 10)$$

low-plasticity clays of at least stiff consistency ($0,75 \leq I_c \leq 1,30$) and above groundwater (I_c is the consistency index)

$$w_1 = 4 N_{10L} + 30 \quad (\text{DPL; range of validity: } 6 \leq N_{10L} \leq 19)$$

$$w_1 = 6 N_{10H} + 50 \quad (\text{DPH; range of validity: } 3 \leq N_{10H} \leq 13).$$

NOTE   These examples were published by Stenzel et al. (1978) and Biedermann (1984) and in DIN 4094-3:2002. For additional information and examples, see X.3.4.

1.8   Insert new test

     The program is based on a graphical input of penetration tests. To insert a new test right click on the insertion point in the work area, select the type of test (progression or borehole) and enter the general data.

X, Y, Z	X and Y representing the location coordinates are automatically entered but may be altered as

	required. Z indicates the altitude.
Depth of boring	Final depth reached by the test.
Water table depth	If any water tables are encountered, it is necessary to insert depths (initial and final).

For SPT test, the list of defined equipment is presented from which the one in use should be selected. For borehole tests, the start depth of the test is required. Each test may be characterized by a particular color set by the user.

After the test position and type is recorded the user can enter the readings' data by pointing to the test and opening the floating menu (right click). This menu (not the same as above) gives a number of options including *Data entry* and also test removal.

Data entry for progression test has a different form that the one for borehole test.

Once the data is entered, right click on the test and choose the command *Process.*

The difference between Process and Reprocess command is the following:

The *Process* command calculates the geotechnical parameters and keeps eventual alterations to them, while the *Reprocess* command recalculates the parameters without keeping eventual alterations made by the user.

1.8.1   Data entry progression test

Nr. of blows

In the left pane, enter in sequence the number of blows (site data) relative to the work depth. The program performs the necessary processing automatically, while the definition of the depth of the layers and the choice of the lithology type (cohesive or cohesionless) is left to the user.

Reduction coefficient

The output data is a correction coefficient that takes into account the loss of energy by "twisting of the rods during the driving" this figure is influenced by the No. of blows and the depth, with direct effect on the dynamic failure resistance and any data allowable load (Herminier).

Stratigraphy

Layer depth

Enter the depth of the layer (homogeneous number of blows) with the mouse or directly in the appropriate box. To insert it with the mouse go on the chart, press the right mouse button and type in the depth of the layer after selecting the "*Insert layer*" command. The corresponding text box under the chart is updated automatically. It is also possible to delete a layer by selecting it in the existing numerical grid and pressing the "*Delete*" key on the keyboard, the stratigraphy will be updated at the same time on the graphical model.

N DPM

Number of blows within the layer. The program evaluates, in function of the depth of the layer, the number of blows - see Statistical analysis.
To update the "*N DPM*" value within the layer the relative depth must be inserted and confirmed with the Enter key.

Rd (kg/cm²) - Dynamic resistance

Specific dynamic resistance of the equipment calculated according to the known Dutch processing.

Cohesive - Cohesionless

Check the appropriate checkbox if you know the type of soil or check both if unsure (the software will perform calculations for both cases).

Unit weight (t/m³)

Enter the estimated unit weight of the layer (or calculate it automatically with Meyerhof).
To calculate it automatically right click on the "*Unit weight"* column.

Correlation coefficient with NSPT

Coefficient that relates the number of blows of a test with Nspt. This coefficient is calculated as the ratio of the specific energy per blow and that of the standard penetration test SPT.

NSPT

Number of blows in the SPT test.

Clay Fraction

Percentage of the fine soil fraction present in the layer

Texture

Insert the reference bitmap from the lithological archive on the right side of the screen: select the bitmap and holding pressed the mouse button, go to the box where you want to place it. To assign a color instead just click with the mouse on the cell and is activated the button to display the color palette.

Description

Type the text corresponding to the nomenclature of the lithology.

Path

Set the path for the texture (if present).

Stratigraphy on equipment step

Sets the detailed stratigraphy of the user. The command allows to create a stratigraphy with thicknesses equal to the equipment step. After processing it is possible to obtain for each layer defined by the user, a set of values for the geotechnical parameters calculated at intervals equal to the equipment step. These values can be used by the user to evaluate the distribution law of values in order to calculate the characteristic geotechnical parameter.

Graphic

When a new test is inserted, data is displayed on a graphical model that shows the identification data of the test, the bar graphic depicting the number of blows at each step, the trend of the tip dynamic resistance, the groundwater table and the lithostratigraphy.

The basic model proposed interacts in the same time with the number of blows entered at each step and the grid in the bottom part of the window, where the management of the stratigraphy is made. Each data entered in the number of blows column is updated on the graphic model, as well as any change performed on the stratigraphy grid is modified on the graphic in the lithostratigraphic column.

The graphical model proposed is manageable from a shortcut menu that is activated with the right mouse button. The options of colors, lines and scale are repeated also in the *Preferences* menu, item *Options.*

Round NSPT

Value of Nspt considered as a decimal number or rounded, up or down.

N(1)100 (Er/100=1)

Standardization of energy ratio.

Observations

Copy-Paste functions allow you to copy or paste the sequence of data (N° blows) from an Excel spreadsheet to the software Dynamic Probing: they are activated with a right click on the column "*Nr. of blows".*

How to insert a layer from the keyboard

Type in the table below the chart (bottom right side in the input window) the depth of the layers.

How to insert a layer with the mouse

Right click on the chart, select the "*Insert layer*" command, click and enter the corresponding elevation of the layer.

Delete a layer

Select an entire row from the stratigraphy table and press "*Delete"* key from the keyboard.

1.8.2 Data entry borehole test

Enter Nblows/15 in sequence relative to the working depth. The program performs the necessary processing automatically, while the definition of the depth of the layers and the choice of the lithology type (cohesive or cohesionless) is left to the user.

⚠ If is not selected the option "*Automatic unit weight estimate"* the unit weight value must be entered by the user, otherwise, choosing the type of lithology, will be estimated automatically by the program.

1.9 Process test data

1.9.1 Process

In the main window of the software, right click on the test to be processed and choose "*Process"* command. This procedure enables automatic processing of penetration data and offers the relevant lithological parameters (see Geotechnical correlations) for each layer, based on the options made in "*Correlations to apply".* The correlations used are indicated by red highlight in the left pane.The values are derived also according to the choices made in the Statistical analysis drop down list.

Correlations applied depend on whether the layer is considered cohesive or cohesionless. In layers where this distinction could not be determined, both types of correlations are applied. The user has the possibility to control this treatment by altering the value of the specific columns in the stratigraphy grid in "*Data Entry*" window.

The correlations used for this test are 'attached' to the test and will be reused for every later use of this command on this test. Thus any subsequent change in "*Correlations to apply"* list will not affect the result of this command on this test.

If after processing is completed, it is desired to either view the result of another correlation author/method or apply that correlation to selected layers please proceed as follows:

1. Click the new correlation type from the list in the left hand pane, and note the results in the computation results pane above the report pane.
   The new result is merely shown in the computation pane.
2. At this point it is possible to apply this new result to the test and update the report preview. Applying it will thereafter permanently modify the set of correlations. To apply the new result and method, select the layer in the computation result pane and execute the floating menu command (right mouse click) *"Send correlation to print page"*.

Thereafter it is this amended correlation set that is associated with the test and will be reused every time "*Process" command* is called.
Note the significant difference in operation of "*Reprocess*" which performs process as if it was a first time use.

1.9.2   Reprocess

⚠ *"Reprocess" command resets the set of correlations for the test to the current choices in the list of "Correlations to apply" thus replacing any previous ones.*

To perform the command,right click on the test of interest and choose "*Reprocess*".
The correlations used are those selected in "*Correlations to apply*" of the "*General data*" menu and are highlighted in red in the list on the left.

1.9.3   Processing on equipment step

This type of processing allows the user to obtain geotechnical parameters of layers with thickness equal to the step of the instrument employed in the execution of the test (eg every 10 cm or 20 cm).

1.9.4 Process with all authors

Complete processing of parameters, using all correlations available in the software.

1.9.5 Summary of geotechnical parameters

Printable summary of the main geotechnical values (eg, unit weight, undrained cohesion, friction angle, etc.)

1.9.6 Include in final report

Includes the input and the output of the current test in the print report of the software.

1.9.7 Allowable pressure Dutch-L'Herminier

Allowable pressure on the layer (with/without allowance for rod shudder) computed according to Herminier's well known method applying a safety coefficient (generally = 20-22) that corresponds to a standard foundation coefficient of 4 with a standard foundation geometry whose width is 1 m and grip 1 m.

1.9.8 Estimate soil category

In the soil determination phase the software loads automatically the data of the current test. If a stratigraphy was defined in the current test, the software automatically determines: Depth, Description, Correlation Coefficient, Type (cohesive, cohesionless or cohesive -cohesionless) , N_{SPT}.

The automatic loaded data can be altered independently of the data from the current test.

Geotechnical parameters assigned by the user
The geotechnical parameters necessary to the soil classification are calculated using the command.
They can also be assigned by the user and the program determines the soil category.

The soil category can be determined on the base of $N_{SPT, 30} - V_{S,30}$, $Cu_{,30}$ values.

In the "*Range subsoil category*" table the minimum and maximum values of the geotechnical parameters that determine the soil category can be set.

1.9.8.1 Soil category for equipment step

Estimation of the soil category based on the indication of soil classification introduced by the Eurocode, considering the thickness of the individual layers equal to the step of the instrument used in the execution of the test.

1.9.8.2 Soil category for current stratigraphy

Estimation of soil category based on the indication of soil classification introduced by the Eurocode, considering the thickness of the individual layers defined by the user as detailed or current stratigraphy.

1.9.8.3 Regenerate input data

In the soil classification the user has the possibility to change the data for Nspt and soil type (cohesive, cohesionless), so if the user wants to cancel the changes and return to the initial values derived from the input, "*Regenerate input data*" command does that.

1.9.9 Shallow fondation bearing capacity

Calculation of bearing capacity and settlement of shallow foundations according to the authors listed below:

Terzaghi & Peck (1948)

- overestimates settlement
- unspecified foundation form (width B)
- considers GWT depth (Coeff. Cw) and foundation grip (Coeff. Cd)

Meyerhof (1965)

- overestimates mat foundation bearing capacity
- unspecified foundation form (width B)
- does not consider GWT depth
- considers foundation grip (Coeff. Cd)

Bazaraa (1967) – Peck & Bazaraa (1969)

- valid only where reworked (fill) soils do not occur adjacent to site
- unspecified foundation form (width B)
- considers GWT depth (Coeff. Cw) with own method
- considers foundation grip (Coeff. Cd) and also of effective stresses (Nspt corrected with lithostatic stress)

Peck, Hanson & Thornburn (1974)

- valid only where reworked (fill) soils do not occur adjacent to site
- unspecified foundation form (width B)
- considers GWT depth (Coeff. Cw)
- does not consider foundation grip
- considers effective pressures (Nspt corrected with lithostatic stress)

Meigh & Hobbs (1975)

- valid for diverse lithotypes
- unspecified foundation form (width B) (based on Terzaghi's method)
- does not consider GWT depth (always value 1)
- considers foundation grip (Coeff. Cd) and granularity through the ratio Nspt/Qc

Burland and others (1977)

- method valid where B>3m
- statistical method based on experience (within 50 – 75% encounterd by Burland)
- does not consider foundation grip

De Beer - Martens (1957)

- method valid for coarse granular soils (sands, gravels)
- unspecified foundation form (width B)
- considers GWT depth (Coeff. Cw)
- does not consider foundation grip (Coeff. Cd)
- considers effective stresses (Nspt corrected with lithostatic stress)

Computation of results occurs as cursor moves to next box.

Example
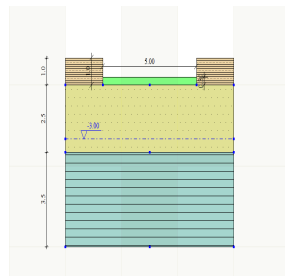
1.9.10   Deep foundation bearing capacity

With this option the bearing capacity of driven pile in tons is calculated using Meyerhof's method, using similarity of the penetrometer driving with piles driven by the hammer.
The following parameters must be supplied:

- Pile length
- Average Nspt pile base
- Average Nspt pile column
- Pile diameter
- Lateral safety coefficient
- Safety coefficient at tip

Calculation occurs as each new parameter is entered and the cursor is tabbed to the next field.
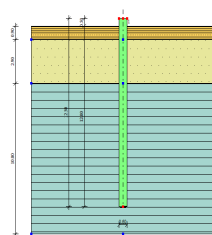
1.9.11   Export test to other GeoStru programs

Export of processing results (geotechnical parameters and stratigraphy) in *.EDP format that can be imported from other applications developed by GeoStru (eg LoadCap, MP, Slope)

1.10   Test management

1.10.1   Draw section

Geological sections can be created simply by connecting multiple tests using the mouse. Choose the "*Draw section*" command and select at least three tests for creating the section. Right click and choose *"Generate section"* command*.*
The section created can be read directly from **Slope** software which can be run directly from Dynamic Probing software, or, in case Slope is not available, an additional module for the creation of the sections can be ordered separately.

1.10.2   3D Stratigraphy

Please note that the automatic reconstruction of 3D stratigraphy is made on the basis of the names assigned to the layers.
For example, the survey 1 is composed of three layers named: A, B, C, and the survey 2 must have the same number of layers with the same names: A, B, C. Follow the same reasoning for the subsequent surveys.
For 3D optimal view is advisable to assign the same color or texture to the layers belonging to different tests and having the same name.

1.11   Raster images

Raster images can be imported to overlay the worksheet, in order that the drawing may be set in relation to some previously established mapping or imaging. To this end three commands are available:

Import raster image
Opens a file open window to enable the path and identity of the file (*.jpg or *.bmp) to be imported. Calibration and positioning may be defined as well.

Calibrate raster image
Normally the import of an image applies the stated scale to map the image to the worksheet that is displaying a down zoomed real scale and no further action is

required. This function can be applied if the result of applying the nominal scale to the image, seems to diverge from real observed dimensions for whatever reason. In this case enter the observed dimension and the rendered dimension in the image (Use Dimensions command to. retrieve) and its position on worksheet to again adjust the image.

Delete raster image
Removes the image background from the worksheet.

1.12   Output

Graphic report
Print of diagrams related to a test (No. blows, resistance, stratigraphy).

Print preferences
Allows the user to choose what results to include in the print report.

Readings
Print only the input data of the tests entered (number of blows corresponding at corresponding depth).

Processing by author
Print the processing result for each test as a function of an author selected from the correlations available.

Process with all authors
Print the processing result for each test considering all available correlations.

Export DXF
Export the current window in *.DXF format.

1.13   Preferences

1.13.1   Options

This window offers the possibility to customize different options:

Worksheet
- Texture - establish the path for predefined textures (a free database is offered by GeoStru - ask our team for more details)
- Graphic - establish line thickness, cursor tolerance and grid interval

Outputs

- Report - set the margins of the page, settings for tables and header for the report

Units of measurement

- System - choose between the tow available systems of measurement units

Company data

- Insert data regarding the company, including logo and signatures

Save

- Set automatic saving option

1.13.2 Graphic report options
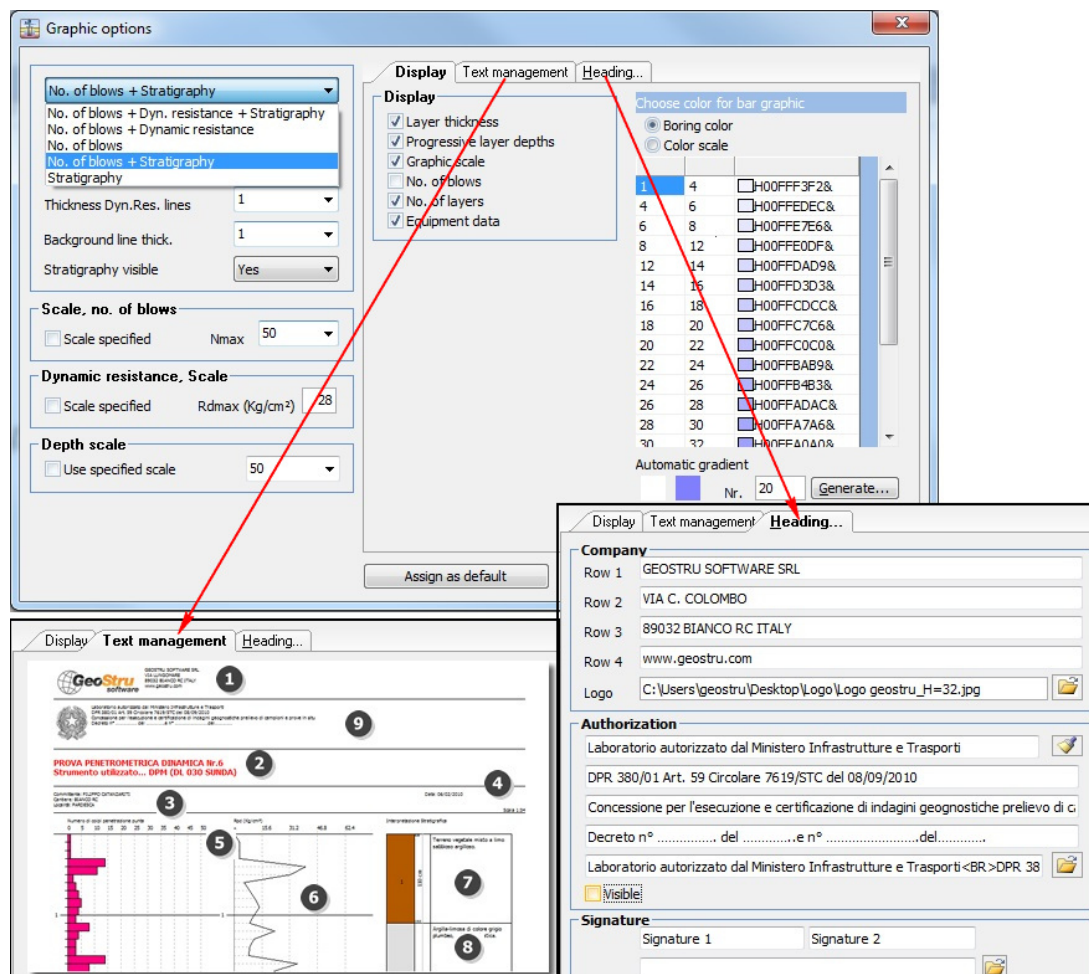
A wide variety of options regarding the graphics are available, so that the user can customize the work according to own needs.

For "*Text management*" click on the number to set text for each area.

1.14 Theoretical notes

1.14.1 Geotechnical correlations

1.14.1.1 Cohesionless soils

1.14.1.1.1 Friction angle

Peck et al. (1974) e Meyerhof (1956)

- valid for non soft soils at depth < 5 m
- correlation valid for **sands** and **gravels**, represents average values
- traditional correlation widely used, valid for soils above groundwater table < 8 m for terrains within groundwater table (stresses <8-10 t/m²)

$$\varphi = 27 + \left(10 \cdot \frac{NSPT_{corr}}{35} \right)$$

Meyerhof, 1956

- correlation valid for **clay and fissured marl clay** and **loose fill**

$$\varphi = a + b \cdot NSPT - c \cdot NSPT^2$$

sand and silt ≤ 5%: a=29.47; b=0.46; c= 0.004
sand and silt > 5%: a=23.7; b=0.57; c= 0.006

Sowers, 1962

- friction angle in degrees valid for **sands** in general
- optimal conditions for depths < 4 m above groundwater table and < 7 m for terrains within groundwater table, σ>5 t/m²

$$\varphi = 25 + 0.28 \cdot NSPT$$

De Mello, 1967

- correlation valid for mainly **sandy soils** with friction angle < 38° at least 2 m depth

$$\varphi = 19 - 3.8 \cdot \sigma_{pv0} + 8.73 \log (NSPT)$$

Malcev, 1964

- friction angle in degrees valid for **sands** in general
- optimal conditions for depths > 2 m and friction angle < 38°

$$\varphi = 25 - 5 \cdot Log(\sigma_{v0}) + 3.73 \cdot Log(NSPT_{corr})$$

Schmertmann, 1977

- friction angle in degrees for diverse lithotypes (max values)
- **N.B.** Values are often overly optimistic as derived from DR % indirect correlations.

$$\varphi = a + b \cdot Dr$$

Uniform fine sands: a= 28; b=0.14
Sands medium uniform: a=31.5; b=0.115
Sands medium grandate, Large uniform sands: a= 34.5, b= 0.1
Sands, gravels little silty, Gravel: a=38, b=0.08
Gravels: a=34.5, b=0.1
Dr=relative density [%]

ROAD BRIDGE SPECIFICATION

- friction angle in degrees (**Shioi and Fukuni, 1982**) valid for **sands, fine sands and silty sands** at minimum 2 m depths below ground level
- optimal conditions for depths >8 m over groundwater table and >15 m for terrains within groundwater table, σ>15 t/m²

(JAPANESE NATIONAL RAILWAY) Shioi-Fukuni 1982

- friction angle in degrees valid for **gravels**
- friction angle in degrees valid for **medium coarse sands gravelly sands and gravels** (degrees) Shioi-Fukuni 1982 valid for minimum depths of 2 m

$$\varphi = 0.3 \cdot NSPT_{corr} + 27$$

Iwasaki et al., 1977

- friction angle in degrees, valid for **sands, medium and coarse and gravelly sands**
- optimal conditions for depths > 8 m above groundwater table and > 15 m for terrains within groundwater table, σ>15 t/m²

1.14.1.1.2 Relative density

Gibbs & Holtz, 1957

- correlation valid for any effective pressure
- Dr is underestimated for **gravels** and over estimated for **silts**

Skempton, 1986

- process valid for Normally consolidated **silts, sands, and fine to coarse sands** at any effective pressure
- Dr is underestimated for **gravels** and over estimated for **silts**

Schultze & Menzenbach (1961)

- for Normally consolidated **fine and gravelly sand**
- method valid for any effective pressure in Normally consolidated deposits
- Dr is underestimated for **gravels** and over estimated for **silts**.

$$Dr = 2.718282^{0.478 \cdot logNSPT_{corr} - 0.262 \cdot log\sigma_{pvo} + 2.84}$$

1.14.1.1.3 Young's Modulus

Terzaghi and Peck (1948)

- correlation valid for **clean sand** and **sand with gravel** without account of the effective pressure

$$E_y = (7 \cdot \sqrt{NSPT_{corr}}) \cdot 10.197$$

Schmertmann et al. (1978)

- correlation valid for various lithotypes

$$E_y = a \cdot b \cdot NSPT_{corr} - c$$

Parameters a, b and c assume different values and depend on lithology and the presence of fine material.

Schultze and Menzenbach (1961)

- correlation valid for various lithotypes

D'Appolonia et al., 1970

- correlation valid for **sand**, **SC sand**, **NC sand** and **gravel**

1.14.1.1.4 Oedometric modulus

Begemann (1974)

- correlation derived from experiences in Greece

$$E_d = a + NSPT_{corr} + b$$

Limo with sand: a=2.05403, b=27,46451
Gravel with sand: a=9.1, b=93

Buismann-Sanglerat

- correlation valid for sand and clay sand

Farrent (1963)

- valid for **sands**, sometimes for **sand with gravel** (modified from experimental data)

Menzenbach and Malcev

- valid for fine sand, sand-gravel and sand and gravel

1.14.1.1.5 Unit weight

Meyerhof, 1956

- correlation valid for **sands, gravels, silt** and **sandy silt**

$$P.U.V. = 1.29968 + 0.05291 \cdot NSPT_{corr} - 0.00106 \cdot (NSPT^2{}_{corr} + 7.58 \cdot 10^{-6} \cdot NSPT^3{}_{corr})$$

1.14.1.1.6 Saturated unit weight

Bowles (1982), Terzaghi-Peck (1948-1967)

- correlation valid for the specific weight of the material equal to about G=2,65 t/m³ and for dry unit weight variable from 1.33 (Nspt = 0) to 1.99 (Nspt = 95).

$$P.V.S._{sat} = a + b \cdot NSPT_{corr}$$

NSPTcorr ≤ 50: a=1.8559, b=0.0062
NSPTcorr > 50: a=2.0414, b=0.0021

1.14.1.1.7 Shear wave velocity

Vs (m/sec) - this correlation is only valid for cohesionless sandy and gravelly soil.

$$Vs = \sqrt{\cdot NSPT_{corr}} \cdot \alpha \cdot \beta \cdot \left(\frac{z}{0.303}\right)^{0.193}$$

Alpha = coefficient that depends on the age of the deposit
Beta = coefficient function of the granulometric composition
z = depth in meters

1.14.1.1.8 Shear deformation modulus

Iwasaki et al., 1977 - G
- Correlation valid for **fine plastic sands** and **clean sands**.

$$G = \frac{a \cdot NSPT_{corr}{}^{b}}{10}$$

Robertson & Campanella (1983) and Imai & Tonouchi (1982)
- Correlation valid particularly for **sands** and for lithostatic stress between 0.5 and 4.0 kg/cm².

$$G = 125 \cdot NSPT_{corr}{}^{0.611}$$

1.14.1.1.9 Coefficient of earth pressure at rest

Navfac (1971-1982) *- Ko*

- Correlation applies to **sand**, **gravel**, **silt**, **sandy silt**.

1.14.1.2 Cohesve soils

1.14.1.2.1 Undrained cohesion

Benassi & Vannelli *- Cu*

- correlations derived by the penetrometer construction company SUNDA 1983.

Sanglerat *- Cu*

- from CPT (Cone Penetration Test) data for **saturated cohesive soils**.
- these correlations are not valid for sensitive clays whose sensitivity is > 5 nor over consolidated or fissured clays or low plasticity silts.

$$Cu = \frac{\frac{2.5 \cdot NSPT_m \cdot 0.5 - 1}{0.8}}{15}$$

Sanglerat *- Cu*

- for **silty-sandy clays** of low cohesiveness
- values valid for penetrometric resistance < 10 blows
- for higher resistance Sanglerat's correlation for **plastic clays** is indicated

$$Cu = \frac{a \cdot NSPT_m \cdot 0.1}{2}$$

a = 1.33 for low sandy sandy clay

(U.S.D.M.S.M.) U.S. Design Manual Soil Mechanics undrained cohesion - Cu

- valid for **silty clay and clay of low, medium or high plasticity**, (Cu-Nspt-degree of plasticity).

Schmertmann (1975) *- Cu - (average values)*

- valid for **clays and clayey silts** of Nc=20 and Qc/Nspt=2

$$Cu = 0.7 \cdot NSPT \cdot 0.1$$

Schmertmann *(1975) - Cu*
- valid for **clays NC** .

$$Cu = 0.0954 \cdot NSPT_m^{1.01187}$$

Fletcher (1965) *(Chicago clay)*
- valid for **clay of low or medium plasticity**

$$Cu = \frac{0.1844 \cdot NSPT_m - 0.00074 \cdot NSPT_m^2}{2}$$

Houston (1960)
- clay of medium-high plasticity

Shioi-Fukuni (1982)
- valid for soils inconsistent and plastic clay of medium to high plasticity

1.14.1.2.2 Static penetrometer tip resistance(Qc)

Robertson 1983 *- Qc*
- Correlations to determine specific static resistance for cohesive soils.

1.14.1.2.3 Oedometric modulus

Stroud & Butler (1975) *- Mo (Eed)*
- for soils of medium plasticity
- valid for medium to high plasticity **clayey soils** – of **glacial clay origin**

$$E_d = 4.588 \cdot NSPT$$

Stroud & Butler (1975)
- for soils of low to medium plasticity (IP< 20)
- valid for medium to low plasticity **clayey soils** – of **glacial clay origin**

$$E_d = 6.118 \cdot NSPT$$

Vesic (1970)

- correlation valid for soft clays (minimum & maximum values)

maximum

$$E_d = 10.1993 \cdot NSPT + 1.7919$$

minimum

$$E_d = 6.118 \cdot NSPT$$

Trofimenkov (1974), Mitchell & Gardner Confined Modulus

- valid for **clayey and clayey-silty soils** (Qc/Nspt ratio=1.5-2.0)

$$E_d = 10.1993 \cdot NSPT + 1.7919$$

Buismann-Sanglerat

- valid for compact clays (Nspt <30), medium and soft (Nspt <4) and sandy loams (Nspt = 6-12)

1.14.1.2.4 Young's modulus

Schultze-Menzenbach Ey (Min. and Max.)

- Correlation valid for **cohesive and clayey silts whose plasticity** index, IP >15.

$$E_y = 4 + 11.5 \cdot NSPT + 24.4$$

D'Apollonia & others (1983)

- Correlation valid for **saturated clays and fissured clays**.

1.14.1.2.5 Unit weight

Meyerhof and others

- Processing relevant for **clay, clayey and silty sand mainly cohesive.**

$$P.U.V. = 1.3936 + 0.0918 \cdot NSPT_m - 0.004 \cdot NSPT_m^2 + 6.2 \cdot 10^{-5} \cdot NSPT_m^3$$

1.14.1.2.6 Saturated unit w eight

Bowles (1982), Terzaghi-Peck (1948-1967)

- correlation valid for the specific weight of the material equal to about G= 2,70 t/m³ and indices of the voids ranging from 1.833 (Nspt = 0) to 0.545 (Nspt = 28)

$$P.U.V._{sat} = \frac{1}{a - b \cdot NSPT}$$

NSPT<18 a= 0.5449, b=0.0025
NSPT>18 a= 0.59, b=0.0056

1.14.2 Subsoil categories and conditions

Once the design seismic action is defined, it becomes necessary to determine the effect of the local seismic response through specific analysis.

In the absence of this analysis, in order to define the seismic action we can refer to a simplified approach, that is based on the determination of the reference subsoil categories. (Tab. 3.2.II and 3.2.III).

Category	Description
A	Outcrop rocky mass or very rigid soils characterized by Vs,30 superior to 800 m/s, eventually including in the surface an alteration layer, with a maximum thickness of 3 m
B	Soft rocks and deposits of very dense coarse grain soils or very dense fine grain soils with thickness superior to 30

Category	Description
	m, characterized by gradual improvement of the mechanical properties with depth and Vs,30 values between 360 m/s and 800 m/s, (or $N_{SPT,30}$ > 50 in coarse grain soils and cu,30 > 250 kPa in fine grain soils).
C	Deposits of medium dense coarse grain soils or medium dense fine grain soils with thickness superior to 30 m, characterized by gradual improvement of the mechanical properties with depth and $V_{s,30}$ values between 180 m/s and 360 m/s, (or 15 < $N_{SPT,30}$ < 50 in coarse grain soils and 70 < $c_{u,30}$ < 250 kPa in fine grain soils),
D	Deposits of poor consistency coarse grain soils or poor consistency fine grain soils with thickness superior to 30 m, characterized by gradual improvement of the mechanical properties with depth and Vs,30 inferior to 180 m/s (or $N_{SPT,30}$ < 15 in coarse grain soils and $c_{u,30}$ < 70 kPa in fine grain soils)
E	Subsoil terrains of C or D type, with thickness not superior to 20 m, laying on the reference substratum (with Vs > 800 m/s)

Table 3.2.II – Subsoil categories

The classification is based on the values of the equivalent propagation velocity $V_{s,30}$ of the shear waves in the first 30 m of depth.

For shallow foundations and retaining walls made of embankments this depth is considered beginning from the footing of the foundation..

The direct measurement of the propagation velocity of the shear waves is highly recommended. In case this determination is not possible, the classification can be done in base of the values of the equivalent number of blows of the dynamic penetration test *(Standard Penetration Test)* $N_{SPT,30}$ in

soils consisting mostly in coarse grain and in base of the equivalent undrained strength $c_{u,30}$ in soils consisting mostly in fine grain.

For the soils in the S1 and S2 categories in Table 3.2.III specific analysis are required to define the seismic actions, especially when the presence of soils susceptible to liquefaction and/or very sensitive clays can produce soil collapse.

Category	Description
S1	Deposits of soils characterized by values of $V_{s,30}$ inferior to 100 m/s (or $10 < c_{u,30} < 20$ kPa), that include a layer of at least 8 m of poor consistency fine grain soils, or include at least 3 m of peat or clays with high organic content.
S2	Deposits of soils susceptible to liquefaction, of sensitive clays or any other subsoil type that can not be classified in the previous types..

Table 3.2.III – Additional subsoil categories

The equivalent velocity of the shear waves $V_{s,30}$ is defined by:

$$V_{S,30} = \frac{30}{\sum_{i-1,N}\dfrac{h_i}{V_{S,i}}}[m/s]$$

The equivalent dynamic penetration strength $N_{SPT,30}$ is defined by:

$$N_{SPT,30} = \frac{\sum_{i-1,M}h_i}{\sum_{i-1,M}\dfrac{h_i}{N_{SPT,i}}}$$

The equivalent undrained strength $c_{u,30}$ is defined by:

$$C_{u,30} = \frac{\sum\limits_{i-1,K} h_i}{\sum\limits_{i-1,K} \dfrac{h_i}{C_{u,i}}}$$

In the previous expressions we have indicated with:

h_i = thickness (in m) of the i layer comprised in the first 30 m of depth

$V_{S,i}$ = velocity of the shear waves in the i layer

$N_{SPT,i}$ = number of NSPT blows in the i layer

$c_{u,i}$ = undrained strength in the i layer

N = number of layers comprised in the first 30 m of depth

M = number of layers of coarse grain terrains comprised in the first 30 m of depth

K = number of layers of fine grain terrains comprised in the first 30 m of depth

In case of subsoils formed by stratifications of coarse grain terrains and fine grain terrains, with similar thickness in the first 30 m of depth, included in one of the categories from A to E, and when direct measurements of the shear waves velocity are not available, one can proceed as follows:

- determine $N_{SPT,30}$ in the coarse grain terrain layers comprised in the first 30 m of depth
- determine $c_{u,30}$ in the fine grain terrain layers comprised in the first 30 m of depth
- determine the categories corresponding to the $N_{SPT,30}$ and $c_{u,30}$ parameters
- refer the subsoil to the worse category

1.14.3   Characteristic parameters

Characteristic parameters with CVsoils

Dynamic Probing software allows to define two stratigraphies: one established by the user based on the number of blows, the other on instrumental step.

The stratigraphy on instrumental step is very useful as the geotechnical parameters are returned in step, which can be exported from the command Export to other GeoStru programs, selecting file xlm for CVsoils. These files can be exported for the new GeoStru program, 'CVsoils', for the determination of characteristic geotechnical parameters.

In order to perform processing on instrumental step is necessary:

a) To define in data entry, in addition to stratigraphy user, even the stratigraphy on instrumental step;

b) To select Elaboration on instrumental step from the shortcut menu of tests.
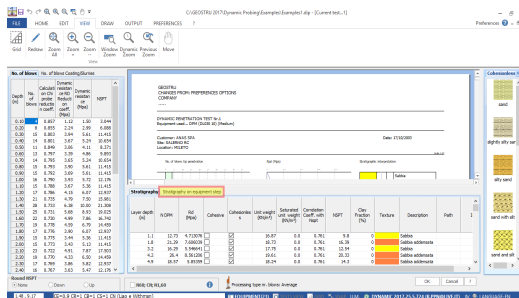
Characteristic parameters with Dynamic

From the menm General Data, Nspt calculation, there is the opportunity to choose how to assess Nspt in the layer. In addition there is the opportunity to select several options, among them a particular clarification:

Normal distribution R.C.

The value of Nspt,k is calculated on the basis of a normal or Gaussian distribution, fixed a probability of no exceedance of 5%, according to the following expression:

$$Nspt,_k = Nspt,_{mean} - 1.645 \cdot \left(\sigma_{Nspt} \right) / \sqrt{n}$$

where σ_{Nspt} is the standard deviation of Nspt.

Normal distribution R.N.C.

The value of Nspt,k is calculated on the basis of a normal or Gaussian distribution, fixed a probability of no exceedance of 5%, treating mean values of Nspt normally distributed:

$$Nspt,_k = Nspt,_{mean} - 1.645 \cdot \left(\sigma_{Nspt}\right)$$

where n is the number of samples.

The first distribution gives values near the minimum, whereas the second provides values close to average.

1.14.4 Liquefaction

The method of *Seed & Idriss* (1982) is the most known and used of the simplified methods and requires only the knowledge of few geotechnical parameters: the granulometry, the number of blows in the SPT test, the relative density, the unit weight.

To determine the value of the reducing coefficient *rd* is used the empirical formula proposed by *Iwasaki* and others (1978):

$$r_d = 1 - 0.015z$$

while for the corrective factor MSF in Table 1 is brought the value of this factor obtained by various researchers, among which *Seed H. B. and Idriss I. M (1982)*.

Magnitude	Seed H. B. & Idriss I. M. (1982)
5.5	1.43
6.0	1.32
6.5	1.19
7.0	1.08
7.5	1.00
8.0	0.94
8.5	0.89

Table 1 - Magnitude Scaling Factor

The liquefaction resistance CRR, is calculated as a function of the magnitude, the number of blows, the effective vertical pressure, the relative density.

By selecting the cases of terrains with liquefaction and no liquefaction during the earthquakes, a graphic (Fig. 1) is obtained.

Initially the correct number of blows at the desired elevation is calculated to take into consideration the lithostatic pressure through the following relation:

$$\left(N_{1.60}\right) = C_N \cdot N_m$$

where:

    N_m   average number of blows in the penetration standard test SPT

    C_N   corrective factor calculated using the following expression:

$$C_N = \left(\frac{Pa}{\sigma'_{v0}}\right)^{0.5}$$

where:

    σ'_{vo} effective vertical pressure;

    Pa   atmospherical pressure expressed in the same s'vo units;

    n   an exponent that depends on the relative density of the soil (Fig. 2)
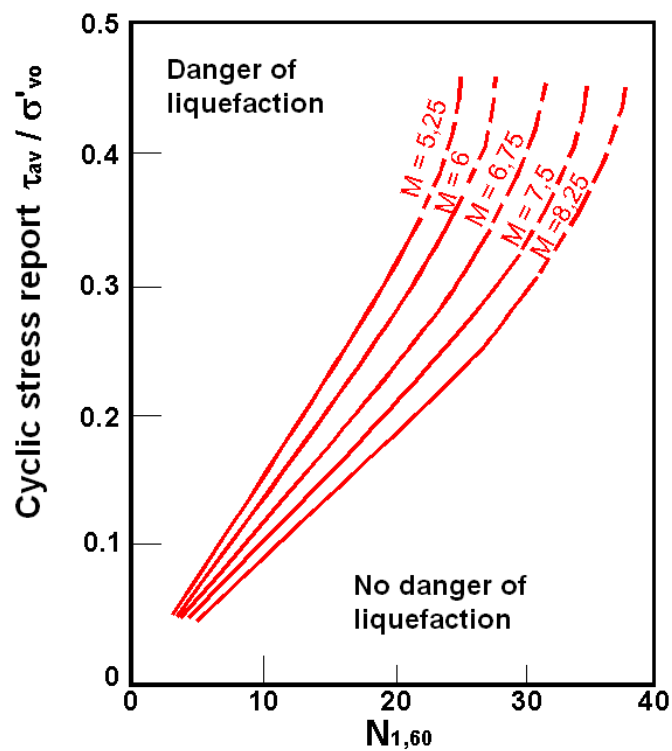
Figure 1 – Correlation between CSR and $N_{1.60}$
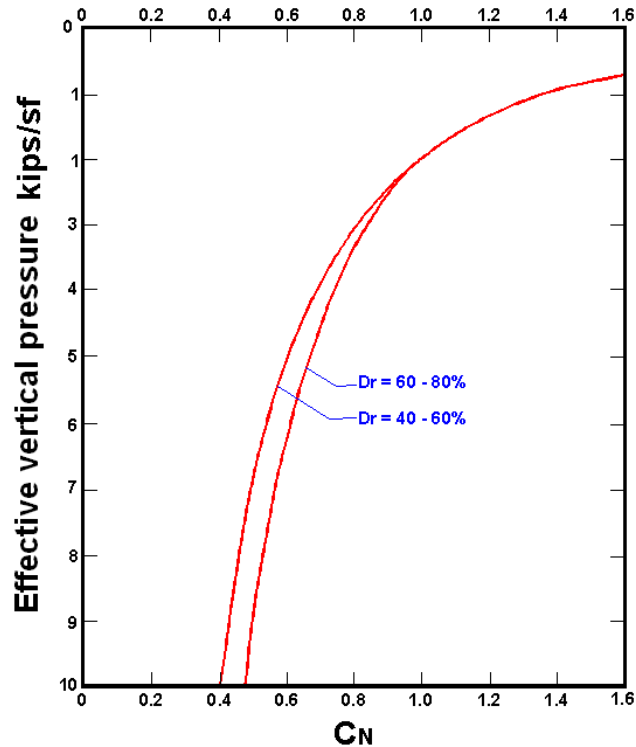
Figure 2 – *Corrective coefficient C_N*

It was demonstrated that for an earthquake of a magnitude equal to 7,5 CRR is:

$$CRR \approx \frac{N_{1.60}}{90}$$

Is therefore applied :

$$F_S = \frac{CRR}{CSR}$$

if FS > 1,3 the deposit can not be liquefied

The Authors have specified that this procedure is valid for sand with D50 > 0,25 mm; for sandy silt and silts they suggest to correct afterwards the value of $N_{1,60}$:

$$\left(N_{1.60}\right)_{CS} = N_{1.60} + 7.5$$

2   Dynamic AGS

AGS Data

The Association of Geotechnical and Geoenvironmental Specialists (AGS) is a non-profit making trade association established to improve the

profile and quality of geotechnical and geoenvironmental engineering. The AGS Format is for the electronic transfer of data in the geotechnical and geoenvironmental industries. The newest version is known as "AGS4" which contains an updated Data Dictionary and revised rules for AGS Format files.

The AGS format exports data from ASCII text files in a specified format. This format is divided into a series of data groups that represent different types of geotechnical and environmental data. Some of these data groups must be present in all files and the rest are optional.
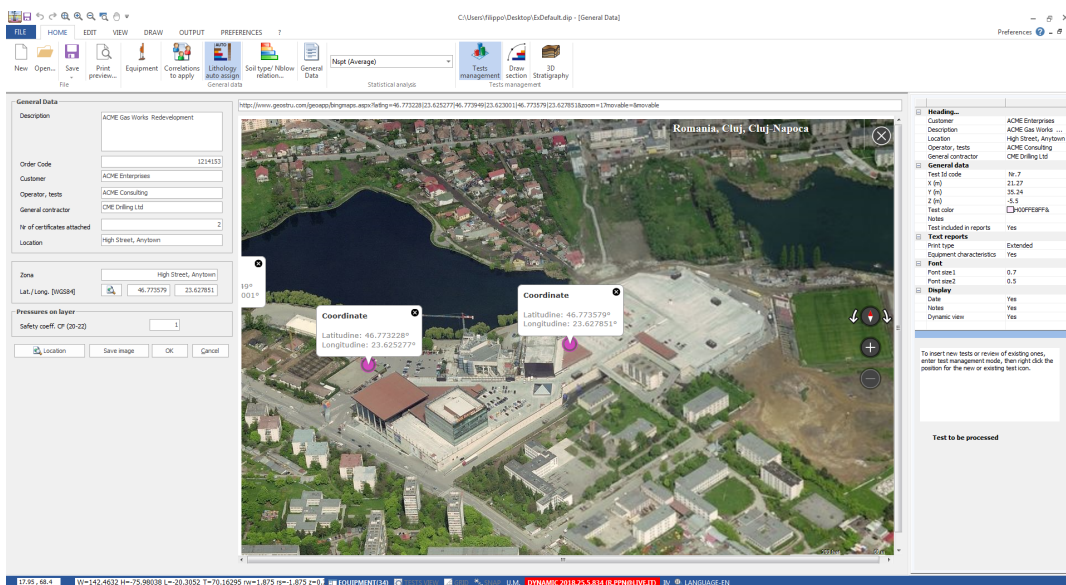
For a complete description of the data dictionary click on the web site below or contact us at GEOSTRU.

http://www.ags.org.uk/data-format/

Below is a list of the data groups currently supported by GEOSTRU. If there is data in a group not currently supported please contact us and we will do our best to add support for that group in the next update.

Required	Group Name	Description
Yes	PROJ	Project Information
Yes	ABBR	Abbreviation Definitions
Yes	TRAN	Data Transmission Information

Yes	TYPE	Definition of Data Types
Yes	UNIT	Definition of Units
No	DICT	User Defined Groups and Headings
No	CORE	Coring Information
No	DCPG	Dynamic Cone Penetration - General
No	DCPT	Dynamic Cone Penetration - Data
No	DREM	Depth Related Remarks
No	ERES	Environmental Contaminant Testing
No	GEOL	Geological Descriptions
No	HORN	Hole Orientation and Inclination
No	IDEN	Density Tests
No	IFID	Volatile Headspace Testing (Flame Ionization)
No	IPID	Volatile Headspace Testing (Photo Ionization)
No	IPEN	Hand Penetrometer Tests
No	ISPT	Standard Penetration Tests
No	IVAN	Vane Tests
No	LOCA	Boring and Well Location Data
No	SAMP	Sample Information
No	SCPG	Static Cone Penetration - General
No	SCPT	Static Cone Penetration - Data
No	WSTD	Water Strike General
No	GRPH	Graph Data

Exporting AGS Data

Before any data can be exported the project must first be opened. After a project has been opened boring and well data can be exported to an AGS file by selecting File > Export AGS4...

3 Geoapp

Geoapp: the largest web suite for online calculations

The applications present in Geostru Geoapp were created to support the worker for the solution of multiple professional cases.
Geoapp includes over 40 applications for: Engineering, Geology, Geophysics, Hydrology and Hydraulics.

Most of the applications are free, others require a monthly or annual subscription.

Having a subscription means:

- • access to the apps from everywhere and every device;
- • saving files in cloud and locally;
- • reopening files for further elaborations;
- • generating prints and graphics;
- • notifications about new apps and their inclusion in your subscription;
- • access to the newest versions and features;
- • support service throught Tickets.

3.1 Geoapp Section

General and Engineering, Geotechnics and Geology

Among the applications present, a wide range can be used for **Dynamic**. For this purpose, the following applications are recommended:

- ➢ NSPT Form
- ➢ Horizontal reaction coefficient of foundation piles
- ➢ Load test on poles
- ➢ Liquefaction (Boulanger 2014)
- ➢ Reinforced earth
- ➢ Soil Classification
- ➢ Bearing capacity
- ➢ Lithostatic tensions

4   Utility

4.1   Conversion Tables

✚ Converting slope inclination into degrees and vice versa

Inclination (%)	Angle (°)	Inclination (%)	Angle (°)
1	0.5729	26	14.5742
2	1.1458	27	15.1096
3	1.7184	28	15.6422
4	2.2906	29	16.1722
5	2.8624	30	16.6992
6	3.4336	31	17.2234
7	4.0042	32	17.7447
8	4.5739	33	18.2629
9	5.1428	34	18.7780
10	5.7106	35	19.2900
11	6.2773	36	19.7989
12	6.8428	37	20.3045
13	7.4069	38	20.8068
14	7.9696	39	21.3058
15	8.5308	40	21.8014
16	9.0903	41	22.2936
17	9.6480	42	22.7824
18	10.2040	43	23.2677
19	10.7580	44	23.7495
20	11.3099	45	24.2277
21	11.8598	46	24.7024
22	12.4074	47	25.1735
23	12.9528	48	25.6410
24	13.4957	49	26.1049
25	14.0362	50	26.5651

✥ Forces conversion

From	To	Operation	Factor
N	kg	Divide by	9.8
kN	kg	Multiply by	102
kN	Tone	Divide by	9.8
kg	N	Multiply by	9.8
kg	kN	Divide by	102
Tone	kN	Multiply	9.8

From	To	Operation	Factor
		b y	

1 Newton (N) = 1/9.81 Kg = 0.102 Kg ; 1 kN = 1000 N

✛ Pressures conversion

From	To	Operation	Factor
Tons/m^2	kg/cm^2	Divide by	10
kg/m^2	kg/cm^2	Divide by	10000
Pa	kg/cm^2	Divide by	98000
kPa	kg/cm^2	Divide by	98
Mpa	kg/cm^2	Multiply by	10.2
kPa	kg/m^2	Multiply by	102
Mpa	kg/m^2	Multiply by	102000

1 Pascal (Pa) = 1 Newton/mq ; 1 kPa = 1000 Pa

4.2 Database of soil physical characteristics

Soil	Minimum value	Maximum value
Loose sand	0.48	1.60
Average compact sand	0.96	8.00
Compact sand	6.40	12.80
Average compact clayey sand	2.40	4.80
Average compact silty sand	2.40	4.80
Compact sand and gravel	10.00	30.00
Calyey soil with qu< 2 Kg/cm²	1.20	2.40
Calyey soil with 2< qu< 4 Kg/cm²	2.20	4.80

Soil	Minimum value	Maximum value
Calyey soil with qu> 2 Kg/cm²	>4.80	

Approximate values of Winkler's constant K in Kg/cm^3

Soil	Minimum value	Maximum value
Dry gravel	1800	2000
Wet gravel	1900	2100
Compact dry sand	1700	2000
Compact wet sand	1900	2100
Loose dry sand	1500	1800
Loose wet sand	1600	1900
Sandy clay	1800	2200
Hard clay	2000	2100
Semisolid clay	1900	1950
Soft clay	1800	1850
Peat	1000	1100

Approximate values of the volume weight in Kg/cm^3

Soil	Minimum value	Maximum value
Compact gravel	35	35
Loose gravel	34	35
Compact sand	35	45
Loose sand	25	35
Sandy marl	22	29
Fat marl	16	22
Fat clay	0	30
Sandy clay	16	28
Silt	20	27

Approximate values of the friction angle j, in degrees, for soils

Soil	Value
Sandy clay	0.20
Soft clay	0.10
Plastic clay	0.25
Semisolid clay	0.50

Soil	Value
Solid clay	1
Tenacious clay	2÷10
Compact silt	0.10

Approximate values of cohesion in Kg/cm^2

Soil	Maximum value of E	Minimum value of E
Very soft clay	153	20.4
Soft clay	255	51
Medium clay	510	153
Hard clay	1020	510
Sandy clay	2550	255
Loess	612	153
Silty sand	204	51
Loose sand	255	102
Compact sand	816	510
Clayey schist	51000	1530
Silt	204	20.4
Loose sand and gravel	1530	510
Compact sand and gravel	2040	1020

Approximate values of the elastic module, in Kg/cm^2, for soils

Soil	Maximum value of n	Minimum value of n
Saturated clay	0.5	0.4
Not saturated clay	0.3	0.1
Sandy clay	0.3	0.2
Silt	0.35	0.3
Sand	1.0	-0.1
Gravelly sand commonly used	0.4	0.3
Loess	0.3	0.1
Ice	0.36	
Concrete	0.15	

Approximate values of the Poisson's ratio for soils

Rock	Minimum value	Maximum value
Pumice	500	1100
Volcanic tuff	1100	1750
Tufaceous limestone	1120	2000
Coarse sand dry	1400	1500
Fine dry sand	1400	1600
Wet fine sand	1900	2000
Sandstone	1800	2700
Dry clay	2000	2250
Soft limestone	2000	2400
Travertine	2200	2500
Dolomite	2300	2850
Compact limestone	2400	2700
Trachyte	2400	2800
Porphyry	2450	2700
Gneiss	2500	2700
Serpentine	2500	2750
Granite	2550	2900
Marble	2700	2750
Syenite	2700	3000
Diorite	2750	3000
Basalt	2750	3100

Approximate values of specific weight for some rocks in Kg/m^3

Rock	Minimum value	Maximum value
Granite	45	60
Dolerite	55	60
Basalt	50	55
Sandstone	35	50
Calyey schist	15	30
Limestone	35	50
Quartzite	50	60
Marble	35	50

Approximate values of the friction angle j, in degrees, for rocks

Rock	E		n	
	Maximum value	Minimum value	Maximum value	Minimum value
Basalt	1071000	178500	0.32	0.27
Granite	856800	142800	0.30	0.26

Rock	E		n	
	Maximum value	Minimum value	Maximum value	Minimum value
Crystalline schist	856800	71400	0.22	0.18
Limestone	1071000	214200	0.45	0.24
Porous limestone	856800	35700	0.45	0.35
Sandstone	428400	35700	0.45	0.20
Calyey schist	214200	35700	0.45	0.25
Concrete	Variable		0.15	

Approximate values of the elastic module and Poisson's ratio for rocks

4.3   Shortcut commands

The bar shown below can be used for a variety of functionalities:

1) With the shortcut letters of the menu followed by Enter you have quick access to commands.
   Ex: N + Enter to create a new file.

2) You can ask a question followed by ? + Enter. In this a case advanced research will be made in Help .
   Ex.: Seism+?+Enter for information on seismic analysis.

3) Opening a program in a quick way.
   Ex.: Slope+Enter to open GeoStru Slope software.

4) Quick access to GeoStru contacts.
   Ex.: Contact+?+Enter to access the contact list.

5) Quick acces to web features:
   Ex.: www.geostru.eu+Enter or info@geostru.eu. + Enter

This bar can be used as shortcut to some commands.
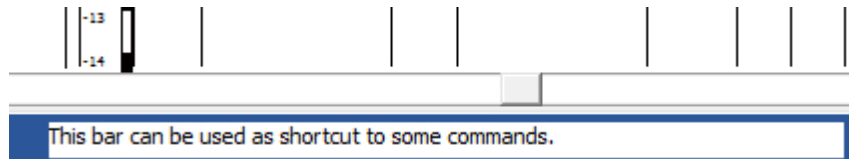
5   Important notes

Important notes

The program is based on the graphic entry of the penetrometric tests. To enter them:

    » Select the Tests management icon (from General Data menu)
    » Go on the work area
    » Click on the right button of the mouse and then choose the test type to input and enter the general data.
    » Right click of the mouse on the test and choose Data entry

In Data Entry a series of quick menus are available, among which:

    » On the unit weight column right click for automatic computation of the weight
    » On the graphic a series of functions among which input of layers with the right click of the mouse, export, etc.
    » To delete a layer select the entire row in the Layer table and press Del.
    » Once the input finished, go on the test and choose Process;
    » In Process, to choose parameters, go on the grid in upper right corner and press the right button of the mouse

*The difference between Process and Reprocess is the following:
the first one calculates the geotechnical parameters and keeps the eventual alteration of the parameters, while the second one recalculates the parameters without keeping eventual alterations brought by the user.

*If the equipment to use is not in the equipment list open the window Equipment from General Data menu, go with the mouse on Equipment, press the right button of the mouse and insert a new penetrometer.

The measurement units can be personalized from Preference menu > Options.

6   Bibliography

A.G.I., 1977. Raccomandazioni sulla programmazione ed esecuzione delle indagini geotecniche – AGI - Roma

Advanced Engineering Geology & Geotechnics STANDARD PENETRATION TEST

Bazaraa, A.R., 1967. "Use of the Standard Penetration Test For Estimating Settlement of Shallow Foundations on Sand." Ph.D. Dissertation, Department of Civil Engineering, University of Illinois, Urbana, Ill.

Begemann H.K.S., 1974. The Delft Continuous Soil Sampler. Bull. Int. Ass. Eng. Geol. 10:35-37.

Bowles, J.E., 1982. Foundation Analysis and Design. 3rd Ed., McGraw-Hill, Inc., New York.

Burland, J.B., Broms, B. and DeMello, V.F.B., 1977. "Behavior of Foundations and Structures." Proceedings of the 9th International Conforence on Soil Mechanics and Foundation Engineering, Vol. 3, pp. 495-546.

Carter M., 1983. Geotechnical engineering-Handbook-Pentech Press-London

Colleselli-Soranzo F., 1980. Esercitazioni di Geotecnica – Ed. Cleup – Padova

Craig R.F., 1985. Soil mechanics – Van Notraan Reinhold (UH) Co.Ltd

D'Appolonia, D.J., D'Appolonia, E., and Brissette, R.F., 1970. closure of "Settlement of Spread Footings on Sand." Journal of the Soil Mechanics and Foundation Division, ASCE, Vol. 96, No. SM2, pp. 754-761.

David Rogers J., Subsurface Exploration Using the Standard Penetration Test and the Cone Penetrometer Test Department of Geological Sciences & Engineering, 125 McNutt Hall, University of Missouri–Rolla, Rolla, MO 65409-0230.

De Mello V.F.B., 1967. Consideracoes Sobre os Ensalos de Penetracao e sua Problemas de Fundacoes Rasas. Thesis University Sao Paulo.

De Mello V.F.B., 1971. The standard penetration test. State of the art, session I) Panam. Conf. Soil Mech. Found. Eng., 7th, Mexico, 1:49-125.

DeBeer, E. and Martens, A., 1957. "Method of Computation of an Upper Limit for the Influence ofHeterogeneity of Sand Layers on the Settlement of Bridges." Proceedings of the 4th International Conforence on Soil Mechanics and Foundation Engineering, Vol. 1, pp. 275-282.

Eurocode 7 - Geotechnical design - Part 2 - Ground investigation and testing

Fletcher, G.F.A., 1965. "Standard Penetration Test: It's Uses and Abuses." Journal of the Soil Mechanicsand Foundation Division, ASCE, Vol. 91, No. SM4, pp. 67-75.

Gibbs H.J. and Holtz W.G., 1957. Research on determining the density of sands by spoon penetration testing. Proc. Of the 4th Internal Conference on Soil Mechanics and Foundation Engineering, Vol.1, pp.35-39.

Hunt R.E., 1986. Geotechnical engineering techniques and practices – MeGraw- Hill – Inc. USA.

Imai T. and Tonouchi K., 1982. Correlation of N-value with S-wave velocity and shear modulus. In: Proceedings of the 2nd European symposium on penetration testing; p. 57–72.

Iwasaki T., Tatsuoka F., Saheki M., 1977. An example of correlation between SPT N-value and strain dependent S wave velocity. In: Proceedings of the 12th Japan national conference on geotechnical engineering, JGS, Tokyo, pp 477-780 (in Japanese).

Malcev A.T., 1964. Interpretation of standard spoon penetration testing. Symp. Econ. Use Soil Testing in Site Investigation, Birmingham, 3, 11-16.

Meigh A.C. and Hobbs N.B., 1975. Soil Mechanics. Section 8, Civil Engineer's Reference Book, 3rd Ed.

Meyerhof G.G., 1965. Shallow Foundations. Journal of the Soil Mechanics and Foundations Division, American Society of Civil Engineers, Vol.91, No.SM2, pp.21-31.

Meyerhof, G. G., 1956. "Penetration Tests and Bearing Capacity ofCohesionless Soils." Journal of the Soil Mechanics Division, ASCE, Vol. 82, SM1, pp. 1-12.

Mitchell, J.K. and Gardner; W.S., 1975. "In Situ Measurement of Volume Change Characteristics," State-of-the-Art Report, Proceedings of the Conference on In-Situ Measurement of Soil Properties, Specialty

Conf. of the Geotechnical Div., North Carolina State University, Raleigh, Vol. II, pp. 279-345.

Peck, R.B. and Bazaraa, A.R., 1969. Discussion of "Settlement of Spread Footings on Sand by D'Appolonia et al.," Journal of the Soil Mechanics and Foundation Division, ASCE, Vol. 95, SM3, pp. 905-909.

Peck, R.B., Hanson, W.E. and Thombum, T.H., 1974. Foundation Engineering. John Wiley & Sons, N.Y.

Pellegrini M., 1982. Geologia Applicata – Ed. Pitagora – Bologna

Pilot G., 1982. Foundation engineering – Ecole national des ponts et chausees – Paris

Robertson P.K. and Campenella R.G., 1983. "Interpretation of Cone Penetration Tests-Part I (Sand)." Canadian Geotechnical Journal, Vol. 20, No.4, pp. 734-745.

Sanglerat, G. 1972. The Penetrometers and Soil Exploration. Elsevier, Amsterdam, 488p. Schmertmann, J., H. 1978.

Schmertmann J.H., 1970."Static cone to compute static settlementoversand."J Soil Mech Found Div, Vol.96(3):1011–1043.

Schmertmann, J.H. (1975) "In-Situ Measurement of Shear Strength," State-of-the-Art Paper, Session III, Proceedings of the Conf. on InSitu measurement of Soil Properties, Specialty Conf. of the Geotechnical Div., ASCE, North Carolina State University, Raleigh, Vol. I, pp. 57-138.

Schmertmann, J.H., Hartman, J.D. and Brown, P.R., 1978. "Improved Strain Influence Factor Diagrams." Journal of the Geotechnical Division, ASCE, Vol. 104, No. GT8, pp. 1131-1135.

Schultze, E. and Menzenbach, E., 1961. "Standard Penetration Test and Compressibility of Soils." Proceedings of the 5th International Conference on Soil Mechanics and Foundation Engineering, Vol. 1, pp. 527-531.

Seed H.B. and Idriss I.M., 1971. Simplified Procedure for Evaluating Soil Liquefaction Potential. J. Geotech. Egrg. Div, ASCE, 97(9), 1249-1274.

Shioi Y. And Fukuy J., 1982. Application of N-Value to Design of Foundations in Japan. In: Proceedings of the Second European Symposium on Penetration Testing, Amsterdam.

Skempton, A.W., 1986. "Standard Penetration Test Procedures and the Effects in Sands of Overburden Pressure, Relative Density, Particle

Size, Ageing and Overconsolidation." Geotechnique, Vol. 36, No.3, pp. 425-447.

Sowers, G.F., 1962. Shallow Foundations, Chapter 6 in Foundation Engineering, ed. by G.A. Leonards, McGraw-Hill, Inc., New York.

Stroud M.A. and Butler F.G., 1975. The standard penetration test and the engineering properties of glacial materials. Proc. Symp. Engineering Properties of Glacial Materials. Midlands Soil Mechanics and Foundations Society.

Terzaghi, K. and Peck, R.B. (1948) Soil Mechanics in Engineering Practice. John Wiley & Sons, Hoboken.

Trofimenkov,J.G., 1974. "PenetrationTestingin Eastern Europe," Proceedings of the European Symposium on Penetration Testing, Stockholm, June 5-7, 1974, Published by National Swedish Building Research, 1975, Vol. 2.1, pp. 24-28.

Vesic, A.S., 1970. "Tests on Instrumented Piles, Ogeehee River Site," Journal of the Soil Mechanics and Foundations Division, ASCE, Vol. 96, No. SM2, pp. 561-584.

7   Contact

Phone

(+39) 0690 289 085
(+40) 737 28 38 54

E-mail

info@geostru.eu
office@geostru.eu

Working hours

Monday – Friday
9 – 17 (GMT + 2)

Customer support

For customer support please open a ticket.