

CV Soil

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1 CV Soil

1.1 Introduction

CV Soil is a complete and innovative tool for the determination of characteristic geotechnical parameters according to a probabilistic approach, considering the statistic quantities obtained from a suitable number of samples.

With the introduction of the concept of *limit state* was developed in parallel also the concept of *characteristic value*.

Eurocode 7 concerning the geotechnical design, introduces for the first time the characteristic values of geotechnical parameters.

The characteristic value, understood as a precautionary estimate of the parameter which influences the onset of the limit state into consideration, must be used in any type of geotechnical verification.

The works must be verified for the ultimate limit states that may occur as a consequence of different combinations of actions and for the serviceability limit state, defined in relation to the expected benefits.

"Limit state is a condition beyond which the structure no longer fulfills the needs for which it was designed."

Ultimate limit state is considered when the limit state is associated with the extreme value of the bearing capacity of the structure. The overcoming of an ultimate limit state is irreversible and is defined collapse. Serviceability limit state is considered when it is linked to the achievement of a particular state of the structure which, while not causing the collapse undermines important functional aspects that limit the performance in operating conditions.

Defining the characteristic value therefore means choosing the geotechnical parameter that influences the behavior of the soil in that limit state, and adopt a value, or estimate, in favor of safety.

To the found characteristic values are applied a series of partial safety factors according to the limit state considered.

CV Soil main features

- The software calculates the characteristic values of the soil by analyzing the parameters obtained from the surveys. The geotechnical

parameters are treated as random variables and the set of values of the parameters as statistical population.

- With CVSoil it is possible to import data from multiple surveys within the same area. Data entry is simple and intuitive.
- The area of investigation can be displayed on Google Maps.
- The parameters that can be statistically analyzed are:
 - Angle of shearing resistance
 - Drained cohesion
 - Undrained cohesion
 - Relative density
 - Consistency index
 - Oedometric modulus
 - Shear modulus
 - Young's modulus
 - Nspt
 - Natural unit weight
 - Saturated unit weight
 - Pocket penetrometer
 - Poisson's ratio
 - Uniaxial compressive strength
 - Static tip resistance
 - Natural moisture
 - Shear waves velocity
 - Custom parameters
- Data related to performed surveys can be inserted and/or searched on the web.
- Automatically import data from Static and Dynamic Probing. The processed data can be automatically sent to all GeoStru software.
- Computation report that can be exported in the following formats: RTF, DOC, DOCX, PDF, HTM, JPEG.

1.2 Technical office data

The "*Technical office data*" section offers the possibility to insert all data related to the technical office, data that will be found in the computation report.

1.3 Area

To insert a new area just press the button "*Add area*" (or use the context menu viewed at a right click in the left panel containing the "*New area*" text in the main window) and specify the name for it.

Several identification data can be inserted for each area (name, description, customer, site, location, country, operator, operator's e-mail, person in charge, notes).

The "*View on map*" option gives the possibility to view the area on Google Maps.

By selecting the image using the "*Capture view*" button the user can send the current position to the computation report to be printed. Various objects (such as lines, circles, rectangles, text) can be inserted in the image, and also modified the color and thickness of the lines, the background color and percentage of transparency.

Other useful options in this window: "*Print preview*", "*Copy*" and "*Save*"



Note: In order to successfully view the area on the map it is necessary to fill **Location** and **Country** fields.

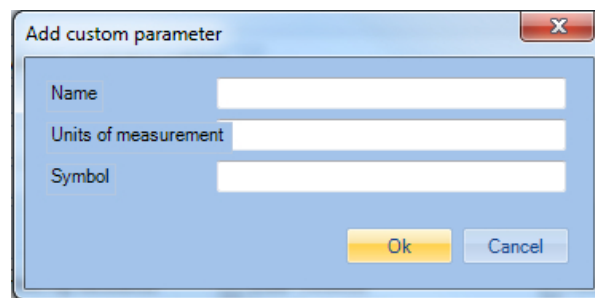
1.4 Survey

To insert a new survey just press the "*Add survey*" button in the "*Project-Survey*" menu (or use the context menu viewed at a right click in the left panel containing the "*New area*" text in the main window) and specify the name for it.

For each survey are available a series fields for general information, as well a list of parameters to be analyzed.

Name	New survey																			
Test date																				
Latitude,Longitude		[°]																		
Altitude	0	[m.s.l.m.]																		
Description																				
Test type	Continuous dynamic penetration soil test																			
Test depth		[m]																		
GWT	Not present																			
Soil category	A																			
Notes																				
Parameters to analyze for the survey	<table><tr><td><input type="checkbox"/> Angle of shearing resistance</td><td><input type="checkbox"/> Shear modulus</td><td><input type="checkbox"/> Poisson's ratio</td></tr><tr><td><input type="checkbox"/> Drained cohesion</td><td><input type="checkbox"/> Young's modulus</td><td><input type="checkbox"/> Uniaxial compressive strength</td></tr><tr><td><input type="checkbox"/> Undrained cohesion</td><td><input type="checkbox"/> N spt</td><td><input type="checkbox"/> Static tip resistance</td></tr><tr><td><input type="checkbox"/> Relative density</td><td><input type="checkbox"/> Natural unit weight</td><td><input type="checkbox"/> Natural moisture</td></tr><tr><td><input type="checkbox"/> Consistency index</td><td><input type="checkbox"/> Saturated unit weight</td><td><input type="checkbox"/> Shear waves velocity</td></tr><tr><td><input type="checkbox"/> Oedometric module</td><td><input type="checkbox"/> Pocket penetrometer</td><td><input type="checkbox"/> Add custom parameter...</td></tr></table>		<input type="checkbox"/> Angle of shearing resistance	<input type="checkbox"/> Shear modulus	<input type="checkbox"/> Poisson's ratio	<input type="checkbox"/> Drained cohesion	<input type="checkbox"/> Young's modulus	<input type="checkbox"/> Uniaxial compressive strength	<input type="checkbox"/> Undrained cohesion	<input type="checkbox"/> N spt	<input type="checkbox"/> Static tip resistance	<input type="checkbox"/> Relative density	<input type="checkbox"/> Natural unit weight	<input type="checkbox"/> Natural moisture	<input type="checkbox"/> Consistency index	<input type="checkbox"/> Saturated unit weight	<input type="checkbox"/> Shear waves velocity	<input type="checkbox"/> Oedometric module	<input type="checkbox"/> Pocket penetrometer	<input type="checkbox"/> Add custom parameter...
<input type="checkbox"/> Angle of shearing resistance	<input type="checkbox"/> Shear modulus	<input type="checkbox"/> Poisson's ratio																		
<input type="checkbox"/> Drained cohesion	<input type="checkbox"/> Young's modulus	<input type="checkbox"/> Uniaxial compressive strength																		
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<input type="checkbox"/> Oedometric module	<input type="checkbox"/> Pocket penetrometer	<input type="checkbox"/> Add custom parameter...																		

The user has the possibility to insert custom parameters (check "Add custom parameter").



The dialog box titled "Add custom parameter" has a close button (X) in the top right corner. It contains three text input fields: "Name", "Units of measurement", and "Symbol". At the bottom, there are two buttons: "Ok" and "Cancel".

The "View on map" option gives the possibility to view the area on Google Maps.

By selecting the image using the "Capture view" button the user can send the current position to the computation report to be printed. Various objects (such as lines, circles, rectangles, text) can be inserted in the image, and also modified the color and thickness of the lines, the background color and percentage of transparency.

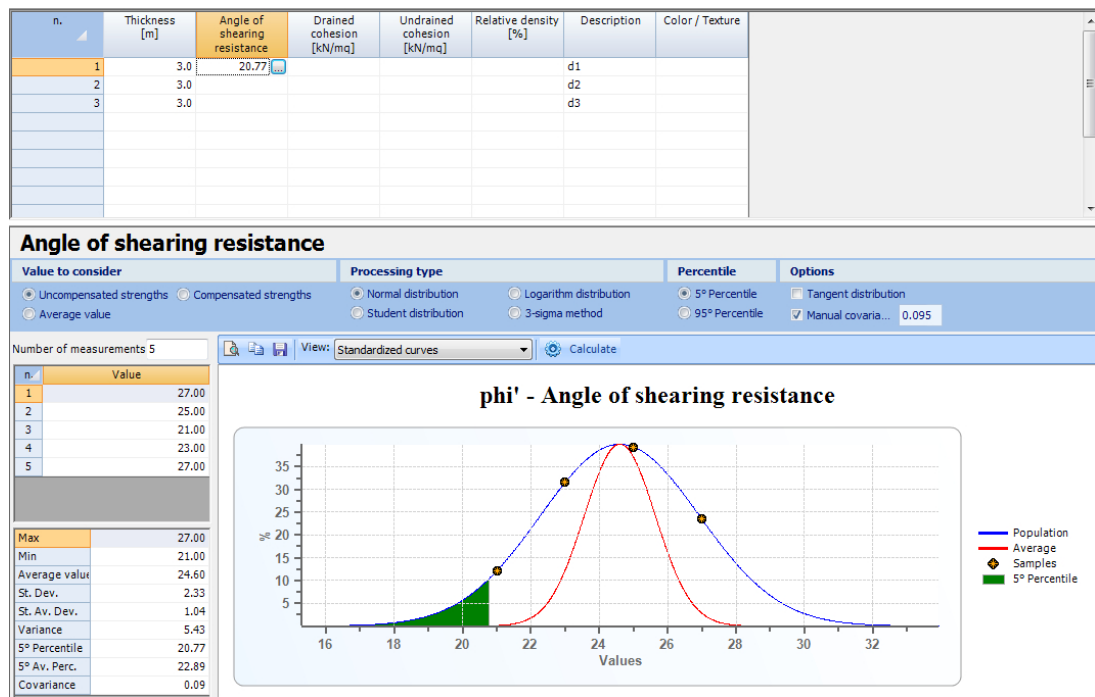


Note: In order to successfully view the area on the map it is necessary to insert correctly the coordinates.

1.4.1 Stratigraphy

The analysis of the geotechnical parameters is performed within the "*Stratigraphy*" section of the survey.

For each considered soil layer are determined the characteristic values of the parameters selected in the survey's [General data](#). To start processing the parameters in a certain layer the thickness must be assigned. Clicking on the button that appears in the sell of a parameter for a layer gives the possibility to insert the data and calculate the characteristic value.



Related to the stratigraphy, the following fields are available:

- *n* - number of the soil layer
- *Thickness* - thickness of the layer
- (*Parameter name*) - value of the characteristic parameter found from the statistic processing
- *Color/Texture* - gives the possibility to select a color or texture to assign to the soil layer

For each selected parameter the user can choose:

- *Value to consider* - Select "*Uncompensated strengths*" to obtain the minimum representative value of the sample,

select "*Compensated strengths*" to obtain the representative value of the average of values.

- *Processing type* - Select the processing type to be used (see [Samples](#)).
- *Percentile* - The user can consider the 5° percentile or 95° percentile of the statistic distribution.
- *Options* - Select the option "*Tangent distribution*" to process data using the tangent distribution of the parameter or "*Manual covar.* " to insert manually the variance coefficient.

Statistic processing

- *Number of measurements* - number of measurements available for the considered soil layer.
- *n* - number of the measurement
- *Value* - value of the measurement



Note: Data can be imported from external files with a simple Copy/Paste operation.



Note: The results from the table can be copied using a simple right click.

(See also [Theoretical notes](#), [Elements of statistics and](#))

1.5 Summary survey

The summary survey is used to gather the results of more surveys for a certain area. A summary survey can be inserted only for an area that has at least two surveys. The use of a summary survey is equivalent to a usual survey, but it is not possible to choose the parameters for which to calculate the characteristic parameters. The processed parameters

are automatically determined according to the ones in the surveys to which the summary survey is reported. To be more specific, the value of a characteristic parameter can be determined if all the surveys of the area include the study of the same parameter.

To insert a summary survey simply click "*Add summary survey*" from the "*Survey*" menu (or use the context menu viewed at a right click in the left panel containing the "*New area*" text in the main window) and specify the name for it.

Summary survey stratigraphy

To import data from surveys already inserted in the area it is necessary to setup a thickness for the soil layer and select the parameter to process by clicking on the appropriate cell.

Under the table are shown the info and measurements for the selected parameter.

Clicking on the button for the data import a window appears that gives the option to select what measurements to import from the surveys in the area.

Once import is made, characteristic parameters can be processed using all the selected measurements (see also [Stratigraphy](#)).

1.6 Database

Activate survey k

Activates the sharing of surveys on GeoStru database. Activating this function, the GeoStru users have the possibility to share between them their surveys and the results obtained.

Contact

Insert contact details to be shown to other users.

Search shared survey

Search the online surveys shared in the vicinity of the area of interest. This can be specified in a descriptive way, or by defining the geographic coordinates WGS84.

It is possible to find a survey by entering the coordinates of the area of interest or a literal description. It will be shown the list of surveys that are included within the search radius, set by the user. For each of the downloaded surveys is shown a lists of results and the summary information.

Share survey on web

Inserts the selected survey in GeoStru a database. Sharing on the web allows users to share between them the results of their work.

1.7 How to set up a new project

- 1 Fill in data regarding the [technical office](#).
- 2 Insert the [area](#) and general information.
- 3 Add one or more [surveys](#) by inserting the appropriate [general data](#).
- 4 Click on [Stratigraphy](#) (for each parameter selected in General data it will be calculated the characteristic value).
- 5 Insert the thickness of the layer and click on the button in the cell of the parameter.
- 6 Choose the value to consider (Uncompensated strengths, Compensated strengths, Average value), the type of processing and further options.
- 7 Insert the number and the value of the measurements.

- 8 Click on "Calculate". The results will be shown in the table and the characteristic value of the parameter will be shown in the appropriate cell. (see point 5).
- 9 Select the Print options and click Print report.



Note: If for an area are inserted at least two surveys then a summary survey can be inserted.

The survey may also be imported from *.xml files using the "*Import project from XML*" command.

The import file can be written using an xml editor or a simple text editor, or can be generated by other GeoStru software like Dynamic Probing or Static Probing. Importing a survey from an xml file automatically sends the characteristic parameters to be calculated to the Stratigraphy section of CV Soil software.

A survey processed with CV Soil can be exported with an *.xml extension and can be used in other GeoStru programs - use "*Export project in XML*" command.

1.8 Theoretical notes

1.8.1 Characteristic geotechnical parameters

CV Soil allows the determination of characteristic geotechnical parameters according to a probabilistic approach.

The geotechnical parameters are treated as random variables, and the set of values assumed by the parameters such as statistic population. It is assumed that the investigated variables (f, cu, etc.) vary randomly within the soil.

The derivation of the characteristic value must be such that the calculated probability of a worst value (worst case) that governs the occurrence of the limit state into consideration is not greater than 5%.

It is therefore a conservative margin of 5% (which may coincide with a 5° percentile or the 95° percentile of a statistical distribution into account), which probabilistically guarantees us to have a 95% certainty in the computation of the characteristic value.

There are indications in the literature that the angle of shearing resistance ϕ does not follow a normal distribution, but its tangent yes, so the variable to be included in the formulas is not ϕ but $\tan(\phi)$. In addition, the undrained cohesion c_u seems to follow a lognormal distribution, so the variable to use for the estimates should not be directly c_u , but his natural logarithm $\ln(c_u)$.

The ϕ e c_u characteristic are obtained by calculating the arctangent, respectively the exponential of the variable x_k obtained as a result.

The criteria under which to choose the calculation procedure of the characteristic parameters within a homogeneous layer of soil are two:

- 1) Based on the number of [measurements taken](#). With the increase of the size of the sample improves the estimate of the mean and standard deviation of the population that are used to construct the curve of the probability density, and then estimate the value corresponding to the probability of not exceeding 5%.

- 2) Based on the presence or absence of resistance compensation of the soil

See also [Elements of statistics and probability](#).

1.8.2 Elements of statistics and probability

The probability

Probability theory is the mathematical study of probability.

Mathematicians refer to the probabilities as numbers in the range from 0 to 1, assigned to "events" whose occurrence is random.

The probability is a number associated with an event (resulting from the observation of an experiment) that may or may not occur.

A priori classical probability

If N is the total number of cases of the sample space of a random variable and n is the number of favorable cases for which the event A is realized, the a priori probability of A is given by:

$$P(A) = \frac{n}{N}$$

The a priori probability can assume a value between 0 and 1. A probability equal to 0 indicates that the event is impossible, a probability equal to 1 indicates that the event is certain.

Frequentist probability

If m is the number of trials in which the event A occurred at a total of M trials, the probability of A is given by:

$$P(A) = \lim_{M \rightarrow \infty} \frac{m}{M}$$

The limit that appears in this definition should not be understood in a mathematical sense, but in an experimental way: the true value of the probability is found only by making an infinite number of trials.

Indicators of a statistical distribution

The description of the data from a statistical sample is done by determining the distribution of the relative frequencies, which implicitly contains all the information that can be drawn from the sample.

The indicators are parameters that describe quantitatively the general aspects of the statistical distribution.

- In the probability theory the probability or distribution function of a discrete random variable x is a function of a real variable that assigns to each possible value of x the probability of the event.
- The expected value m (also called average or hope) of a random real variable x is a number that formalizes the heuristic idea of average value of a random phenomenon and is defined as:

$$\mu(x) = \frac{\sum_{i=1}^n x_i}{n}$$

- The variance of a random variable x is a number $\text{Var}(x)$, which provides a measure of how different are the values taken by the variable, ie how much they deviate from the mean m . The variance of x is defined as the expected value of the square of the random centered variable. In statistics is often preferred the square root of the variance of x , the standard deviation indicated by the letter σ . For this reason, the variance is indicated with σ^2 . In statistics are used usually two estimators for the variance of a sample of cardinality n :

$$\sigma_n^2(x) = \frac{\sum_{i=1}^n [x_i - \mu(x)]^2}{n} \quad \text{e} \quad \sigma_{n-1}^2(x) = \frac{\sum_{i=1}^n [x_i - \mu(x)]^2}{n-1}$$

The estimator σ_{n-1} has an expected value equal to its variance, by contrast, the estimator σ_n has a value different from the expected variance. A justification of the term $n-1$ is given by the need to estimate also the mean. If the mean μ is known, the estimator σ_n becomes correct.

- Starting from the standard deviation is also defined the coefficient of variation or relative standard deviation as the ratio between the standard deviation and the arithmetic mean of the values:

$$C.O.V. = \frac{\sigma(x)}{\mu(x)}$$

This new parameter (often used as a percentage) is used to make comparisons between different types data dispersions, regardless of their absolute amounts.

The way in which is distributed the probability of a random variable depends on many factors, and, as there are infinite possible graphics of functions, we can have endless ways for different probability distributions.

The most significant probability distributions are:

- 1) Normal distribution

- 2) Lognormal distribution
- 3) Student's t-distribution

Normal distribution

The random variable Normal (also called random Gaussian variable or Gaussian curve) is a continuous random variable with two parameters, conventionally indicated with:

$$N(\mu; \sigma^2)$$

It is one of the most important random variables, especially continuous, as it is the starting base for the other random variables (Chi Square, Student t, F Snedecor etc.).

The Gaussian random variable is characterized by the following probability density function, which often refers to the term Gaussian curve or Gaussian:

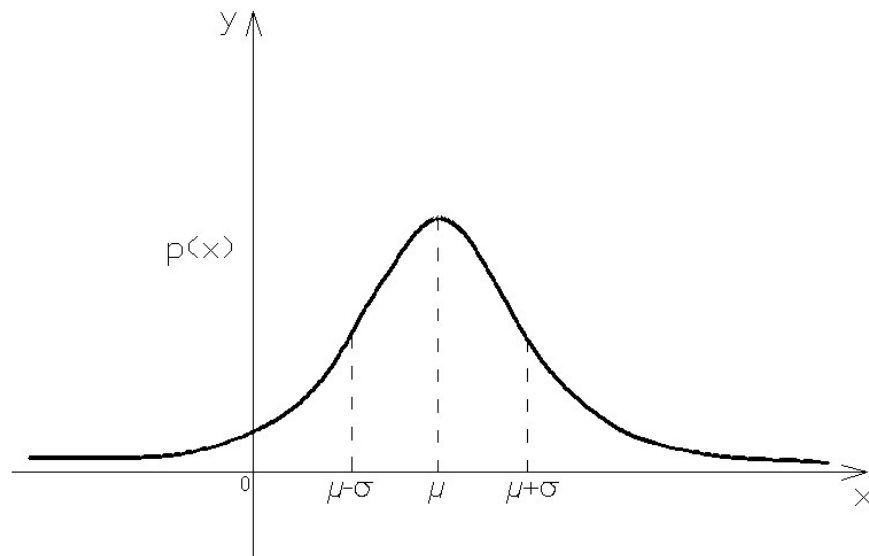
$$p(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

where x is the size of which we must calculate the probability

$$-\infty < x < \infty$$

and where μ and σ represent the average population and the standard deviation. The equation for the density function is constructed such that the area under the curve represents the probability. Therefore, the total area is equal to 1.

One of the most noticeable characteristics of the normal distribution is its shape and perfect symmetry. Notice that if you fold the picture of the normal distribution exactly in the middle, you have two equal halves, each a mirror image of the other. This also means that one half of the observations in the data fall on each side of the middle of the distribution. The midpoint of the normal distribution is the point that has the maximum frequency. That is, it is the number or response category with the most observations for that variable. The midpoint of the normal distribution is also the point at which three measures fall: the mean, median, and mode. In a perfect normal distribution, these three measures are all the same number.



Resorting to standardization (statistics) of the random variable, ie the transformation such that:

$$Z = \frac{x - \mu}{\sigma}$$

where the resulting variable

$$-\infty < Z < \infty$$

also has normal distribution with parameters $\mu = 0$ and $\sigma = 1$, the curve of gauss can be written as:

$$p(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{z^2}{2}}$$

The characteristic value can be estimated by using the expression:

$$x = \mu + Z\sigma$$

With a probability of 5% Z (from the table) is equal to -1.645 , so the above expression can be rewritten as:

$$x = \mu - 1.645\sigma$$

Dividing both sides by the mean μ the relationship becomes:

$$x = \mu [1 - 1.645 C.O.V.]$$

The lognormal distribution

A random variable x has a lognormal distribution with parameters μ eg, if $\ln(x)$ is normally distributed with mean μ and standard deviation s .

Equivalently:

$$x = \exp(y)$$

and

$$y = \ln(x)$$

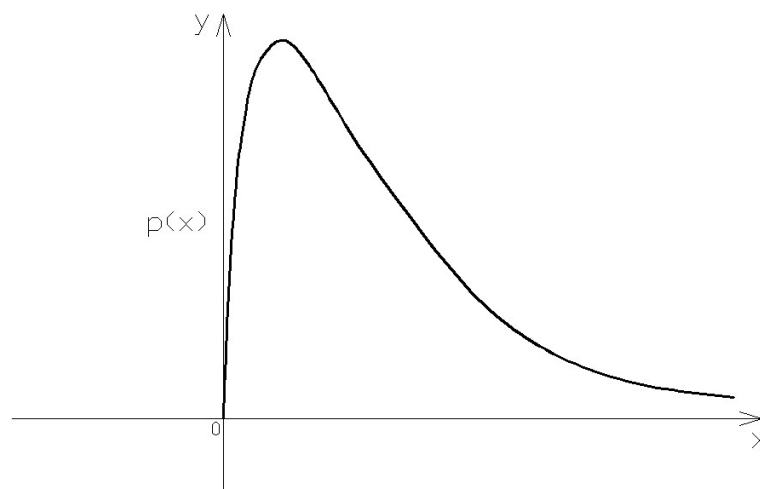
where y is normally distributed with mean μ and standard deviation s .

The parameter μ can be any real, while s must be positive.

The distribution curve of the probability takes the following form:

$$p(x) = \frac{1}{x\sqrt{2\pi\sigma^2}} e^{-\frac{(\ln x - \mu)^2}{2\sigma^2}}$$

Because of the asymmetry of the curve, the values of mean, mode and median do not coincide, unlike what happens instead in the normal distribution. The maximum point of the curve is, in fact, shifted to the left compared to the average value.



Student's *t*-distribution

The Student's *t*-distribution considers the relationship between the mean and variance in small samples, extracted from a normally distributed population, using the variance of the sample.

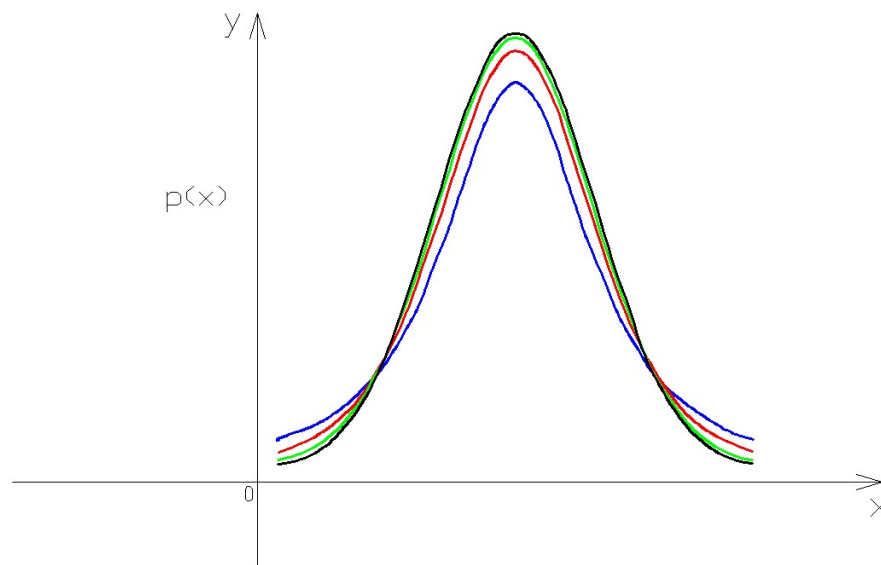
Given a normally distributed population, one draws a random sample of n observations, and calculate the random variable t , defined by the following equation:

$$t = \frac{x - \mu}{s / \sqrt{n}}$$

where s is the sample variance.

t follows a Student t law with $n-1$ degrees of freedom. The quantity in the numerator is called the standard error of the sample.

The shape of the distribution depends on the degrees of freedom, ie, by the size of the sample. For large n (>30) t tends to a normal.



Rule of three-sigma

In a normal distribution 99.73% of the measurements fall at a distance from the mean value of three times the standard deviation, ie there is a probability of 99.73% that a measure drawn randomly from the population lies within $\pm 3s$ compared to the average m .

Once known the highest value measured in the population given by:

$$HCV = \mu + 6\sigma$$

and the lowest:

$$LCV = \mu - 6\sigma$$

the standard deviation of the population can be calculated as:

$$\sigma = \frac{HCV - LCV}{6}$$

Bayes' Theorem

Bayes' theorem, proposed by Thomas Bayes, stems from two fundamental theorems of probability: the probability theorem and the absolute probability theorem. It is often used to calculate the posterior probabilities given by observations.

This theorem can be expressed as:

$$P(A \setminus B) = \frac{P(B \setminus A) \cdot P(A)}{P(B \setminus A) \cdot P(A) + P(B \setminus A') \cdot P(A')}$$

Where:

- $P(A)$ the *prior*, is the initial degree of belief in A (the probability that event A occurs)
- $P(A \setminus B)$ the *posterior*, is the degree of belief having accounted for B (the probability that event A occurs if event B occurs)
- $P(B \setminus A)$ the probability that event B occurs if event A occurs
- $P(B \setminus A')$ the probability that event B occurs if it doesn't occur the event $A=1-P(B \setminus A)$
- $P(A')$ the probability that it doesn't occur the event $A=1-P(A)$.

1.8.3 Samples

Large number of samples

In case n is greater than or equal to 30 are valid the expressions of the normal distribution and of the lognormal distribution.

If we talk about compensated or uncompensated strengths from direct measurements and in the considered limit state is involved a high volume of soil (eg. in shallow foundations or in a landslide the volume affected by the failure surface is very large) is run a conservative estimate of the average value of geotechnical parameters.

In the case of small volumes of soil, when direct measurements are performed outside of the significant volume and we speak about uncompensated strengths from measurements extrapolated in the calculation of the characteristic value it's estimated a value close to the minimum measured.

In the geotechnical field is quite often met the need to perform some checks in the presence of limited data. This generally happens in projects of modest importance when performing surveys with SPT or laboratory tests on samples extracted, of which only a few affecting the homogeneous layer or the thickness of influence of the limit state. A frequent objection to the statistical treatment is that this can not be done with a few data. On the other hand, using the discrimination and technical judgment and a priori regional and local knowledge, a statistical treatment is possible even in the extreme case of only one data available (or, at least, no data available, in this case by relying solely on prior knowledge).

Small number of samples

If n is comprised between 5 and 30 are valid expressions of the Student's t-distribution ([Gosset, 1908](#)).

For uncompensated strengths from extrapolated measurements can be used the rule of three-sigma replacing, in the calculation of the standard deviation of the population, at the value 6 of the denominator a variable, function of the number of measurements.

Very small number of samples

If n is between 1 and 5 it will be used the Student's t-distribution ([Gosset, 1908](#)).

For uncompensated strengths from extrapolated measurements we estimate the coefficient of variation. The values of the coefficients of variation can be obtained from the scientific literature. The higher the

value of the C.O.V. the greater the dispersion of the data, and therefore the lower the minimum value of the parameter estimated.

Unit sample

In the case of the unit sample is assumed that the single measurement represents the average value having an approximate idea of the variability of the parameter in the considered soil.

In this case it is applied the Bayes' theorem.

Null sample

In this case we refer to measures available in areas close to the one investigated, considering soils with similar geotechnical characteristics.

For the estimation of m and C.O.V. are used the specifications provided by [Orr and Cherubini C. \(1999\)](#):

$$\mu = \frac{a + 4b + c}{6}$$

$$C.O.V. = \frac{c - a}{a + 4b + c}$$

with a minimum estimated value of x , b estimated as most probable value of x , c estimated as maximum value of x .

Outliers

In the presence of values much lower or much higher than most of the data, the determination of the characteristic parameters can be altered significantly. Is therefore necessary to eliminate these extreme values (outliers) before calculating characteristic values.

1.9 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 through Tickets. Enter topic text here.

1.9.1 Geoapp Section

General and Engineering, Geotechnics and Geology

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

- [Sismogenetic zone](#)
- [Soil classification SMC](#)
- [Seismic parameters](#)
- [NSPT](#)
- [Slope stability](#)
- [Landslide trigger](#)
- [Critical heigh \(maximum depth that can be excavated without failure\)](#)
- [Bearing capacity](#)
- [Lithostatic tensions](#)
- [Foundation piles, horizontal reaction coefficient](#)
- [Liquefaction \(Boulangier 2014\)](#)

2 References

Bayes T., 1763. An Essay towards solving a Problem in the Doctrine of Chances. By the late Rev. Mr. Bayes, F. R. S. communicated by Mr. Price, in a letter to John Canton, A. M. F. R. S., Philosophical Transactions, Giving Some Account of the Present Undertakings, Studies and Labours of the Ingenious in Many Considerable Parts of the World, 53:370–418.

Bayes T., 1763/1958. Studies in the History of Probability and Statistics: IX.

Thomas Bayes' Essay Towards Solving a Problem in the Doctrine of Chances, Biometrika 45:296–315. (Bayes' essay in modernized notation).

Gosset W.S., 1908. The probable error of a mean. Biometrika. 6 (1): 1–25.

Orr T.L and Cherubini, 2003. Use of the ranking distance as an index for assessing the accuracy and precision of equations for the bearing capacity of piles and at-rest earth pressure coefficient. Canadian Geotechnical Journal, 40 (6): 1200-1207.

3 Recommended book

Geotechnical, engineering, and geology books

Portal books: [explore the library](#)

• Methods for estimating the geotechnical properties of the soil

[Methods for estimating the geotechnical properties of the soil](#):

semi-empirical correlations of geotechnical parameters based on in-situ soil tests.

This text is designed for all professionals who operate in the geotechnical subsurface investigation. The purpose of this text is to provide an easy reference tool relatively to the means available today.

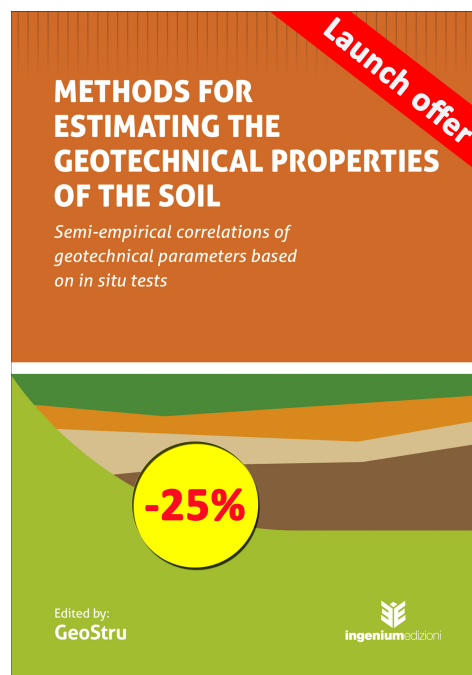
Theoretical insights have been avoided, for which please refer to the bibliography attached, except in cases where these were considered essential for the understanding of the formulation. The reason for this is obvious: make the text as easy to read as possible.

After a brief introduction about volumetric and density relationships with the most common definitions used for soils, in the following

chapters we briefly described some of the most widespread in situ geotechnical testing and correlations to derive empirically geotechnical parameters and a number of useful formulations available today in the field of Geology.

The text concludes with the inclusion of formulas used in Technical Geology, considered of daily use to those working in the sector.

The topics are intended to provide a basic understanding of the in situ geotechnical testing and evaluation of geotechnical parameters necessary to define the geotechnical model.



4 External links

Bayes' theorem at the [Encyclopædia Britannica](#)

Weisstein E.W., [Distribuzione t di Student](#), in MathWorld, Wolfram Research.

5 Contact



See the contact page on the website for more information about our contacts and offices' addresses in Italy and abroad.

