

HANDHELD CPT PENETROMETER



The hand-pushed CPT penetrometer is a portable and handy tool for simple, quick and accurate assessment of soil conditions for various purposes. It is easy and straightforward to operate; it can be pushed into the ground using the weight of one's own body.

The penetrometer provides very accurate information on soil strength, or resistance to penetration, to some depth. The acquired data make it possible to determine the bearing capacity of the ground (N/mm²). However, strength measurements are affected by moisture, porosity, and rock content and are to be taken into account. When combined with other information, such as soil moisture, structure, and texture, data from penetrometers can contribute to a very accurate picture of soil properties.

The penetrometer has many advantages; it is relatively inexpensive, provides high quality measurement data, it is compact and lightweight, easy to operate and requires little maintenance.

Typical Uses

Handheld CPT penetrometers are primarily used to determine the bearing capacity of the upper 2-3 meters of the soil. Using this device the penetration resistance is determined; this is representative for the bearing capacity of the soil. Since it is an easy to use measuring tool and it allows for quick and accurate assessment of soil conditions, it is used for various purposes, e.g.:

Suitability of Roads for Heavy Vehicles

Construction works depend on the use of heavy machinery, like dozers, excavators, crawler cranes, hydraulic cranes, and alike. These machines generate high ground pressures, whilst the access roads to the job sites and the job site itself are in general not paved. The risk exists that the bearing capacity of the soil is not sufficient and a machine subsides or even tips over. The handheld CPT penetrometer has proved to be an indispensable tool for assessing the roads and job site terrains.



Geotechnical Soil Investigation

Since the handheld CPT penetrometer is a useful tool to measure soil compaction and the bearing capacity of the ground, it can also be used for basic advise for the foundations of roads, small buildings, pedestrian bridges, and alike.

Agriculture

The agricultural industry could benefit from information provided by a hand-held CPT penetrometer, such as identification of areas of high compaction, plow pans, and clay zones to help determine appropriate irrigation, fertilization, and cultivation practices. Agronomists can use the penetrometer for the research of the (expected) growing circumstances of plants in the soil.

Farming

In farming the handheld CPT penetrometer is used to determine the settings for farming machinery.

The horticulture is an industry that is developing rapidly and becomes more and more automated. This



high degree of automation is essential, since todays green-houses can be as large as several hectares. The transport inside the green-houses is primarily done by means of fully automated tube-rail-systems. Because of the dynamic forces to which this system is exposed and the fact that it is based on soft and during the growing process constantly changing mould, it is of paramount importance to have exact data available of the soil conditions. This to avoid any instability or even tipping over of the carts running on the tube-rail-systems.

Wood Logging

Assessing the impact of logging operations on forest soil compaction is important. The hand-held CPT penetrometer helps soil scientists and contracting officers verify that specifications on soil compaction limits are being followed.

Contractors

In civil engineering the hand-held CPT penetrometer can help pinpoint compaction problems that might require more extensive soil testing. It's also useful for looking at variability or changes in soil strength caused by equipment, vehicles, and foot traffic.

Tree Planting

Forest tree nurseries en landscape gardeners could benefit also from the hand-held CPT penetrometer. Soil compaction begins to inhibit the root growth of most plants when the soil's strength is about 1,500 kPa. The roots of many plants quit growing when the soil's strength reaches about 2,500 kPa. A hand-held penetrometer can help identify these areas fast and easy and help to enhance the (expected) growing circumstances of plants in the soil.

Soil Compaction

In cases where the soil was compacted artificially, the hand-held CPT penetrometer has proved to be an excellent tool to evaluate how well the compaction of the soil was done and at what rate.



Handheld CPT Penetrometer Sets

The handheld CPT penetrometer composes of:

- A measuring body with 2 push handles and an accurate hydraulic reading dial (range up to 10,000 kN/m2 (= 10,000 kPa), accuracy ± 8% of FS) equipped with drag pointer
- 3 stainless steel sounding rods (D = 15 mm, L = 450 mm)
- 1 stainless steel sounding rods (D = 10 mm, L = 450 mm) with a 1 cm² conical tip
- 3 conical tips, i.e. a 2 cm² (D = 16 mm), a 4 cm² (D = 22 mm), and a 6 cm² (D = 28 mm) tip
- 3 open ended spanners
- Cone wear gauge to check the dimensions of the conical tips
- Compact aluminium carrying case
- Measurement data conversion chart
- Calibration certificate and instruction manual
- Optionally extra sounding rods for testing to a depth of max. 3 meter and a hand operated auger



Weight and Dimensions

The handheld CPT penetrometer set suitable for tests up to 1 metre depth weights 11 kg and measures 59x19x28 cm. The set suitable for tests up to 3 metre depth weights 20 kg and measures 60x40x20 cm.

Principle of Operating

To use, apply constant pressure on the built-in hand grips to push the sounding rods and conical tips perpendicularly into the ground. Resistance of the soil is determined by dividing the reading by the surface area of the selected conical tip. A drag pointer records the highest value measured. Avoid jerking pushes, since they yield values which are too high and which do not represent the soil.

The resistance measured by the cone can be read from the pressure gauge as indicated by the black pointer. The maximum



resistance recorded during the entire test is indicated by the drag pointer. The resistance to penetration (kPa/cm²) of the soil can now be determined by dividing the recorded value by the surface of the conical tip. The value of the resistance to penetration to be expected determines the surface of the conical tip to be used.





For high values a small conical tip is to be used and for low values a larger conical tip is to be applied. The larger the conical tip the more accurately the value of the resistance to penetration can be determined.

In order to acquire reliable data the sounding rods and conical tip are to be pushed into the ground at a consistent speed. An operator's field notes are helpful when data require editing because of unusual conditions, such as very rocky soils, large roots, voids, buried organic materials, and very dry conditions. Conduct multiple tests at several locations in a given area to better understand variations in soil conditions and reduce the effects of operator inconsistency.

Operating Procedures

Before starting the measurements, check whether the black pointer of the manometer (2) is at zero. Because of internal friction the pointer may sometimes not return to zero. By turning the plunger and pulling it out a little the pointer must return to zero. If the black pointer is not at zero, no soundings can be made (the apparatus must be returned to the factory for control).

The red maximum pointer can be turned to zero with the help of the adjusting screw (1). If both pointers are at zero, select a cone (9) appropriate for the expected density of the soil that is to be sounded. The hand penetrometer is an instrument for indicative measurement of maximal resistance to penetration. The apparatus has a mean deviation of + and - 8%. For a long term and accurate use a measuring range of 200 - 700 N is advised (green zone on manometer). Measurements in the range of 0 to 100 N are not possible. In the range 100 to 200 N the deviation is +/- 15%. The large deviation can be avoided by choosing another cone. Measurements in the range 700 to 1000 N must be avoided because they shorten the life cycle of the manometer. When temperature is below 5 °C, deviation will be larger as a result of thickening of the oil.

Fit the cone to the rod (8) and connect the rod, via an extension rod (7) and the plunger (6), to the measuring instrument (5). Next apply uniform pressure to the hand grips (4), push the cone into the ground at a constant rate of 2 cm/sec. During the measurement, the resistance can be read under the black pointer of the manometer. The maximum resistance, while measuring that section, is indicated by the red maximum pointer. Before starting the following section, turn the maximum pointer once again to zero.

The apparatus is withdrawn by pulling with one hand on the measuring instrument (5) and one hand on the rod (8). When applying the nylon quick-coupler use the push/pull handle to withdraw the rods from the soil. With cones 1 and 2, the maximum sounding depth, without augering, for a single sounding is 50 cm. The resistance is read in N (Newton) and noted for the appropriate depth. The base area of the cone should also be noted because the cone resistance is expressed in N/cm2.







Example: A manometer reading of 300 N and a cone base area of 5 cm² means a cone resistance of: $300/5 = 60 \text{ N/cm}^2$. Or: $60 \text{ N/cm}^2 = 600 \text{ kN/m}^2 = 0.6 \text{ MPa}$ (mega-Pascal = 10^6 Pascal).

Cone surface/ Manometer value in N	1 cm ²	2 cm ²	3 ¹ / ₃ cm ²	5 cm ²
100	100	50	30	20
150	150	75	45	30
200	200	100	60	40
250	250	125	75	50
300	300	150	90	60
350	350	175	105	70
400	400	200	120	80
450	450	225	135	90
500	500	250	150	100
600	600	300	180	120
700	700	350	210	140
800	800	400	240	160
900	900	450	270	180
1000	1000	500	300	200

Table in N/cm² (100 N/cm² = 1000 kN/m² = 1 MPa) (N x 1.45 = PSI and N x 0.01 = MPa)

Maintenance and control

Apparatus

• Keep the apparatus dry and clean. Apply a drop of oil to the screw threads to prevent them from rusting.

Check if:

- The measuring needle is straight and the pointer (above 100 N) increases without shocks.
- The red maximum pointer is straight and works well.
- Whether the black pointer returns to zero after a measurement, within the black marking. By turning the plunger and pulling it out a little the pointer must return to zero.
- The apparatus leaks oil.
- The displacement of the plunger is not too big. If so it needs to be refilled with oil. To do this: Open the plug of the oil filler (3) with a socket-head screw wrench. Remove the ball of the oil filler by shortly turning the apparatus (use a cloth). Holding the filler at the highest possible point, pour in the spare oil (included in the bag of tools). Be sure the plunger is in the lowest position. Replace the ball (preferably a new one) and screw the plug in, remove overplus of oil with a cloth.

If the apparatus is still not functioning it must be returned to the producer/supplier for repair.





Cone	Base area	Diameter	Rejection diameter
No.1	1 cm ²	11.28 mm	11.00 mm
No.2	2 cm^2	15.96 mm	15.55 mm
No.3	$3^{1}/_{2}$ cm ²	20.60 mm	20.08 mm
No.4	5 cm ²	25.23 mm	24.59 mm

Sounding cones

- Keep the cones dry and clean. Apply a drop of oil to the screw threads to prevent them from rusting.
- Check the wear of the cones by using the cone check. If you are measuring the diameter with a caliper gauge: If their base area is 5% less than the prescribed base area they should be replaced. If the conical surface is damaged, the cone must be replaced.

Sounding and extension rods

• Keep the rods clean and dry. To prevent rusting, apply a drop of oil to the screw threads. Check the rods on straightness and on easy turning of the screw threads.

Checking the Wear on the Cones



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Calibration

We advise to return the apparatus every year for calibration.