FUGRO
CONE PENETRATION TESTS

The objective of all site investigations is to obtain data that will adequately quantify the variability of the geotechnical properties of the site. Cone Penetrometer Testing (CPT) provides a rapid and cost effective way to achieve this.

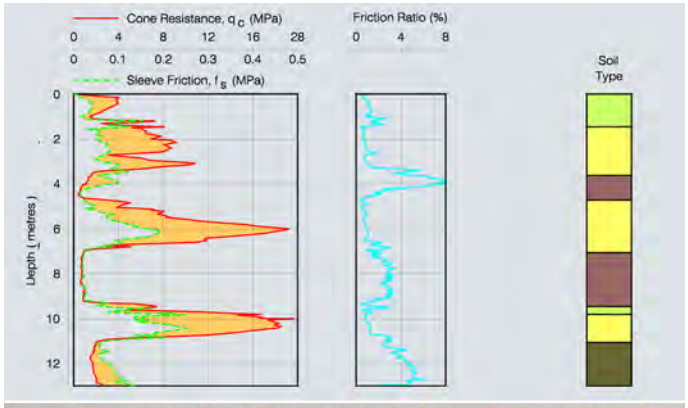
INTRODUCTION

Sufficient data is required to assess the impact of soil variability within a time frame such that it can be allowed for within the geotechnical design and/or construction.

CPT units can be mobilised as road-going 6x6 trucks or a variety of tracked and crawler units, ideally suited to traversing soft, water logged terrain or entering sites with limited access. Fugro's development of CPT applications has a number of advantages that combine well with boring, sampling and standard penetration tests:

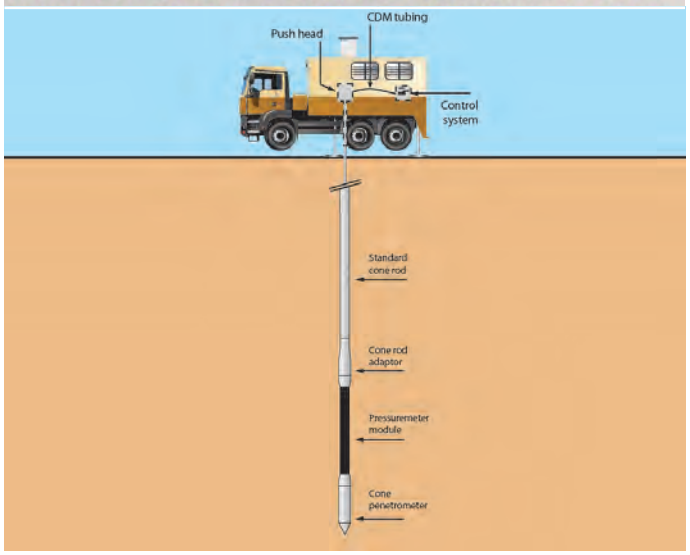
- Identifies soil stratigraphy in terms of general soil behaviour and, to lesser degree, soil type
- Provides a continuous (although indirect) record of ground conditions, avoiding the ground disturbance associated with boring and sampling
- Data may be used in long-established semi-empirical design methods, for example, analysis of foundation bearing capacity, foundation settlement, pile carrying capacity and liquefaction potential
- Routinely, ground engineering properties (c_u, ϕ', E_{oed} , E' and D_r)may be derived from the data, the accuracy of assessment increasing when a piezocone is deployed
- Piezocones (CPTU) can also be used to assess hydrostatic head, consolidation and permeability characteristics
- Yields thousands or tens of thousands of data points that can be digitally stored and transferred in real time
- Cost-effective method employing rapid probing rates to accredited test procedures

CPT generates high value data and adapts readily to the environmental sensitivities of many investigations in favourable types of material, generally excluding bedrock, very dense granular fill and strata containing cobbles and boulders.

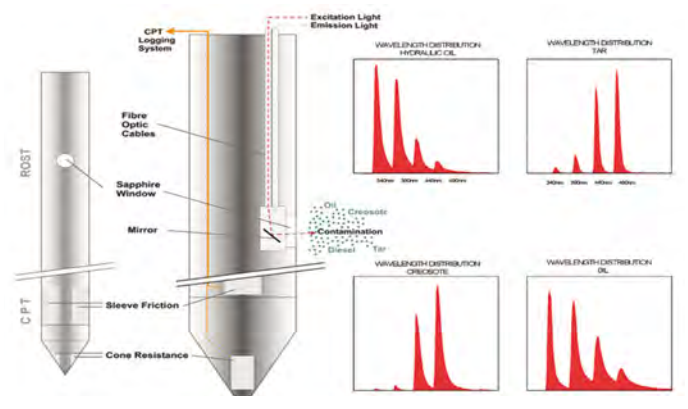


Cone resistance versus sleeve friction results into soil type clasification.

Porous elements in the shoulder of the cone.



Reliable measurement of the in situ strength and load deformation behaviour of the soil.



Rapid Optical Screening Tool (ROST) Screening of hydrocarbon derived contamination in soil and groundwater.

CPT APPLICATIONS

Soil type and stratification

- Detailed characterisation of soil types
- On-site determination of strata variations
- UKAS accredited testing procedures
- Continuous real-time data
- Accurate depth control
- Slope indicator
- High production rates (>100 m/day)

Hydraulic behaviour

- The piezocone incorporates a porous element in the shoulder of the cone. An internal pressure transducer measures the transient pore water pressure variations during cone penetration
- Rapid dissipation of pore water pressure is indicative of permeable strata and features, whilst excess pore water pressures are indicative of clays. Features as thin as 1 cm can be detected
- Pore pressure dissipation with time provides data from which estimates of the coefficient of consolidation of the soil can be derived. This data can be used to estimate soil permeability
- Pore water pressure data can be used to estimate over consolidation ratio in clays

Soil deformation

Fugro's Cone Pressuremeter (CPM) provides a reliable measurement of the in situ strength and load deformation behaviour of the soil. Results from cone pressuremeter tests can be used to derive parameters such as:

- Undrained shear strength
- Shear modulus
- Effective horizontal stress
- Relative density

Data from the cone penetrometer can be used to ensure that the pressuremeter is positioned within the zone of soil interest.

Geoenvironmental cones

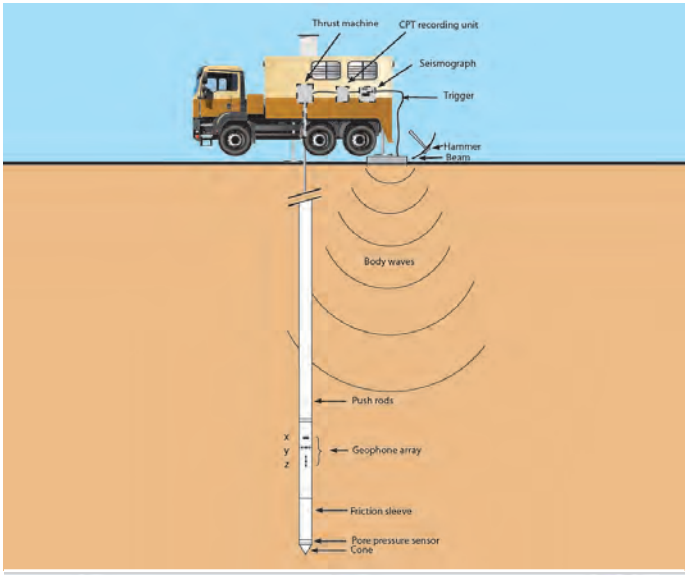
The CPT cone is used as an adapter for two different geoenvironmental screening methods to detect contaminants present in the subsurface.

- Rapid Optical Screening Tool (ROST) Screening of hydrocarbon derived contamination in soil and groundwater.
- Membrane Interface Probe (MIP) Direct measurement of organic compounds and chlorination hydrocarbons in the soil.

Detailed lithological information of the subsurface soil available from the CPT cone.

Dynamic properties

- The Seismic Cone Penetration Test (SCPT) is a reliable, cost-effective technique to determine the in situ seismic wave velocity
- Seismic wave velocities give an indication of ground characteristics such as low strain shear modulus and Poisson's ratio
- Data from the cone penetrometer is used in delineating the strata changes identified by seismic results

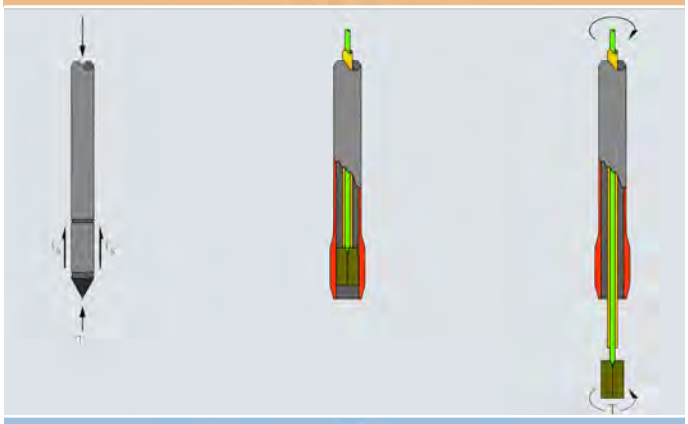


Reliable, cost effective technique to determine in situ seismic wave velocity.

In situ strength

In situ strength can be determined from the results of cone penetrometer tests and/or in situ vane shear tests using a Geonor vane deployed from a CPT rig, where:

- q_c = measured cone resistance
- S_u = undrained shear strength
- N_k = cone factor
- σ_v' = effective overburden pressure
- N_q = bearing capacity factor related to friction angle ϕ'



Left to right: normal cone, in situ vane, in situ vane deployed.

Obstacle detection

- Magcone (triaxial magnetometer mounted in a piezocone)
- Deployed from CPT rigs
- As fast as standard CPT
- Up to 3 m diameter of detection gives multiple pile clearance
- Used to clear piles, CPT and BH locations
- Penetrates most pile mats and fill

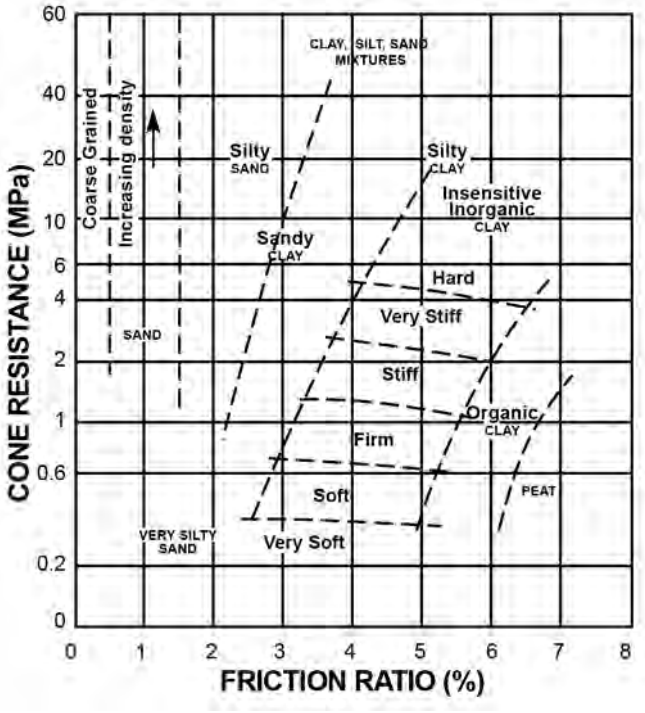
Up to 3 m diameter of detection gives multiple pile clearance.

Mostap soil sampling

Interpretation of CPT results can be enhanced by the use of site-specific correlations. Such correlations are obtained by performing laboratory tests on soil samples obtained from the location of the CPT tests.

- Soil samples can be obtained using CPT equipment and proprietary samplers such as the Mostap 35/65
- Soil samples of up to 1.5 m in length and either 35 mm or 65 mm diameter can be obtained, dependent upon depth and soil conditions encountered

Soil sampling during CPT tests for laboratory testing.



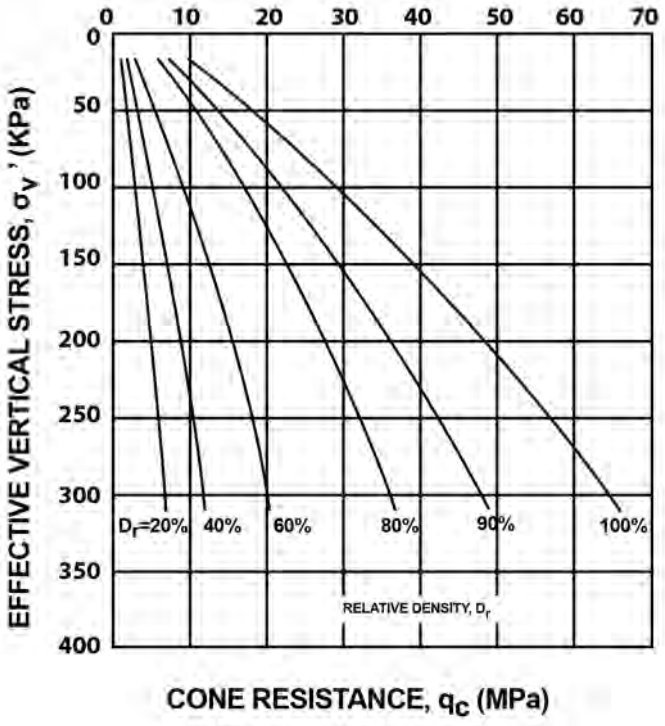


Figure 1 (above left) shows a graphical form for the estimation of soil type for British soils from cone and resistance and friction ratio.

Figure 2 (above right) shows a correlation between q_c and D_r which takes into account the effective vertical stress σ_v'.

Table (below) It should be noted that the guide table applies to unaged, uncemented sands up to about 10 to 15 metres depth.

Cone Resistance (q_c) (MPa)	Compaction of Fine Sand	SPT (N)	Relative Density D_r (%)	Angle of Internal Friction
<2	very loose	<4	<20	<30
2 - 4	loose	4 - 10	20 - 40	30 - 35
4 - 12	medium dense	10 - 30	40 - 60	35 - 40
12 - 20	dense	30 - 50	60 - 80	40 - 45
>20	very dense	>50	80 - 100	>45

geoservices.uk@fugro.com

WWW.FUGRO.COM