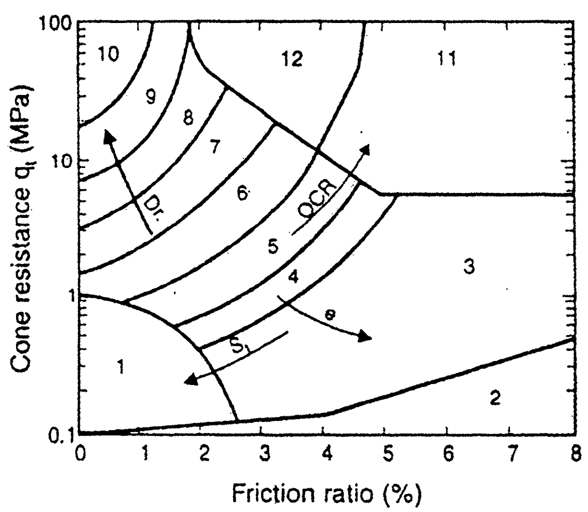
CPT Soil Profiling and Classification [1]

Soil samples are not recovered during CPT testing; however, it is possible to obtain an approximate soil classification using from cone resistance q_c and friction ratio R_f. Literature has shown that q_c is relatively high in sands and low in clays. Further, R_f is relatively low sands and high in clays. Soil types based on CPT results are usually referred to as soil behavior type (SBT). Soil classification charts have been adapted and improved based on expanded databases. One of the most commonly used behavior type charts, Figure 1, is suggested by Robertson (1986). Using q_c and R_f, this chart gives reasonable predictions of soil behavior up to 60 feet in depth.



Zone	Soil behaviour type
1	Sensitive fine grained
2	Organic material
3	Clay
4	Silty Clay to clay
5	Clayey silt to silty clay
6	Sandy silt to clayey silt
7	Silty sand to sandy silt
8	Sand to silty sand
9	Sand
10	Gravelly sand to sand
11	Very stiff fine grained*
12	Sand to clayey sand*

* Overconsolidated or cemented

Figure 1: Soil behavior type classification chart (after Robertson, 1986)

Since both penetration resistance and sleeve friction increase with depth due to the increase of effective overburden stress (σ_{vo}), CPT data requires correction (normalization). Robertson (1990) developed a normalized CPT soil behavior chart, Figure 2, using normalized friction ratio, R_f, and normalized cone resistance, Q_t.

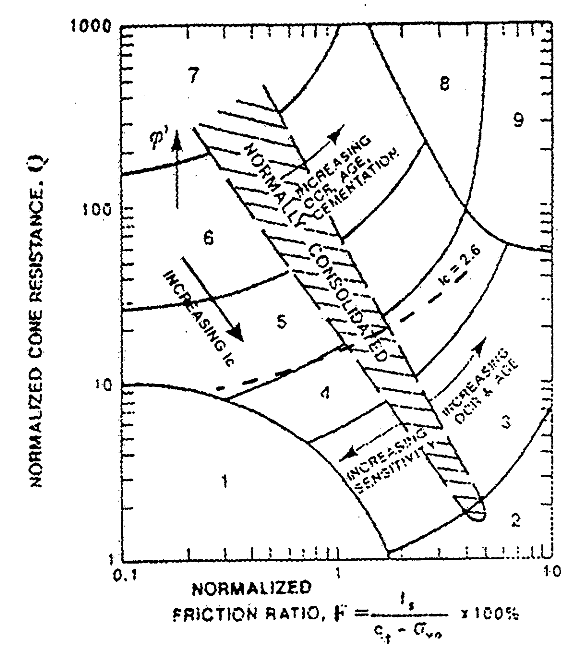
$$F_r = \left[f_{sc}/\left(q_c - \sigma_{v_0}\right)\right] \times 100 \qquad Q_t = \left(q_c - \sigma_{v_0}\right)/\sigma'_{v_0}$$

The Equivalent Soil Description for the CPT boring logs were based on correlations with the above soil behavior type classification chart using CPT data, visual field classification, and laboratory test results. The soils obtained from adjacent SPT soil test, auger probe, and geoprobe borings were visually classified and verified in the laboratory using the AASHTO soil classification system. These were correlated with the CPT data and presented on the CPT boring logs and profiles.

[1] Jefferies, M. G. and Davies M. P. (1993), "Use of CPT to Estimate Equivalent SPT N_{60}", Geotechnical Testing Journal , Philadelphia, Pennsylvania.

Robertson, P. K. (1989) "Soil Classification using Cone Penetration Test", Canadian Geotechnical Journal, Edmonton, Alberta.

Robertson, P. K. (1998) "Cone Penetration Testing for Geotechnical and Environmental Site Investigation", ConeTec Inc.



Zone	Soil Behaviour Type	I_c
1	Sensitive, fine grained	N/A
2	Organic soils – peats	> 3.6
3	Clays – silty clay to clay	2.95 – 3.6
4	Silt mixtures – clayey silt to silty clay	2.60 – 2.95
5	Sand mixtures – silty sand to sandy silt	2.05 – 2.6
6	Sands – clean sand to silty sand	1.31 – 2.05
7	Gravelly sand to dense sand	< 1.31
8	Very stiff sand to clayey sand*	N/A
9	Very stiff, fine grained*	N/A

* Heavily overconsolidated or cemented

Figure 2: Normalized soil behavior type classification chart (after Robertson, 1990)

Note the charts are based on a broad sampling and are not regionally specific. Overlap in some zones should be expected and adjusted based on local experience.

Proposed by Jeffries and Davies (1993), the following equation combines the normalized cone parameters into a soil behavior type index, I_c.

$$I_c = \left((3.47 - \log Q_T)^2 + (\log F_r + 1.22)^2\right)^{0.5}$$

Collecting additional parameters such as the pore water pressure during testing improves soil classification.

Correlation between CPT Data and SPT N_{60}

Standard penetration test (SPT) N-values can be correlated to CPT cone penetration resistance, q_c. The following equation was developed by Jeffries and Davies (1993):

$$\frac{(q_c/P_a)}{N_{60}} = 8.5\left(1 - \frac{I_c}{4.6}\right)$$

Where I_c is the aforementioned soil behavior type index and q_c is normalized by P_a (atmospheric pressure). Corrections for the grain size influence are included in the equation.