METHOD | CPT CLASSIFICATION

Robertson chart in glacial till

Why the CPT classifies overconsolidated glacial till as sand – and why every group of CPTs therefore has a borehole alongside.

AT A GLANCE

PURPOSE
Interpret the soil behaviour type from the CPT correctly where the ground moraine is glacially preloaded.

INPUT
q_c and f_s per centimetre; borehole log of a key borehole; water level for the effective stress.

OUTPUT
Robertson zone as behaviour type, not as soil type; a flag wherever CPT and borehole disagree.

LIMITATIONS
From q_c and f_s alone, glacial till cannot be reliably distinguished from dense sand. Without u_2 measurement, $q_t \approx q_c$.

STANDARDS
DIN EN ISO 22476-1, DIN EN ISO 14688-1, DIN 18196

The CPT measures how the soil behaves – not what it consists of.

Principle, after Robertson [1]

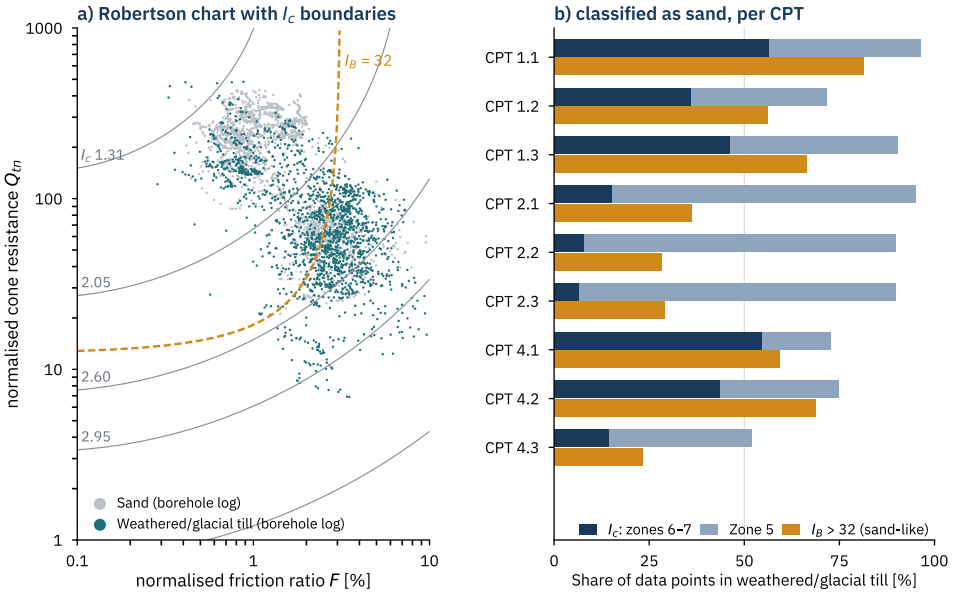


Figure 1. Wind farm in Saalian ground moraine, four sites each with one key borehole and three CPTs (anonymised). a) Data points from 2 m depth, coloured by borehole description; b) share of points in weathered till and till classified as sand by I_c or I_B, zone 5 shown separately. One site has no cohesive section down to 11 m.

01 Findings at approx. 5 300 data points in weathered till and till

25 %
sand by I_c (zones 6–7), a further 59 % sand mixtures (zone 5) – not wrong for SU*/ST*

44 %
sand-like by I_B (> 32)

15 %
clay-like by I_B (< 22) – correctly identified

96 %
dilative (CD > 70) – consistent with heavy preloading

02 Why this happens

The CPT responds to the mechanical behaviour in the ground, not to the grain size distribution [1]. Very stiff, heavily overconsolidated fine-grained soils behave like coarse-grained soils and dilate on shearing [1]. For these, the chart provides zones 8 and 9, "overconsolidated or cemented" [1]; the I_c circles of zones 2 to 7 do not capture them. At low overburden, normalisation also raises Q_{tn}. I_B [2] separates only partly as well: the till plots where dense silty sand also plots.

03 How we evaluate

- ☑ **Key borehole per site:** it shows what is in the ground; the CPT provides depth, variability and strength [3].
- ☑ **Zone as behaviour type,** never as soil type; always both I_c and I_B.
- ☑ **House rule:** zone 6–7 with q_c above 30 MPa where the borehole shows ground moraine → flag "sand or preloaded till – compare with borehole".
- ☑ **Parameters within their range of validity:** no relative density in till, c_u there as an upper estimate.

$$I_c = \sqrt{[(3.47 - \log Q_{tn})^2 + (\log F + 1.22)^2]} \quad I_B = 100(Q_{tn} + 10) / (Q_{tn} \cdot F + 70) \quad CD = (Q_{tn} - 11)(1 + 0.06F)^{17} \qquad (1)$$

I_c after Robertson & Wride [4], I_B and CD after Robertson [2]; Q_{tn} normalised cone resistance, F normalised friction ratio [%]. Without u_2 measurement, $q_t \approx q_c$; $\sigma'_{v0} = \sigma_{v0}$, as no free groundwater was encountered down to final depth. Five CPTs refused at 34 to 46 MPa before target depth – possibly on cobbles, but unconfirmed.

STANDARDS AND REFERENCES

[1] **Robertson, P. K. (2010)** Soil behaviour type from the CPT: an update. 2nd Int. Symp. on Cone Penetration Testing (CPT'10), Huntington Beach; cpt-robertson.com, accessed 24 Sept. 2026
[2] **Robertson, P. K. (2016)** Cone penetration test (CPT)-based soil behaviour type (SBT) classification system – an update. Canadian Geotechnical Journal 53, 1910–1927
[3] **GeoStudys Method sheet 01 (2026)** Layer boundaries with confidence level · **DIN EN ISO 22476-1:2023-04** · **DIN EN ISO 14688-1:2020-11** · **DIN 18196:2023-02**
[4] **Robertson, P. K.; Wride, C. E. (1998)** Evaluating cyclic liquefaction potential using the cone penetration test. Canadian Geotechnical Journal 35(3), 442–459