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Development of the heat flow cone penetration test (HF-CPT)

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The heat flow cone penetration test (HF-CPT) provides in-situ values of thermal conductivity (patent pending). The HF-CPT test records include (1) heat flow (HF) measurements acquired by a CPT add-on module, i.e. heating power and temperature versus time and (2) cone penetration test (CPT) measurements, i.e. cone resistance, sleeve friction and pore pressure versus depth and time. The test method requires a short interruption of the continuous CPT penetration phase, to allow stationary HF heating and cooling cycles. Values of thermal conductivity are derived similarly to the principles for laboratory thermal needle probes described in common ASTM standards, particularly [1].

Data processing makes use of an advanced interpretation method that accounts for the short-cylinder effects of the HF module and short timeframe heat fluxes. The novel interpretation method includes inversion of a numerical forward model of the interaction between the heat flow module and the surrounding soil. The interpretation method also integrates standard CPT results, such that both a semi-continuous thermal conductivity profile and a continuous standard CPT profile are obtained.

Validation of the interpretation method included comparison of thermal conductivity values derived from other test methods, notably laboratory transient plane source tests [1], in-situ thermal needle probe tests (based on [2]) and thermal cone penetration tests [3]. Figure 1 presents an example of validation results for predominantly clay soil. The results are seen to closely match those derived from an in-situ needle probe. As the HF-CPT measurements were taken two metres apart horizontally from the in-situ needle probe measurements, some deviation between the results is to be expected due to heterogeneity of the soil.

Data statement

All data used is presented in the paper.

Contributor statement

Concpetualisation: Philip J. Vardon, Joek Peuchen; Formal analysis: Leon Vrielink; Investigation: Leon Vrielink, Nico Parasie; Validation: Leon Vrielink, Nico Parasie; Writing Original Draft: Leon Vrielink, Philip J. Vardon, Joek Peuchen, Nico Parasie, Alexandros Daniilidis; Writing Review and Editing: Leon Vrielink, Philip J. Vardon, Joek Peuchen, Nico Parasie, Alexandros Daniilidis

References

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[2] ISO (2022). *ISO 22007-2:2022 Plastics — Determination of thermal conductivity and thermal diffusivity — Part 2: Transient plane heat source (hot disc) method*. ISO
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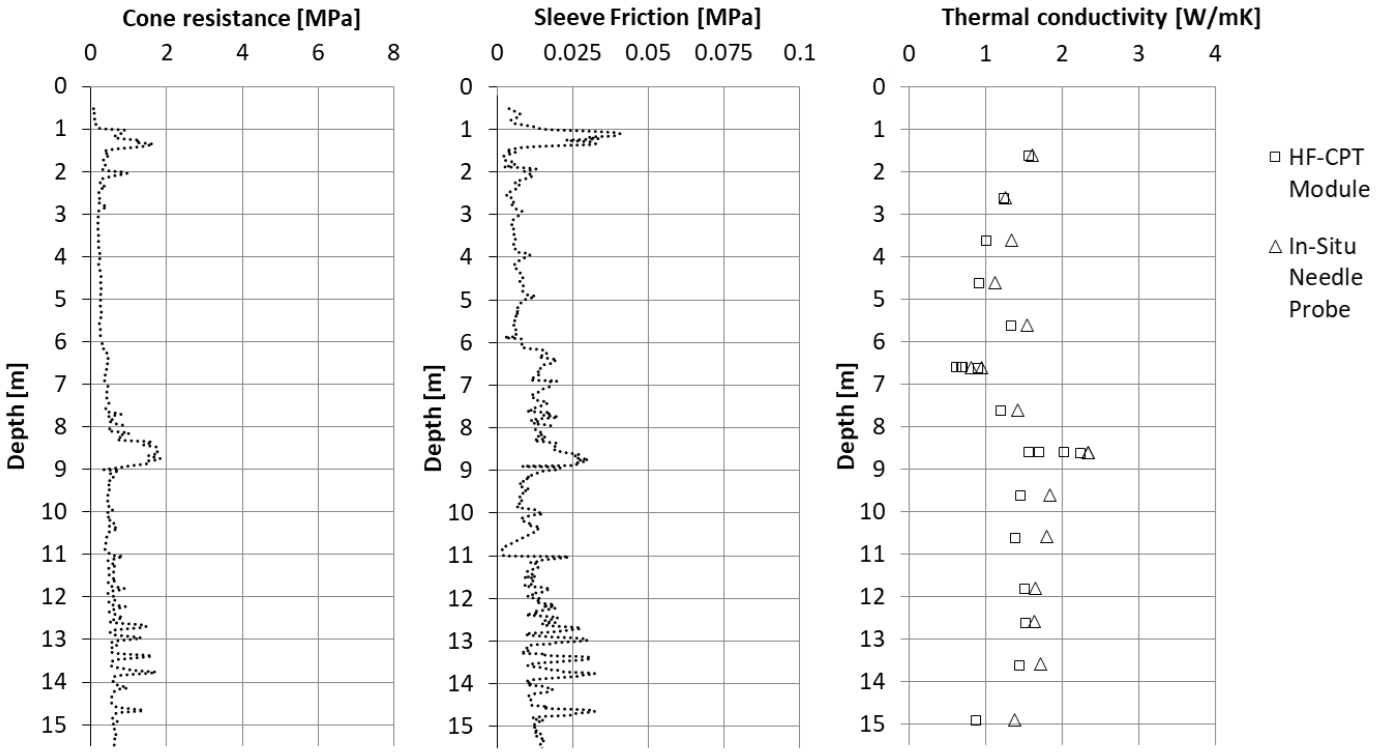

Figure 1: HF-CPT in-situ test results with cone resistance (left), sleeve friction (middle) and thermal conductivity (right, squares). In-situ needle probe results are included for comparison (right, triangles).