Geotechnical and Geophysical Site Characterisation 5 – Lehane, Acosta-Martínez & Kelly (Eds)

Session Report: Developments in Technology and Standards

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ABSTRACT: The paper presents a review and discussion of the eight papers presented in the Technical Session, entitled, 'Developments in Technology and Standards'. The papers cover a wide range of topics. Some experience of the reporters related to errors in friction sleeve measurements is provided to supplement findings from one of the papers presented at this session.

1 INTRODUCTION

Thirteen papers have been reviewed by the reporters, however only eight out of the papers have been included in the Proceedings, and six presented in Technical Session 1. Table 1 presents the origin of the papers.

Table 1. Papers from countries.

Country	Number of papers
Australia	3
New Zealand	1
Netherlands/Finland	1
France	1
Belgium	1
Croatia	1

A wide range of topics were covered by the papers, as shown in Table 2.

Due to the specific experience of the reporters of the present Session Report, the paper presented by Holtrigter and Thorp on a correction for CPT f_s errors due to variation in sleeve diameter will be discussed in more detail in this report.

Table 2. Topics covered.

Authors	Title	Technique
Woolard et al.	Additional parameters in CPT	CPT
Ekanayake et al.	Integration of invasive and non-evasive technologies	CPT/PS/HVSR
Escobar et al.	Deform. Modulus and wave velocity parameters using Panda	DynPen
Holtrigter and Thorp	Correction for CPT f_s errors due to sleeve diameter effects	CPT
Iskander	Reduced pressuremeter test time procedure and new anal meth	PM
Kovacevic et al.	Comparison of Unified and European Soil Class systems	N/A
Look	SPT N-value errors examined with digital technology	SPT
McKenna and Roberts-Kelly	Televiewer imaging of boreholes in rock	Televiewer

2 COMMENTS ON THE PAPERS

2.1 *Additional parameters measured in a single CPT, by Woolard, Storteboom, Länsivaara and Selänpää*

The authors describe a CPT system which allows the use of different devices without the need of changing cones, cables and data loggers. Seismic, conductivity, magneto and vane modules have been presented. The practical significance of this system is significant.

The main advantage of the vane device is measuring the torque close to the blade. Tests have been performed in a very soft clay site in Finland, to compare the undrained shear strength, s_u, from CPTU (from the cone factors N_{KT} and $N_{\Delta u}$) and vane test. Good results have been obtained.

2.2 *Integration of invasive and non-invasive techniques in ground characterization, by Ekanayake, Leo, Liyanapathirana and Harutoonian*

The authors present a case study where non-invasive Horizontal-to-Vertical Spectral Ratio (HVSR) of micro tremors was used to assess the compaction of a large compacted site.

The HVSR technique uses ambient vibrations in soil to determine the V_s profile rather than an artificial source, and can survey large areas.

Results are less reliable than invasive techniques, thus a methodology was developed to calibrate and verify the V_s profile against the data obtained from CPTs. The results were compared to the V_s profile from P-S logging technique (Figure 1). Reasonable match between P-S and HVSR has been obtained, except close to the surface. V_s gradients from HVSR are less pronounced than from P-S logging.

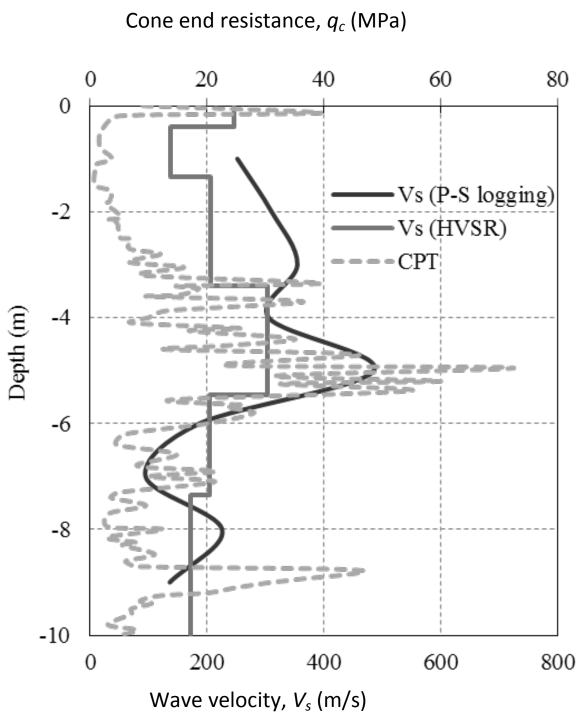

Figure 1. V_s from HVSR and P-S logging.

2.3 *In-situ determination of soil deformation modulus and the wave velocity parameters using the Panda 3®, by Escobar, Benz Navarrete, Gourvès, Breul and Chevalier*

The authors present the results of in situ tests performed with the Panda 3 penetrometer (Figure 2), which is similar to a monitored dynamic load test performed in a pile, where strain (force) and acceleration is measured just below the top of the pile. It is also based on wave equation analysis. From some hypotheses and simplifications, a number of parameters can be obtained.

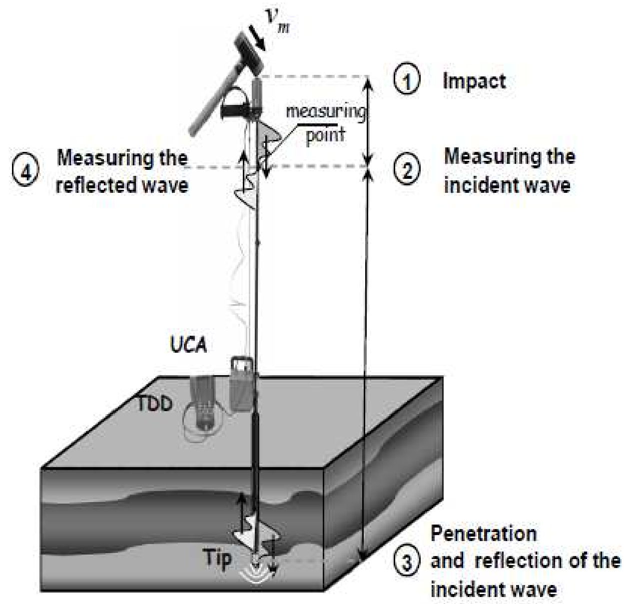

Figure 2. Panda 3 penetrometer.

A comparison with established in situ tests (CPT, PMT and MASW) was carried out. Reasonable match was obtained between q_c (CPT) and q_d (Panda), E_m (PMT) and E_{kd} (Panda), however not as good in V_s (MASW) versus V_s (Panda).

Although in the paper it is mentioned that it is presently limited to 6 – 7 m depth, in their presentation the authors mentioned that the penetration was also carried out to 18 m depth.

2.4 *Reduced pressumeter test time procedure and new analysis method, by Iskander*

The author suggests a new definition for pressure limit in pressuremeter testing, which is determined in only three loading step procedure, thus reducing the time for running the test.

The new pressure limit is defined by the applied pressure at the start of the radial cracks at the cavity surface around the probe.

2.5 *Comparison of Unified and European Soil Classification Systems, by Kovacevic, Juric-Kacunic, Libric*

An interesting historical review on the development of soil classification systems has been presented in the introduction.

A comparison between Unified (USCS) and European (ESCS) Soil Classification System showed that procedures for soil classification are very similar; names of soil groups are relatively similar, whereas the symbols of soil groups are completely different.

A program (CLASSIF) was developed that allows classification from both systems using same input data.

It is a useful tool if a comparison between the Unified (USCS) and European (ESCS) Soil Classification System is needed.

2.6 *The SPT N-value errors examined with digital technology, by Look*

The Pile Driving Monitoring (PDM) device – which remotely measures set, temporary compression and velocity of piles using optically safe infrared laser technology – was used to measure the true increment in each step of the test (nominal value 150 mm). A quite interesting picture was obtained, as can be seen in Figure 3.

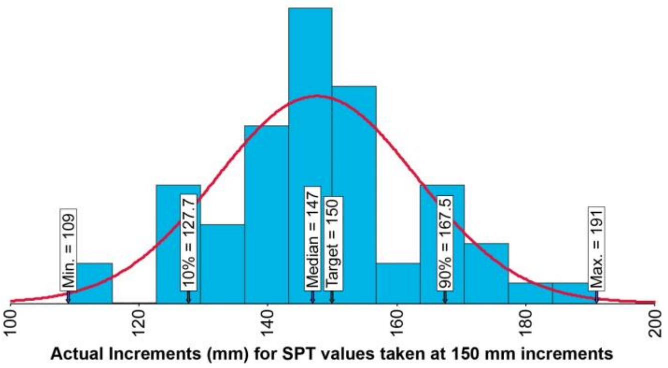

Figure 3 PDM Digital Measurements of 150mm increments Site 1 (54 No.)

The reporters would like to point out that the difference would probably be even more significant in the case of low N-values than high N-values.

Using the results of site 2 and the measured energy by the PDA analyser (also used in the investigation), the correction (efficiency) factors have been determined.

The reporters would like to point out that measured energy losses are essential in using the N-value as a design value. The errors are amplified when multiple drill rigs are used on the same project.

2.7 *Televiewer imaging of boreholes; benefits and some considerations for its interpretation in the absence of physical rock core, by McKenna and Roberts-Kelly*

The paper aims to provide a comparison of televiewer data against rock cores, borehole logs and core photographs so the reader can make an educated assessment of the likely defect conditions in the absence of rock cores during the design period.

Two case studies have been presented in paper. In the Southeast Queensland case Sedimentary Optical and acoustic televiewer have been compared with log and core photographs (Figure 5).

It was emphasized that calibration with physical rock core by experienced personnel is vital in interpreting televiewer data accurately. Televiewer data are a powerful tool for understanding the ground conditions and structural geology data, however understanding the limitations of televiewer imaging is critical.

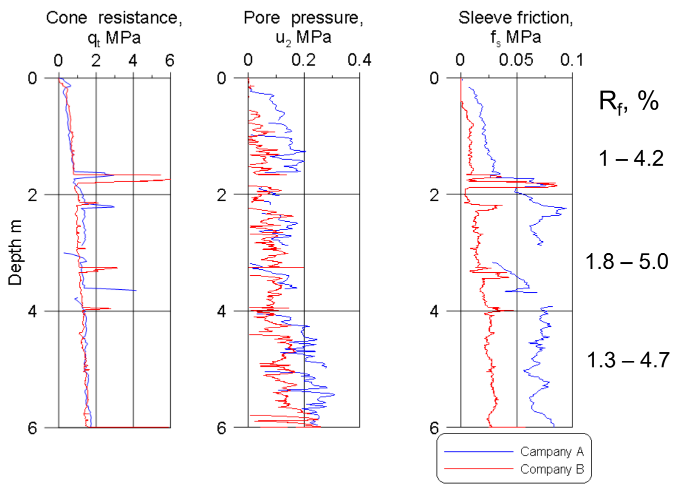

Figure 4. Piezocone tests from two companies in an offshore clay

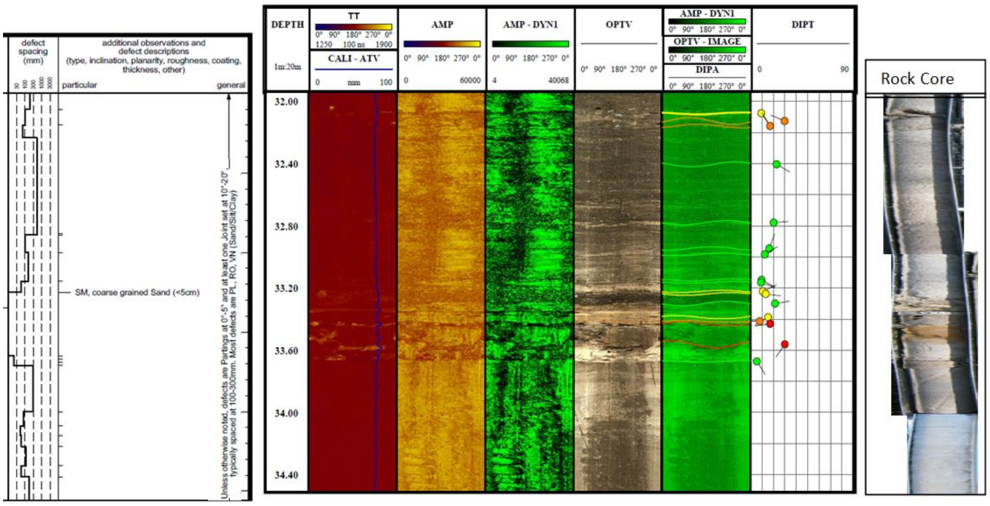

Figure 5. Case Study information; borehole log, optical and acoustic televiewer and rock core photograph.

2.8 *Correction for CPT f_s errors due to variation in sleeve diameter, by Holtrigter and Thorp*

Since the subject of the paper has been a major concern for the reporters for many years, the comments about the reviewed paper will follow some initial thoughts.

NGI and other consultants frequently receive CPT data on projects where two or more soil investigation contractors have done the testing.

The general experience in soft clays is that:

i) *Corrected cone resistance q_t*: Good repeatability from one cone type to another.

ii) *Pore pressure at cone shoulder u_2*: Best repeatability.

iii) *Uncorrected sleeve friction f_s*: Not good repeatability – less reliable of all piezocone measurements.

Some examples from recent projects are presented below. The first one refers to CPTU profiles from two companies in 300 m water depth in Norwegian Sea, carried out in 2008 and 2009 (Figure 4).

The second example (Figure 6) is from tests performed by four companies at NGI´s soft clay test site in Onsøy, where all cones are used in offshore soil investigations.

Correcting for unequal end areas reduce differences, as shown in Figure 8. However different pore pressures at each end of sleeve can also cause some differences. The reporters think that the status on sleeve friction readings is that reliability has improved due to more cone types now having equal end areas and efforts in more detailed calibrations. However more research is needed on this subject.

The third example (Figure 7) is from offshore tests performed by two companies, with very dense sand overlaying stiff OC clay.

From the reasons above, due to less reliable f_s results this measurement is not used so much in interpretation. Fortunately, due to log scale some variation in F_r is not so critical for Soil Behaviour Type (SBT) when used is classification charts, like the one presented by Robertson (1990).

According to Lunne and Andersen (2007), reasons for lack of accuracy in f_s are: (i) pore pressure effects on ends of the sleeve; (ii) tolerance in dimensions between the cone and the sleeve; (iii) surface roughness of the sleeve; (iv) load cell design and calibration.

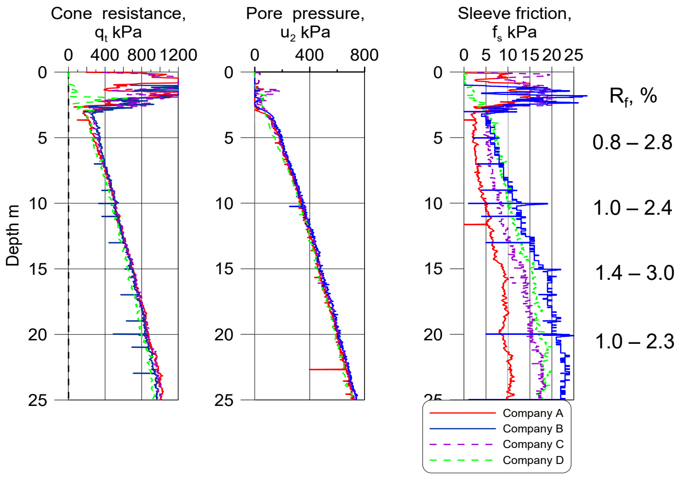

Figure 6. Results of CPTU profiles from four cone penetrometers at NGI's soft clay test site in Onsøy

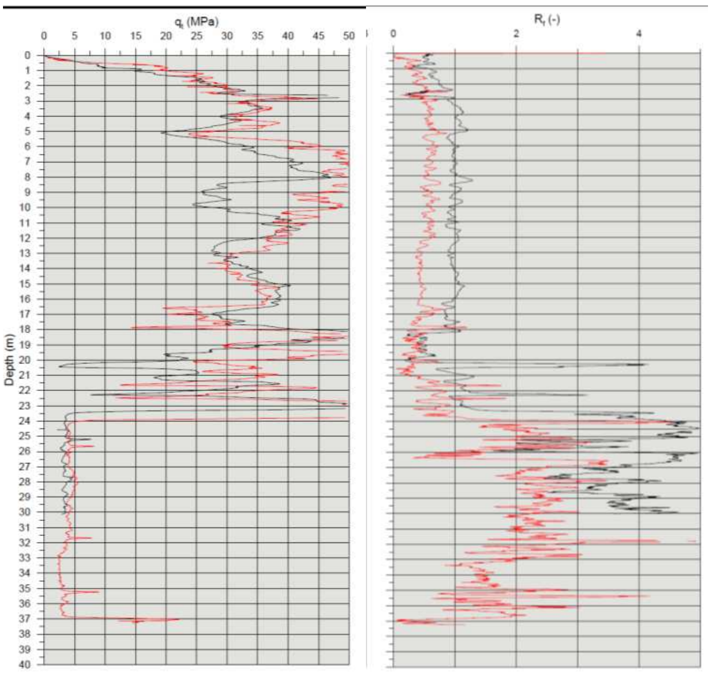

Figure 7. Results of CPTU profiles by two contractors in North Sea, with very dense sand overlaying stiff OC clay.

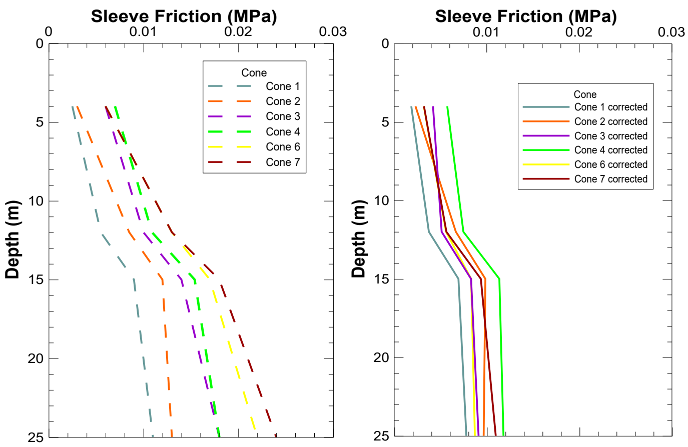

Figure 8. Pore pressure correction for unequal end areas, results from Onsøy soft clay test site.

In this context the study by Holtrigter and Thorp represents an important contribution. They studied four diameters, 35.70 (nominal value), 35.85, 36.05 and 36.15 mm, representing increases of 0.15, 0.35, 0.45 mm with respect to the nominal value. Test results in clay indicate that the cone resistance is not much affected by the increase in sleeve diameter, but the sleeve friction increases with the sleeve diameter increase (Figure 9).

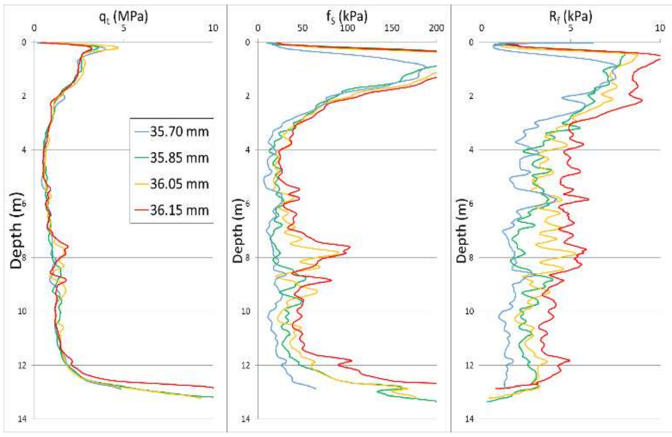

Figure 9. Results of CPTU profiles in clay with four sleeve diameters, tests performed by Holtrigter and Thorp.

Test results in sand show the same trend, although not as clear as in the case of clay (Figure 10). An empirical correlation was proposed by the authors to account for the difference in friction sleeve diameter (which, however, depends on the "correct" value).An important conclusion is that tighter tolerances in standards will very likely reduce differences in f_s readings.

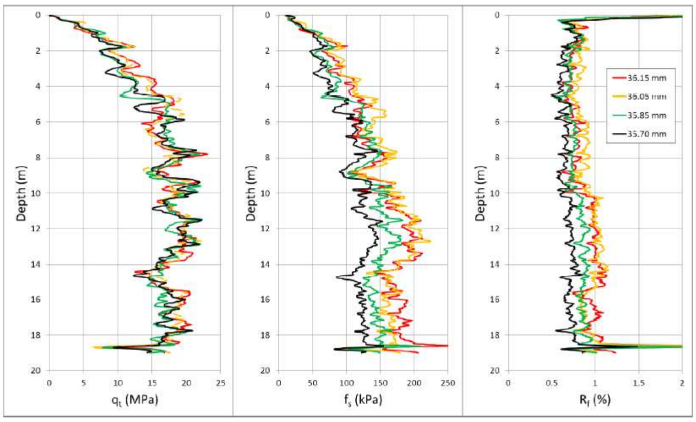

Figure 10. Results of CPTU profiles in sand with four sleeve diameters, tests performed by Holtrigter and Thorp.

It is hoped that the reliability of f_s readings can be further increased to be at same level as q_c and u. This will potentially open up for a new range of correlations and interpretation methods.

3 REFERENCES

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Robertson, P.K. 1990. "Soil classification using the cone penetration test". Canadian Geotechnical Journal, 27(1): 151-158.