COMPARISON BETWEEN PANDA PENETROMETER TESTING AND TRADITIONAL TESTING METHODS IN NZ – A MORE BEARABLE PROCEDURE.

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ABSTRACT

Lack of site investigation data is a common problem that geotechnical engineers face on a daily basis. Whilst typically permanent works would involve a scope and budget for site investigation, lack of information on subgrade geotechnical parameters is a common issue for temporary work designs such as crane platforms. Panda Penetrometer is a Variable Energy Dynamic Cone Penetrometer that has recently been used in New Zealand for geotechnical data collection. A study has been undertaken to evaluate Panda penetrometer application as a quick and cost effective site investigation method. Due to limited information available on Panda Penetrometer performance in New Zealand's soil conditions, a series of locations have been selected and the tests were run to compare standard tests methods such as: CPT, drilled boreholes with SPTs and shear vanes against Panda Penetrometer results. This has been undertaken to confirm the accuracy of the recorded properties. Scope of works and the preliminary findings of the comparative study have been reported in this paper.

1 INTRODUCTION

Spatial variability of geological strata and the cost of typical geotechnical investigations, often results in lack of detailed, well defined geotechnical parameters for geotechnical designs that fall outside the scope of permanent works. Lack of design parameters for temporary works such: temporary working platforms, temporary cuts or temporary retentions is a common occurrence in the industry (*e.g.* Gilbert-Milne et al 2018). Further, commonly applied cost-effective/manual method, such dynamic cone penetrometer (i.e. DCP/scala) is of question, due to variability and inconsistency of results based on the equipment operator. Resulting from the above, the geotechnical team from Brian Perry Ltd (NZ) in conjunction with the University of Auckland undertook a study to assess applicability of Panda penetrometer in New Zealand conditions. Panda penetrometer in the worldwide literature has been recognised as a quick and reliable source of information on soils bearing capacity, correlations with CBR are available as well as with and shear vane – undrained shear strength (Langton, D.D. 1999).

The basis for this study comprises a comparison of Panda penetrometer testing results against other available standard geotechnical testing methods. For all of the reported Panda tests, boreholes (BH) with shear vanes (SV), cone penetration tests (CPT's), DCPs or hand augers (HA) were available. The comparison and interpretation of data was undertaken to evaluate correlation and repeatability of the panda penetrometer testing.

Originally developed in France in 1991, Panda penetrometer has been tested and calibrated worldwide (e.g. Langton 1999, Athapaththu & Tsuchida, 2016). To Author's knowledge the study reported in this paper are the first Panda application in NZ. In addition this study is to be used as an evaluation of the potential for Panda penetrometer further utilisation in the country.

2 PANDA PENETROMETER EQUIPMENT

Panda is a lightweight (20kg) cone penetrometer that can be operated by one person. It recognises variable energy of the hammer. Panda penetrometer kit comprises: a central acquisition unit, a dialogue terminal power pack, a hammer, an anvil strain gages bridge, nine 0.5m rods, and the various cone sizes ($2cm^2$, $4cm^2$ and $10cm^2$ in selected locations). The penetrometer is a user independent piece of equipment which measures the energy of each hammer blow, compares it to the depth penetrated, and returns the cone resistance (in MPa). The results at the end of each sounding (test) can be seen in a graph of cone resistance (MPa) vs depth (m), which can then be exported into an excel file.

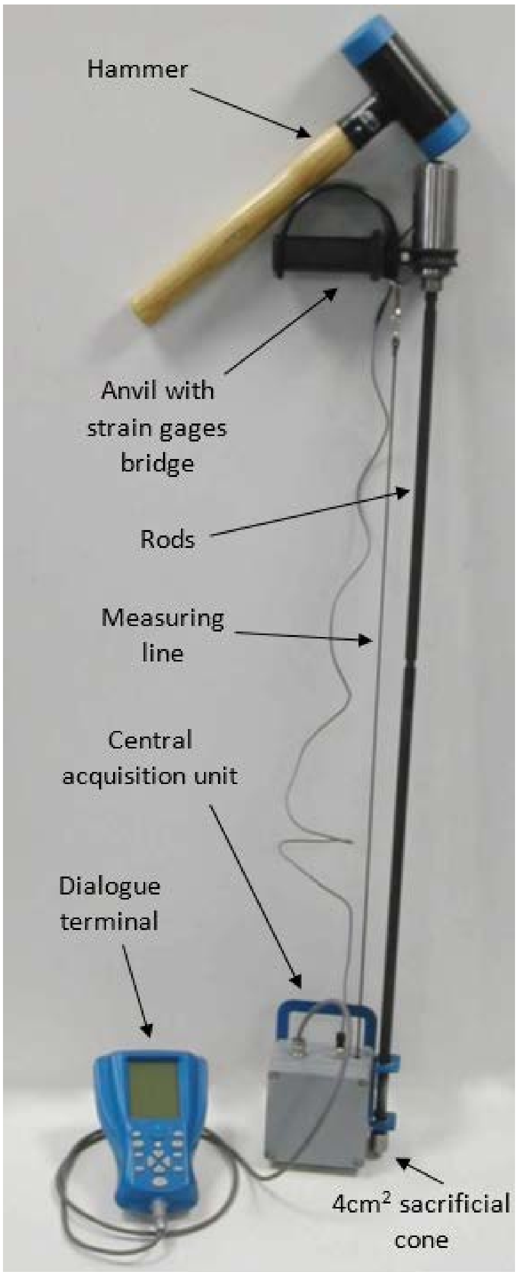

Figure 1: Panda penetrometer equipment description (left), the process of data collection (top right), overview of the site kit (bottom right).

3 PANDA PENETROMETERS NZ TESTING SCHDULE

This study comprises the series of tests undertook on various sites across NZ North Island in various geological strata. The location of testing included sites in-between Puhoi and Warkworth (eight sites) – North of Auckland, Tauranga (two sites) and sites in-between Peka-Peka and Otaki (fifteen sites). These sites encompassed a range of soils, mostly clays and silty clays but also some sand (various degree of weathered sandstone and siltstone), gravels, alluvium and peat (river sediments). A number of different geological formation were tested e.g. variably weathered sandstone, river deposits beach sediments, virgin soil surface, cuts as well as compaction on temporary working platforms. The below Table 1 presents the summary of the preliminary Panda penetrometer tests undertaken for this study.

Where HA or DCP were not available, these were undertaken for Panda correlations.

Table 1: Summary of undertaken tests

	PANDA 2cm	PANDA 4cm	PANDA 4cm new	PANDA 10cm	Scala	Hand Auger/ Shear vane
6014	Yes	Yes	No	No	Yes	Yes
6013	Yes	Yes	No	No	Yes	No
6104B	Yes	Yes	No	No	Yes	Yes
4042	Yes	Yes	No	No	Yes	Yes
352	Yes	Yes	Yes	Yes	Yes	Yes
351	Yes	Yes	Yes	Yes	Yes	Yes
5310	No	Yes	Yes	Yes	Yes	Yes
TS31	Yes	Yes	No	No	No	Previosuly tested
Manhole	No	No	No	No	No	No
Sea	No	No	No	No	No	No
V1	Yes	No	No	No	Yes	Yes
V2	Yes	No	No	No	Yes	Yes
V3	Yes	Yes	No	No	Yes	Yes
V4	Yes	Yes	No	No	Yes	Yes
V5	Yes	Yes	No	No	Yes	Yes
V6	Yes	Yes	No	No	Yes	Yes
1	No	Yes	No	No	No	No
2	No	Yes	No	No	No	No
3	No	Yes	No	No	No	No
4	No	Yes	No	No	No	No
5	No	Yes	No	No	No	No
P1	Yes	No	No	No	Yes	No
P2	Yes	No	No	No	Yes	No
P3	Yes	No	No	No	Yes	No
P4	Yes	No	No	No	Yes	No
OP1	Yes	No	No	No	Yes	No
OV1	Yes	Yes	No	No	Yes	Yes
OV2	Yes	Yes	No	No	Yes	Yes
OV3	Yes	No	No	No	Yes	Yes
OV4	Yes	No	No	No	Yes	Yes

4 PANDA PENETROMETER TESTING RESULTS

The below Figure 2 presents the typical output of Panda testing compared against other available in the location geotechnical testing methods.

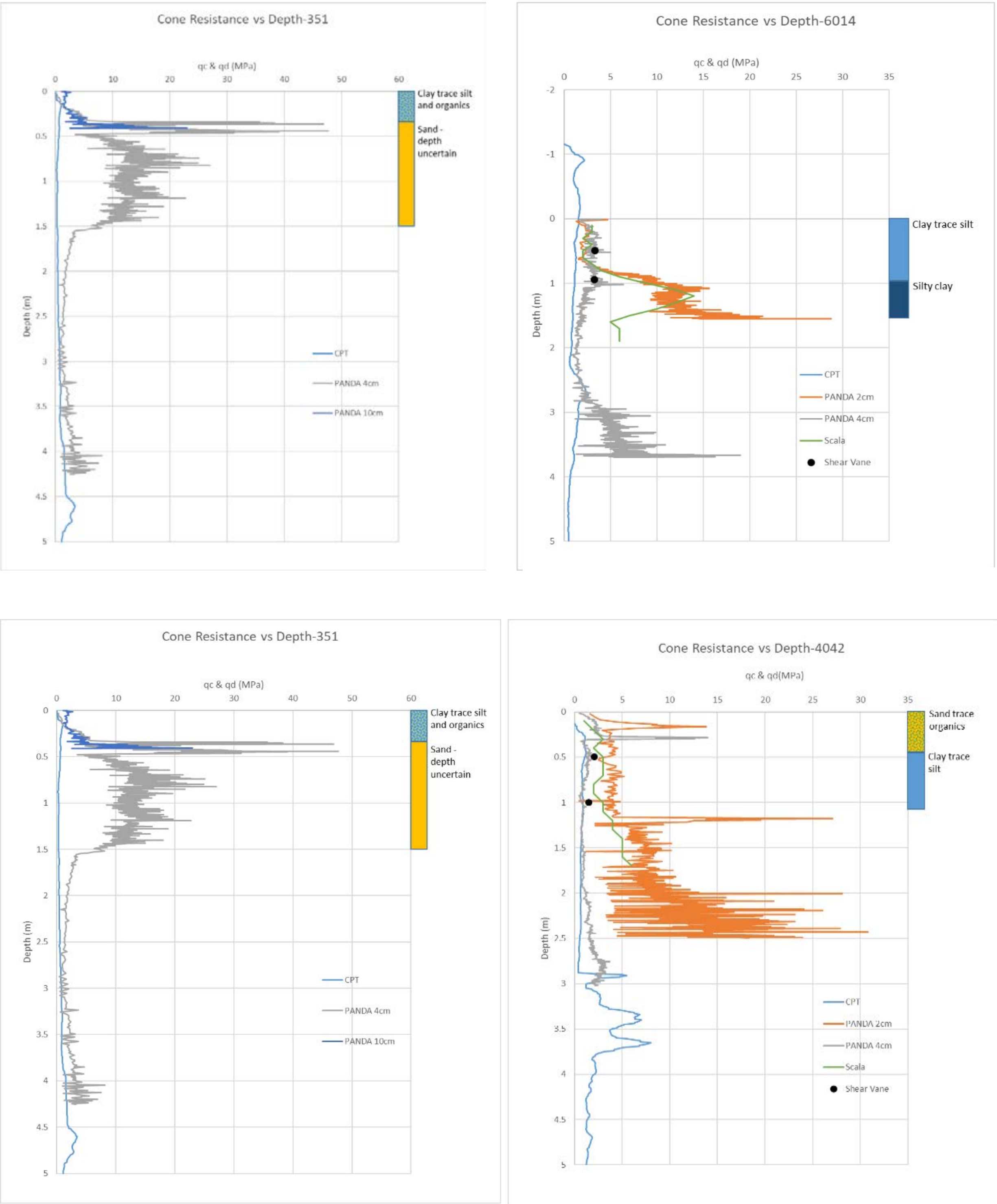

Figure 1: Preliminary results of Panda comparison study for four selected locations.

5 RESULTS INTERPRETATION

The initial results of the Panda penetrometer comparison study indicated allows the following observations to be made:

- At early depths, the $2cm^2$, $4cm^2$, and $10cm^2$ cones were all found to slightly overestimate the cone resistance when compared to the CPT, while generally remaining fairly consistent to each other.
- The $2cm^2$ cone resistance tended to sharply increase at a depth of around 1m, plus or minus 0.5m.
- The $4cm^2$ and the $10cm^2$ cones remained consistent with the CPT readings until a far greater depth (while still slightly overestimating).
- The above finding is likely due to sleeve friction acting stronger on the $2cm^2$ cone compared to the larger ones. The $2cm^2$ cone is similar in radius to the Panda's testing rods resulting in most of the rods being in contact with the surrounding soil and with the abundance of cohesive clays in the testing sites, the sleeve friction was likely very high.
- In addition, a testing was made using locally manufactured testing cones which were proven to be as effective as manufacturers supplied cones. There was little difference in cone resistances between the $4cm^2$ cone supplied with the PANDA and the $4cm^2$ cone from a new manufacturer. Both cones have identical areas, so this is expected.
- Generally, it took the $10cm^2$ cone significantly longer to penetrate the same depth compared to the $4cm^2$ cone. More blows were required as the force of each blow was dissipated over a larger surface area in the ground, thus less pressure was exerted on the sand, even though the cone resistance (N/mm^2) remained the same. This concept is similar to the difference between a blunt needle and a sharp needle. The sharp needle requires less force to penetrate due to a smaller surface area.
- The $2cm^2$ cone produced significantly noisier data than the $4cm^2$ and $10cm^2$ cones. The response of the cone was far more inconsistent and varied than the larger cone sizes at every site investigated. Again, this could be due to sleeve friction acting on the rod, however there could be other factors contributing to the inconsistencies in these results.
- It can be observed that similarly to Panda $2cm^2$, DCM testing indicates the same degree of overestimating penetration resistance for relatively shallow depths. Considering that DCM cone has similar diameter as the rods the cone is attached to, this represents the same type of behaviour – rods skin friction affecting the overall readings.

5 CONCLUSIONS

It is understood that this is a preliminary study and further comparisons and Panda calibrations against various soils needs to be undertaken. However, at his early stage of the study it can be clearly observed that Panda $2cm^2$ cone greatly overestimates soils penetration resistance as compared against CPTs or other cone sizes. Interestingly similar to Panda $2cm^2$, DCM follows that trend.

One of the early and main conclusions of this study based on the undertaken site testing, is that the $2cm^2$ cone greatly overestimates the cone resistance for depths beyond 1m, likely due to greater sleeve friction acting on the rods as the depth increases. This behaviour is consistent with DCM testing which is subjected to the same limitations relating to rods skin friction. The issue of sleeve friction is reduced greatly when using the $4cm^2$ and $10cm^2$ sacrificial cones, as the rods are far less likely to come in contact with the soil until a greater depth.

Both the $4cm^2$ and the $10cm^2$ cones return very similar results to each other and consistently slightly overestimate the cone resistances compared to the pre-existing CPTs.

The $4cm^2$ cones provided with the PANDA 2 return almost identical results for cone resistance as the new batch of $4cm^2$ cones produced in New Zealand. This is very promising as it shows the results are quite consistent between tests.

The $10cm^2$ cone proved unsuitable for use through coarse soils such as sand due to the large surface area and cone resistance. It required a far higher force to be applied to achieve the same amount of penetration as a $4cm^2$ cone.

The major advantages of using the PANDA 2 is that it is cheap, quick, easy to use, and user independent, which are all good attributes for a soil investigation test. Further investigation is required to determine more detailed correlations against NZ soils. However, up to date study confirmed the suitability of the testing to provide a valuable source of information for temporary works design.

REFERENCES

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