17 June 2013

Canterbury Geotest Limited
39 Ascot Avenue
CHRISTCHURCH 8083

Attention: Nigel Dixon

Dear Nigel

CANTERBURY GEOTEST - HYDRAULIC SCALA MACHINE

Further to your instructions we have reviewed the design and operation of the Hydraulic Scala Machine and comment as follows:

Introduction

We understand that some of your Clients have concerns about the acceptability of the Hydraulic Scala Machine to be used in lieu of a hand operated Scala penetrometer for investigating shallow foundation conditions for residential dwellings. In particular they are seeking assurance that the results from the Hydraulic Scala Machine will be acceptable to the consenting authorities.

We have studied the design and operation of the machine and comment as follows:

Scope of Study

We have carried out the following work in fulfilment of our brief:

- Review of the design of the machine, probes, and push rods
- Review of the operation of the machine
- Review of direct correlations with a standard hand operated Scala penetrometer from three different sites in Christchurch

Description of machine

The machine consists of a pair of hydraulic driving cylinders mounted on a rubber tracked Yanmar carrier (see Figure 1). The cylinders drive a standard Scala penetrometer probe into the ground through a guide tube while measuring the force required by using an electric load cell (see Figure 2). The weight of the Yanmar carrier is sufficient to o[provide the necessary reaction to the thrust of the cylinders pushing the probe into the ground (up to about 1 tonne reaction).

Figure 1. View of Hydraulic Scala Machine

Figure 2. View of electric load cell at top of push rods.

The Scala penetrometer probe and driving rods are of standard manufacture, identical to those used for a hand driven Scala. The main difference is the method of driving: A standard Scala is driven by impact of a falling weight, raised and dropped by hand, while the hydraulic Scala is driven at a constant rate of penetration (2 cm / second) using hydraulic cylinders.

The force required to drive the probe into the ground is measured electronically by an electric load cell (Figure 2) and recorded digitally on a laptop computer (Figure 3). For a standard hand operated Scala penetrometer, the resistance to driving is measured by the number of weight drops required to drive the probe for 100 mm increments.

Figure 3. Recording data onto a laptop computer.

Operation of the machine is very efficient, with the hard work of driving the probe and then extracting the rods carried out hydraulically instead of requiring manual labour. The operator controls the cylinders using normal hydraulic valves while screwing and unscrewing additional driving rods as required. This compares to the heavy physical labour of lifting and dropping the drop weight hundreds of times for a typical sounding using the hand operated Scala and the difficulty of extracting the probe by hand when driven into firm ground.

Theory of operation

The main theory behind the Scala penetrometer is that there is a direct correlation between the force required to drive the probe into the ground and the strength and density of the soil. Correlations have been devised for the ultimate bearing capacity of the ground based on this theory.

The only difference between the hydraulic Scala and the hand operated Scala is the method used for driving the probe into the ground and for measuring the force required. The hand operated Scala is driven using the impact of a falling weight and the force required to drive the probe is calculated indirectly by calculating the work done on the probe by the energy of the falling weight. For the hydraulic Scala, the force required to drive the probe is measured directly by an electric load cell.

The hand operated Scala is subject to significant errors including: Loss of energy by radiation of vibration into the ground, bouncing of the weight, incorrect lifting of the weight, sliding friction of the weight, errors in logging of results, and friction of the driving rods in the ground. The only error with the hydraulic Scala, by comparison, is friction of the driving rods in the ground.

Certain types of soil are known to respond differently to shock loading (such as from the falling weight of the hand operated Scala) and quasi-static loading (such as from the hydraulic Scala).

For all of the above reasons, it is very difficult to obtain an exact theoretical correlation between the two penetrometers. Instead, it is recommended that a correlation may be obtained more simply by direct field comparisons, i.e. carry out soundings using both penetrometers at the same field location and compare the results. The results of such field comparisons are discussed below.

Field correlations

A direct correlation between standard hand operated Scala penetrometer soundings and hydraulic Scala soundings were carried out at three different sites around Christchurch. The results of these three soundings have been over-plotted and are presented in Appendix A.

In all three cases the correlations are very good, although some variances are unavoidable given high variability of ground conditions and the many error sources inherent in the hand operated Scala: At Kyntyre Estate, the ground was mostly relatively dense (about 10 blows / 100 mm) and both penetrometers gave very similar results. A Butts Valley road, the hydraulic Scala picked up a layer of dense gravel that is not identified in the hand Scala log, otherwise they are very similar. At Ascot Avenue, a soft ground site, the two traces are very similar.

All three sites used exactly the same correlation coefficient, and we consider the degree of similarity to be remarkably good given the range of conditions among the three sites. However, it is possible that certain soils may give a different correlation and we recommend that a check correlation be carried out periodically when carrying out testing in a new area.

Conclusions and Recommendations

From our review of the machine design, operation, and correlations with results from a standard hand operated Scala penetrometer, we recommend that results from the hydraulic Scala machine of Canterbury Geotest **should be considered an acceptable equivalent**, if not superior to results from a standard hand operated Scala penetrometer.

The hydraulic Scala machine has significant advantages over the standard hand operated Scala including many fewer sources of error, less subject to operator skill, more efficient, more sensitive, continuous output trace, and fewer health and safety risks for the operator.

There is a possibility that the correlation factor developed to date may not be appropriate for every soil condition encountered and we recommend that a check correlation with a standard hand operated Scala penetrometer be carried out at sites where soil conditions are different from those previously verified, and generally at a rate of one hand Scala per each fifty hydraulic Scala soundings in production at large sites.

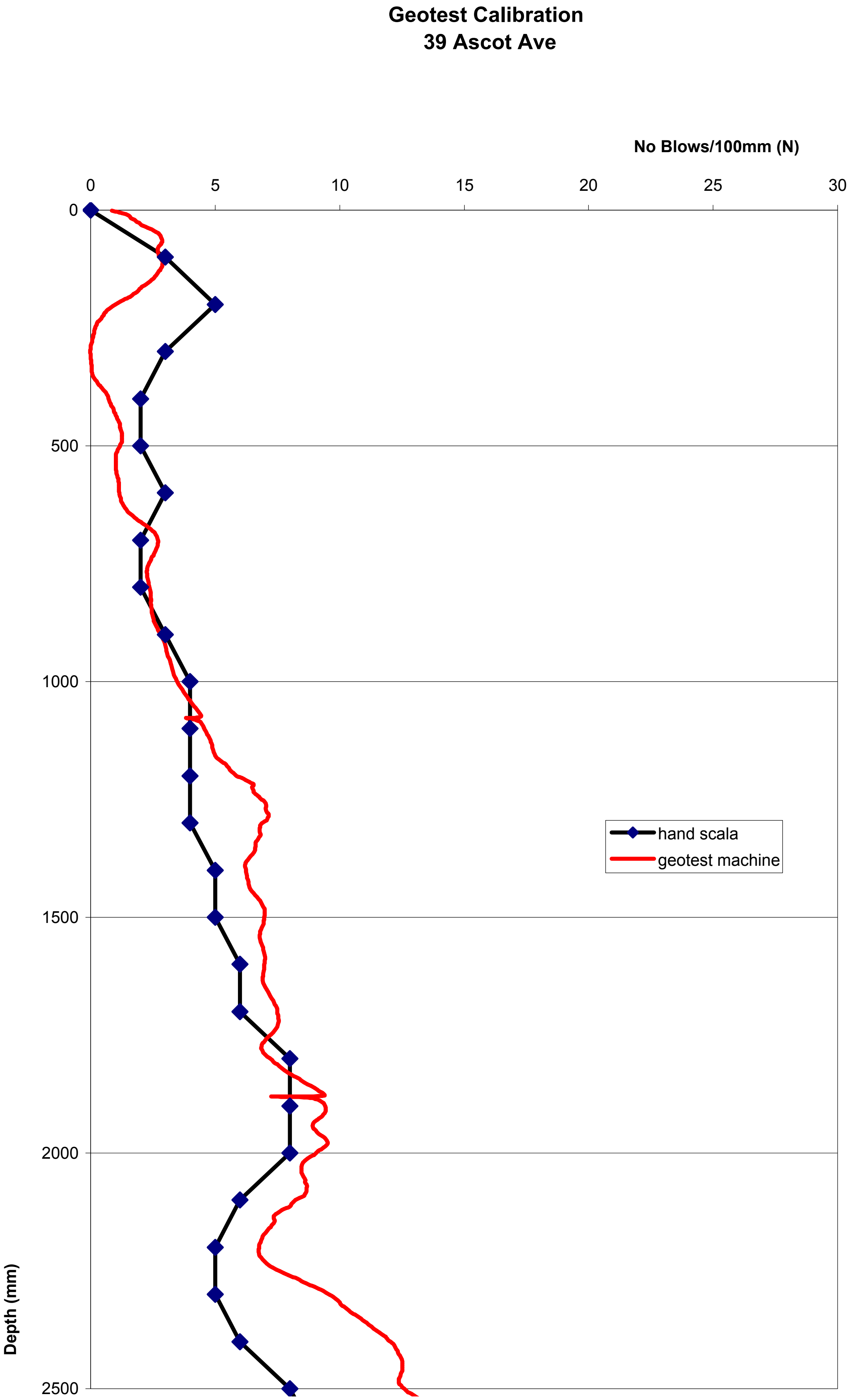
Limitations

The conclusions and recommendations contained within this report are based on review of the results from data provided to us by Canterbury Geotest Limited.

Yours faithfully,
McManus Geotech Ltd.

Kevin McManus
PhD FIPENZ CPEng
Principal

APPENDIX A: FIELD CORRELATIONS BETWEEN HAND OPERATED SCALA AND HYDRAULIC SCALA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Depth (mm)
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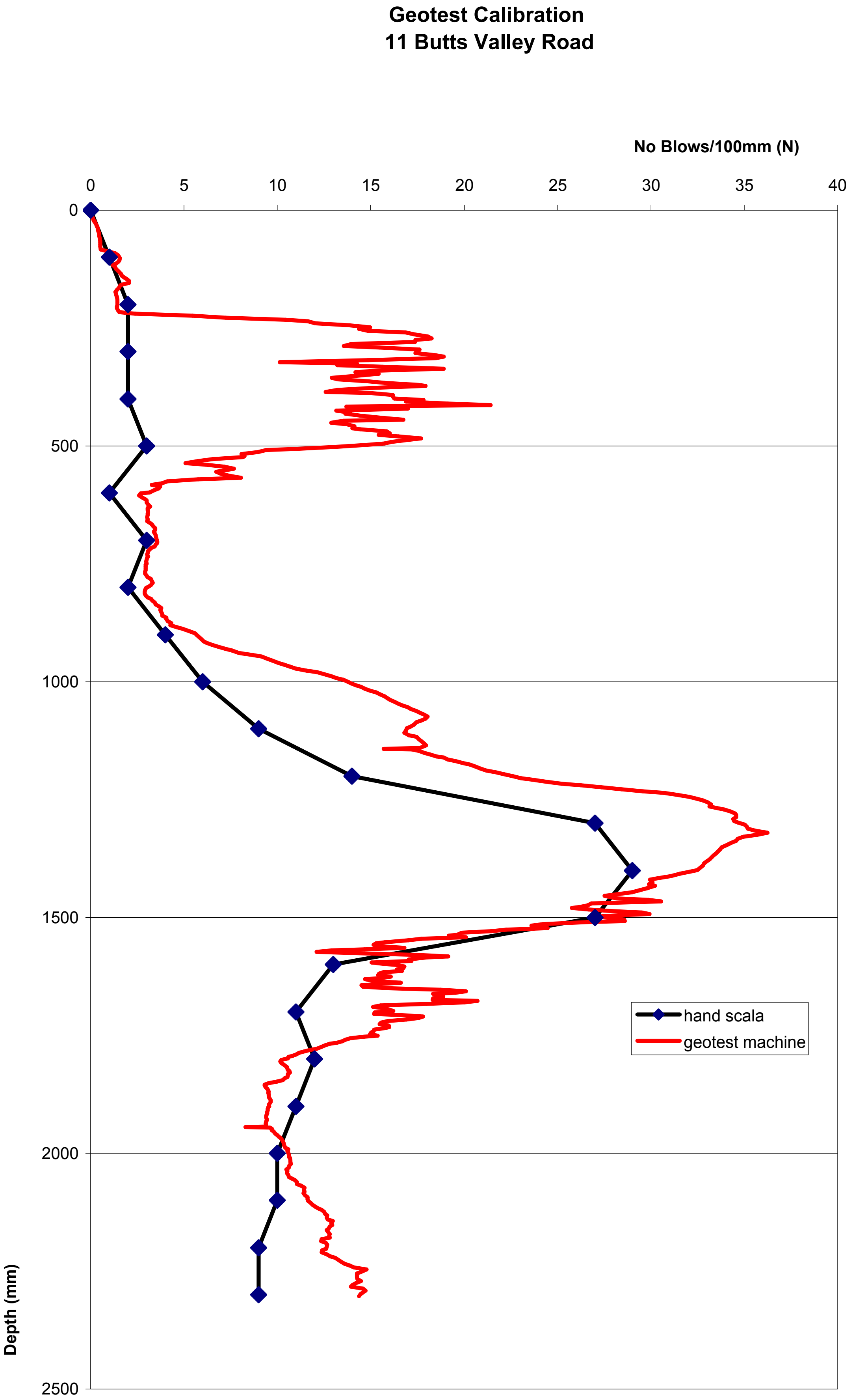
geotest machine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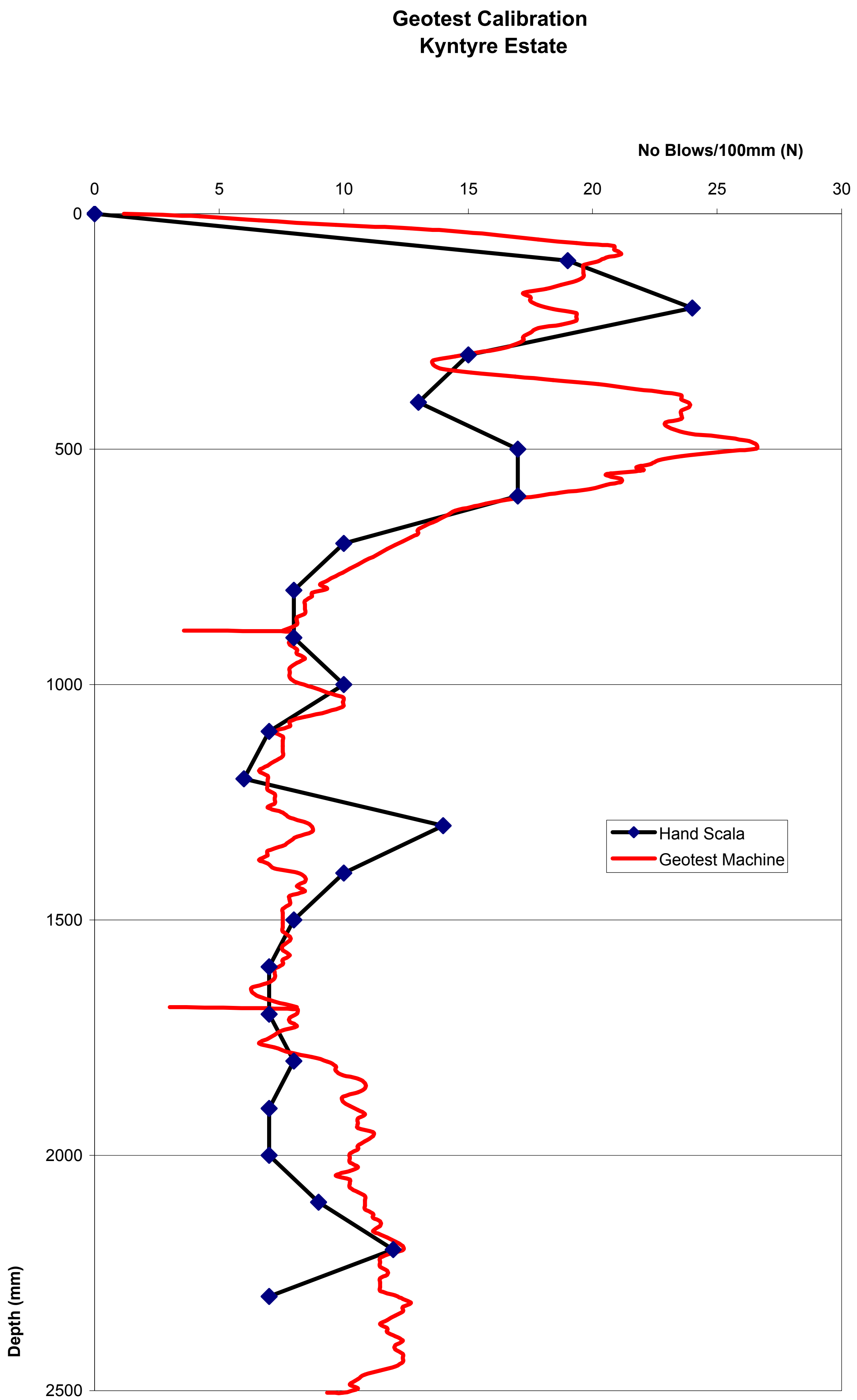

Geotest Calibration
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