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Technical Note

INTERPRETATION OF PIEZO-CONE PENETRATION TESTS

1. INTRODUCTION

This note provides information and guidance for the use and interpretation of Piezo-Cone Penetrometer tests. A Piezo-Cone Penetrometer is a valuable and effective geotechnical investigation tool, which is particually suited for assessing in-situ soil parameters in difficult or soft ground. Detailed interpretation of Piezo-Cone Penetrometer test results will require consultation with GeoPave Geotechnical engineers.

2. CONE PENETROMETER TEST

VicRoads has been using the Cone Penetration Test (CPT) for many years to evaluate and classify sub-surface materials for roadways and bridges. The electrical friction-cone penetrometer currently in use, was developed by VicRoads engineers in GeoPave (formerly Materials Research Division of the Country Roads Board) in the early 1960s. The friction-cone penetrometer is pushed into the ground at a steady rate from a special investigation vehicle, and measures cone resistance and sleeve resistance. From these two measurements it is possible, in most instances, for a geotechnical engineer to determine the soil profile, including the strength of the soil, at a particular site. However, it is often difficult to differentiate between soft silts and loose sands with the standard friction-cone penetrometer. These difficulties can be overcome with a Piezo-Cone Penetrometer or Piezo-Friction-Cone Penetrometer.

3. PIEZO-CONE PENETROMETER

A Piezo-Cone Penetrometer is very similar to a standard friction-cone penetrometer, except that it measures water pressure instead of sleeve resistance. A Piezo-Friction-Cone Penetrometer measures cone resistance, sleeve resistance and water pressure. Some Piezo-Cone Penetrometers or Piezo-Friction-Cone Penetrometers have multiple filters for measuring water pressure at various locations concurrently. It should be noted that the water pressure measured will vary according to the location of the filter.

VicRoads have been using a Fugro Piezo-Cone Penetrometer since 1982. This device has a porous filter located on the face of the cone. The filter is made from either a porous ceramic or a porous plastic. Figure 1 shows details of this device.

4. WHAT IS THE PIEZO-CONE PENETROMETER USED FOR?

The Fugro Piezo-Cone Penetrometer can provide a great deal of information to the geotechnical engineer, by providing a continuous record of two parameters; cone resistance (q_c) and pore water pressure (u), which are functions of all major soil properties.

Figure 1: Fugro Piezo-Cone Penetrometer (Right) with standard Friction Cone Penetrometer (Left)

The Fugro Piezo-Cone Penetrometer has been successfully used to obtain information about:

- the soil type, materials identification, differentiation between soft silts and clays and loose sands, and organic deposits such as peat or brown coal,
- the soil stratification, including detection of thin sand, silt and organic layers,
- the soil strength or relative density of the deposit,
- the stress history of soft soil deposits, in particular the over consolidation ratio for clays,
- the consolidation characteristics of soft soil deposits, in-situ,
- the degree of consolidation of soils beneath an embankment,

for staged construction control,

- the static equilibrium pore pressure,
- the liquification potential of loose sands and silts,
- in-situ effective stress parameters,
- the location of the failure surface within a slip failure,
- estimation of pile driving behaviour.

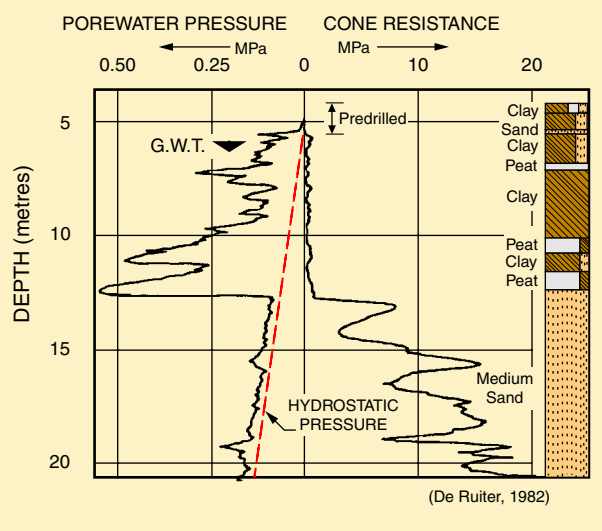

Figure 2: Typical Fugro Piezo-Cone Penetrometer Test Result

During a Piezo-Cone Penetrometer or Piezo-Friction-Cone Penetrometer test (PCPT) the movement of the cone through the soil generates a dynamic pore pressure (u_d). This differential pore pressure can be positive or negative with respect to the in-situ static Equilibrium Pore Pressure (u_s), which is the pore water pressure existing in the soil at any given location prior to carrying out the CPT or PCPT. (Note that this may not be the hydrostatic pressure (u_o) as given by a linear increase of 10 kPa/m below the water table). The Piezo-Cone Penetrometer or Piezo-Friction-Cone Penetrometer measures the total pore pressure (u**)** which is the sum of the Static Equilibrium Pore Pressure and the Dynamic Pore Pressure.

The Piezo-Cone Penetrometer or Piezo-Friction-Cone Penetrometer can also be used to carry out a dissipation test**.** This test involves halting the penetration of the probe at the required depth below ground level, and recording the rate of dissipation of the dynamic pore pressure. Full dissipation of dynamic pore pressure may occur in as little as 5 minutes (in sand), or can take up to 24 hours in clay, and requires constant operator supervision. Even a partial dissipation of dynamic pore pressure (at least 50%) may still require up to several hours.

A Dissipation test can assist in determining:

- in-situ static Equilibrium Pore Pressure (u_s),
- settlement characteristics,
- relative permeability,
- effective stress parameters.

5. WHAT DO THE TEST RESULTS MEAN?

The test results obtained with the Fugro Piezo-Cone Penetrometer consist of a plot of cone resistance (q_c), and total pore pressure u and the pore pressure ratio (u/q_c), plotted against depth of penetration. If a dissipation test has been carried out, a plot of (u) against time is also provided. The most significant measurement with the Fugro Piezo-Cone Penetrometer is the measured pore pressure, and the pore pressure ratio u/q_c. Pore pressure measurements will vary according to the type of soil. Table 1 below provides an indication of how this information can be used to identify various soil types.

Soil Type	Cone resistance qc (MPa)	Dynamic Pore Pressure ud (kPa)	Pore Pressure Ratio u/qc (%)
Loose sand	<5	low or negative	<10
Soft silt/clay	<1	200-500	50-120
Interbedded soft silt loose sand	<1	Fluctuating between zero and 500	50-100
Sand/Gravel	1-50	0-100	<10
Clay	0.5-5	600	100
Peat	2-3	up to 5000+	60
Weathered rock	10-50	-100	<0

Table 1: **Typical output values from Fugro Piezo-Cone Penetrometer**

6. REFERENCES

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