DEVELOPMENT OF A PORTABLE SOIL SAMPLER FOR USE AT SHALLOW DEPTH & TRIALS OF AUTOMATIC PIEZOMETRIC DATA ACQUISITION SYSTEMS

GEO REPORT No. 117

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SPECIAL ADMINISTRATIVE REGION

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PREFACE

In keeping with our policy of releasing information which may be of general interest to the geotechnical profession and the public, we make available selected internal reports in a series of publications termed the GEO Report series. A charge is made to cover the cost of printing.

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R.K.S. Chan
Head, Geotechnical Engineering Office
October 2001

EXPLANATORY NOTE

This GEO Report consists of two Technical Notes in two separate research and development projects carried out by the Special Projects Division in 2000.

They are presented in two separate sections in this Report. Their titles are as follows:

SECTION 1: DEVELOPMENT OF A PORTABLE SOIL SAMPLER FOR USE AT SHALLOW DEPTH

M.H.C. Chan

This report was originally produced in December 2000 as GEO Technical Note No. TN 7/2000

FOREWORD

In 1998, a pilot project was initiated to develop a portable soil sampler that is capable of recovering undisturbed samples at shallow depth and that can be set up easily on sloping ground, in order to facilitate slope investigations.

This Technical Note presents the work carried out under the pilot project. Details of the sampling system developed and initial applications of the soil sampler are given. The development work and field trials of the sampler were carried out by Vibro (HK) Limited under the supervision of the staff of the Geotechnical Engineering Office (GEO).

The pilot project was undertaken by Dr M.H.C. Chan under the supervision of Mr B.N. Leung initially and later Mr T.S. Kwong. Useful feedback on the use of the sampler for slope investigations and on the draft version of this Technical Note was obtained from colleagues in the GEO Landslip Investigation Division and their consultants and colleagues in the Materials Division. All contributions are gratefully acknowledged.

P.L.R. Pang
Chief Geotechnical Engineer/Special Projects

ABSTRACT

For slope investigations, it is often necessary to obtain soil samples for ground characterisation and laboratory testing. This Technical Note presents the work carried out under a pilot project to develop a portable soil sampler to facilitate the work.

The development work and field trials of the sampler were carried out by Vibro (HK) Limited under the supervision of the staff of the Geotechnical Engineering Office. The new sampler developed (named as the Portable Triple-tube Sampler) is capable of recovering undisturbed samples of 74 mm diameter and 500 mm long, in colluvial, residual and saprolitic soils, at shallow depth. The sampler can be set up easily on sloping ground and inside pits of about 1.5 m by 1.5 m on plan. Apart from soil sampling, the drillholes formed by the sampler can also be used for installation of piezometers and other instruments. Compared with conventional drilling and sampling using drilling rigs and core barrels, considerable savings in cost and time could be achieved by using the new sampler. Also, traffic disruption could be minimised for investigations of roadside slopes as the system components can be relatively easily located above the slope toe (e.g. using lightweight scaffold support), or within a small area at the slope crest, thus removing the need for prolonged road closure (i.e. closure will be limited to the short period in setting up the system).

The sampler system developed has been used for two landslide investigation projects. Good quality undisturbed soil samples were recovered successfully from depths up to about 6 m.

CONTENTS

1. INTRODUCTION

For slope investigations, it is often necessary to obtain soil samples for ground characterisation and laboratory testing. In Hong Kong, the common method for taking undisturbed soil samples is by rotary drilling using a drilling rig incorporating a triple-tube core barrel. In this method, erection of access scaffolding/working platform and clearance of vegetation are usually needed for the mobilization of drilling rigs on site. These are time-consuming processes and can incur considerable costs and are environmentally unfriendly. Apart from core samples, undisturbed block samples can be obtained from excavated trial pits. However, considerable efforts are required to excavate the pits, recover the samples, and trim specimens to a suitable size from the block samples for laboratory tests. For safety reasons, trial pits are often limited to a depth of 3 m. There is also a need to backfill the pits with compacted soil afterwards to prevent undesirable localised infiltration which could affect slope stability. Therefore, there is a need to develop a sampler which is able to be mobilised and set up on sloping sites quickly and economically.

A pilot project was initiated in November 1998 to develop a portable sampler which could be capable of recovering undisturbed samples of 74 mm diameter, in colluvial, residual and saprolitic soils, at shallow depth. The sampler was required to be capable of being set up on sloping ground and inside pits of about 1.5 m by 1.5 m on plan. The development work and field trials of the sampler were carried out by Vibro (HK) Limited under the supervision of the staff of the Geotechnical Engineering Office. This Report presents the work carried out under the pilot project.

2. THE SAMPLING SYSTEM AND SAMPLING PROCEDURES

The sampling system developed under this project is composed of a steel frame onto which an electric drill motor is mounted (Figure 1 and Plate 1), a water pump fitted with a pressure gauge and a portable generator (Plate 2). The motor is connected to a drill rod and a triple-tube core barrel. The legs of the steel frame are adjustable so that the frame can stay upright when sampling on sloping ground (Plate 3). Either water or air foam can be used as a flushing medium. A sump pump may be needed for pumping water out of the pit where sampling is carried out inside a pit (Plate 4).

The sampler has been named as “Portable Triple-tube Sampler”, with the abbreviated form being “PT Sampler”. The entire sampling setup is called the “Portable Triple-tube Sampling System”, and the samples obtained using the system are called “PT samples”.

The PT Sampler (Figure 2) resembles a typical Mazier sampler but is shorter in length and lighter. It comprises a triple tube with a retractable cutting shoe, and is capable of recovering samples up to 500 mm long.

The sampling procedures for PT samples are basically the same as those for Mazier samples except that in every run, a 500 mm long sample (together with an approximately 50 mm long disturbed sample within the cutting shoe) is aimed to be recovered. The sampler is advanced manually by turning the control wheel of the drill motor. There is no drill casing for the present setup. For sampling at shallow depth (say, less than 6 m), drilling without the provision of drill casing is still practical for most of the soil types with sufficient fine grains above the groundwater table and an open hole about 100 mm in diameter is formed after sampling. The PT sampling procedures are given in Appendix A.

3. FIELD TRIALS

Field trials using the PT Sampler (with water as the flushing medium) were carried out at four sites, located at Pak Kong (Sai Kung), Wan Tsui Road (Chai Wan), Tai Po Road (Kowloon) and Ma On Shan. The sites are mainly underlain by colluvium and completely decomposed tuff or completely decomposed granite. Sampling was carried out at 13 investigation holes, and 31 samples at up to 4.9 m depth were recovered (Table 1). For comparison purposes, 3 block samples were collected from trial pits excavated adjacent to the drillholes. Details of the field trials are given in Vibro (2000a).

At the Tai Po Road site and at investigation stations GEO TP2 and GEO TP10, layers of fill containing cobbles and gravel and saprolitic soil were encountered (with GCO probe reaching refusal at less than 2 m depth). Therefore, only disturbed samples were recovered from these locations.

The field trials reveal that the components of the sampling system can be easily carried up and down steep slopes manually. With a crew of 3 to 4 persons, the system could typically be assembled in 1 to 2 hours. The time taken to recover an undisturbed sample ranged from about 5 to 30 minutes, depending on the soil characteristics, sampling depth and flushing medium.

4. LABORATORY EXAMINATION AND TESTING

The PT samples recovered from the field trials, which were colluvial or saprolitic soils, were taken to the Public Works Central Laboratory for extrusion, splitting and detailed visual examination. On the whole there was little evidence of sample disturbance to the samples. Generally, the samples showed intact soil structure with a quality similar to those observed in standard Mazier samples. For about a quarter of the PT samples, the surfaces of the samples appeared to be wetter than the corresponding block samples. A number of moisture content tests were carried out on specimens taken from the PT and block samples. These did not show any significant differences in moisture contents (within 2%). The wet surfaces of the PT samples might be due to the use of water as a flushing medium.

A number of classification, triaxial compression and oedometer tests were also carried out on specimens prepared from the PT samples and the block samples. The results of the triaxial tests did not show any significant differences in strength properties. Plotting the triaxial failure stresses of the two sample types on the same s'-t diagram indicated that all the data points were generally within the same band (Figure 3). Oedometer tests carried out on the two sample types showed a relative percentage difference of about 3% in the coefficients of consolidation. As the total number of tests carried out is small, this may not be sufficient to enable definitive conclusions to be drawn. The details of the laboratory tests are given in the relevant test reports (PWL, 1999a, 1999b and 1999c; GCEMTL, 2000).

5. INITIAL APPLICATIONS

An application of the PT Sampler was carried out in October 1999 for the investigation of the landslide incident at Sham Tseng San Tsuen (FMSWJV, 2000). Six drillholes, with the use of air foam as the flushing medium, were sunk to a maximum depth of 6 m in the vicinity of the landslide scar. 39 PT samples were taken from the colluvium and the medium- to fine-grained completely decomposed granite layers. GCO probe tests were carried out at locations adjacent to the drillholes. The blowcounts ranged from a few to over 40 blows per 100 mm. Standpipe piezometers were installed in two of the drillholes. The details of the ground investigation are given in Vibro (2000b). Laboratory testing including triaxial compression and classification tests were also carried out. The details of the laboratory tests are given in PWL (2000).

Another application of the PT Sampler was for a natural terrain landslide study in Lantau Island in April 2000 (Vibro, 2000c). The investigation works were conducted on an open field located approximately 1.5 km northeast of Tung Chung above the North Lantau Expressway. Ten drillholes, with the use of water as the flushing medium, were sunk to a maximum depth of 6 m. The site was underlain mainly by colluvium and completely decomposed tuff. GCO probe tests were carried out at locations adjacent to the drillholes, with blowcounts up to 30 blows per 100 mm. Standpipe piezometers were installed in seven of the drillholes and ground movement probe access tubes were installed in the other three drillholes. The recovered PT samples were extruded, split and visually examined in the laboratory. Good sample quality similar to that of typical Mazier samples was observed. The disturbed samples (about 50 mm long) recovered from the cutting shoe were used in particle size distribution and Atterberg limits tests.

The relative advantages/disadvantages of the PT Sampling System, when compared with conventional ground investigation methods with rotary drilling, are listed in Table 2. The cost and time required for the field work of the two application cases have been compared with those of conventional ground investigation methods using a drilling rig. The results are presented in Tables 3 and 4. In the first case, cost and time savings of about 47% and 24% respectively can be achieved when using the PT Sampling System. In the second case, cost and time savings of 33% and 48% respectively can be achieved. If the field work is to be carried out by conventional methods using two drilling rigs, the time required would be similar to that of the two application cases. However, the PT Sampling System can have a cost saving of about 40% over the conventional methods. It is possible that the cost of the PT sampling could reduce in future as more contractors are armed with the tool and have familiarised their staff with the technique, and when there is a significant amount of work sharing out the capital cost of acquiring the system components.

6. CONCLUSIONS

A portable and compact soil sampler (the PT Sampler) has been developed and trialled on level as well as sloping ground. In the field trials, good quality samples of colluvial, residual and saprolitic soils have been recovered successfully from depths up to 4.9 m.

The PT Sampling System developed has subsequently been used in two landslide investigation projects. Undisturbed samples were successfully taken from colluvium, completely decomposed granite and completely decomposed tuff, up to 6 m depth. The samples recovered were used for logging, soil classification and determination of shear strength parameters. The drillholes formed by the PT Sampler were also used for installation of piezometers and other instruments. Compared with conventional drilling and sampling methods, considerable savings in cost and time could be achieved by using the Sampler. Also, traffic disruption could be minimised for investigations of roadside slopes as the system components can be relatively easily located above the slope toe (e.g. using lightweight scaffold support), or within a small area at the slope crest, thus removing the need for prolonged road closure (i.e. closure will be limited to the short period in setting up the system).

7. FURTHER WORK

It is recommended that further development work on the PT Sampler be explored to enable the recovery of undisturbed samples at greater depths (say, up to 10 m). The possible areas of improvement to the System to achieve this include:-

(a) provision of a drill casing to prevent hole collapse,

(b) use of a percussive drill bit to overcome rock/boulders,

(c) use of a lever and additional counter-weight to increase the downward thrust, and

(d) installation of suitable measuring instruments to monitor drilling parameters such as downward thrust, advance rate and drilling fluid pressure so that change in drill bit and downward thrust can be made at appropriate times.

8. REFERENCES

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Vibro (2000c). Forensic Study of Debris Flow Incident at Sham Tseng San Tsuen on the 23rd August 1999. Factual Report on Ground Investigation. Works Order No. 990151/CF19.74/PT1 under Agreement No. CE101/98. Report prepared by Vibro (HK) Limited for the Geotechnical Engineering Office, Hong Kong.

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Table 1 - Summary of Field Trials

Site	Investigation Station	Number of Investigation Holes	Number of Samples Taken		GCO Probe Blowcounts	Maximum Drillhole Depth (m)	Ground Conditions	Note
			Block	PT				
A	GEO TP 1	5	1	6	11 to 22	2.3	Topsoil/ Colluvium/ Completely Decomposed Tuff	
	GEO TP 2	0	0	0	5 to >100	-	Topsoil/Highly Decomposed Tuff	(2)
	GEO TP 3	3	1	10	7 to 19	4.9	Topsoil/ Residual Soil/ Completely Decomposed Tuff	
B	GEO TP 4	2	0	2	-	1.7	Topsoil/ Residual Soil/ Completely Decomposed Tuff	
C	GEO TP 6	1	0	4	>100	3.8	Fill/Completely To Highly Decomposed Granite	
	GEO TP 7/7A and 8	0	0	0	10 to >100	-	Fill/Completely to Highly Decomposed Granite	(2)
D	GEO TP 9	2	1	9	-	4.0	Residual Soil/ Completely Decomposed Granite	
	GEO TP 10	0	0	0	-	-	Fill	(2)

Legend:

Site A	Pak Kong	Site B	Wan Tsui Road
Site C	Tai Po Road	Site D	Ma On Shan

Notes:
(1) GEO TP5 scheduled to be carried out at Site B was cancelled.
(2) Position abandoned as the material was too strong to be sampled.

Table 2 - Advantages/Disadvantages of the PT Sampling System

Aspects	Advantages
Ease of mobilisation	The PT Sampling System can be manually transported through narrow access, e.g. narrow road/path adjoining slope toe or structure/backyard adjoining slope toe.
Works area	The PT Sampling System needs a small works area and can be operated directly on sloping ground. No scaffold platform is needed.
Need for vegetation clearance and scaffold access	The PT Sampling System can be set up on natural ground without the need for vegetation clearance or erection of scaffold access.

Aspects	Disadvantages
Depth of sampling	The PT Sampler has a limited depth of sampling (presently about 6 m in saprolitic soil).
Sampling materials	The PT Sampler is not suitable for sampling rock, strong soils, and soils with strong particles larger than gravel size.

Table 3 - Cost and Time Comparisons for the Landslide Investigation at Sham Tseng San Tsuen

Ground Investigation (G.I.) Method	Mobilization and Moving Costs ($)	Sampling and Other Costs ($)	Total G.I. Cost ($)	Number of Days Required
PT Sampling System	146,000	178,000	324,000	13
Conventional Drilling with One Drilling Rig	323,000	283,000	606,000	17
Conventional Drilling with Two Drilling Rigs	343,000	283,000	626,000	14

Saving in total G.I. cost of PT sampling over conventional drilling (one drilling rig) = 47%
Saving in time of PT sampling over conventional drilling (one drilling rig) = 24%
Saving in total G.I. cost of PT sampling over conventional drilling (two drilling rigs) = 48%

Notes: (1) Time and cost for conventional drilling (including erection of access scaffolding/working platform and vegetation clearance) are estimated based on information from GEO Materials Division 1999/2000 term contracts.
(2) Scope of the ground investigation work is given in Section 5 of the Technical Note.

Table 4 - Cost and Time Comparisons for the Landslide Investigation at Tung Chung East, Lantau Island

Ground Investigation (G.I.) Method	Mobilization and Moving Costs ($)	Sampling and Other Costs ($)	Total G.I. Cost ($)	Number of Days Required
PT Sampling System	92,000	397,000	489,000	14
Conventional Drilling with One Drilling Rig	521,000	214,000	735,000	27
Conventional Drilling with Two Drilling Rigs	595,000	214,000	809,000	14

Saving in total G.I. cost of PT sampling over conventional drilling (one drilling rig) = 33%
Saving in time of PT sampling over conventional drilling (one drilling rig) = 48%
Saving in total G.I. cost of PT sampling over conventional drilling (two drilling rigs) = 40%

Notes: (1) Time and cost for conventional drilling (including erection of access scaffolding/working platform and vegetation clearance) are estimated based on information from GEO Materials Division 1999/2000 term contracts.
(2) Scope of the ground investigation work is given in Section 5 of the Technical Note.

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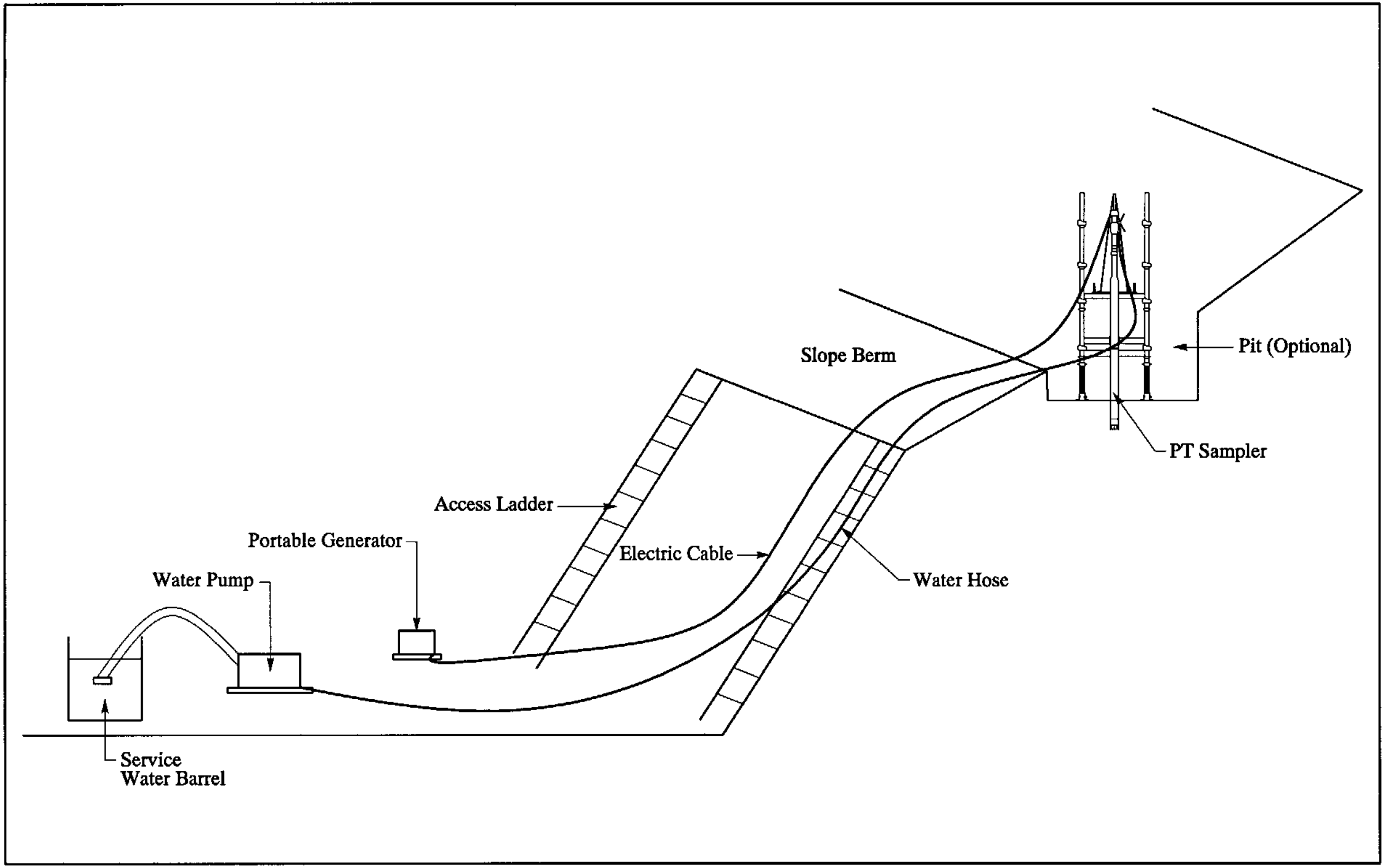


Figure 1 - Schematic Set Up of the PT Sampling System

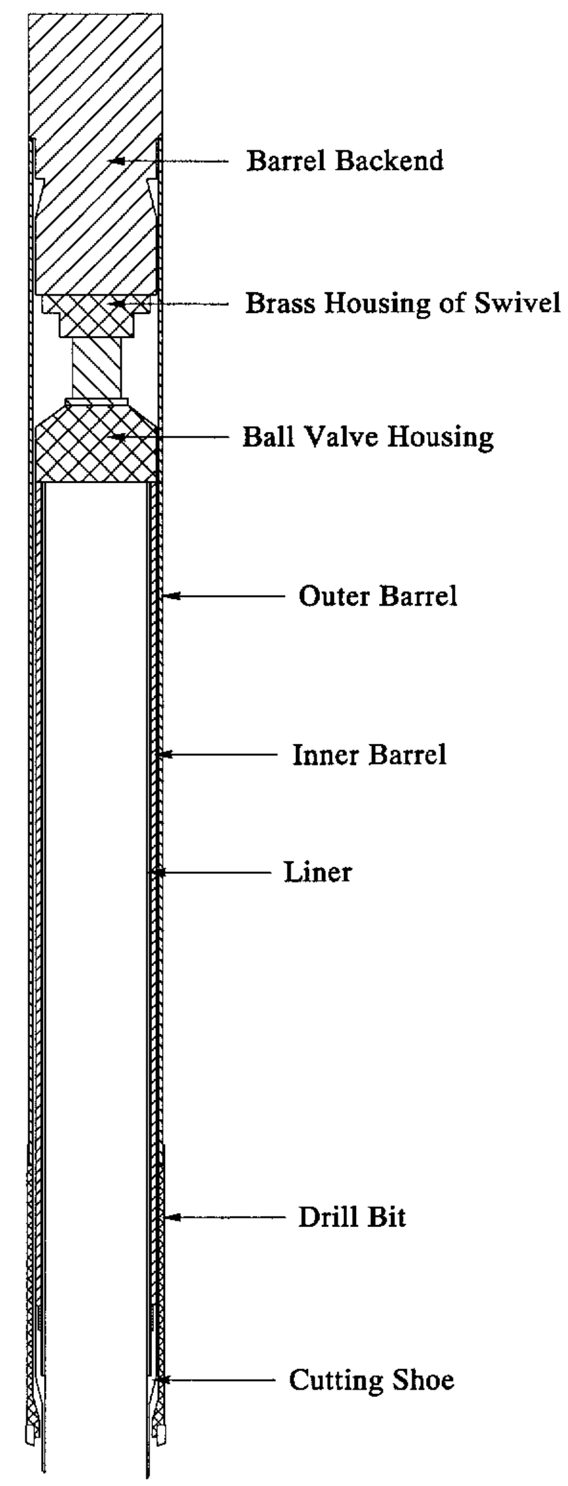
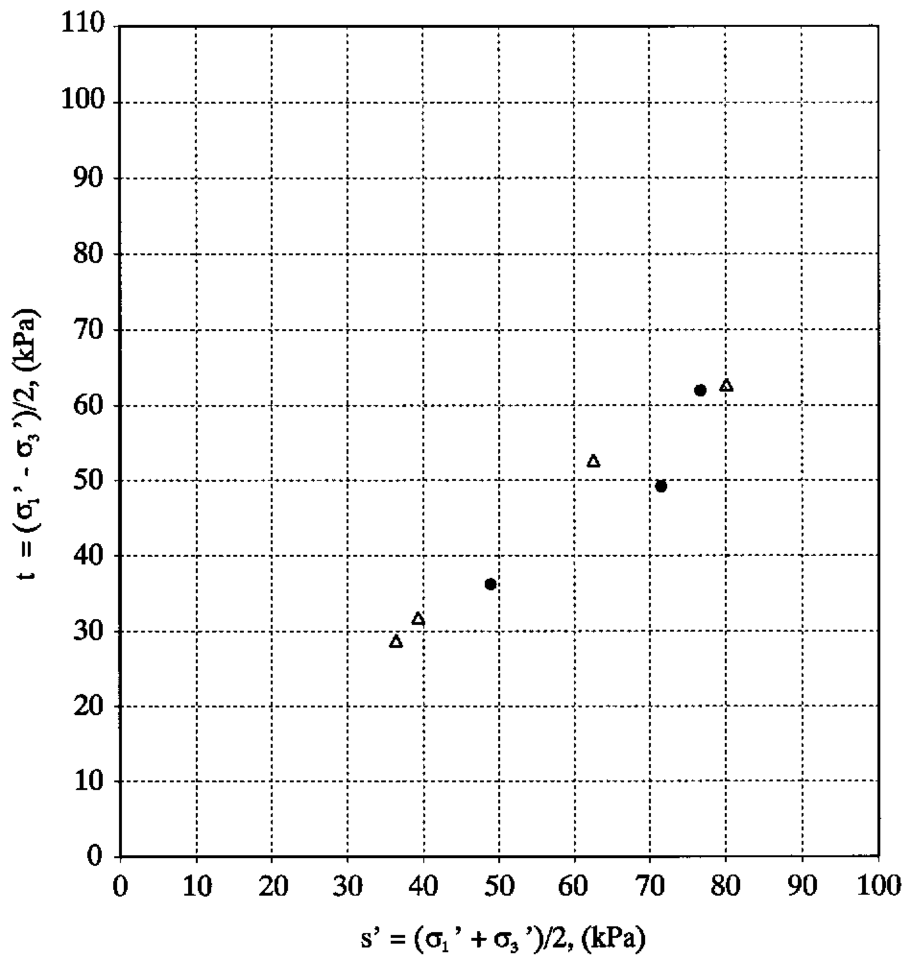


Figure 2 - Cross Section Through the PT Sampler Barrel



Legend:

- ● Block samples
- Δ PT samples

Note: Only stress states at failure are plotted. The maximum stress ratio (σ_1' / σ_3') failure criterion was adopted.

Figure 3 - s' versus t Diagram for Samples Taken from Investigation Station GEO TP1

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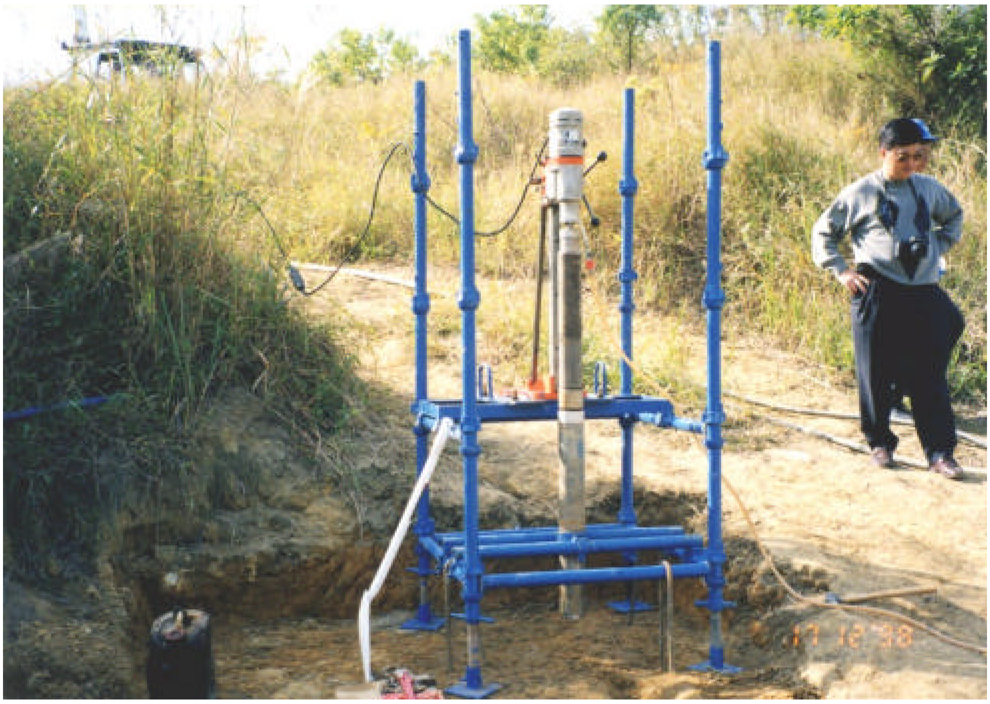

Plate 1 - Support Frame with the PT Sampler Set Up

Plate 2 - Diesel Water Pump and Service Water Barrel to Support Drilling Operation

Plate 3 - Sampling Frame Set Up Directly on Slope

Plate 4 - Sampling Frame Set Up Inside a Pit

APPENDIX A

THE PT SAMPLING PROCEDURES

The PT sampling procedures are as follows:

1. Assemble the frame and drill motor directly over the investigation station.

2. Dig a small pit (about 0.2 m x 0.2 m x 0.15 m depth) by the investigation station with a small trench to allow the flushing water to drain to a sump fitted with a pump, or to open ground at a safe discharge location.

3. Connect the PT Sampler core barrel via the drill rods to the drill motor and lower the barrel onto the ground surface.

4. Turn on the drill motor. Manually advance the core barrel by turning the control wheel of the motor. Apply flushing water or other medium if necessary. Adjust the flushing pressure to facilitate drilling (as a start, flushing pressure of about 30 to 60 psi may be used). Carefully adjust the downward thrust so that the motor would not be stopped by excessive soil resistance at the drill bit.

5. After advancing the barrel for about 500 mm, stop the motor and the flushing. Retrieve the barrel and remove the soil sample from the PT Sampler.

6. If another sample is needed, clear the hole bottom by wash boring if necessary and repeat Steps 3 to 5 above.

Note: The Construction Sites (Safety) Regulation's provisions on working at height should be followed at all times.