RESEARCH DILATOMETER TESTING IN SANDS AND IN CLAYEY DEPOSITS

by

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Abstract

The development of Marchetti's flat dilatometer, method of testing, changes of Marchetti's (1980,1981) original correlations and Schmertmann's (1982,1983) proposed correlations are briefly described.

Factors affecting results of the dilatometer test (DMT) are discussed. In order to improve the understanding of the Marchetti dilatometer test (DMT), an electronic research dilatometer was developed at UBC. The research dilatometer can measure; pore pressure at the center of the membrane, membrane displacement, applied pressure, pushing force and verticality.

Test results obtained from the research dilatometer in sand and in clayey deposits at 4 sites in the Lower Mainland of B.C. are presented. Soil parameters interpretated using Marchetti's (1980,1981) and Schmertmann's (1982,1983) correlations are discussed. Comparison is made to other in-situ testing methods such as cone penetration test, vane shear test and pressuremeter test.

Based on a better understanding of the DMT, future potential methods of improving or checking the existing correlations are proposed.

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Chapter 1

Introduction

1.1 Historical Review

In a paper submitted to the 1975 Raliegh ASCE Specality Conference, S.M. Marchetti introduced a new in-situ testing device called the "flat dilatometer". The instrument was designed to investigate the horizontal soil deformability of laterally loaded driven piles.

In 1978, Marchetti revised his in-situ tool to a more streamline shape with a sharper cutting edge in order to minimize soil disturbance during penetration of the instrument. After performing dilatometer tests (DMT) at over 40 well documented sites in Italy, Marchetti established a set of empirical correlations for soil classification and property estimation.

The instrument was first introduced into North America with Marchetti's (1980) publication and Schertmann's (1981) discussion in the Geotechnical Division Journal of the ASCE. After this introduction, the use of the flat dilatometer test (DMT) in North America has increased gradually.

1.2 Purpose and Scope

Recent research has changed many of Marchetti's (1980,1981) original empirical correlations. However, due to the simple design of the instrument and operation of the test, the fundamental soil behaviour of the test is still not well understood.

In order to better understand the test, the in-situ testing research group at the University of British Columbia (UBC) has developed an electronic research dilatometer (McPherson 1985). The UBC research dilatometer is identical in operation to Marchetti's dilatometer and can continuously measure:

1. pore pressure during penetration and during the dilatometer test,
2. the total and effective soil stresses together with the soil deformation during the dilatometer test,
3. the penetration force behind the instrument,and
4. the inclinaton of the probe.

The purpose of this thesis is to present test results in sand and clayey deposits obtained with the research dilatometer from 4 sites in the Lower Mainland of British Columbia. The soil stress, pore water pressure and soil deformation characteristics of the dilatometer test are illustrated and discussed. Soil parameters obtained from tests using both Marchetti's (1980,1981) original and recent improved correlations are presented and discussed. Reference is made to data obtained from laboratory tests on recovered samples and other in-situ tests such as cone penetration test, vane shear test and pressuremeter test, whichever is applicable.

Based on an improved understanding of the test, future potential methods of improving or checking the existing correlations are proposed.

Chapter 2

The Standard Flat Dilatometer

2.1 Development of the Instrument

The device was developed by S. Marchetti at L'Aquila University in Italy.

When first introduced in 1975 (Marchetti, 1975), the flat dilatometer consisted of a stainless steel plate, 80mm wide and 20mm thick, with a pyramid shaped tip. On both sides of the blade, a thin steel circular membrane of 60mm diameter was mounted flush with the plate surface.

In order to minimize soil disturbance during penetration but still to have a device rigid enough for insertion, Marchetti revised his original design (Marchetti, 1980). The present dilatometer in commercial use has a streamline shape blade, 95mm wide and 14mm thick with a curved cutting edge. A single stainless steel membrane, 0.25mm thick and 60mm in diameter is mounted flush on one side of the blade, as shown in figure 2.1.

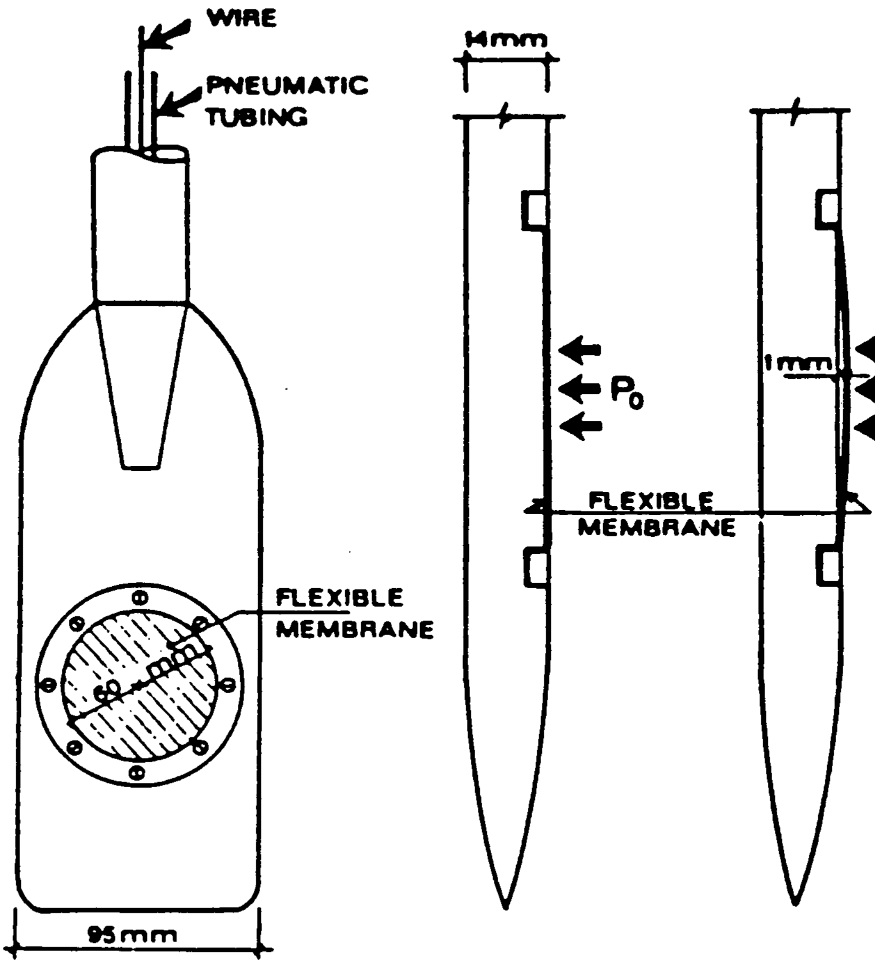


Figure 2.1 Marchetti's Flat Dilatometer

2.2 The Dilatometer Test and Procedures

The dilatometer is connected to a control unit at the ground surface by a nylon tube prethreaded through the penetration rods (figure 2.2). The dilatometer, is pushed into the soil at a rate of approx. 2-4cm/sec. Generally, the penetration rate is set at 2cm/sec which is the standard adopted for the cone penetration test. At 20cm depth intervals, penetration is stopped and the dilatometer test (DMT) is performed without delay by starting to inflate the membrane. The membrane is inflated by gas pressure (usually compressed nitrogen) supplied through the control box and the nylon tube.

As the membrane is inflated, two readings are manually taken from a pressure gauge mounted on the control unit: the lift off pressure of the membrane (Reading A) and the pressure to cause 1mm deflection at the center of the membrane (Reading B). Beneath the membrane is a simple electronic device which is connected to the control unit by an electrical wire inside the nylon tube. During penetration, the membrane is in contact with a sensing disc and the device turns on a buzzer in the control unit. The device turns the buzzer off when the membrane starts to lift off the sensing disc, and turns the buzzer on again when the center of the membrane reaches a deflection of 1mm (figure 2.3).

Figure 2.2 Dilatometer and Control-Unit

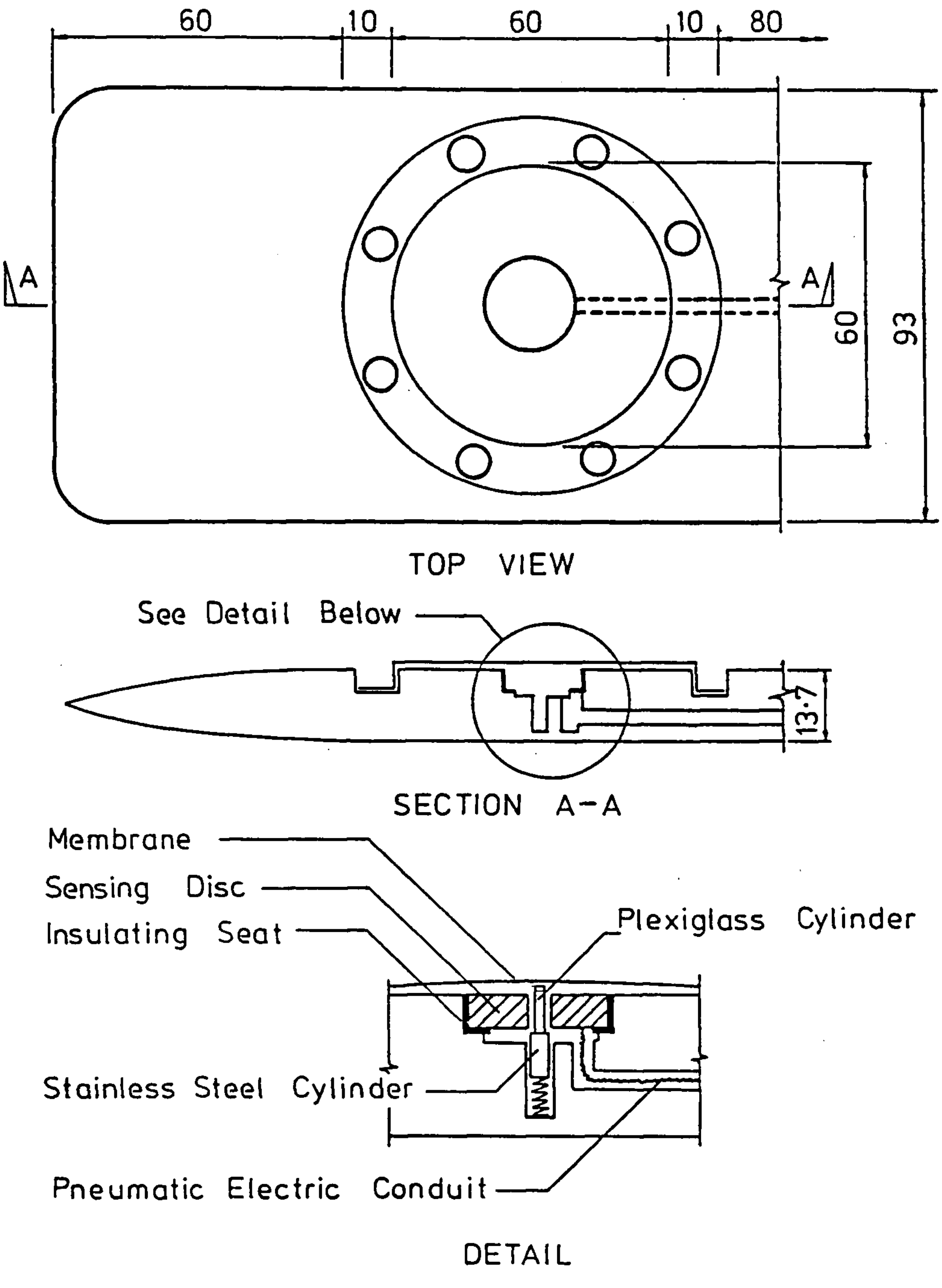


Figure 2.3 Schematic of Dilatometer

The rate of inflation is controlled through a valve in the control box and is usually adjusted in such a way that the dilatometer test (the entire expansion) takes about 15 to 30 seconds. Once the 1mm deflection at the center of the membrane is reached, the test is completed, and the pressure inside the dilatometer is vented and penetration for another test is continued. Full details of the standard flat dilatometer and testing procedures are given in the Flat Dilatometer Manual by Marchetti and Crapps (1981) and in a recent publication by ASTM (Schmertmann, 1986).

2.3 Data Reduction

In order to determine the pressures, P_0 and P_1, which are applied to the soil at the start and at the end of the expansion respectively, the two Readings A and B are corrected for membrane stiffness. The expressions for the correction are:

$$P_0 = A + \Delta A \quad (2.1)$$

$$P_1 = B - \Delta B \quad (2.2)$$

where ΔA = the vacuum required to keep the membrane just in contact with the sensing disc in free air since the membrane acquires a permanent outward curvature once used.

where ΔB = the pressure required to cause a 1mm deflection at the center of the membrane in free air.

(ΔA ad ΔB are determined before and after each sounding.)

From the two pressure measurements P_0 & P_1, Marchetti (1980) proposed three index parameters: the dilatometer modulus (E_D), the material index (I_D) and the horizontal stress index (K_D). The expressions for the index parameters are:

$$E_D = 38.2(P_1-P_0) \qquad (2.3)$$

$$I_D = (P_1-P_0)/(P_0-u) \qquad (2.4)$$

$$K_D = (P_0-u)/\sigma_v' \qquad (2.5)$$

where u =equilbrium pore water pressure prior to blade insertion

σ_v' =vertical effective soil stress

The dilatometer modulus is derived using the theory of elasticity. Marchetti (1975 & 1980) assumed that the soil adjacent to the blade is an elastic half space and is uniformly loaded by the 60mm dilatometer membrane with a displacement of exactly 1mm. The membrane is considered as a rigid disc so that there is no soil pressure redistribution. Further, it was assumed that there is no settlement external to the loaded area, i.e. area of the membrane, during the expansion. The other two indices are normalized parameters which Marchetti (1980) introduced to establish empirical correlations for soil properties with the use of E_D. The parameters I_D and K_D require a knowledge of the in-situ equilibrium water pressure. The in-situ water pressure is usually assumed to be hydrostatic and thus, the only information required is the depth to the ground water level (GWL). The in-situ vertical effective stress is calculated using the assumed hydrostatic water pressure and the soil unit weight determined from the empirical correlations based on I_D & E_D.

Because of the configuration of the measuring system of the dilatometer (i.e. an actual deflection of 1.1mm), expressions for the membrane stiffness correction and the dilatometer modulus are slightly modified in the data reduction program (Crapps & Schmertmann, 1981) supplied with the instrument. Equations 2.1 and 2.3 are changed to:

$$P_0 = (A+\Delta A) - (5/105(B-\Delta B) - (A+\Delta A)) \qquad (2.6)$$

$$E_D = 34.7(P_1-P_0) \qquad (2.7)$$

A full discussion on this configuration correction is given in the Flat Dilatometer Manual by Marchetti & Crapps (1981).

2.4 Soil Properties Interpretation

With the experience and information gained after performing dilatometer tests at over 40 sites in Italy, Marchetti (1980) developed a set of empirical correlations between the three dilatometer index parameters, I_D, K_D & E_D and various soil properties of soil type, soil unit weight, coefficient of earth pressure at rest (K_0), overconsolidation ratio (OCR), drained constrained modulus (M_D) and undrained shear strength of coeshive soils (Su). The correlations were based on test results at 10 selected well documented sites. As the majority of the sites consisted of clay deposits with only two sites of sand, Marchetti did not have enough information to establish the correlation of friction angles of sands (ϕ') in his (1980) paper. The correlation to determine the friction angle of sand was proposed in an un-published technical note (Marchetti, 1981) supplemented with the Flat Dilatometer Manual (Marchetti & Crapps, 1981) after obtaining test data from four additional sand sites.

The 1981 Flat Dilatometer Manual presents the earliest complete set of soil properties correlations from dilatometer testing. Some of the original correlatons presented in Marchetti's (1980) paper were slightly modified in the Manual, and those modifications are:

1. The correlation of soil classification has included the use of the dilatometer modulus, E_D, to sub-divide the soil classification and give an estimate of the soil density.
2. The correlation of OCR for cohesionless soil has been slightly adjusted in order to differentiate between sands with $I_D > 2$ and silty materials with I_D between 1.2 and 2.
3. In the transition zone of I_D from 0.9 to 1.2, the

dilatometer cannot precisely indicate the soil type and therefore, no strength parameters (ϕ' or Su) are calculated.

A computer progam, DILLY, is provided with the instrument. The program was written by Crapps & Schertmann (1981) to reduce the raw test data to the dilatometer indices and then interprete the soil properties.

The correlations developed by Marchetti (1980 & 1981) were highly empirical. As more DMT data became available from large scale calibration chamber tests and more well documented field sites, it was apparent that Marchetti's correlations were not valid for all sands. The correlations tended to overestimate the values of K_0 and OCR in sand and underestimate the friction of angle. However, users have reported good correlations in soft clay deposits using DMT results (Schertmann, 1981, and Lacasse & Lunne, 1982). This is not surprising since Marchetti's correlations were mainly based on data obtained from uncemented cohesive soils (ie. clay deposits).

When developing the correlations of K_D versus K_0, Marchetti (1980) did not expect any unique relationship between K_D & K_0 (P_0 & σ'_h) for all soils. The calibration chamber test work in Italy has shown that K_D depends on both soil relative density and in-situ stress history for sands

(Bellotti et al, 1979). However, a single curve fitted well all the available data (mostly for clay) and thus, Marchetti had accepted the correlation for both clay and sand. The correlation of OCR and friction angle for sands were also based on a very limited amount of data. Furthermore, Marchetti (1981) considered his proposed method of estimating the friction angle of sand as only a possible framework in which new data should be included as they become available.

Schmertmann (1982) provided a more rational method to calculate the friction angle of sand using the bearing capacity theory developed by Durngunoglo and Mitchell (1975). Schmertmann's (1982) method is complex and iterative, and requires the pushing forces to advance the dilatometer as additional input data. To improve the prediction of K_o in sand, Schmertmann (1983) developed a new correlation for K_o Vs K_D with ϕ' as an additinal input parameter, based on the chamber test data available up to 1983. For the improvement of the OCR prediction, Schmertmann (1983), also based on the available chamber test data, proposed a correlation by slighty modifying Mayne and Kulhawy's approach (1982) which also requires the use of a drained friction angle.

Schmertmann (GPE, Inc., DMT Digest Series) recommended that the above three methods should replace Marchetti's original correlation for determining ϕ', K_0 and OCR in sands. Bullock (1983) developed a new data reduction program, DILLY4, which incorporated all these changes. Marchetti's (1981) correlation of ϕ' was, however, retained as an option for the users since Schmertmann method requires the additional input data of the pushing force.

2.5 Advantages and Disadvantages of the Dilatometer Test

The main advantage of the dilatometer test is the instrument's low initial cost and the simplicity of the operation and maintenance since no sophisticated electronics are required. The test does not require highly skilled operators or technicans and has been found to be a highly repeatable test that is almost operator independent (Lacasse and Lunne, 1982).

Although the dilatometer test (DMT) is extremely simple, it provides an impressive range of soil parameters through empirical and semi-empirical correlations.

Finally, it appears that the test results can also be used for evaluation of other geotechnical problems such as; liquefaction potential, coefficent of horizontal subgrade reaction prediction and lateral pile movement prediction.

The main disadvantage of the dilatometer test is that the instrument can be easily damaged when penetrating through very dense sands or gravels. The membrane, which is thin to make it expandable, is fragile and susceptible to damage. Gravels can easily tear the membrane. In dense sands, there can be significant frictional force to make a stretch or wrinkle on the membrane. However, stronger membranes have been developed recently.

One final concern is the level of confidence in the interpretated soil parameters obtained form the dilatometer test. The test is still relatively new and the correlations proposed by Marchetti (1980,1981) and Schmertmann (1982,1983) were based on a limited amount of test results. As the test is simple with only two measurements taken, it is often difficult for users to justify the interpretated soil parameters without a greater fundamental understanding of the test.

2.6 Dilatometer Testing at the University of British Columbia

At the University of British Columbia (UBC), dilatometer testing has been performed using the in-situ testing research vehicle (Campanella & Robertson, 1981). The instrument has been pushed into the ground at a rate of 2cm/sec. Two readings A & B are read manually from the pressure gauge in the control unit at 20cm depth intervals. The measurements are reduced and interpretated using the computer programs DIL.RED or DILLY4. The program DIL.RED was adapted from the program DILLY written by Crapps and Schmertmann (1981) with plotting sub-routines added at UBC.

The program, DILLY4, is the program developed by Bullock (1983) which incorporates the improved correlations for sands as mentioned in section 2.4. To calculate the friction angle of sand using Schmertmann's method (1982), a load cell has been used at the pushing head to continually measure the penetrating force. The measured thrust together with the two pressure measurements A & B are then reduced and analysed using the program, DILLY4.

Chapter 3

The Research Flat Dilatometer

3.1 Factors Affecting Results from the Dilatometer Test

Marchetti's dilatometer is extremely simple to operate and maintain. However, the simplicity of the equipment and operation are offset by the difficulties in understanding the test and interpretating the results. During the use of the flat dilatometer, several significant aspects affecting the data collection and interpretation have been observed.

3.1.1 Inclination

It is almost impossible to push any instrument into the ground without developing some non-verticality (inclination), especially for deep soundings. This problem is particularly important if the instrument measures lateral stresses, such as the dilatometer. The two readings obtained from the dilatometer test can be significantly influenced by vertical stresses due to non-verticality. The influence can affect the interpretation of soil parameters. Experience gained with cone penetration tests at UBC would suggest that good verticality can usually be maintained in uniform soft deposits for penetration depth up to about 15m. However in less uniform dense deposits, the maximum depth to maintain good verticality is uncertain.

3.1.2 Pore Pressure

The correlated soil parameters from dilatometer test data are based on the three dilatometer index parameters, I_D, K_D and E_D. The parameters I_D and K_D require a knowledge of the in-situ equilibrium water pressure before penetration (u_0). The data analyses assumes the in-situ equilibrium water pressure to be hydrostatic although this may not always be the case. The assumption of hydrostatic water pressure can therefore influence the index parameters especially in soft deposits where P_0 and P_1 can be small relative to the assumed u_0, and subsequently affect the interpretated soil parameters.

The existing test procedures assumes that the membrane inflation is performed immediately after penetration is stopped at each 20cm intervals. The rate of pressure applied is set so that the test (expansion) is completed within 15 to 30 seconds. However, it is not always possible to maintain a constant time of testing. This is because the rate of expansion is generally constant but P_0 and P_1 may vary considerably. Thus, the time needed to reach P_0 and P_1 will vary. Also, the time between stopping the penetration and starting the expansion is not always constant.

Results from piezometer cone penetration testing have indicated that penetration into saturated soft cohesive and/or silty deposits can generate very large pore pressures. Dissipation of these large excess pore pressures takes places immediately after the penetration is stopped. As the dilatometer records total stress measurements (A and B), these high pore pressures around the dilatometer will have a significant influence on the test results.

McPherson (1985) has shown that if the time between stopping penetration and starting the expansion test in a saturated soft cohesive deposits is varied, the dilatometer index parameters will also vary. McPherson (1985) showed that as the excess pore pressure decreased, the measured values of P_0 and P_1 also decreased, and this caused an increase in the index parameters I_D and E_D, but a decrease in K_D. The decrease in K_D is due to the decrease in P_0 as a direct result of the decreasing pore pressure around the dilatometer membrane. The increase in I_D and E_D is due to the fact that the drop in P_0 is greater than the drop in P_1.

Campanella and Robertson (1983) anticipated that in many low permeability cohesive deposits, variations in the existing testing procedure will have little influence in the DMT results. However, when the test is performed in relatively high permeability deposits such as silt or silty fine sands where significant high pore pressures can still be generated during penetrating, the existing testing procedure may cause inconsistent results due to rapid pore pressure dissipation.

3.1.3 Modulus of Elasticity

The expression for the dilatometer modulus, E_D, derived by Marchetti (1975 & 1980) was based on the theory of elasticity. The soil adjacent to the dilatometer membrane is assumed to be an elastic material, but the validity of this assumption is uncertain. This uncertainity is less important provided that the parameter, E_D, is only used as a parameter for empirical correlaton purposes. Though Marchetti (1975) derived the expression of E_D and considered the dilatometer as a fundamental in-situ testing tool with sound theoretical background, he has never suggested to derive the elastic deformation modulus of a soil (E) based on the value of E_D. Some users of the dilatometer have suggested that the soil may behave in an elastic manner during the dilatometer test and thus believe that the E_D value could give a reasonable estimate of the soil modulus of Elasticity (E) which engineers often require for design.

The membrane of the dilatometer is located in the center of one side of the flat plate at a short distance behind the tip. Observations and cavity expansion theories have indicated there is some total stress relief behind the tip of most penetration devices, since the total stresses required to open the cavity at the tip are larger than the stresses required to maintain the cavity. In the case of a penetration cone, the theory of spherical cavity expansion relates approximately to the tip and theory of cylinderical cavity expansion to the shaft (Gillespie, 1981). It seems that a similar analogy exists for the penetration of the dilatometer, and therefore the soil element in contact with the membrane may have undergone some stress relief (ie. unloading) before membrane expansion.

Experience with pressuremeter testing shows that elastic soil modulus can be obtained by performing an unload-reload cycle during a pressuremeter expansion test. According to the theory of plasticity, if the elastic limit of the soil during the unloading phase is not exceeded, the soil behaves elastically during the unloading-reloading phase until the reloading stress reaches the yield surface that occured at the previous maximum stress level before unloading.

The inflation of a flat dilatometer membrane after penetration may represent a reloading of the soil element in contact with the membrane. It is therefore expected that the soil would deform as an elastic medium during the test. However, Campanella and Robertson (1983) anticipated that the expansion of 1mm at the center of the membrane may exceed the stress level at the previous unloading, and hence, the assumption of elasticity may not hold true for the entire membrane inflation, resulting in a modulus softer than the elastic modulus.

3.2 Development of the UBC Research Dilatometer

In order to obtain a more fundamental understanding of the soil behaviour (ie. the soil deformation and pore pressure characteristics) during penetration and membrane expansion of the flat dilatometer test; and to study how the factors described in the preceeding section affect the DMT results, McPherson (1985) designed a research dilatometer at the University of British Columbia (UBC). The UBC research dilatometer includes the following features:

1. a pore pressure transducer in the center of the membrane to measure the pore pressure during penetration of the dilatometer and expansion of the membrane,
2. a pressure transducer inside the blade to measure the applied gas pressure,
3. a strain gauge deflector arm attached to the center of the membrane to continuously measure deflection of the membrane during inflation,
4. a slope sensor to measure the verticality of the blade during penetration, and
5. a load cell behind the blade to continuously measure the pushing force during penetration.

A load cell behind the blade was included because a direct measure of pushing force would allow a direct calculation of ϕ' using the Durngunoglo & Mitchell bearing capacity theory (1975) as proposed by Schmertmann (1982). While it is difficult to measure pushing force directly behind Marchetti's standard dilatometer, Schmertmann suggested measuring the pushing force above ground surface and to assume the friction along the penetration rods behind the friction reducer to be negligible. For this study, the pushing force was also measured at the ground surface using an additional load cell.

The purpose of developing the research dilatometer was not to replace the use of Marchetti's standard dilatometer but to provide additional information and to provide a better understanding of flat dilatometer testing. In addition to all the electronic measuring devices, Marchetti's measuring system was retained in the UBC research dilatometer so that direct comparison could be made between the research data and the standard dilatometer data.

The dimensions and shape of the UBC research dilatometer are identical to Marchetti's ,except that the flat plate of the research model has a longer shoulder and stem so that all the added electronic features could be incorporated (figure 3.1). Figures 3.2, 3.3 and 3.4 illustrated the design of the research dilatometer. Details of the design are given by McPherson (1985).

When the research dilatometer was first designed, it was intended that the pore pressure transducer mounted flush on the steel membrane measure only the pore pressure outside

Figure 3.1 UBC Research Dilatometer

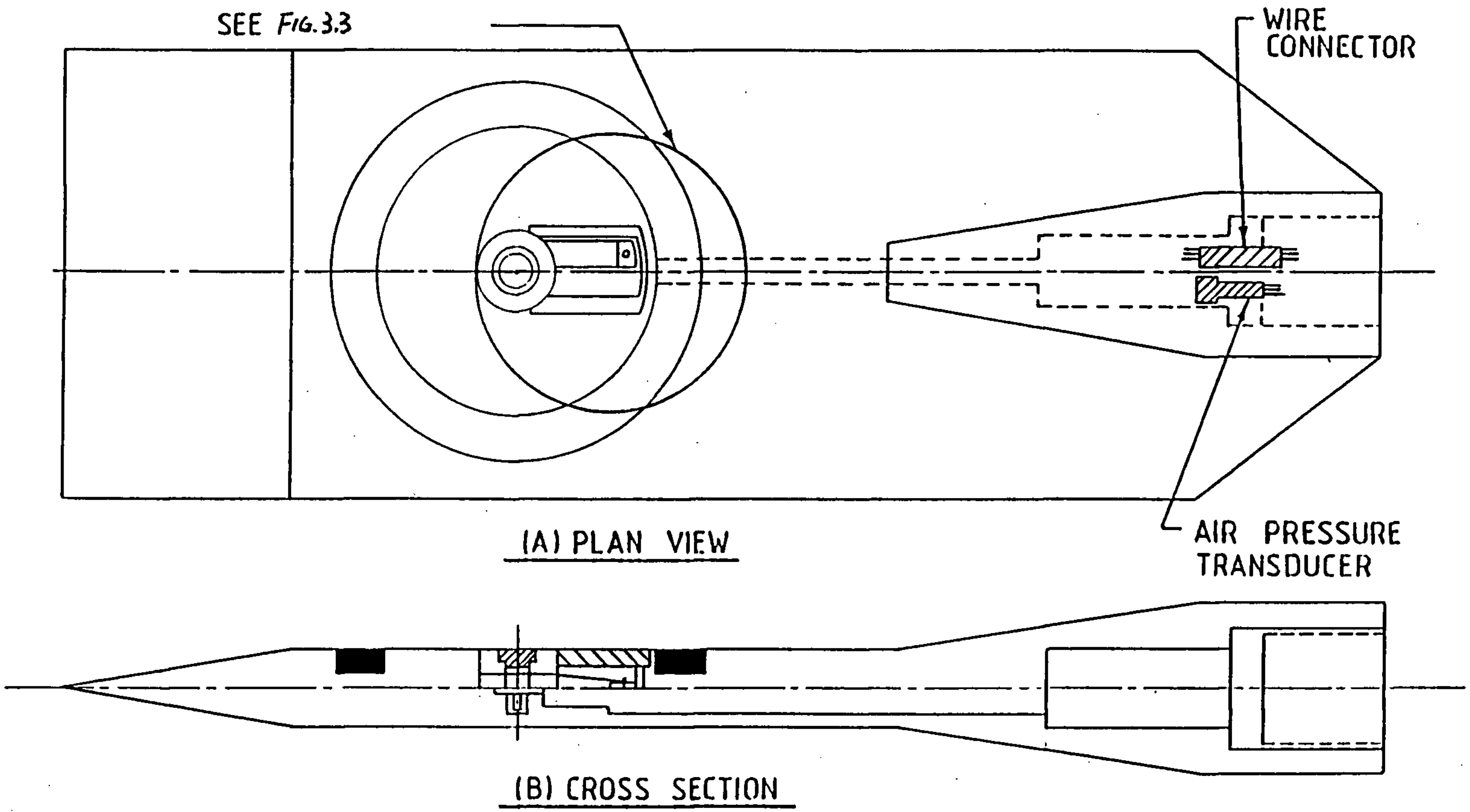


Figure 3.2 Design Detail of Research Dilatometer (Adapted from McPherson, 1985)

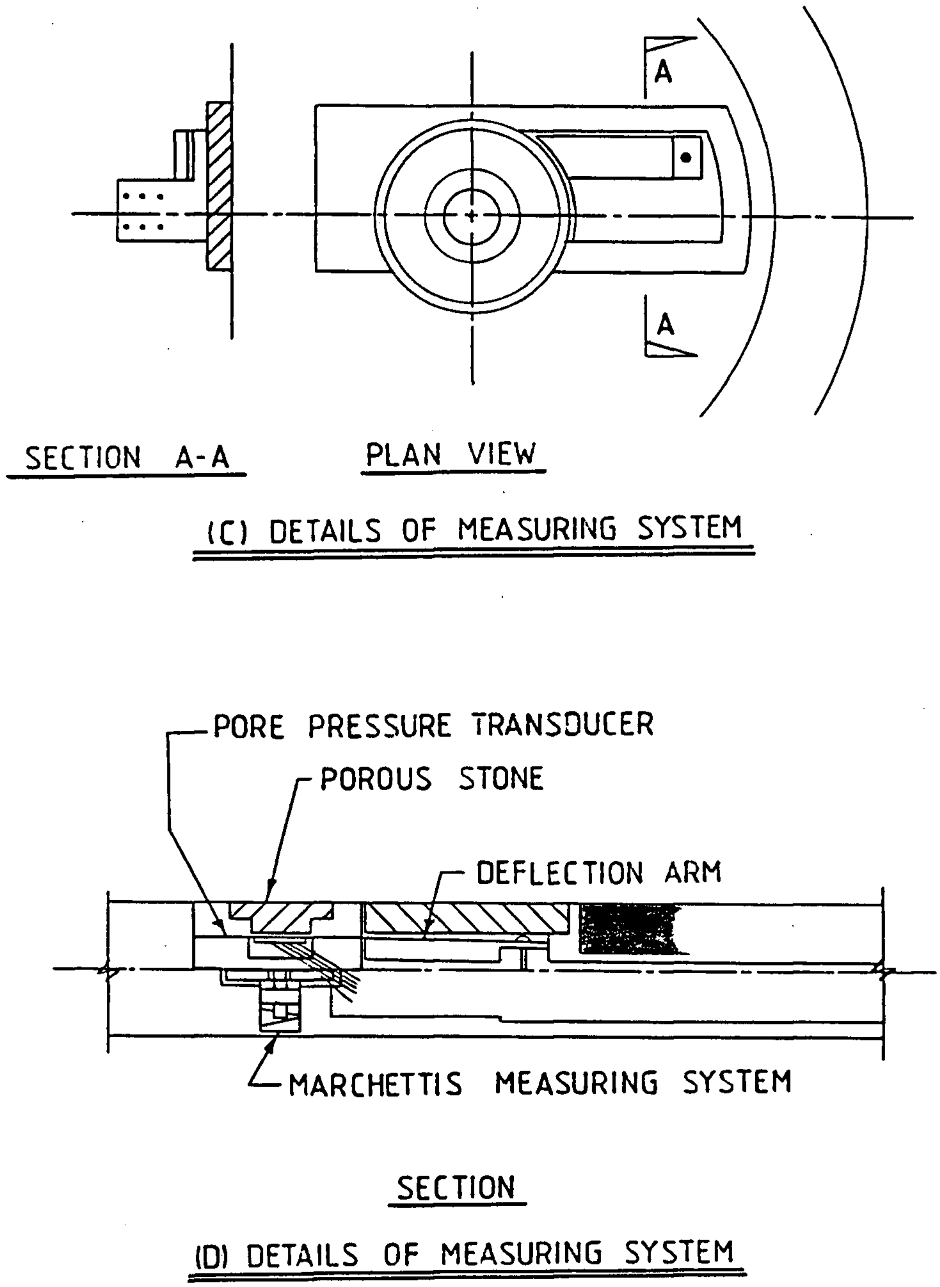


Figure 3.3 Design Detail of Research Dilatometer (Adapted from McPherson, 1985)

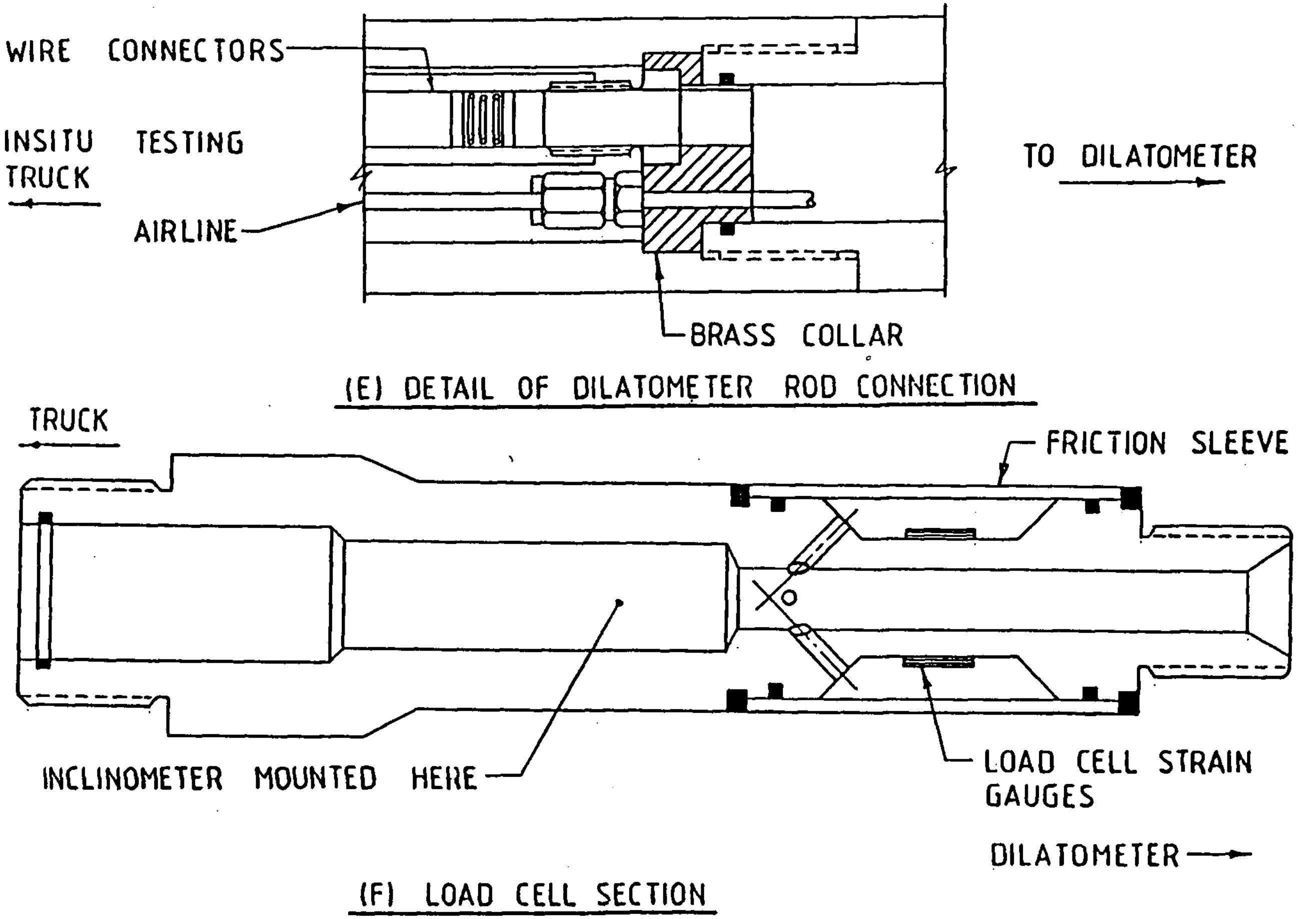


Figure 3.4 Design Detail of Research Dilatometer
(Adapted from McPherson, 1985)

the membrane during penetration and expansion, and the pressure transducer inside the blade measure the applied gas pressure during the expansion. The effective pressure on the membrane could then be calculated by substracting the pore pressure from the applied gas measurement. However, when the instrument was made, it was impossible to seal the pore pressure transducer from the applied gas inside the blade. The "pore pressure" transducer, therefore, measures the differential pressure between the inside of the blade and the external pore pressure. Hence, the "pore pressure" transducer measures pore pressures outside the membrane during penetration (inside of membrane vented to atmospheric pressure) and effective pressures on the membrane during expansion (air pressures minus pore pressures). Pore pressures on the membrane during expansion are therefore calculated by substracting the effective pressure measurements from the applied gas pressure measurements.

3.3 Test Procedures and Data Acquistion

The research dilatometer was pushed into the ground using the UBC in-situ testing research truck similar to the standard dilatometer. The power supply and electronic systems developed for applied cone research at UBC was used for the dilatometer research testing. A complete description of the power supply and electronic system is given by Campanella and Robertson (1981).

The testing procedure for using the UBC research dilatometer was identical to that used for Marchetti's standard DMT. The two main DMT measurements, A and B, were recorded manually from the gauge on the control box. In addition, two chart recorders were used to record the data from the electronic devices. The blade inclination, pore water pressure, and the pushing forces measured behind the blade and at the ground surface during penetration were recorded on a strip chart recorder. The strip chart was controlled by a switch on the pushing head and a depth encoder so that the chart advance only when the push-rods were being pushed. The strip chart recorder, however, could also be easily switched to time control instead of depth control by simply pressing a time-control button on the recorder. Therefore, when it was intended to study the effect of pore pressure dissipations during a stop in penetration, the strip chart was continuously advance to record pore pressures against time.

The other chart recorder used was a X-Y-Y recorder. The X-Y-Y recorder was used to record the measured air pressure and effective pressure (ie. air pressure minus pore pressure) versus deflection at the center of the membrane during the entire dilatometer expansion and deflation phases.

3.4 Data Reduction

The recorded data; applied air pressure Vs membrane deflection and effective pressure Vs membrane deflection, during the expansion test were corrected for membrane stiffness in order to determine the corrected expansion curves; total stresses Vs membrane deflection and effective stresses Vs membrane deflection. The deformation curve of the membrane (ie. membrane stiffness) in free air was also recorded using the X-Y-Y recorder when the correction values, ΔA and ΔB were measured.

The corrected expansion curves obtained using the UBC research dilatometer provide a more complete picture of the dilatometer test. In addition to obtaining the total stresses, P_0 & P_1 at the start and at the end of the expansion, the total stress at the closure of the membrane (P_c) was also obtained from the following expression:

$$P_c = C + \Delta A \qquad (3.1)$$

where C is the applied total pressure measured at the closure of the membrane.

The corresponding effective soil stresses P_0', P_1' and P_c' were obtained using the following expressions:

$$P_0' = A' + \Delta A \qquad (3.2)$$

$$P_1' = B' - \Delta B \qquad (3.3)$$

$$P_c' = C' + \Delta A \qquad (3.4)$$

where A', B', C' are the effective pressure measurements (applied pressure inside minus pore pressure outside the membrane) when the membrane is at lift off, 1mm deflection and at closure, respectively.

Pore pressures during the test were calculated by substracting the effective stresses from the total stresses. The pore pressures at different stages of the test are:

$$u_0 = P_0 - P_0' \quad (= A - A') \qquad (3.5)$$

$$u_1 = P_1 - P_1' \quad (= B - B') \qquad (3.6)$$

$$u_c = P_c - P_c' \quad (= C - C') \qquad (3.7)$$

where u_0, u_1 and u_c are the pore pressures when the membrane is at lift off, at 1mm deflection and at closure, respectively.

Although the UBC research dilatometer provided additional data, only the two basic readings, A and B, and the penetration push force were used in the data reduction and interpretation using the computer programs, DIL.RED or DILLY4, as described in Section 2.6.

The calculation of friction angle of sand in DILLY4 uses Schmertmann's (1982) method which is based on the penetration force measured at the ground surface, with the assumption that friction forces along the penetration rods behind the friction reducer are negligible. In order to use the penetration force measured immediately behind the blade obtained with the UBC research dilatometer to directly calculate the friction angle of sand, the input data of the program DILLY4 was slightly modified to suit this purpose (Appendix I).

Chapter 4

Research Dilatometer Testing in Sands

4.1 Scope

The field programme using the research dilatometer in sands was conducted at the McDonald's Farm research site on Sea Island, Richmond. A detailed study consisting of various in-situ testings and laboratory testings has been carried out at the site as an on-going UBC research effort. The tests used for comparison in this study were:

a) cone penetration test (CPT),

b) down-hole seismic CPT,

c) self-boring pressuremeter test (SBPMT),

d) full displacement presuremeter test (FDMPT) and

e) laboratory drained triaxial compression test.

As only one sand site was tested for this study, three soundings, MRD-1, MRD-2 & MRD-3 were made using the research dilatometer to check the repeability of the results.

4.2 Site Geology and Description

McDonald's Farm is an abandoned farm at the Northern edge of Sea Island in the municipality of Richmond (figure 4.1). Sea Island is located between the North Arm and Middle

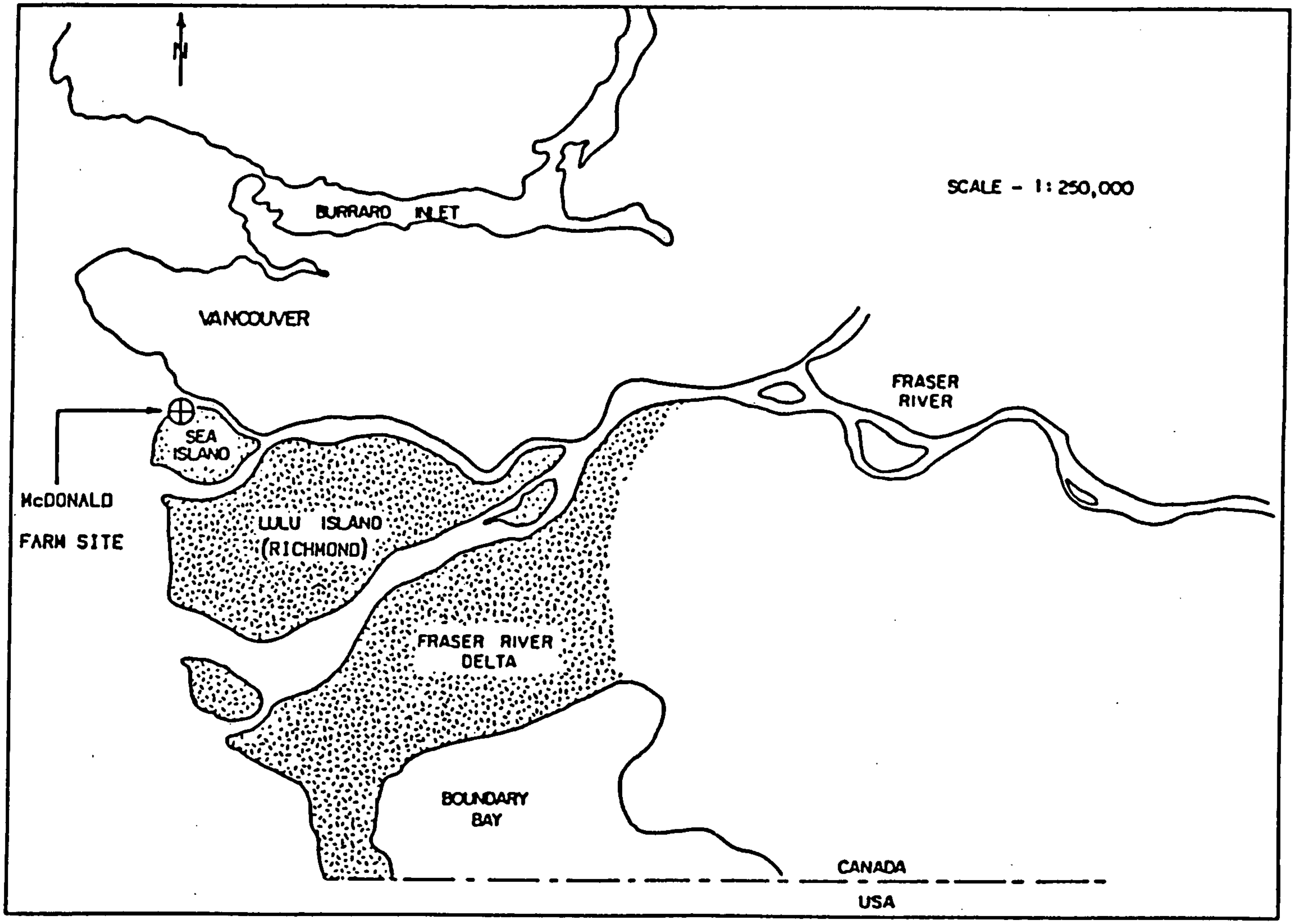


Figure 4.1 General Location of McDonald's Farm Site

Arm of the Fraser River Delta extending westwards into the Strait of Georgia. The Island is contained by a system of dykes to protect against flooding from the river. The site is approximately level with the general ground elevation at 1.6m (Geodetic Datum), and is covered mainly with weeds. The groundwater table underlying the site is about 1.5m below the ground surface, and varies with the tidal fluctuation in the adjacent Fraser River.

Sea Island and its adjacent islands in the Fraser River Delta are less than about 8000 years old (Blunden, 1975). Some 8000 to 10,000 years ago, after the ice sheets of the Fraser Glaciation had retreated, the Fraser River began to discharge into the Strait of Georgia. Sand, silt and clay brought down by the river were accumulated along the shore line to create new land surfaces as the present Fraser River Delta.

A typical cone penetration test profile is presented in figure 4.2 and shows that the general soil profile consists of:

0 - 2m	soft organic silty clay
2 - 13m	medium to coarse sand; variable density
13 - 15m	fine sand, some silt (transition zone)
> 15m	soft normally consolidated clayey silt.

Blunden (1975) indicated that the clay silt deposit extends to at least 150m depth in this part of Sea Island.

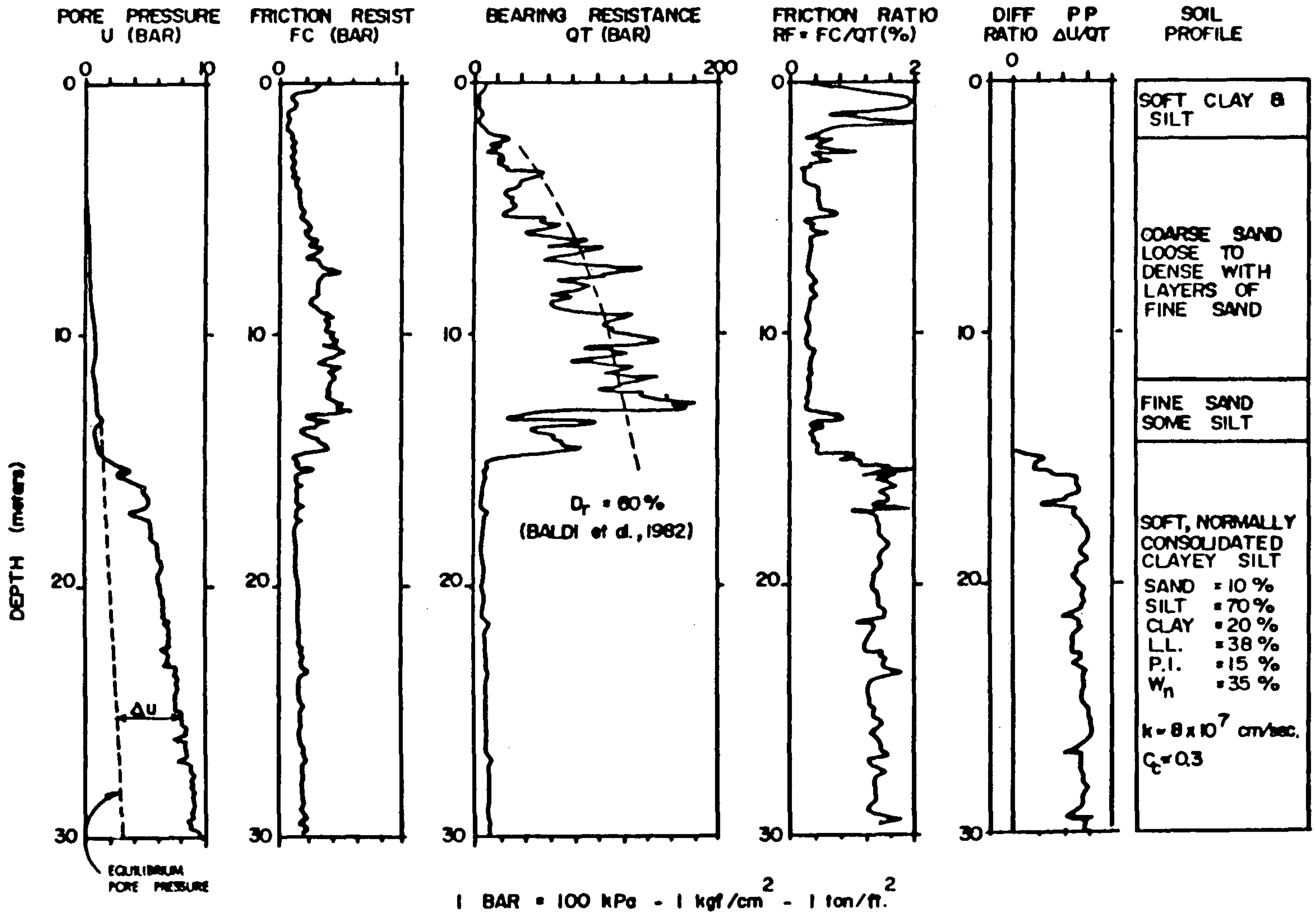


Figure 4.2 Typical CPT Profile at McDonald's Farm Site

The dilatometer test provides a similar soil profile of the site, except that the clay silt deposit below 15m is interpreted as clay. The DMT results of sounding MRD-1 are presented in figures 4.3 & 4.4. The results of soundings MRD-2 & MRD-3 are included in Appendix II. The three soundings show a very high repeatability of the DMT results.

This chapter will discuss only the results obtained in the sand deposits from 2 - 13m depth. Test results obtained in the clayey silt deposit from 15 - 30m will be presented in Chapter 5.

4.3 Soil Deformation Characteristics

With the use of the research dilatometer, deformation curves (stresses Vs membrane deflection) for dilatometer tests in the sand at the McDonald's Farm site were obtained. Typical results from the research dilatometer tests in dense and loose sands at McDonald's Farm are illustrated in figures 4.5 & 4.6 respectively. For comparison, figures 4.7 & 4.8 (Hughes & Robertson, 1984) show typical results of self-boring and full displacement pressuremeter tests in the sands at the same site. The DMT curves are very similar in shape to the pressure expansion curves obtained from self-boring and push-in (full displacement) pressuremeter probes.

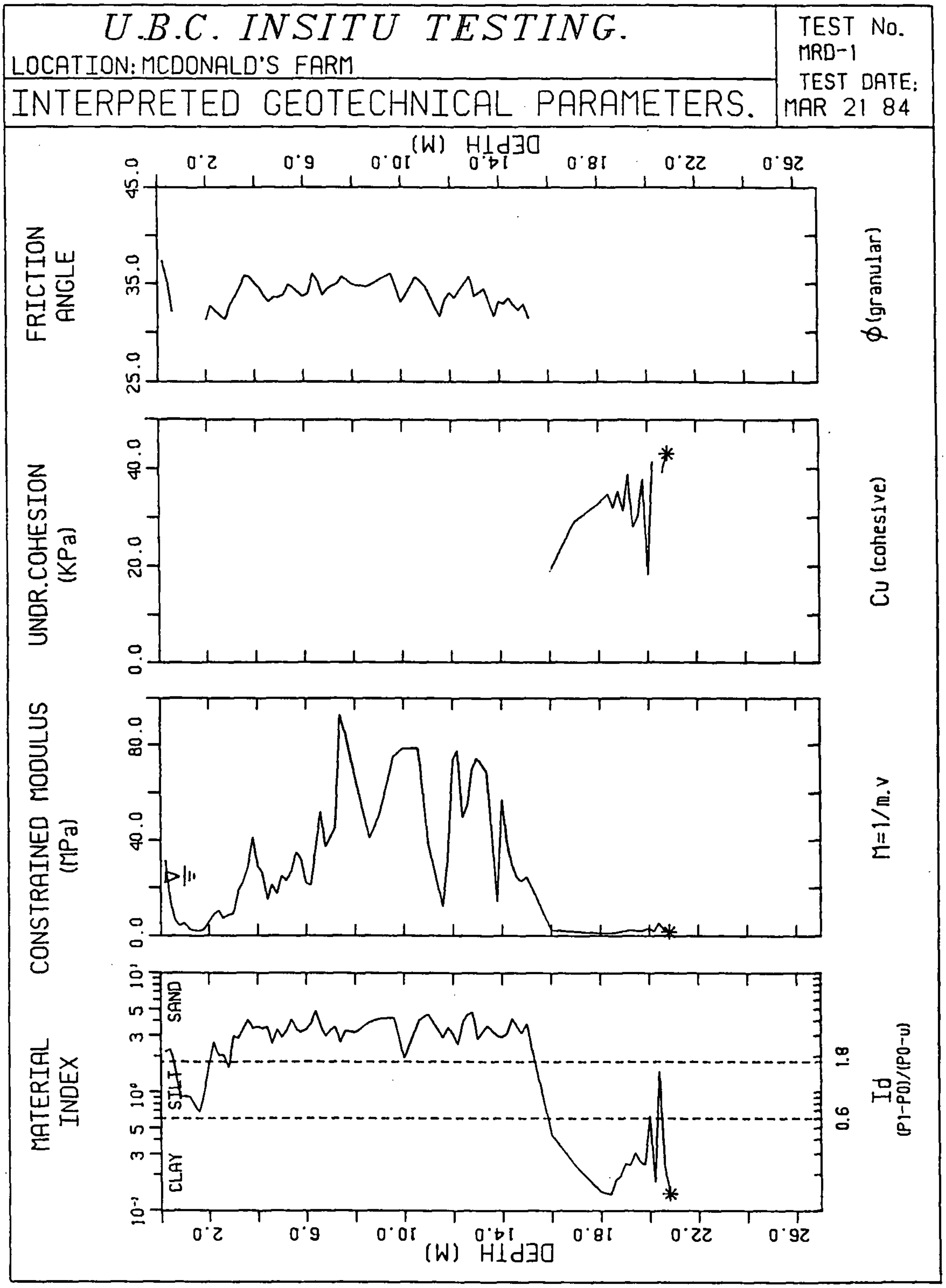


Figure 4.3 DMT Profile at McDonald's Farm
- Interpreted Geotechnical Parameters
(Sounding MRD-1, DIL.RED)

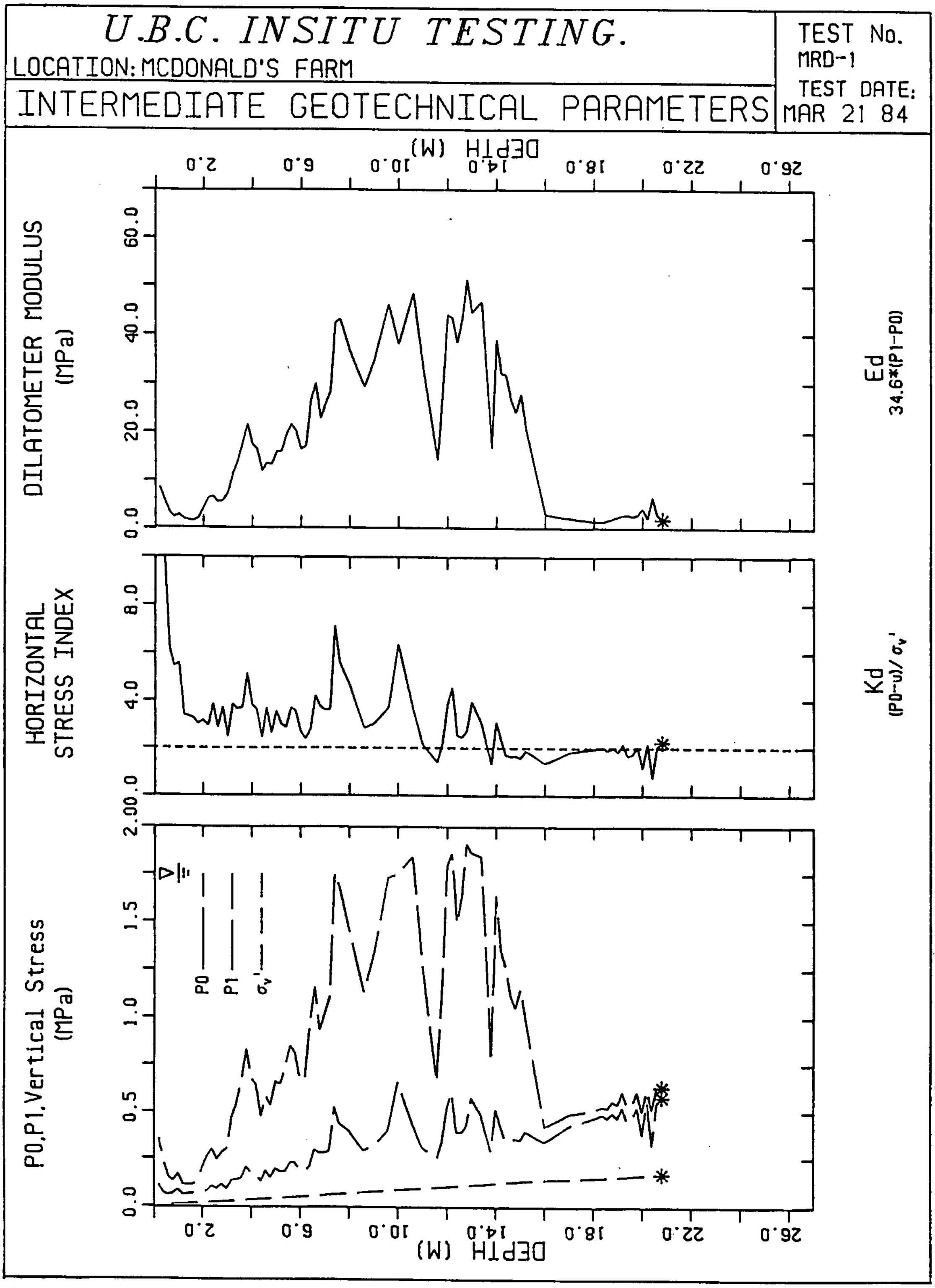


Figure 4.4 DMT Profile at McDonald's Farm - Intermediate Geotechnical Parameters (Sounding MRD-1, DIL.RED)

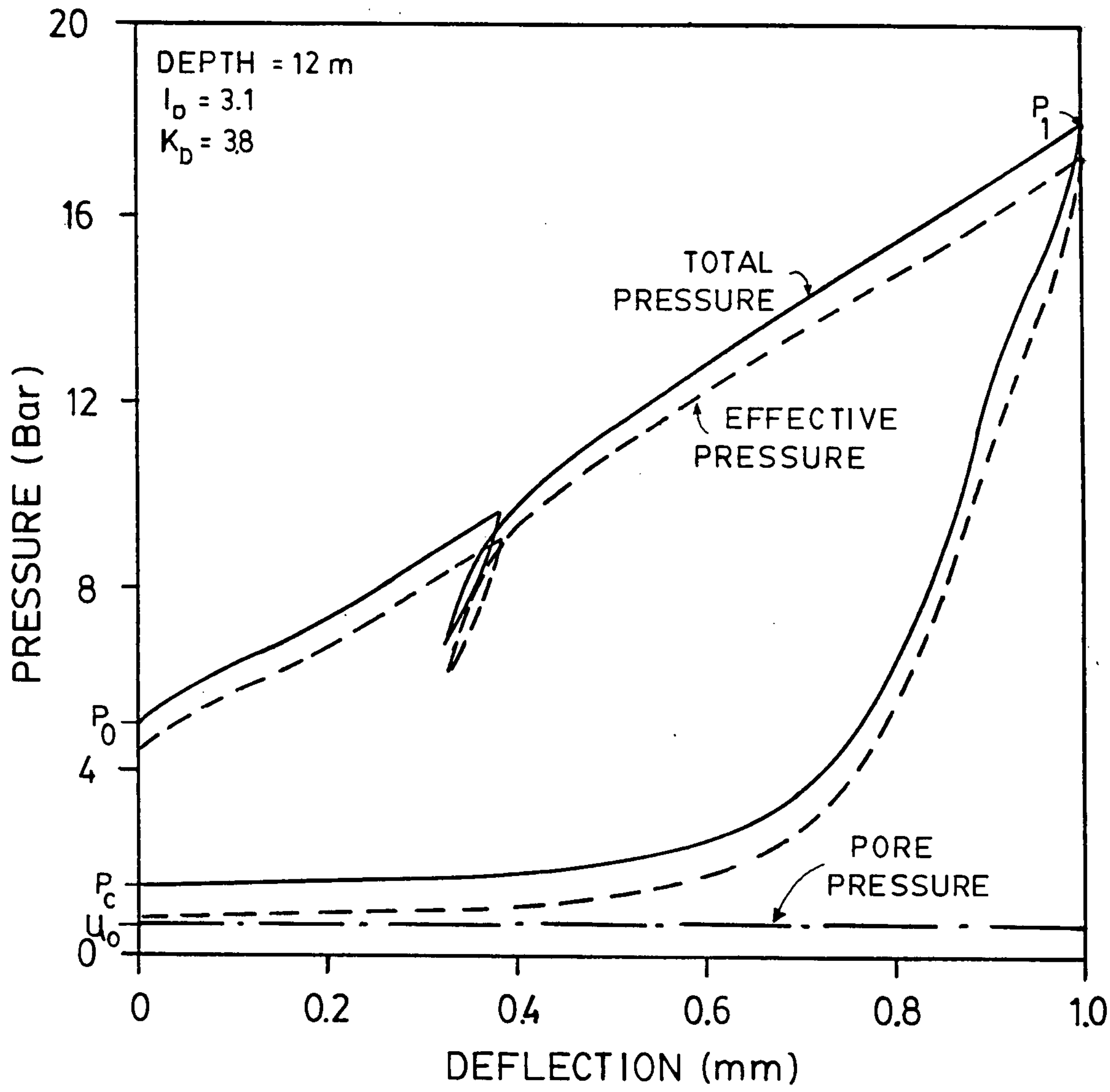


Figure 4.5 Typical Result of Research DMT at McDonald's Farm Site - Dense Sand

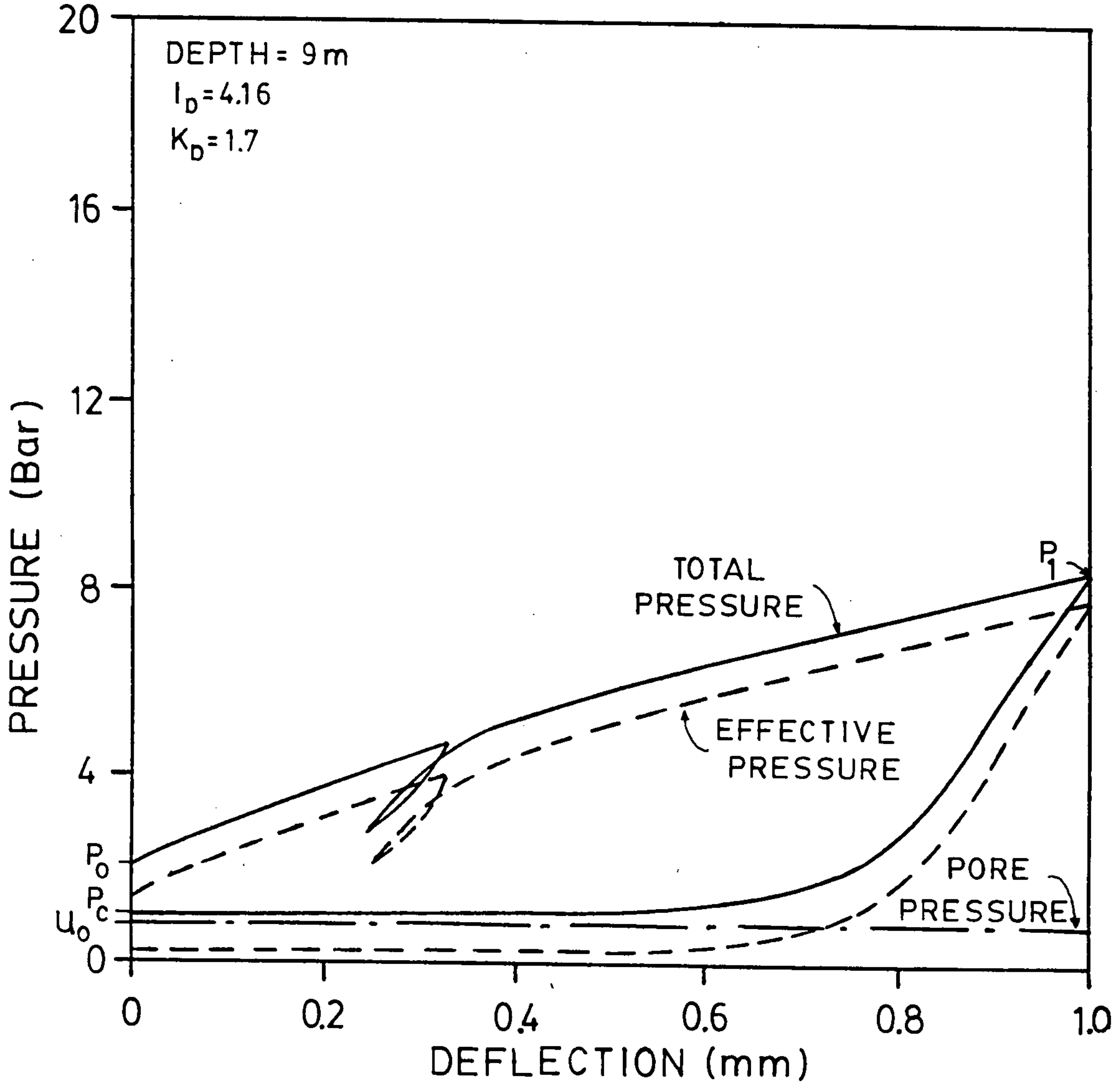


Figure 4.6 Typical Result of Research DMT at McDonald's Farm - Loose Sand

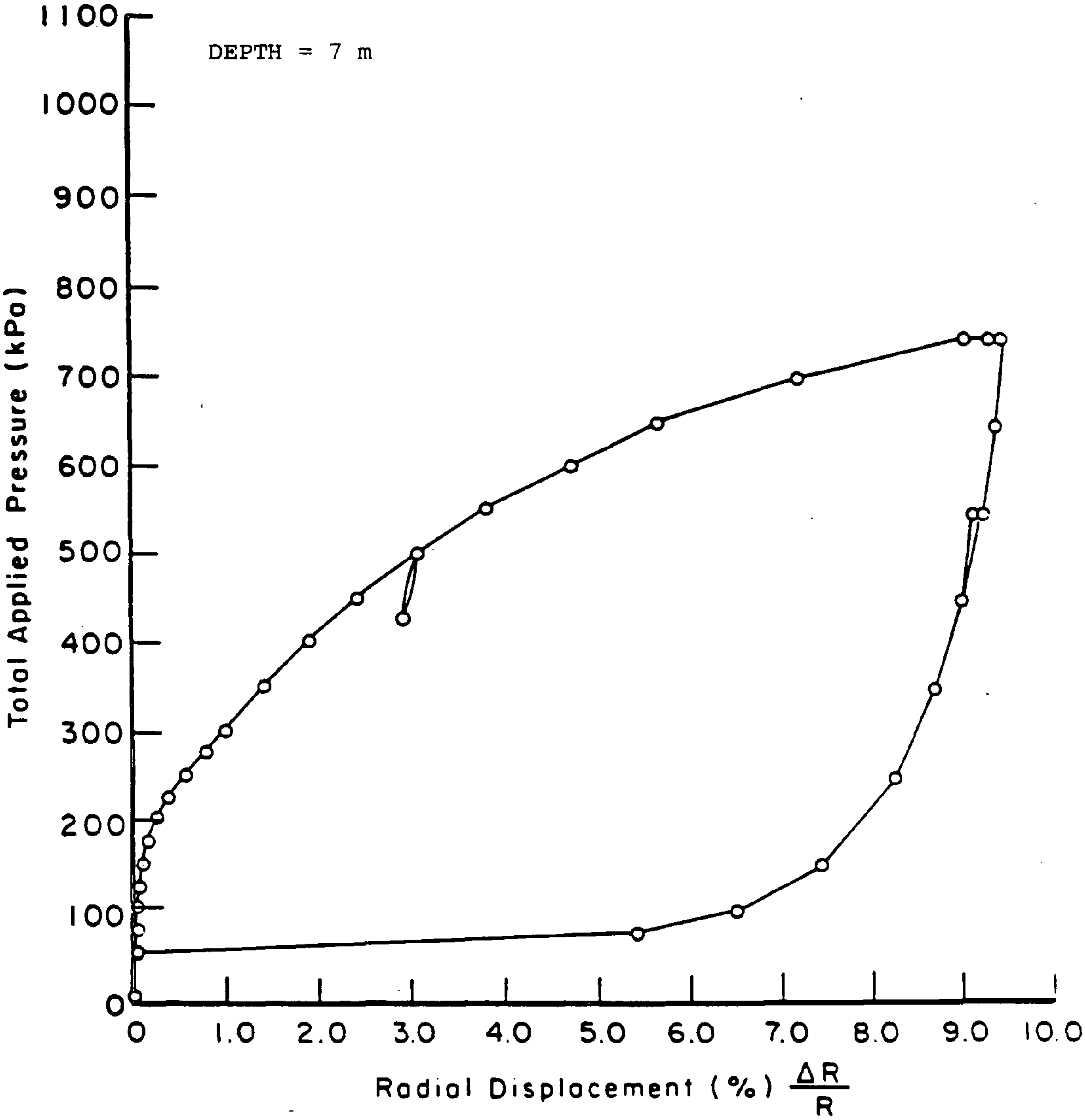


Figure 4.7 Typical Result of Self-bored Pressuremeter Test at McDonald's Farm Site (Adapted from Hughes and Robertson, 1984)

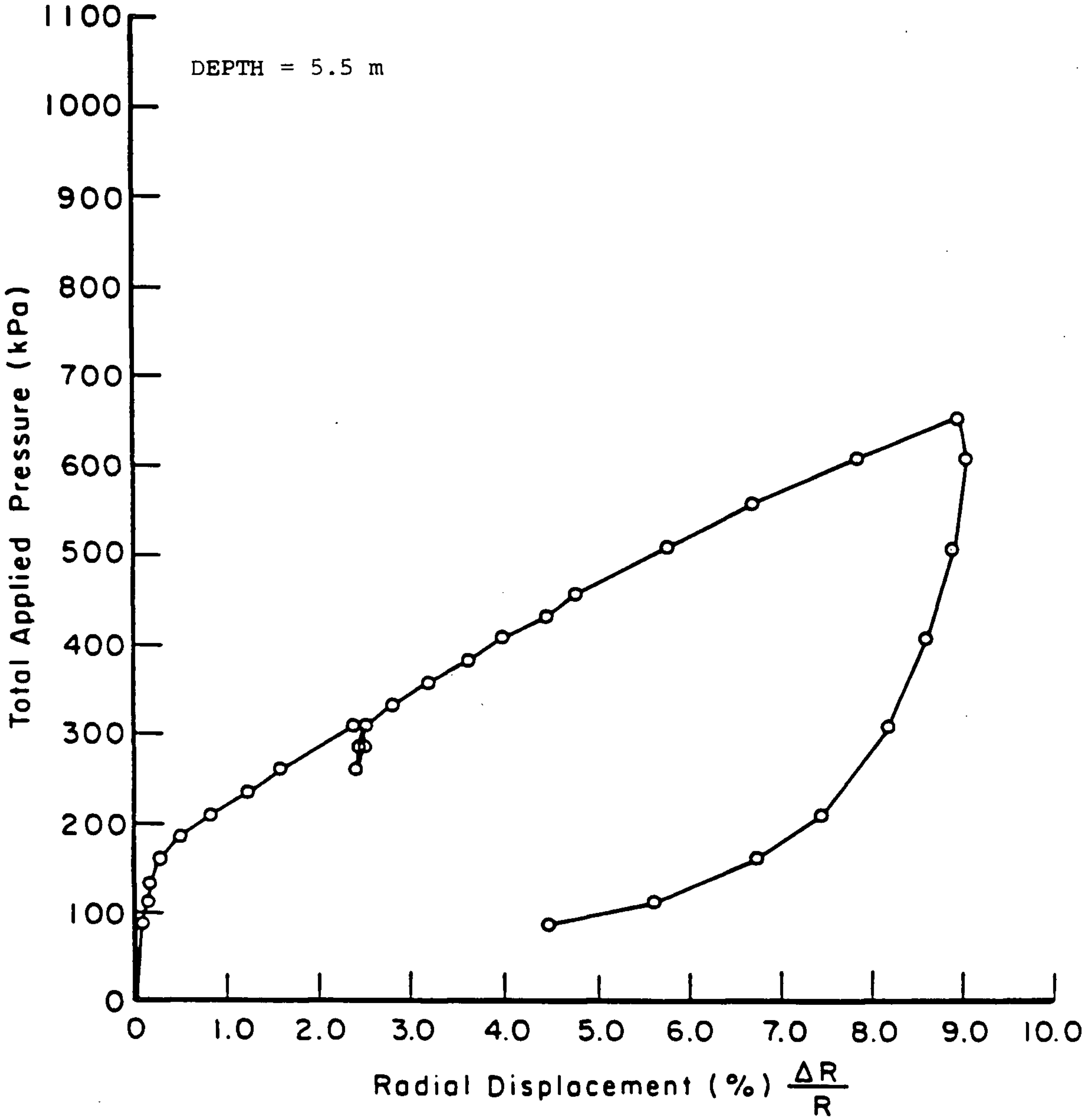


Figure 4.8 Typical Result of Full-displacement Pressuremeter Test at McDonald's Farm Site (Adapted from Hughes and Robertson, 1984)

For the research dilatometer testing in sand at McDonald's Farm, there was almost no excess pore pressures measured during both the penetration and expansion phases of the test. The measured pore pressures were approximately equal to the equilibrium pore pressures. The shapes of the effective stress curve and the total stress curve are identical and the values of the total stress curve are larger by the amount approximately equal to the in-situ water pressure, u_0 (figures 4.5 & 4.6).

The measured DMT lift off pressures, P_0, are higher than the expected in-situ total horizontal stresses, σ_h (where $\sigma_h = K_0 \cdot \sigma_v' + u_0$ assuming $K_0 \doteq 0.5$). Unloaded-reload cycles were performed during the expansion phase of some tests. The slopes of the unload-reload cycles were considerably steeper than the slopes of the expansion phase from P_0 to P_1. After the expansion, the membrane was deflated and returned to its closed position at a pressure approximately equal to the in-situ pore pressure, u_0. All these deformation characteristics are observed in pressuremeter testings in sand. The total and effective pressure measurements at lift off, 1mm deflection and at closure of the expansion curves are summarized and presented in Appendix III.

The slope of the straight expansion phase at any stress level from P_0 to P_1 is much less than the slope of the unload and reload cycles. This observation indicates that the soil during the dilatometer expansion test is no longer elastic after the penetration. As discussed in section 3.1, the soil in contact with the membrane has experienced stress relief due to the penetration process. It is therefore expected that the soil would deform in an elastic manner, at least to a certain extent, when the soil is reloaded during the expansion. However, the data presented in figures 4.5 and 4.6 clearly shows that the elastic response of the soil is exceeded after a very small expansion (less than 1 micronmeter). For the majority of the DMT expansion, the soil is deformed plastically; except during the small unload-reload cycles, where the soil responds elastically.

4.4 Modulus

The dilatometer modulus, E_D is defined as:

$$E_D = 38.2\ (P_1 - P_0) = E/(1-\mu^2) \qquad (4.1)$$

When deriving the above expression, Marchetti (1975 & 1980) assumed that the soil is elastic; the membrane is rigid so that the soil is uniformly loaded by the membrane without any soil pressure redistribution; and no deformation occurs external to the loaded area during the expansion. Though Marchetti used E_D only as a correlation parameter, it seems to many users that the E_D expression can give a direct estimate of a soil's deformation modulus, E, provided that

Marchetti's assumptions are valid to a certain extent and a reasonable value of the Poisson's ratio, μ, can be assumed. Equation 4.1 can be rewritten as:

$$E = (1-\mu^2)E_D \qquad (4.2)$$

For sands, Poisson ratio usually varies from 0.2 to 0.4. As a result, the calculated E ranges from 0.84 E_D to 0.96 E_D.

From the previous discussion in Section 4.3, it appears the assumption that the soil is elastic during the DMT expansion is not valid. However, Campanella & Robertson (1983) observed that the dilatometer moduli E_D obtained from tests in sands was close to the Young's moduli at approximately 25% of the failure load, E_{25}. Jamiolkowski et al (1985) also reported similar findings in normally consolidated sands from recent calibration chamber test by ENEL, Italy.

The moduli obtained from E_D appears to provide reasonable moduli for design in sands for the following reasons:

1. The stress level during the DMT expansion is considerably higher than the in-situ stresses, therefore the soil is somewhat stiffer, and
2. the strain level during the 1mm expansion from P_0 to P_1 is large and the soil deforms plastically, therefore the soil is somewhat softer.

These two factors, when combined, appear to produce reasonable Young's moduli for most design purposes in sand.

The shear modulus, G, is defined as:

$$G = 0.5*E/(1+\mu) \qquad (4.3)$$

Substituting equation 4,2 into equation 4.3, the shear modulus can be defined as:

$$G = 0.5*E_D*(1-\mu^2)/(1+\mu) \qquad (4.4)$$

Figure 4.9 presents the calculated shear modulus profiles for the sand at McDonald's Farm assuming μ= 0.2 and μ= 0.3 and using equation 4.4 (G ranges from $0.35E_D$ to $0.4E_D$).

The soil deformation curves (stresses Vs membrane deflection) for the dilatometer tests are similar in both characteristic and shape to the expansion curves obtained from the pressuremeter tests. Hughes (1982) and Wroth(1982) showed that the "elastic" shear modulus of a soil can be measured from an unload-reload cycle of a pressuremeter expansion curve. If the soil is perfectly elastic in unloading, then the unloading - reloading cycle will have a slope equal to 2G. The shear modulus of sand deposits obtained in this manner appears to be insensitive to the method installation of the pressuremeter probe. (Hughes and Robertson, 1984).

It would appear that the shear modulus of sand at the McDonald's Farm site can also be estimated from the unloading - reloading cycles of the pressure expansion

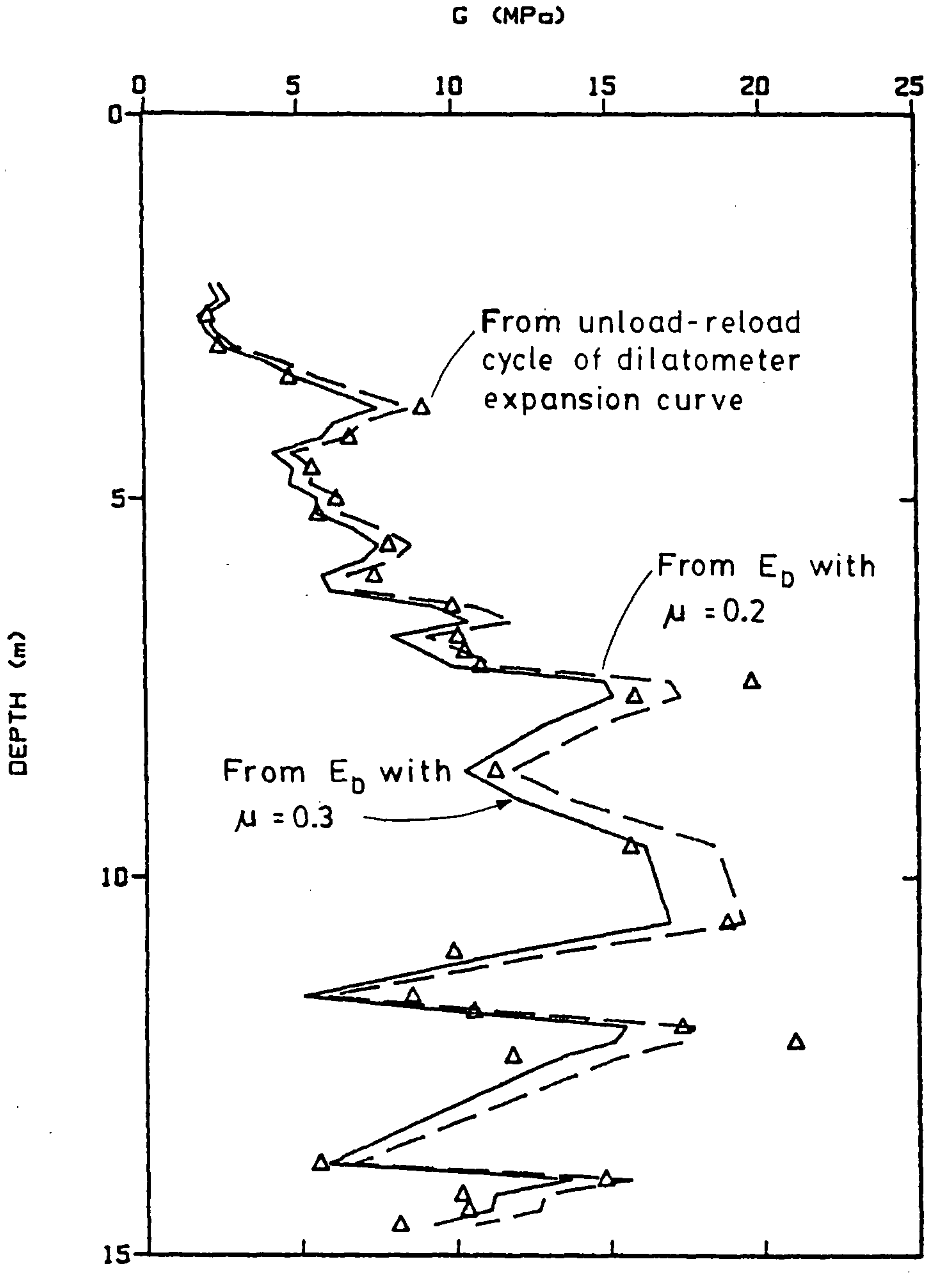


Figure 4.9 Comparison of Shear Moduli from E_D and from Unload - Reload Cycle of Dilatometer Expansion Curve (Sounding MRD-1)

curves obtained from the research dilatometer.

Results of pressuremeter tests are analysed using the theory of cylinderical cavity expansion. The expansion of a pressuremeter probe simulates a plain strain cylindrical cavity expansion. The kind of expansion caused by the dilatometer membrane is difficult to exactly model. However, the DMT expansion could be considered to be somewhat between a flat cavity expansion and a spherical cavity expansion. It is therefore assumed that the shear modulus of a soil can also be estimated from the gradient of the DMT unload - reload cycles obtained from the research dilatometer.

Without knowing the exact kind of expansion that the dilatometer membrane simulates, it is impossible to calculate the cavity strain level at the 1mm deflection in the DMT. However, to simplify this problem, a cavity strain of 14%, which is equal to 1mm deflection divided by half of the blade thickness (7mm), is assumed. The unload-reload shear moduli, G_{ur}, of the sand at the McDonald's Farm site, calculated from the slopes of the DMT unload-reload cycles are also presented in figure 4.9. The shear modulus is assumed to equal one-half the slope of the unload-reload cycles.

As shown in figure 4.9, the elastic shear moduli calculated from the unload - reload cycles are almost the same as the shear moduli calculated from the dilatometer modulus, E_D.

The profile of dynamic shear moduli of sand (G_{max}) at McDonald's Farm has been determined using a seismic cone (Rice, 1984). Figure 4.10 shows that the shear moduli, G, determined from unload-reload cycles and from E_D are about one-fifth of the dynamic shear moduli, G_{max}. Similar results were found for shear moduli obtained from self-bored and full-displacement pressuremeter results, corrected for stress level (Hughes and Robertson, 1984).

When examining the dilatometer expansion curves, there existed a consistant relationship between the slope of the unload-reload cycle and the slope of the straight expansion phase (figure 4.11). It is expected that elastic shear moduli of sand can be estimated using this relationship when dilatometer tests are performed using Marchetti's standard instrument. Moreover, with the shear moduli obtained from this relationship, the shear moduli calculated from the E_D values can be compared.

Figure 4.11 shows that the slope of the unload-reload cycle is generally about 3.6 times larger than the slope of the expansion from P_0 to P_1. Similar results have been observed when comparing the slope of unload-reload cycles and expansion curves for pre-bored pressuremeter test in

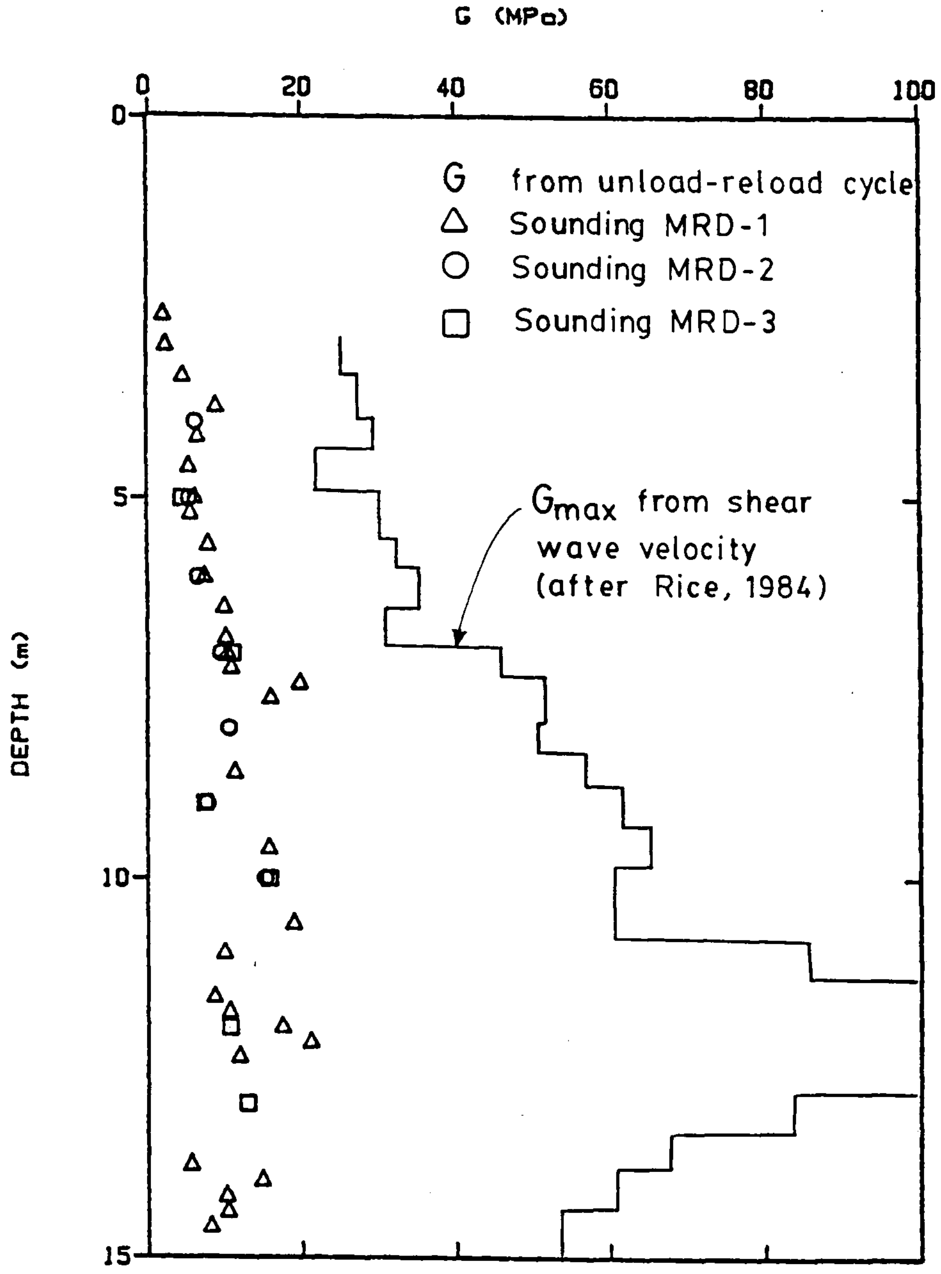


Figure 4.10 Comparison of Shear Moduli from Unload - Reload Cycle of Dilatometer Expansion Curve and from Downhole Seismic Shear Wave Velocity

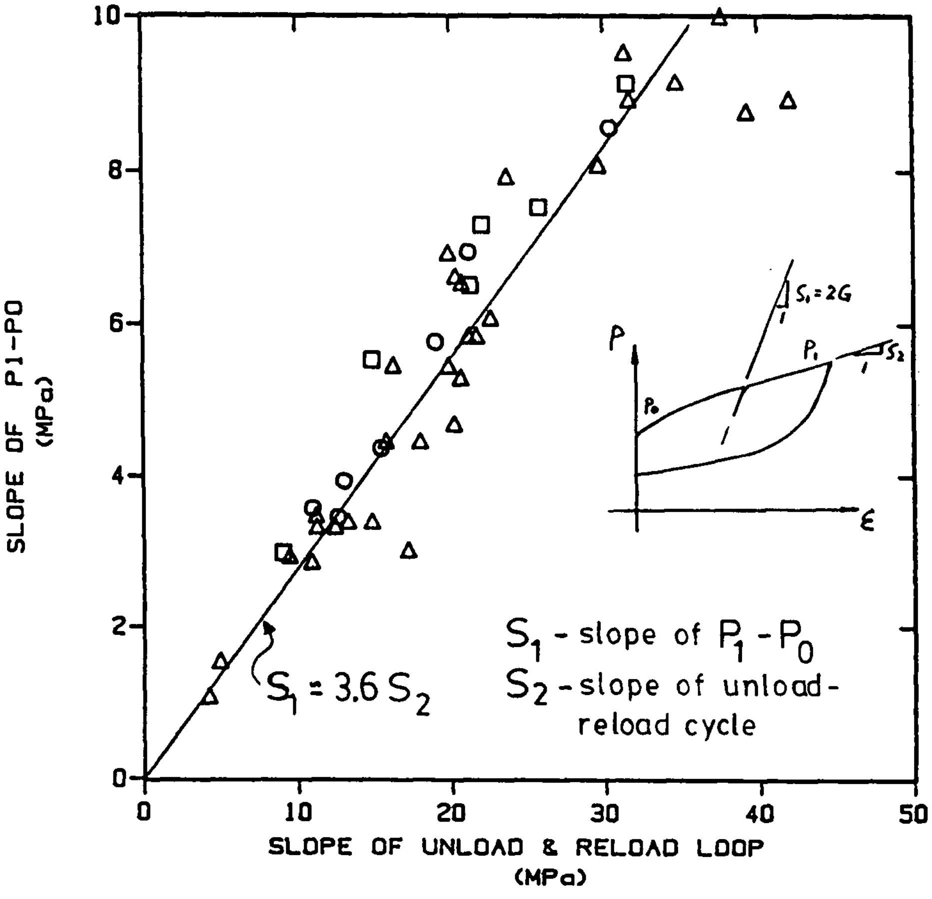


Figure 4.11 Relationship between Slope of Unload - Reload Loop and Slope of P_1 - P_0

sand (Brauid, 1980).

4.5 Friction Angle

The profile of friction angle of the sand at McDonald's Farm has been determined using results obtained from cone penetration test, self-boring pressuremeter tests and laboratory triaxial tests (Robertson, 1982). These tests suggest an average ϕ' value of about 40° (figure 4.12).

Figure 4.13 presents the three different friction angle profiles obtained by the dilatometer test using the following:

1. Marchetti's (1981) empirical correlation,
2. Schmertmann's (1982) method with penetration force measured at the ground surface, and
3. Schmertmann's (1982) method with penetration force measured directly behind the Research Dilatometer.

The shape of the friction angle profiles determined by the three methods are very similar. The average friction angle obtained using Marchetti's (1981) correlation is about 32°. This value is significantly lower than values determined from the other tests. This agrees with other observers that Marchetti's (1981) correlation usually gives values of the friction angle which are too low.

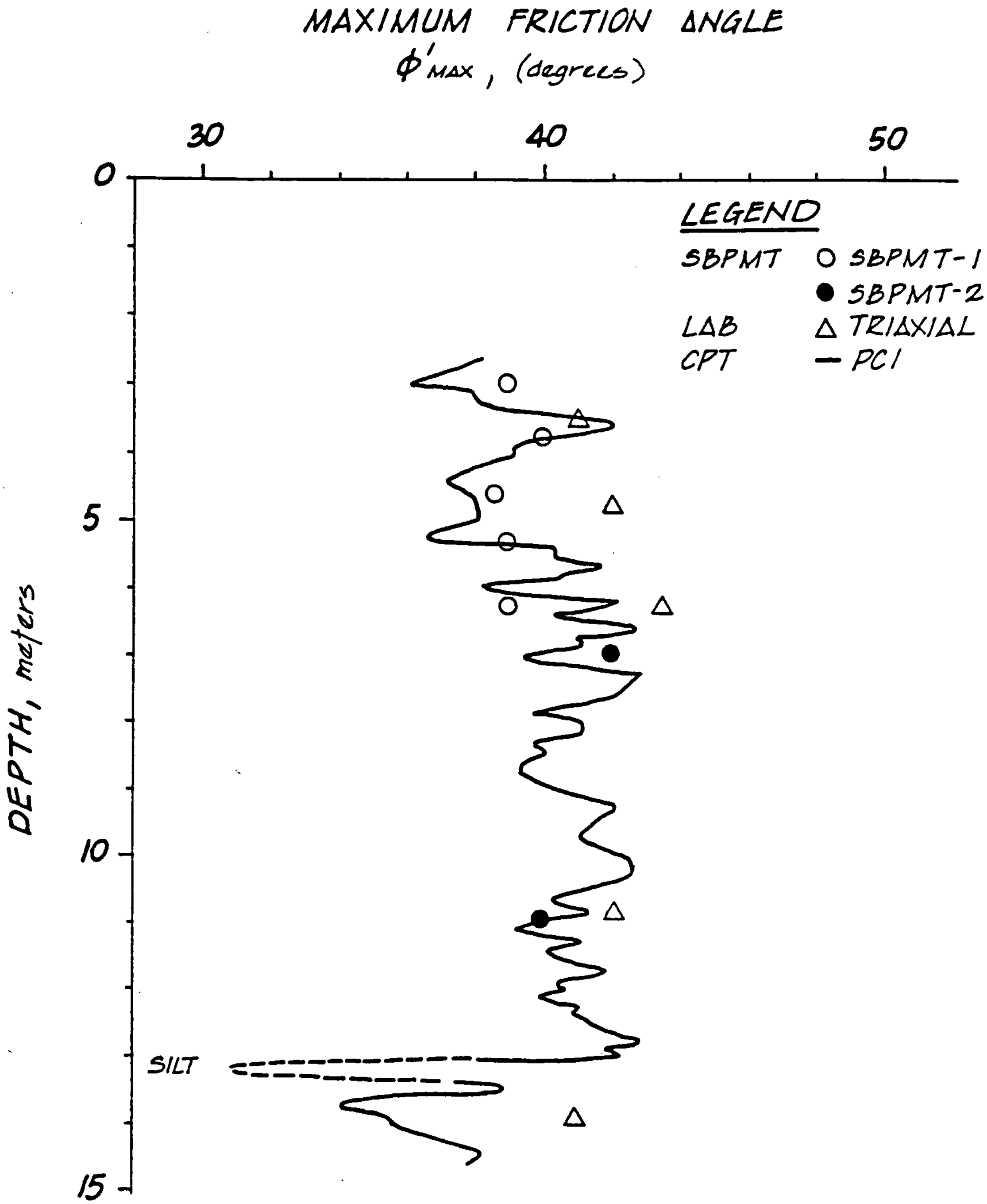


Figure 4.12 Comparison of Laboratory Triaxial Peak Friction Angle with CPT and Self-boring Pressuremeter Values (Adapted from Robertson, 1982)

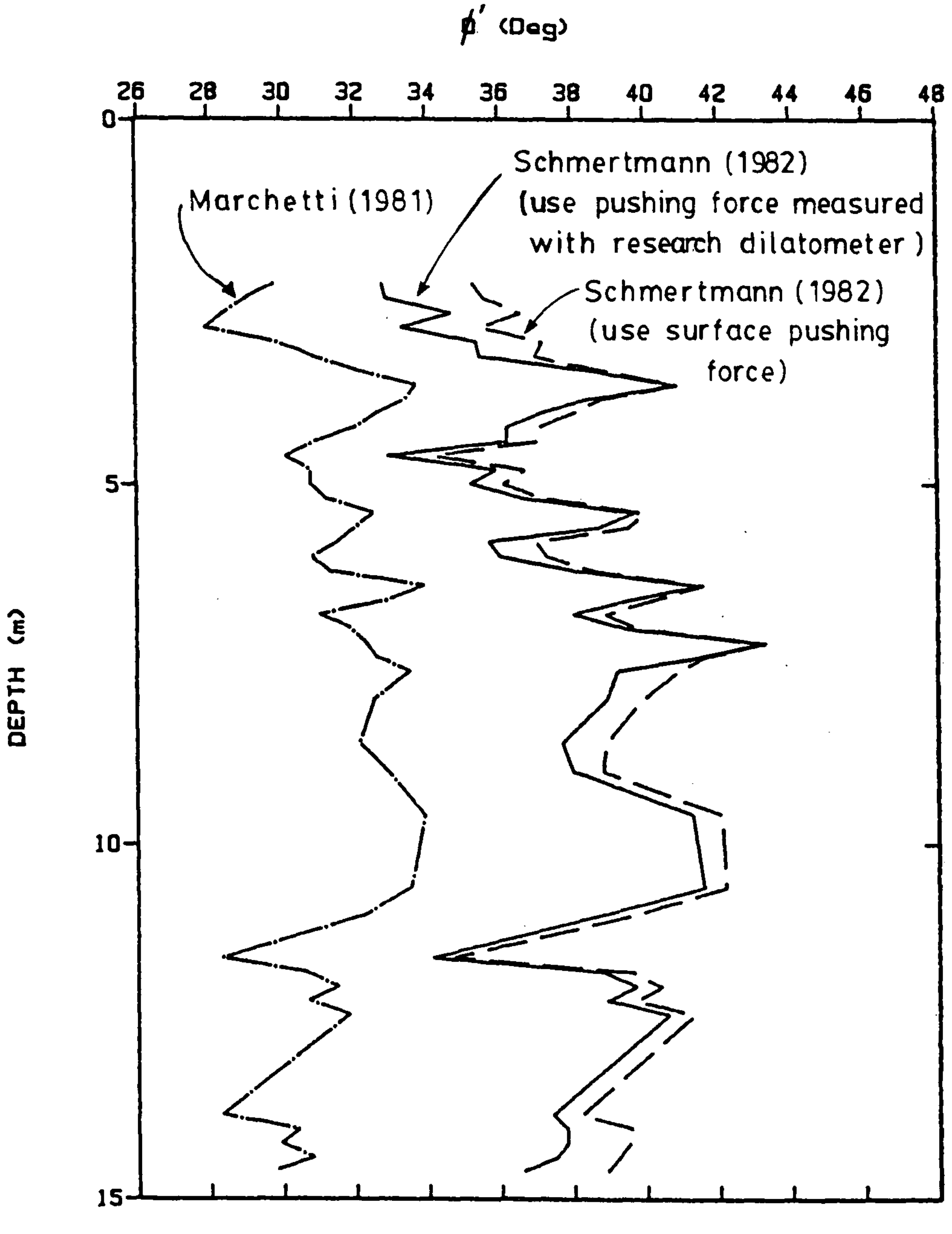


Figure 4.13 Friction Angles Estimated by DMT results (Sounding MRD-1)

Schmertmann's (1982) method was based on Durngunoglo and Mitchell's (1975) bearing capacity theory. The friction angle values of sand can be directly calculated with the use of the penetration force measured behind the blade. If penetration force is measured at the ground surface, it is necessary to first evaluate the thrust at the blade. Schmertmann (1982) suggested that the friction force acting along the penetration rods behind the friction reducer could be neglected. When performing dilatometer tests using Marchetti's standard instrument, it is generally only possible to obtain the thrust at the ground surface. Figure 4.13 shows that the ϕ' values computed using the pushing force measured at the ground surface are only slightly higher than the values calculated using the force measured behind the blade; at some depths the values are almost identical. This shows that the assumption made by Schmertmann (1982) that friction along the penetration rods behind the friction reducer could be neglected is very close to reality at the McDonald's Farm site. However, this may not always be valid, especially if the sand layer is overlain by a thick clay deposit.

It is worth mentioning that the values of friction angle determined using Schmertmann's (1982) method are friction angle derived under condition of pain strain, ϕ'_{ps}. ϕ'_{ps} are usually 1° - 4° higher than values derived under condition of axial symmetry, ϕ'_{ax} (Lee, 1970). However as explained by Schmertmann (1982), friction angles determined using wedge penetration theories are usually conservatively on the low side. Figures 4.12 and 4.13 show that the values of ϕ_{ps}' determined using Schmertmann's (1982) DMT method, have an average of 40°, and are in an excellent agreement with the values of ϕ' obtained from cone penetration test, pressuremeter test and laboratory triaxial tests.

The pressure expansion curves in sand are extremely similar for both the dilatometer test and the pressuremeter test. In Section 4.4, it has already been illustrated that the elastic shear modulus of sand can be estimated from an unload-reload cycle during a dilatometer expansion test similar to that from a pressuremeter test. In this section, it is attempted to determine the ϕ' values of sand at the McDonald's Farm site from the expansion curves obtained from the Research Dilatometer using a method similar to that proposed by Hughes et al (1977) for self-boring pressuremeter tests. The friction angle at constant volume, ϕ_{cv}, for the sand deposits at McDonald's Farm was assumed to be 36° (Robertson, 1982). With the use of this ϕ_{cv} value, the friction angles evaluated from the expansion curves of the dilatometer test are obtained and presented in figure 4.14. The method by Hughes et al (1977) uses the slope (s) of a log expansion pressure versus log cavity strain plot. A similar assumption has been made for the dilatometer expansion curves.

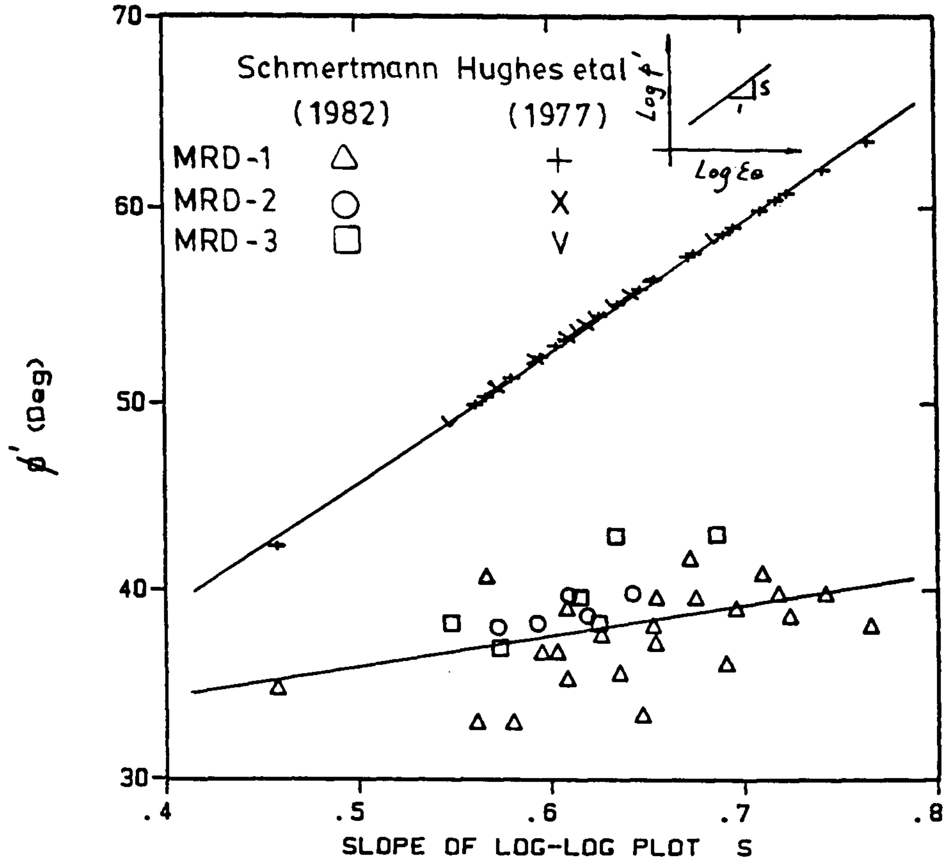


Figure 4.14 Comparison of Friction Angle from Dilatometer Expansion Curve and from DMT results

The friction angles determined from the expansion curves of the dilatometer tests were much higher than the corresponding values directly calculated using Schmertmann's (1982) approach. The average ϕ' value predicted using Hughes et al's approach was about 55°. Hughes and Robertson (1984) obtained similar unacceptably high ϕ' values when using the same method for analyses of full-displacement pressuremeter results. This once more gives the indication that a dilatometer test in sand is in many ways similar to a full-displacement pressuremeter test.

When examining the profiles of I_D, K_D and E_D obtained from dilatometer soundings, the shape of the E_D profiles is very compariable to the cone bearing profiles. The friction angle of sands can be estimated from the bearing profiles of cone penetration tests. Figure 4,15 (Robertson & Campanella, 1983) shows that the values of ϕ' are closely related to the cone bearings. A similar relationship may thus be expected to exist between the friction angle and the dilatometer moduli. Figure 4.16 aims to investigate this possibility.

The correlation of friction angle developed by Marchetti (1981) made use of the dilatometer moduli. According to the preceeding discussion, Marchetti's correlation should give a reasonably good estimation of ϕ' values in sands. However, the correlation has been found to be unsuccessful perhaps because it was derived based on

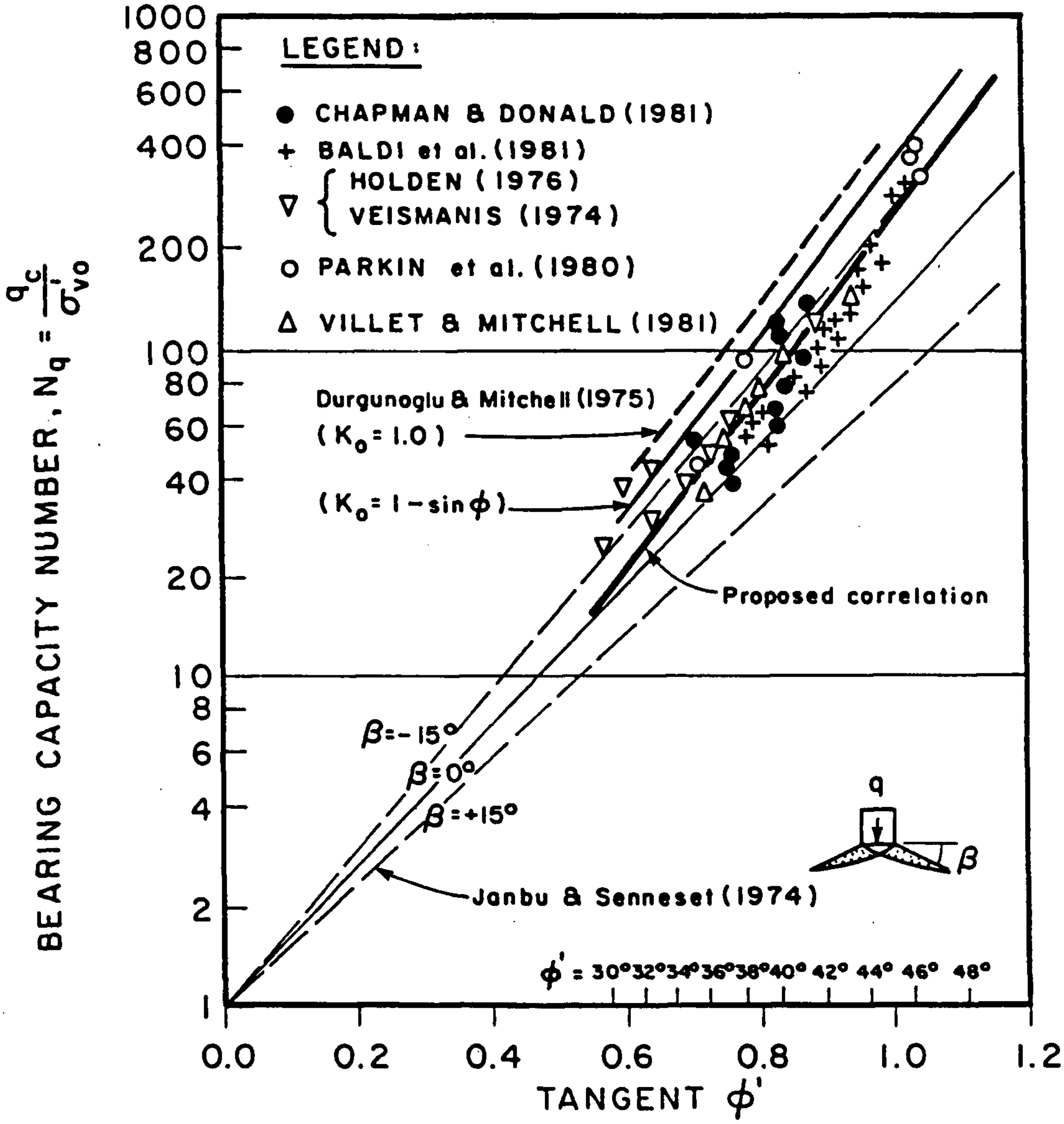


Figure 4.15 Relationship between Bearing Capacity Number and Friction Angle from Large Calibration Chamber Tests (Adapted from Robertson and Campanella, 1983)

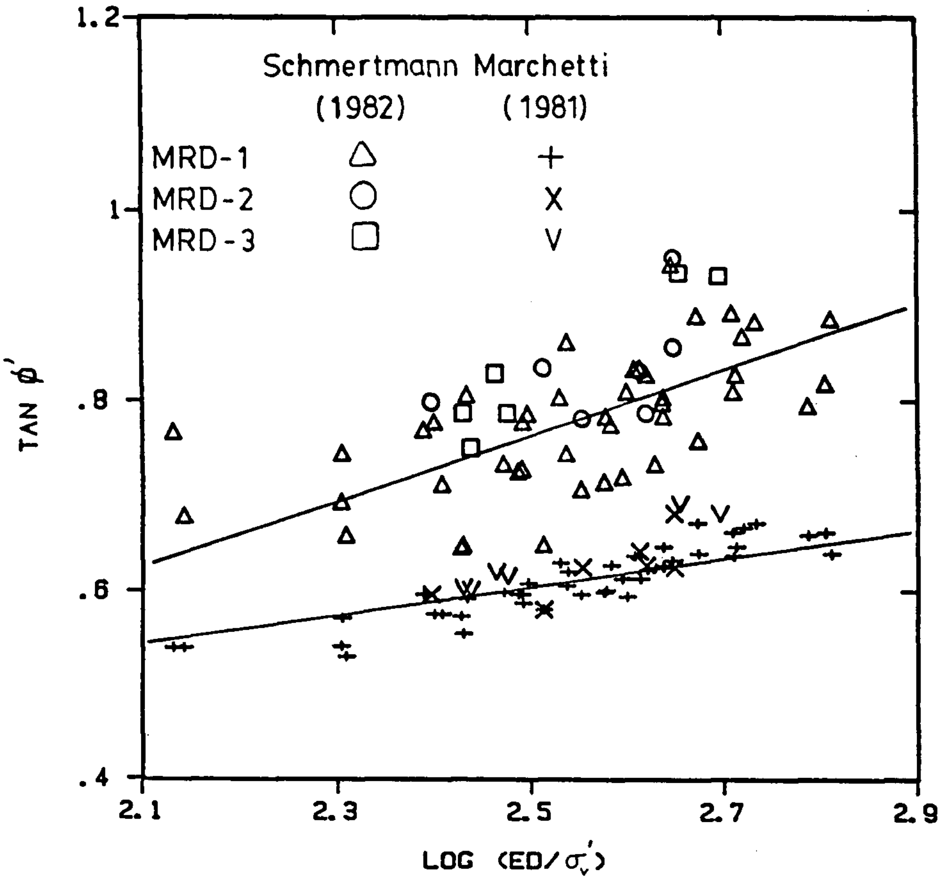


Figure 4.16 Relationship between Friction Angle and Dilatometer Modulus

limited test data from only six sites. It is believed that Marchetti's (1981) correlation of friction angle could be improved by including more recent data. If Marchetti's (1981) correlation of friction angle for sand could be improved, the test could resume its original simplicity without the need of monitoring penetration forces. Also, it can provide users an alternative of estimating the friction angle or as a comparison to Schmertmann's Method.

4.6 OCR and K_0

Figure 4.17 presents the K_0 vaues of sand at McDonald's Farm, determined using both Marchetti's (1980) correlation and Schmertmann's (1983) method. Figure 4.18 presents the OCR determined using both Marchetti's (1980) correlation and Mayne and Kulhawy's formula that was modified by Schmertmann (1983).

The geology of the Fraser Delta suggests that the sand deposit at the site is normally consolidated, which would indicate a K_0 value ranging from 0.4 to 0.5. Because of the turbulent environment in which the sand was laid down and past seismic activities, additional horizontal stress may have been locked into the sand. This would suggest a possible K_0 value value of about 0.6 to 0.7 (Robertson, 1982).

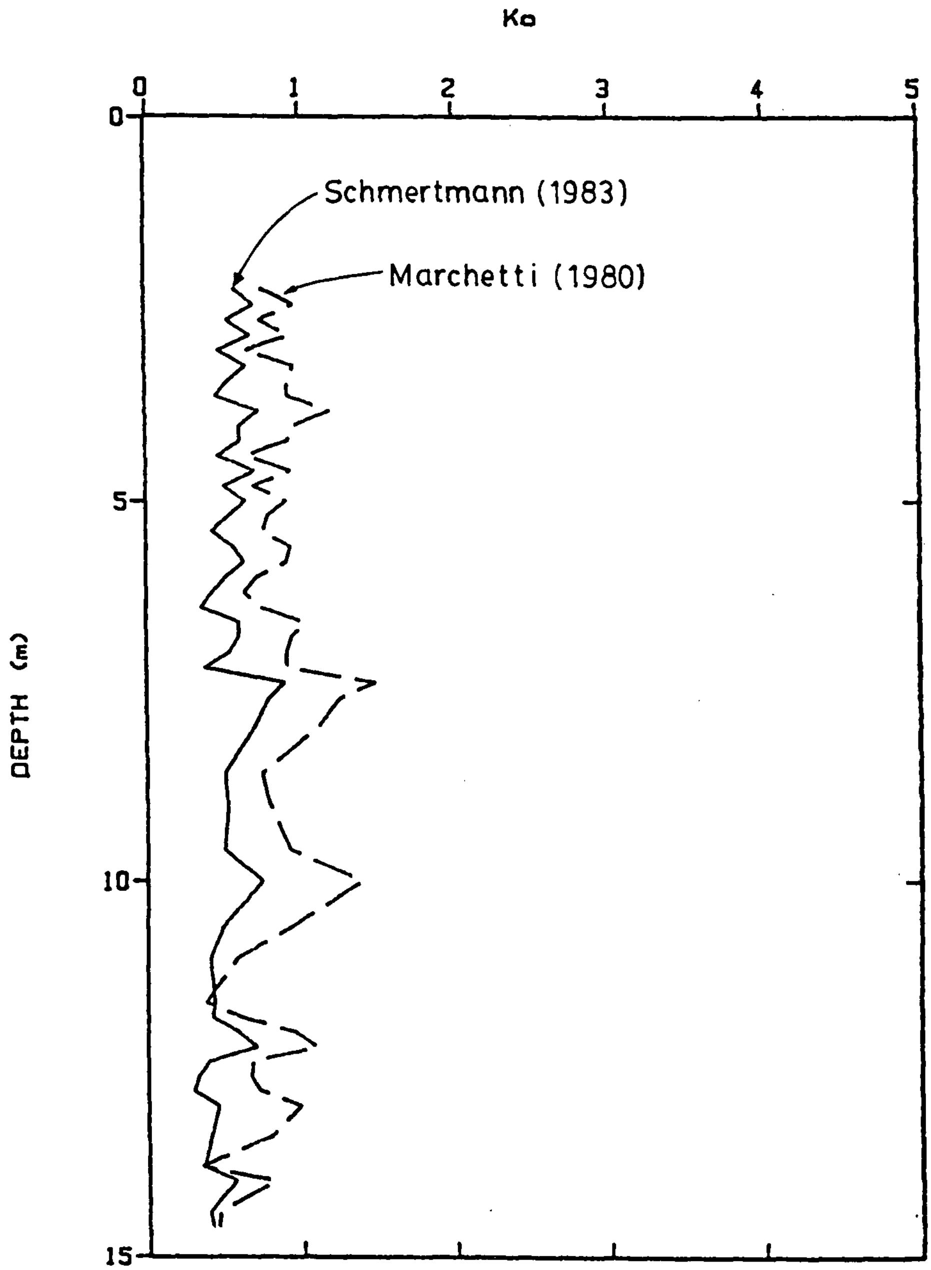


Figure 4.17 In-situ Earth Pressure Coefficient Vs Depth at McDonald's Farm (Sounding MRD-1)

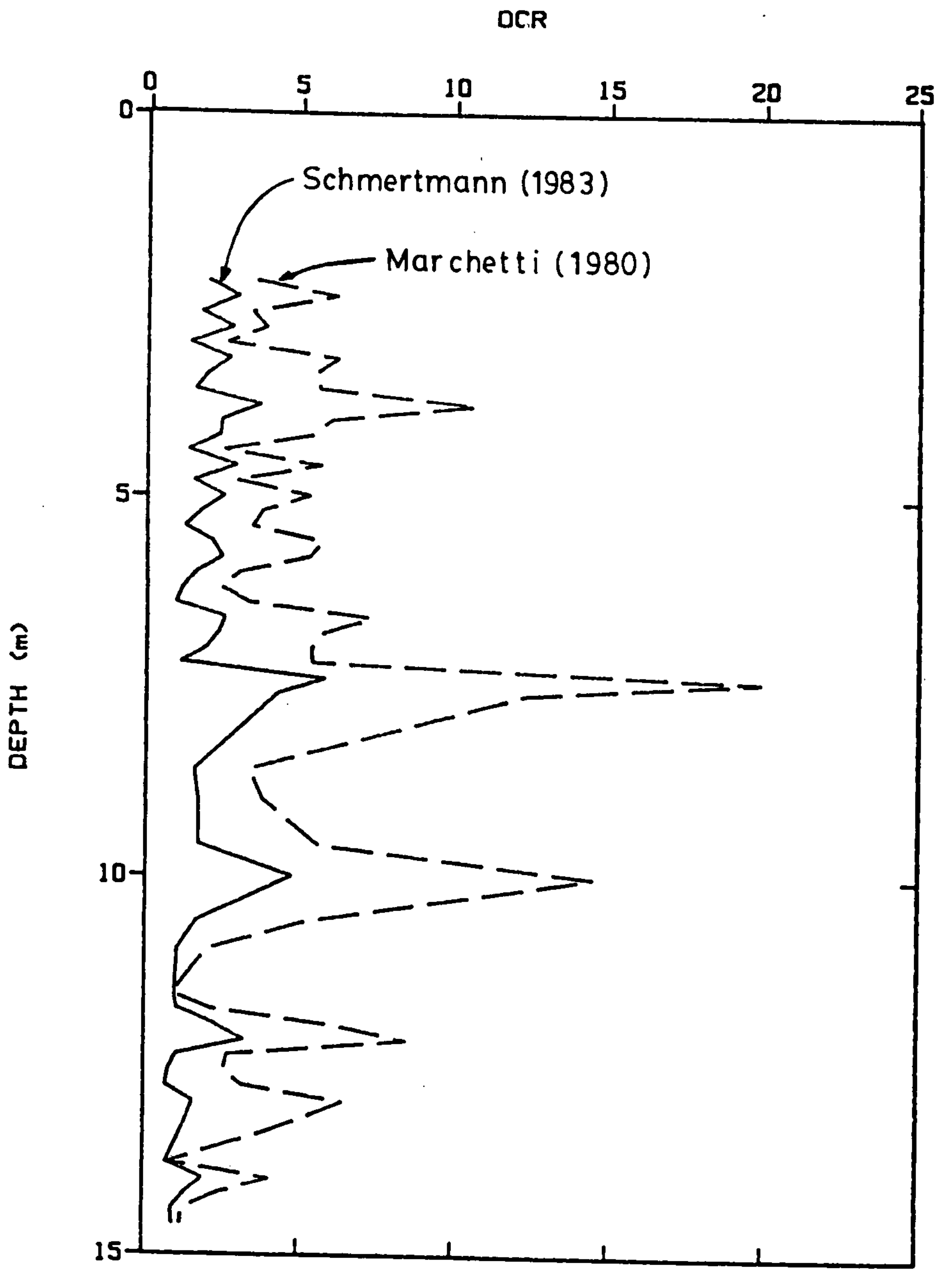


Figure 4.18 Overconsolidation Ratio Vs Depth at McDonald's Farm (Sounding MRD-1)

The K_0 and OCR values determined using Marchetti's (1980) correlations were higher than the anticipated values described above. It has been found that Marchetti's correlations generally overpredicted the K_0 and OCR values (Bullock, 1983). It seems that the OCR and K_0 values determined using the approaches suggested by Schmertmann (1983) provide a much better description of the site.

Chapter 5

Research Dilatometer Testing in Clayey Deposits

5.1 Scope

A field programme of performing research dilatometer tests in clayey deposits was conducted at the following sites in the Lower Mainland of British Columbia:

1) Sea Island - McDonald's Farm
2) Langley - B.C. Hydro Railway Crossing Site
3) Langley - 232nd St. Interchange, lower site
4) Langley - 232nd St. Interchange, upper site

The general locations of the sites are shown in figure 5.1. Like the McDonald's Farm site, the three sites in Langley are also research sites for the in-situ testing group at UBC. Detailed investigation of the Langley sites has been made using various in-situ testing techniques. The tests used for comparison in this study are:

1) field vane shear test (FVST),
2) cone penetration (CPT),
3) downhole seismic test,
4) self-boring pressuremeter test (SBPMT), and
5) full displacement pressuremeter test (FDPMT).

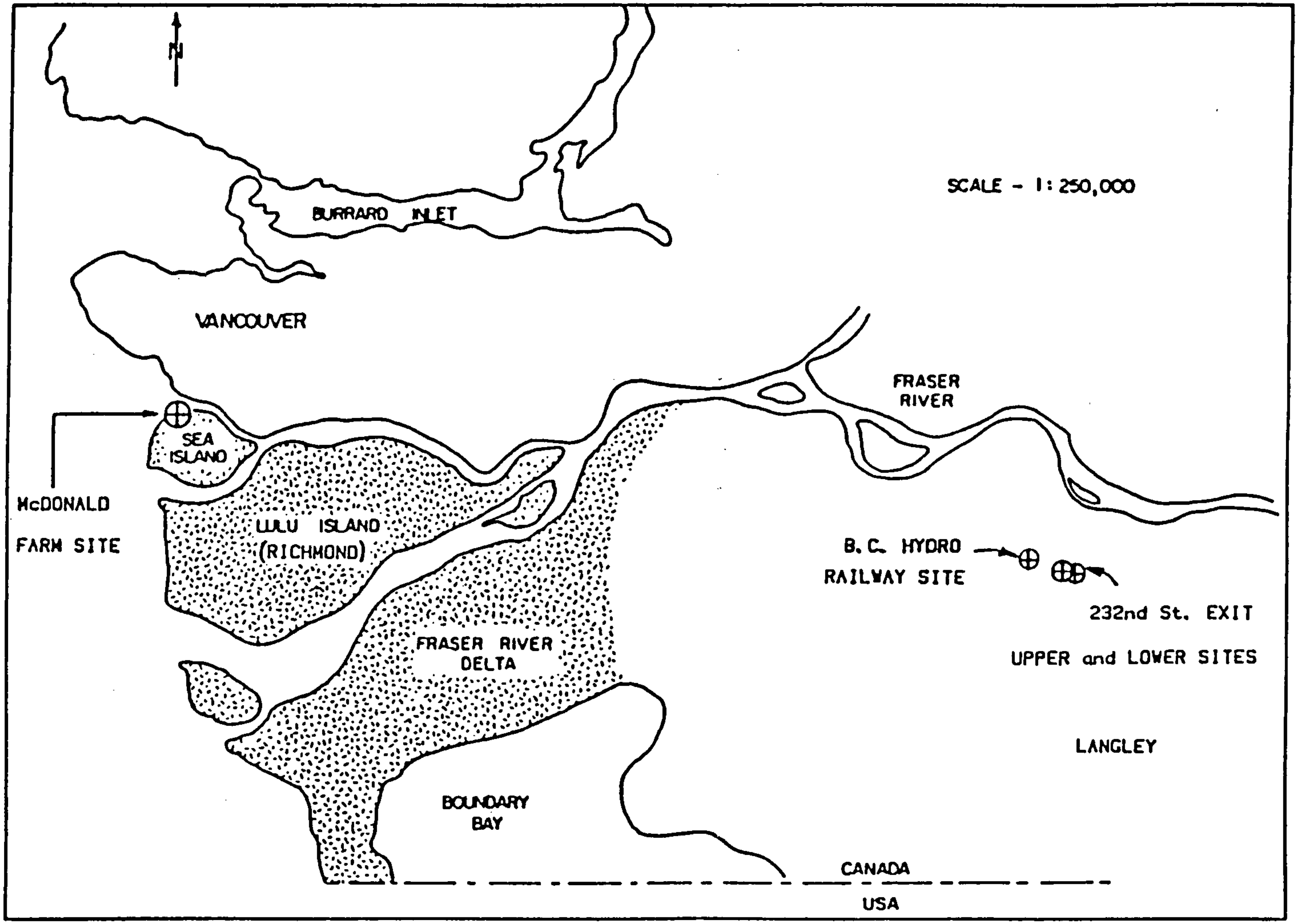


Figure 5.1 General Location Plan of Research Sites

5.2 Site Geology and Description

5.2.1 McDonald's Farm

(As presented in Section 4.2)

5.2.2 B.C. Hydro Railway Crossing Site

The site is located approximately 100m west of the B.C. Hydro railway overpass near the 232nd St. exit of the Trans Canada Highway in Langley. The site is situated at the base of an approximately 5m cut adjacent to the shoulder of the west-bound traffic.

Geologically the site is located at the eastern extent of the Capilano sediments which consist of raised deltaic, marine and glaciomarine sediments and marine shore deposits (Armstrong, 1978). A typical CPT profile is presented in figure 5.2 which shows that the site stratigrahpy consists of:

0 - 2.5m mixed gravel and sandfill

2.5 - 10m silty clay, overconsolidated with interbeded silty sand layers

10 - 30m silty clay, slightly overconsolidated to normally consolidated with some thin silty sand layers.

Figures 5.3 and 5.4 present the DMT results which also clearly identifies the clay deposits.

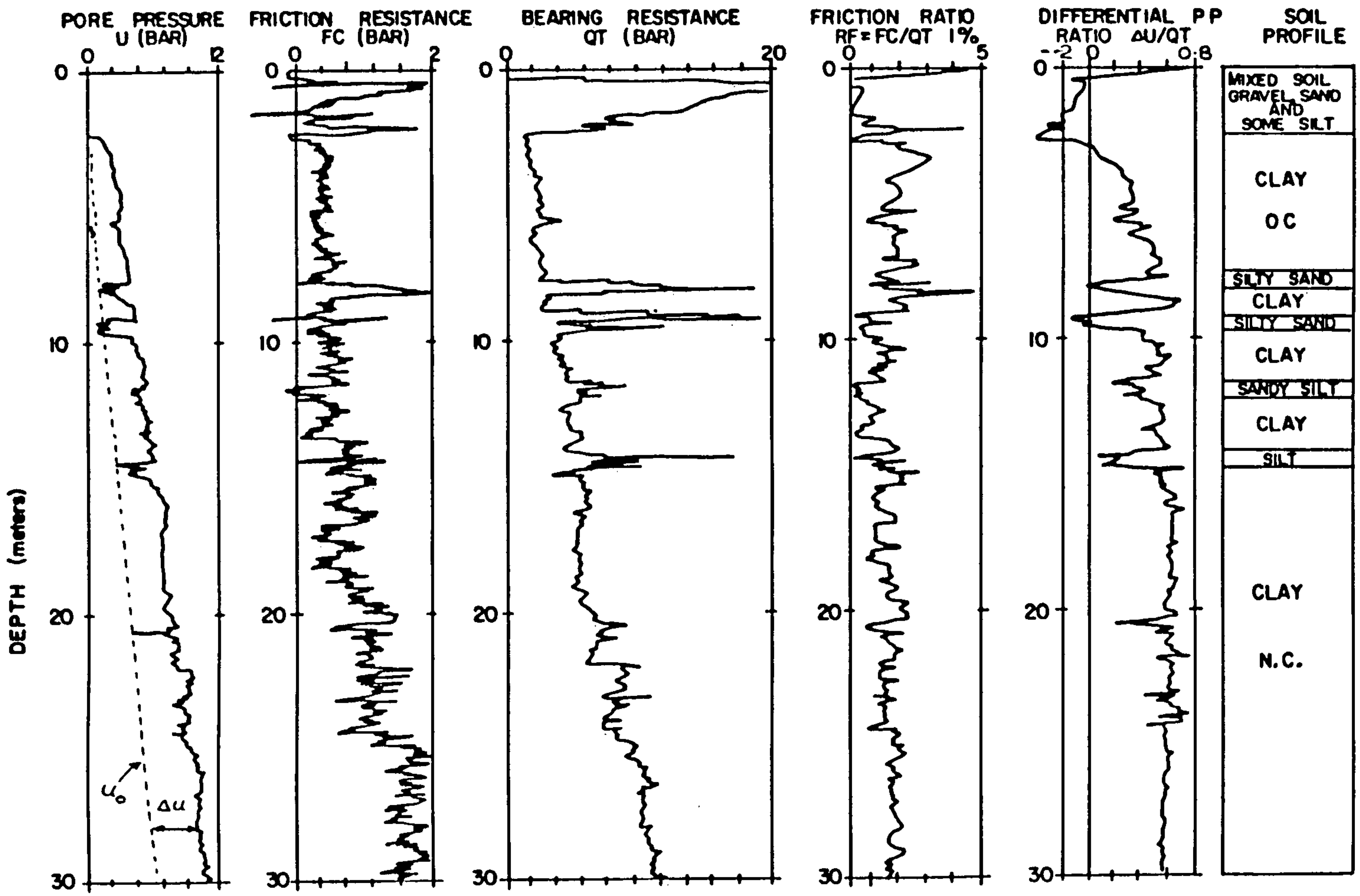


Figure 5.2 Typical CPT Profile at Langley Railway Site

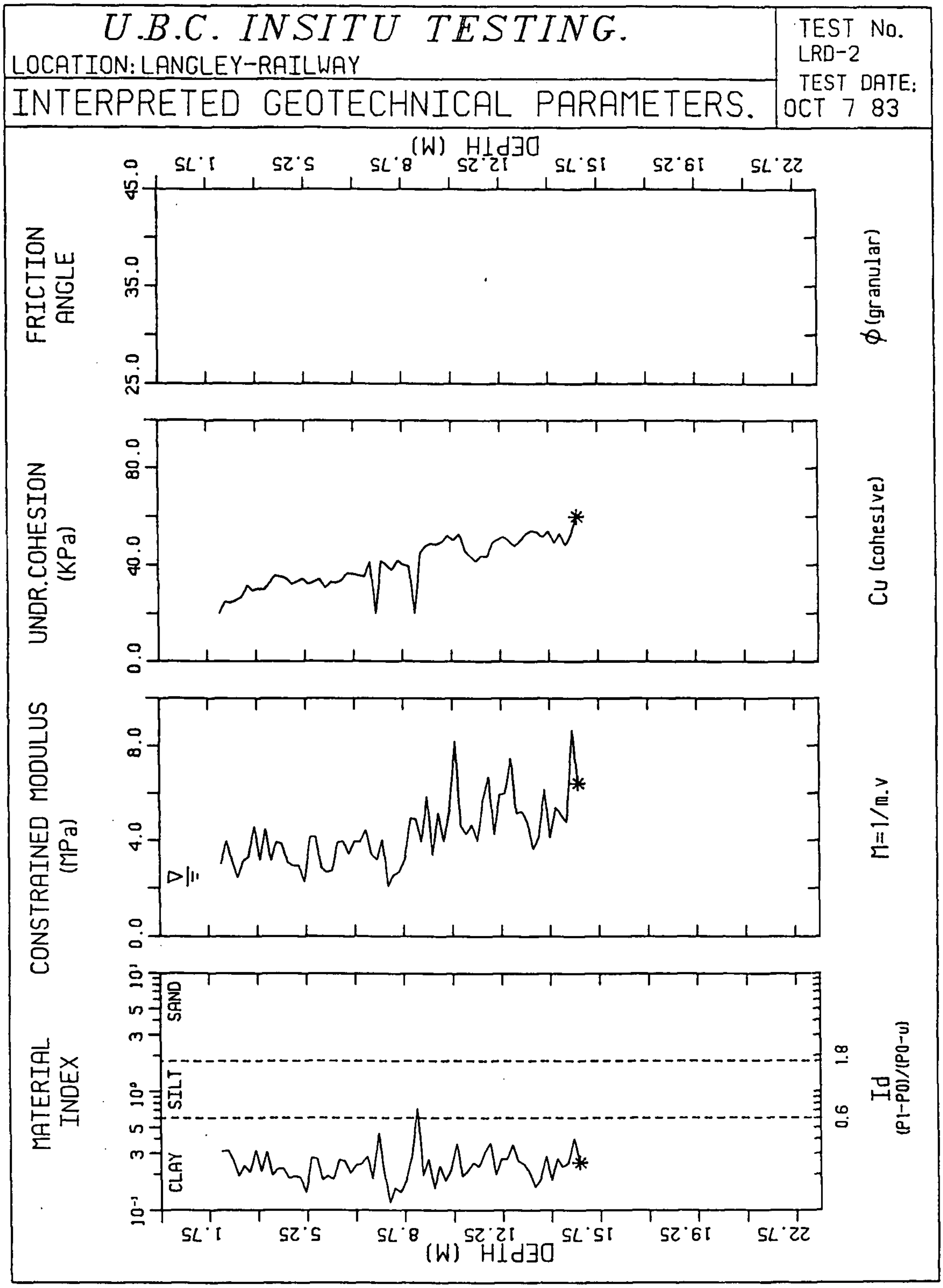


Figure 5.3 DMT Profile at Langley Railway Site - Interpreted Geotechnical Parameters

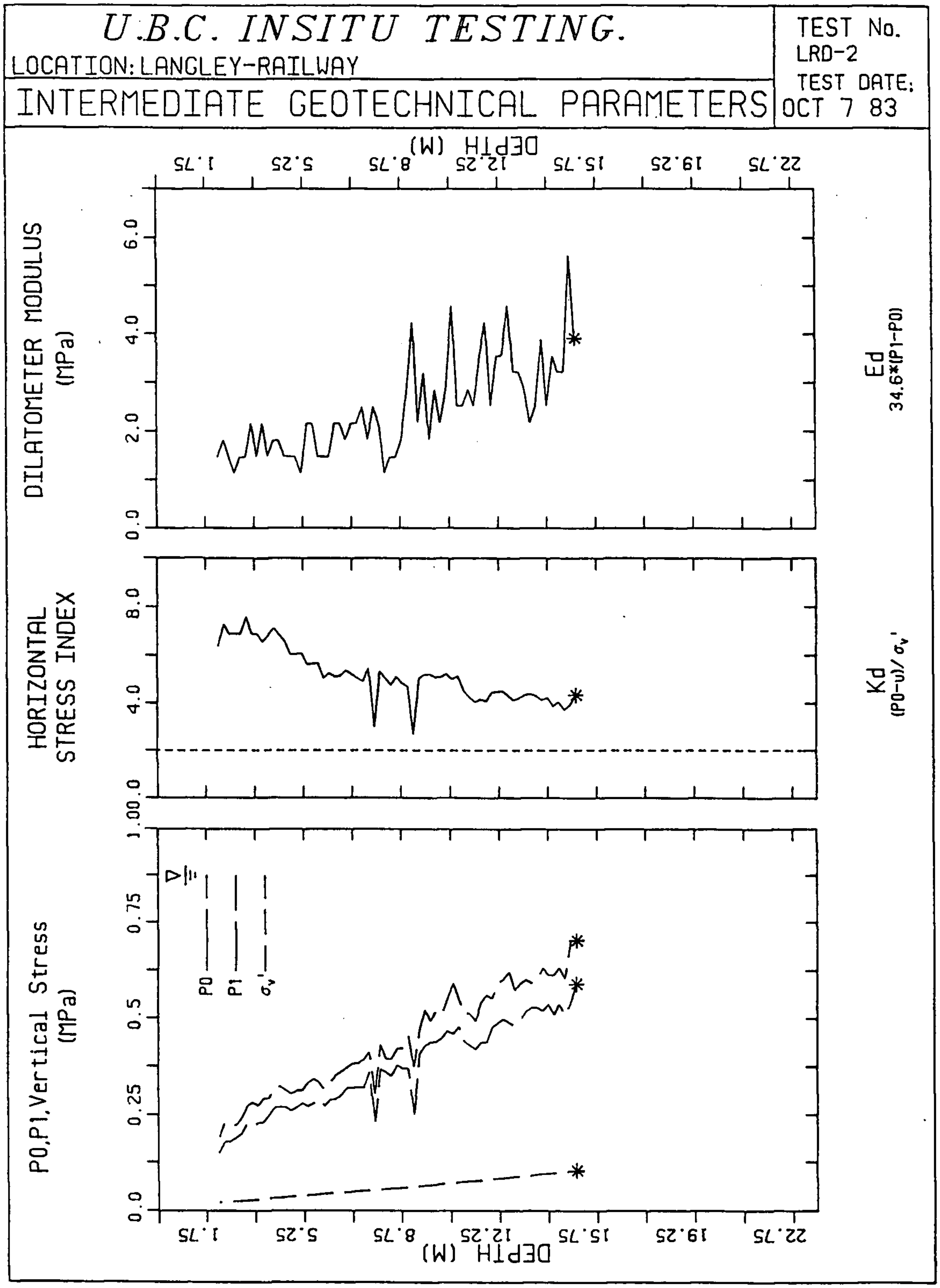


Figure 5.4 DMT Profile at Langley Railway Site
Intermediate Geotechnical Parameters

5.2.3 232nd St. Interchange - Lower and Upper Sites

These two sites are located at the interchange of the west-bound Trans Canada Highway and the 232nd St. in Langley, which is approximately 1 km east of the B.C. Hydro railway crossing site. The lower site is located near the exit to the highway. The upper site is located 4.8m above the lower site and is situated on a compacted clay fill that forms approach from the 232nd St. overpass.

These two sites lie at the western extent of the Fort Langley formation which consists of interbeded marine, glaciomarine and glacial sediments. Typical CPT profiles for the lower and upper sites are presented in figure 5.5 and figure 5.6, respectively.

The stratigraphy of the lower site is very similar to the railway crossing site and consists of:

0 - 2m overconsolidated organic silty clay
2 - 10m overconsolidated silty clay
10 - 20m slightly overconsolidated to normally consolidated silty clay with occasional silty sand lenses.

The stratigraphy of the upper site consists of:

0 -4.5m compacted clay fill
4.5- 8m overconsolidated silty clay
8 - 15m normally consolidated silty clay with interbeded silty sand lenses.

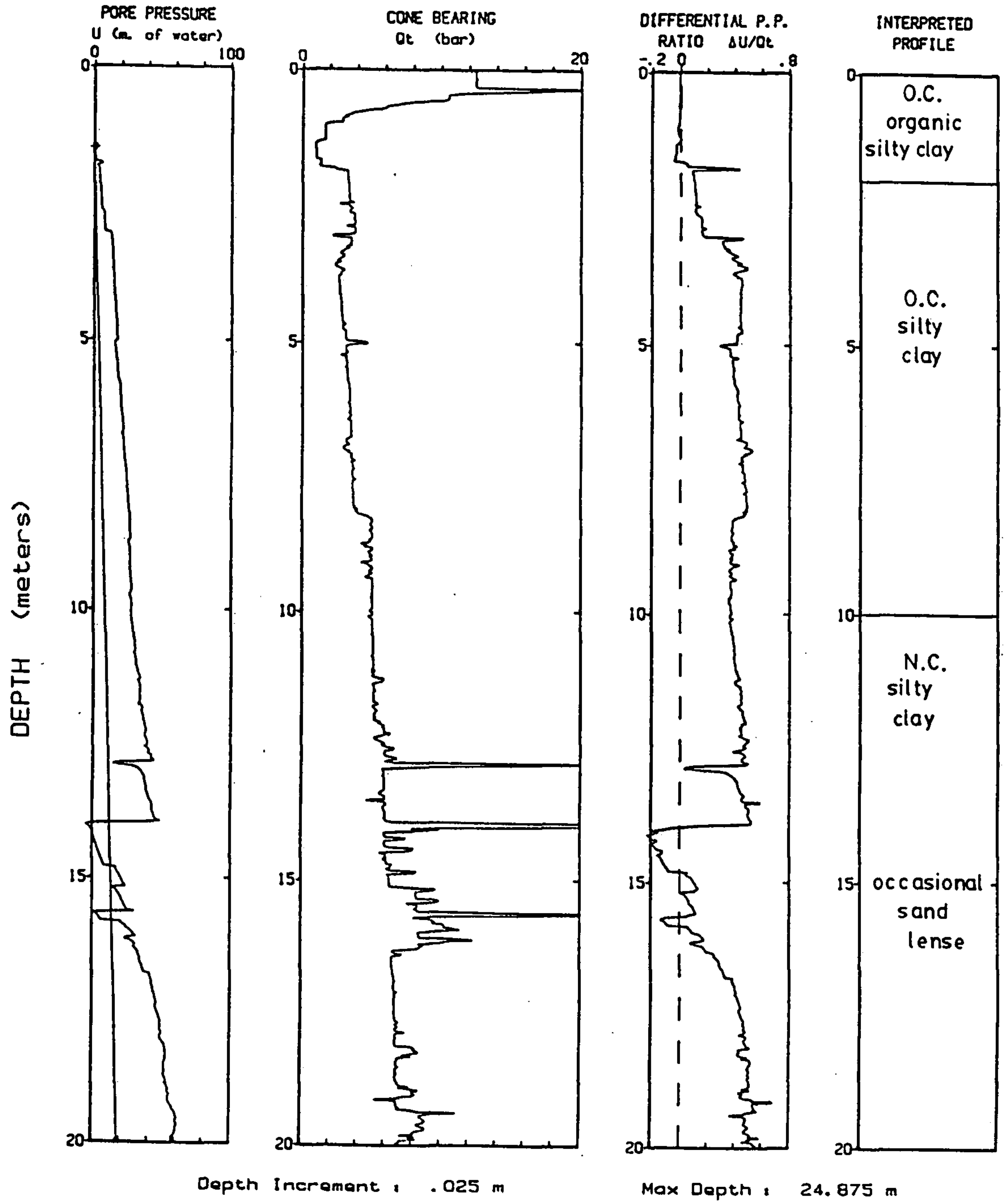


Figure 5.5 Typical CPT Profile at Lower 232nd St. Site

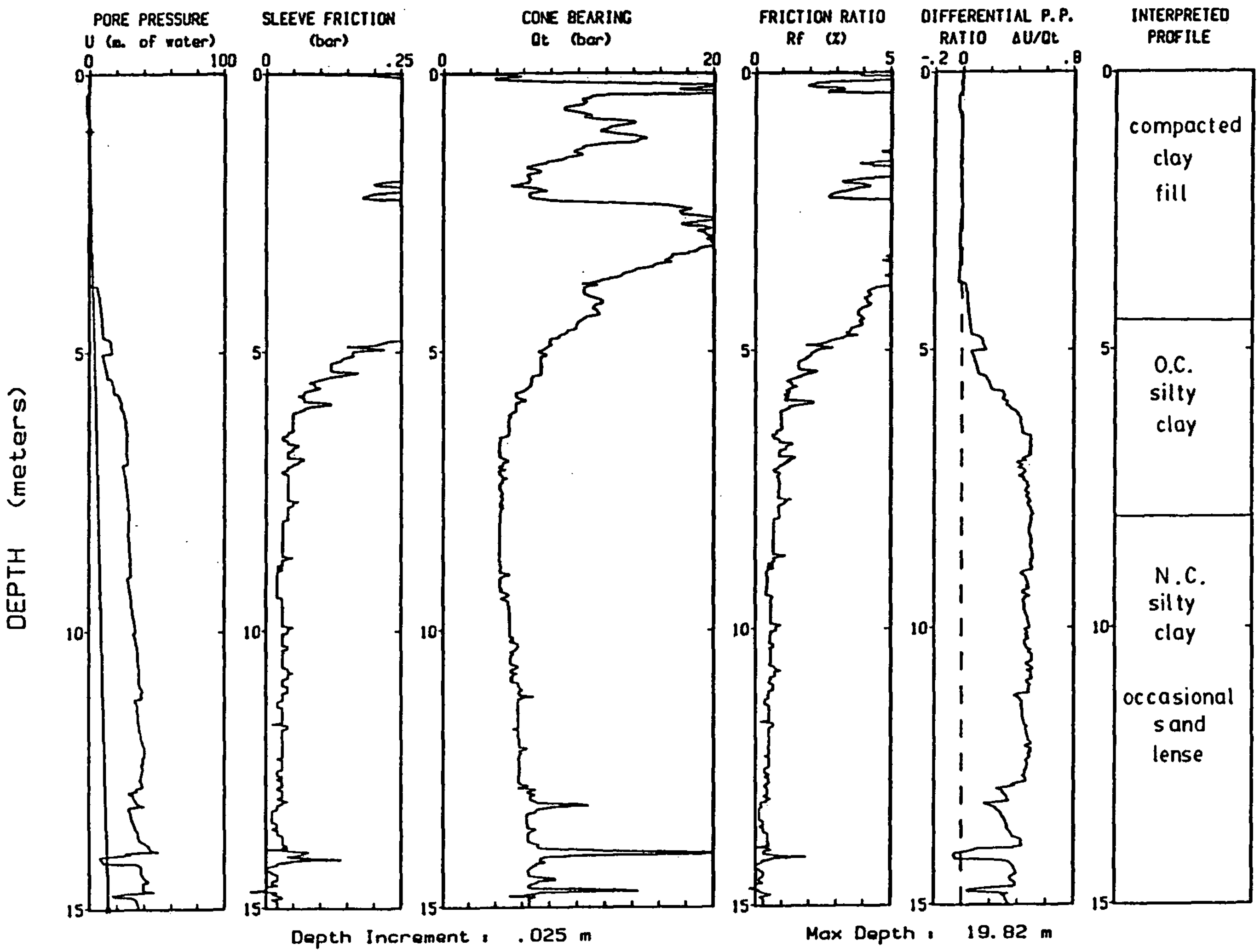


Figure 5.6 Typical CPT Profile at Upper 232nd St. Site

Figures 5.7 to 5.10 present the DMT results at the lower and upper sites. The DMT results in general clearly identify the clay deposits at the two sites. However, the DMT results indicate that the upper approx. 5m of compacted clay at the upper site as sandy silt material and occasionaly classify the very soft clay at the lower site as mud (also, see Appendix II).

5.3 Soil Deformation Characteristics

Typical pressure expansion curves for the clay deposits obtained using the research dilatometer are presented in figures 5.11 to 5.13. Figure 5.11 illustrates the result in compacted clay with high overconsolidation ratio at the upper Site in Langley. Figure 5.12 and figure 5.13 illustrate the test results in normally consolidated clayey silt at McDonald's Farm and slightly overconsolidated silty clay at the lower site in Langley, respectively. Similar to the tests in sands, the results exhibit remarkable similarity in shape to the pressure expansion curves obtained from push-in pressuremeter probes.

The test results in the highly overconsolidated compacted clay show that negative pore pressures are generated during the penetration phase of the tests. The magnitude of the negative pore pressure drops slightly after the expansion-deflation phase. The slope of the straight

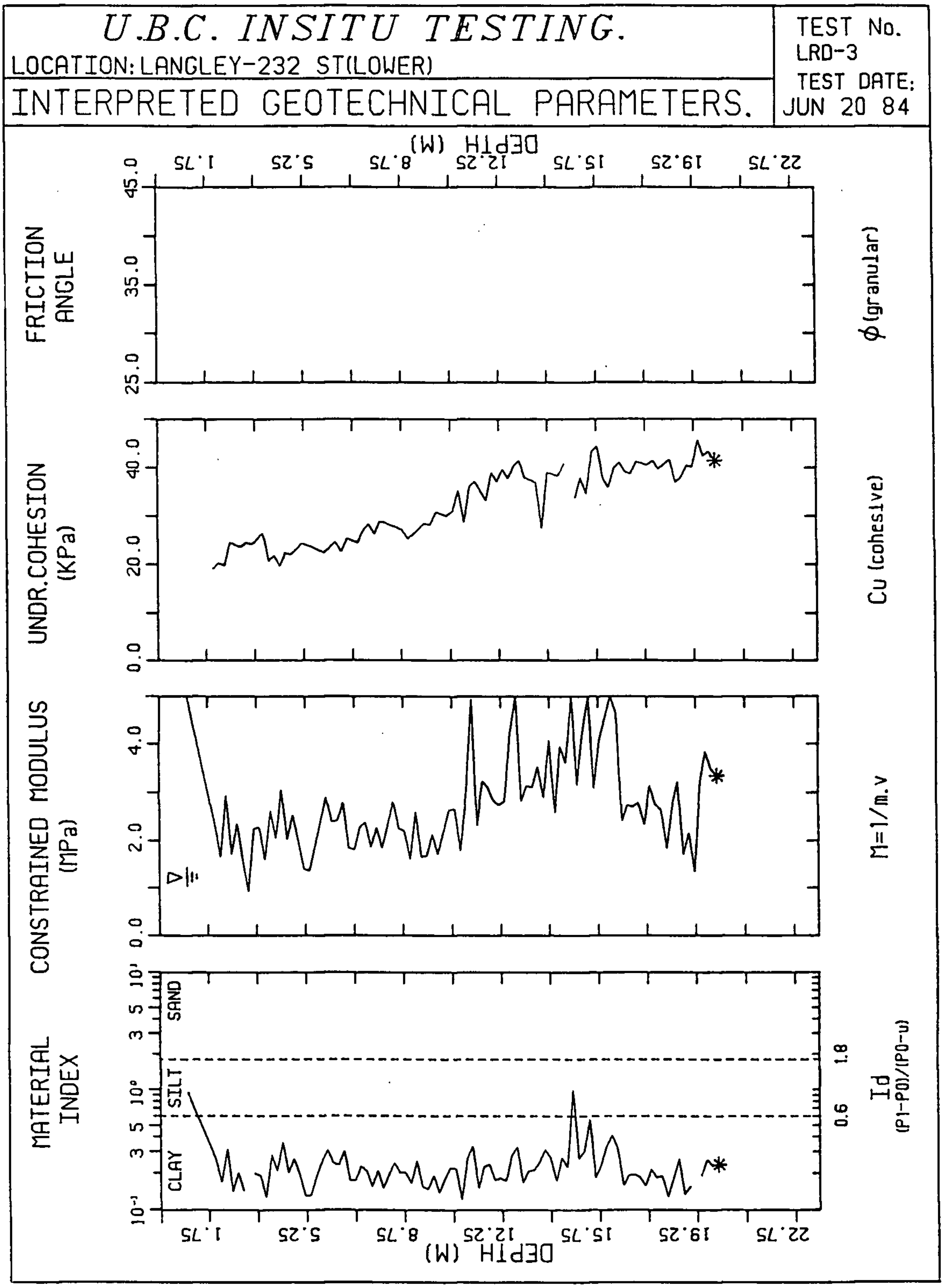


Figure 5.7 DMT Profile at Lower 232nd St. Site - Interpreted Geotechnical Parameters

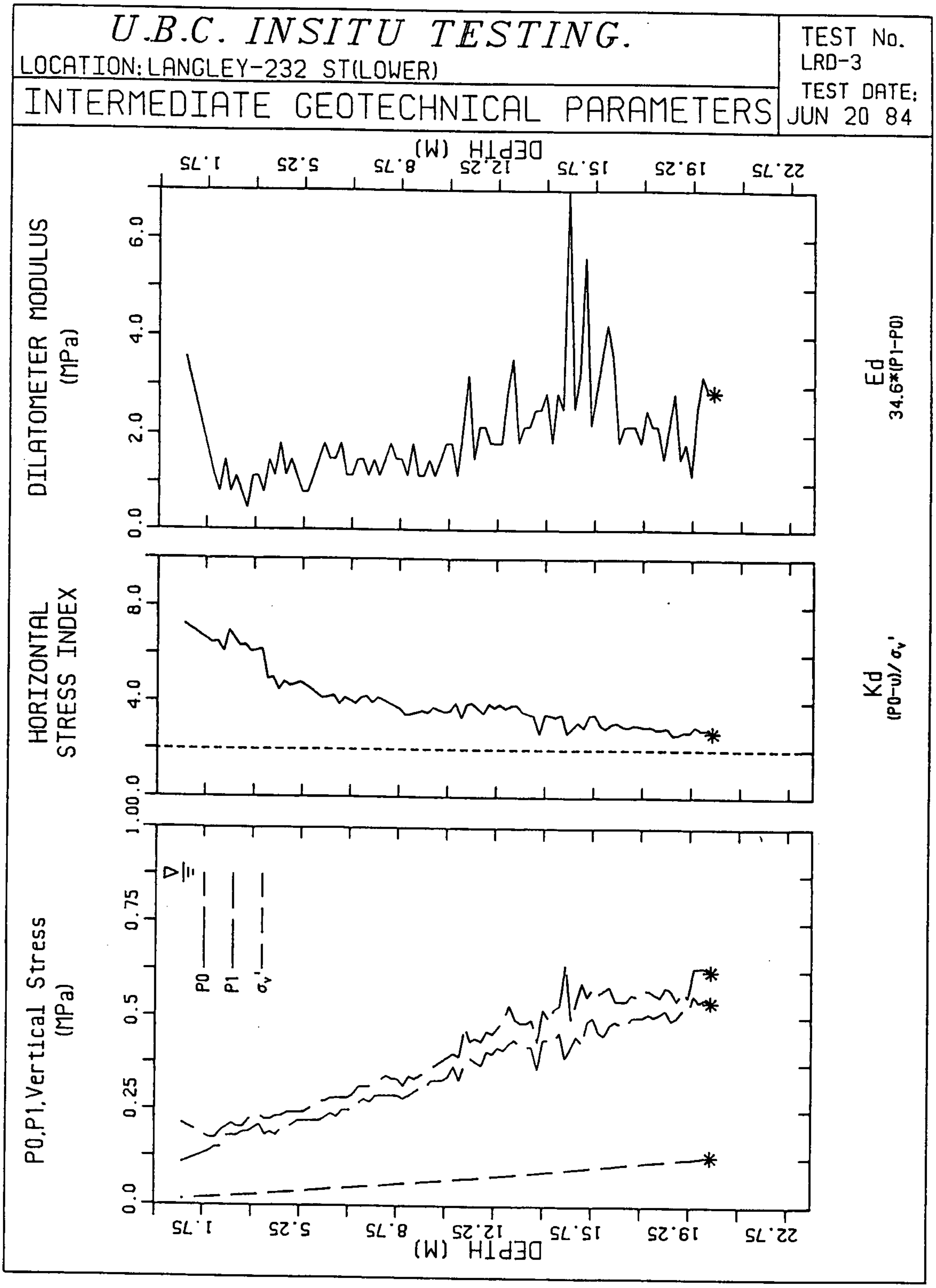


Figure 5.8 DMT Profile at Lower 232nd St. Site - Intermediate Geotechnical Parameters

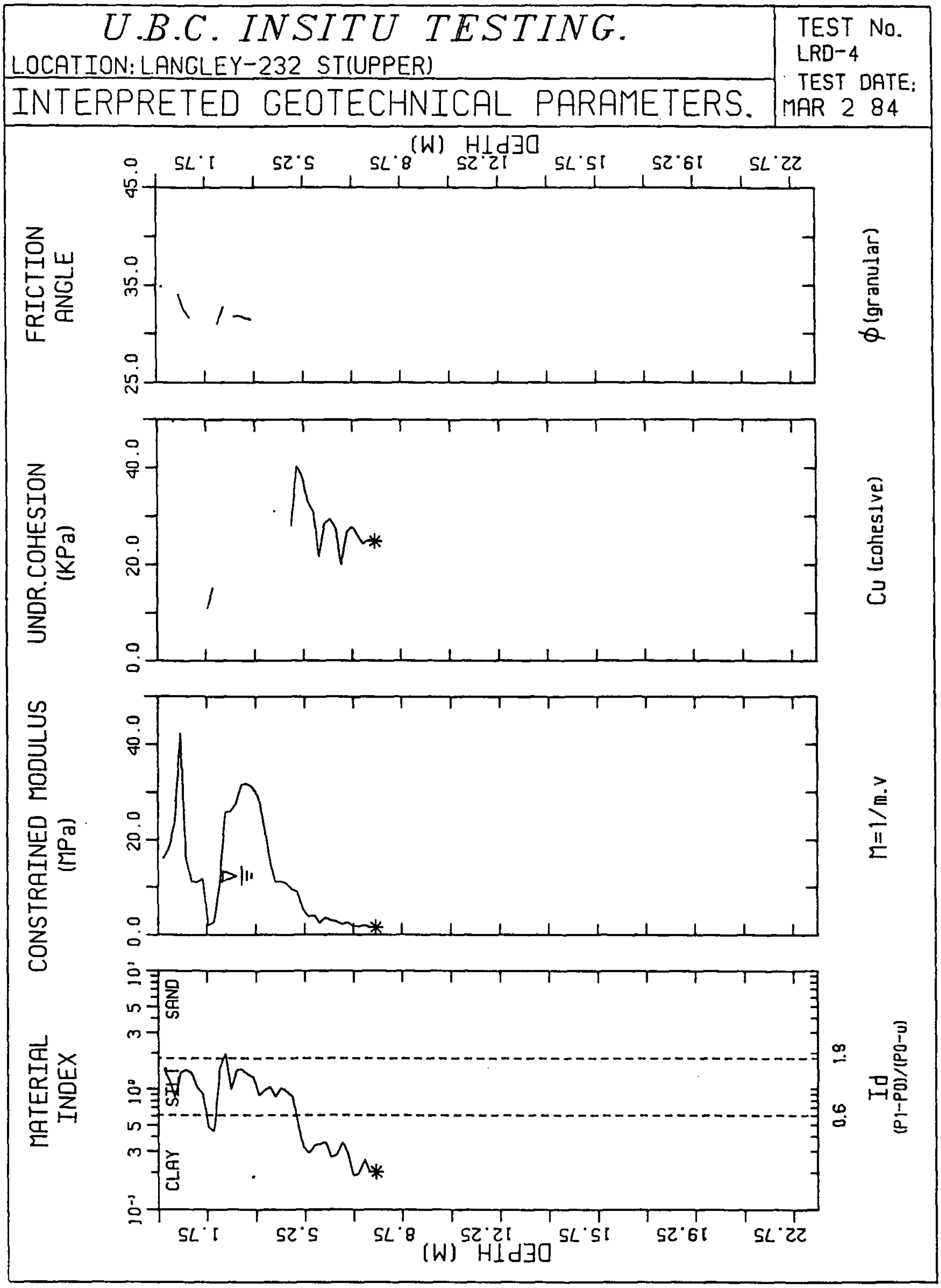


Figure 5.9 DMT Profile at Upper 232nd St. Site - Interpreted Geotechnical Parameters

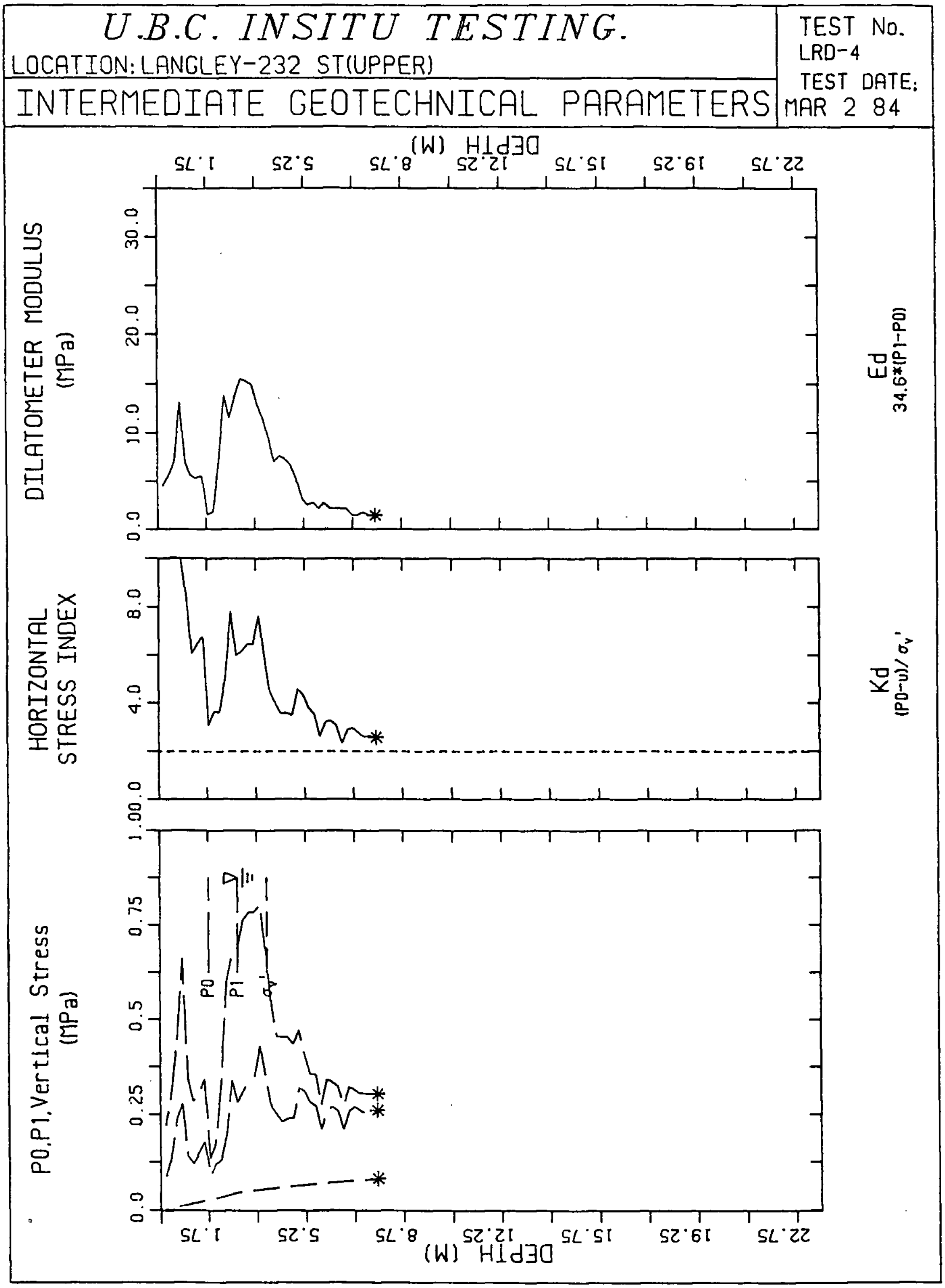


Figure 5.10 DMT Profile at Upper 232nd St. Site - Intermediate Geotechnical Parameters

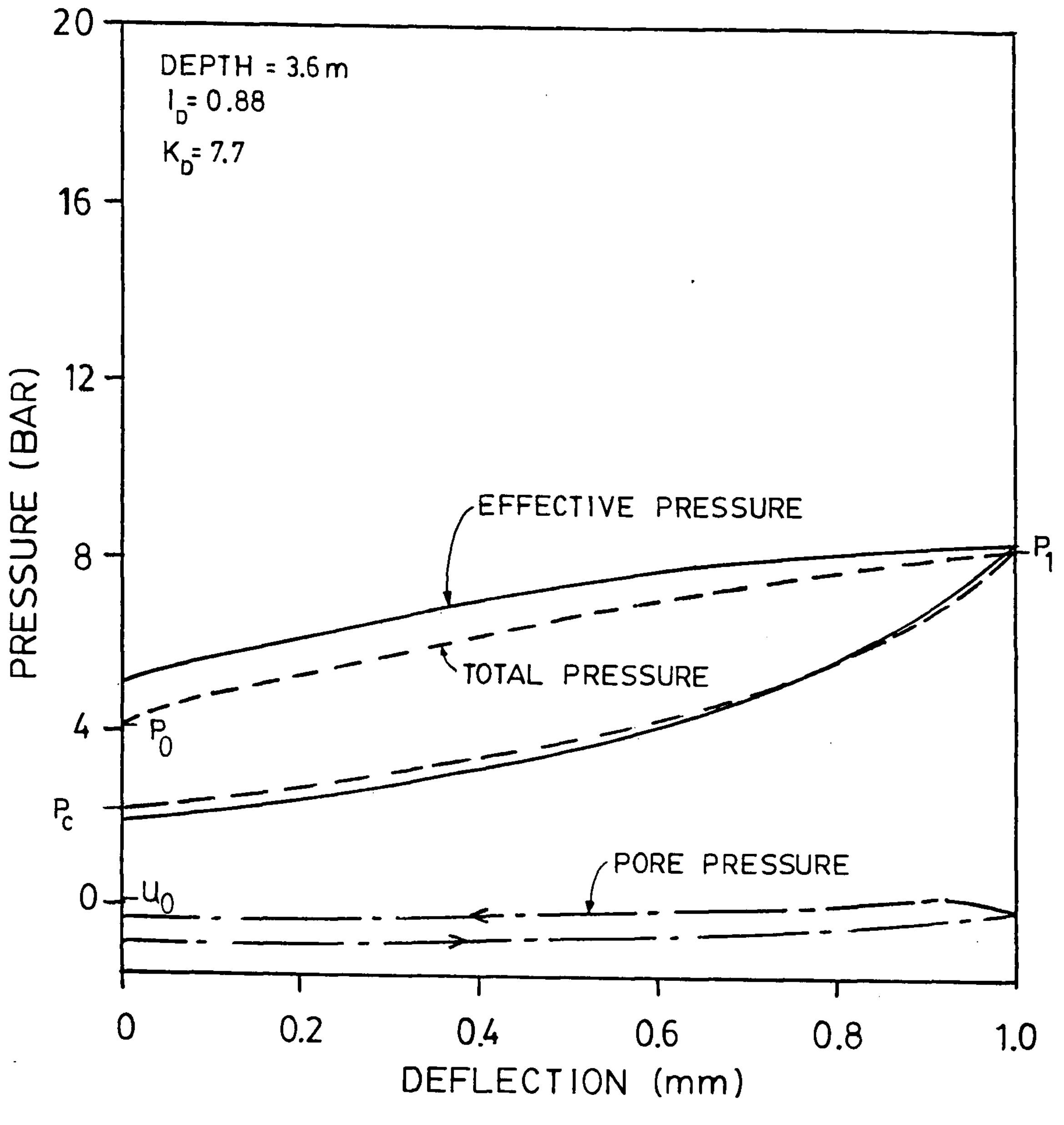


Figure 5.11 Typical Result of Research DMT at Upper 232nd St. Site - Compacted Clay

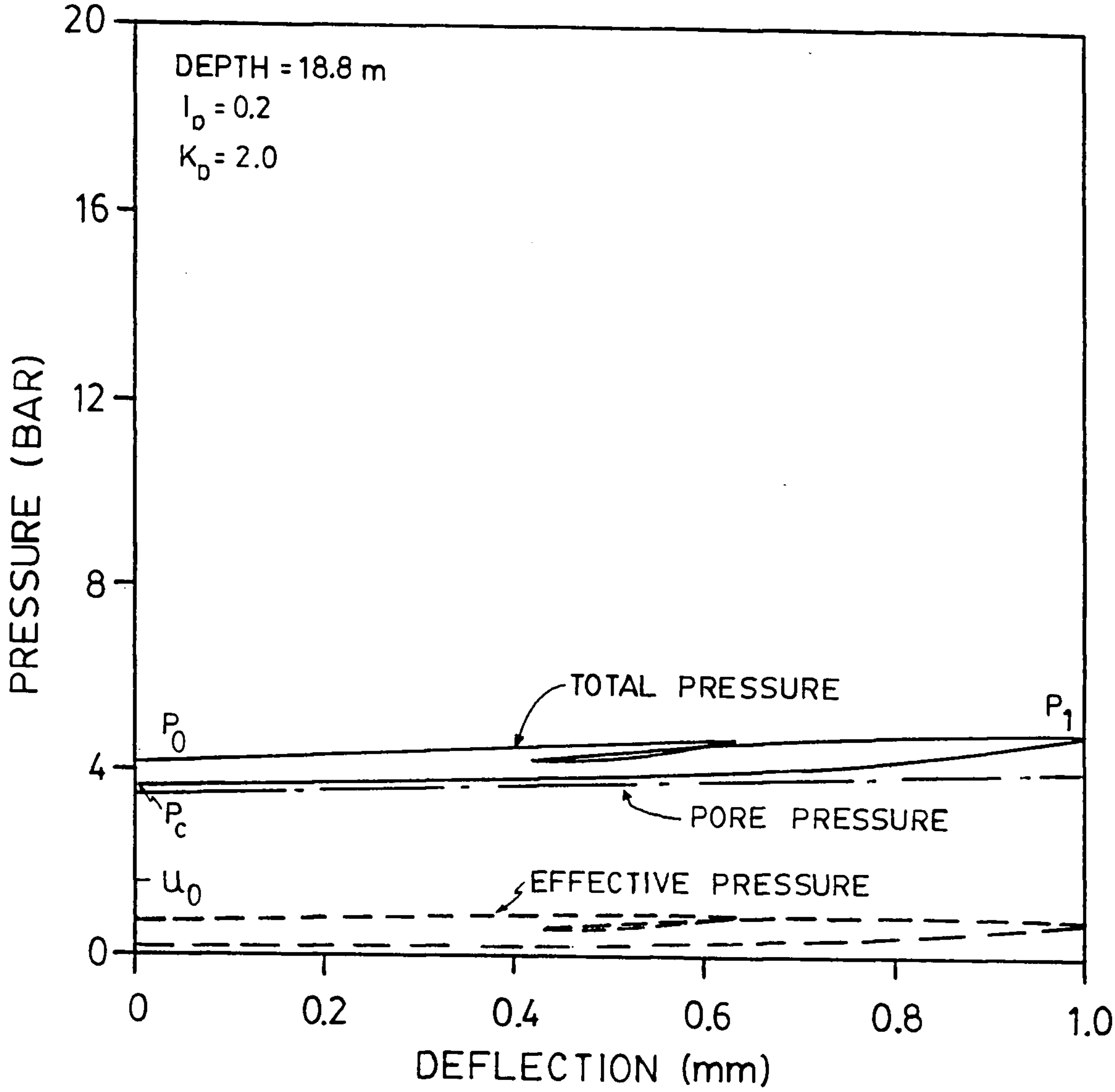


Figure 5.12 Typical Result of Research DMT at McDonald's Farm Site - Clayey Silt

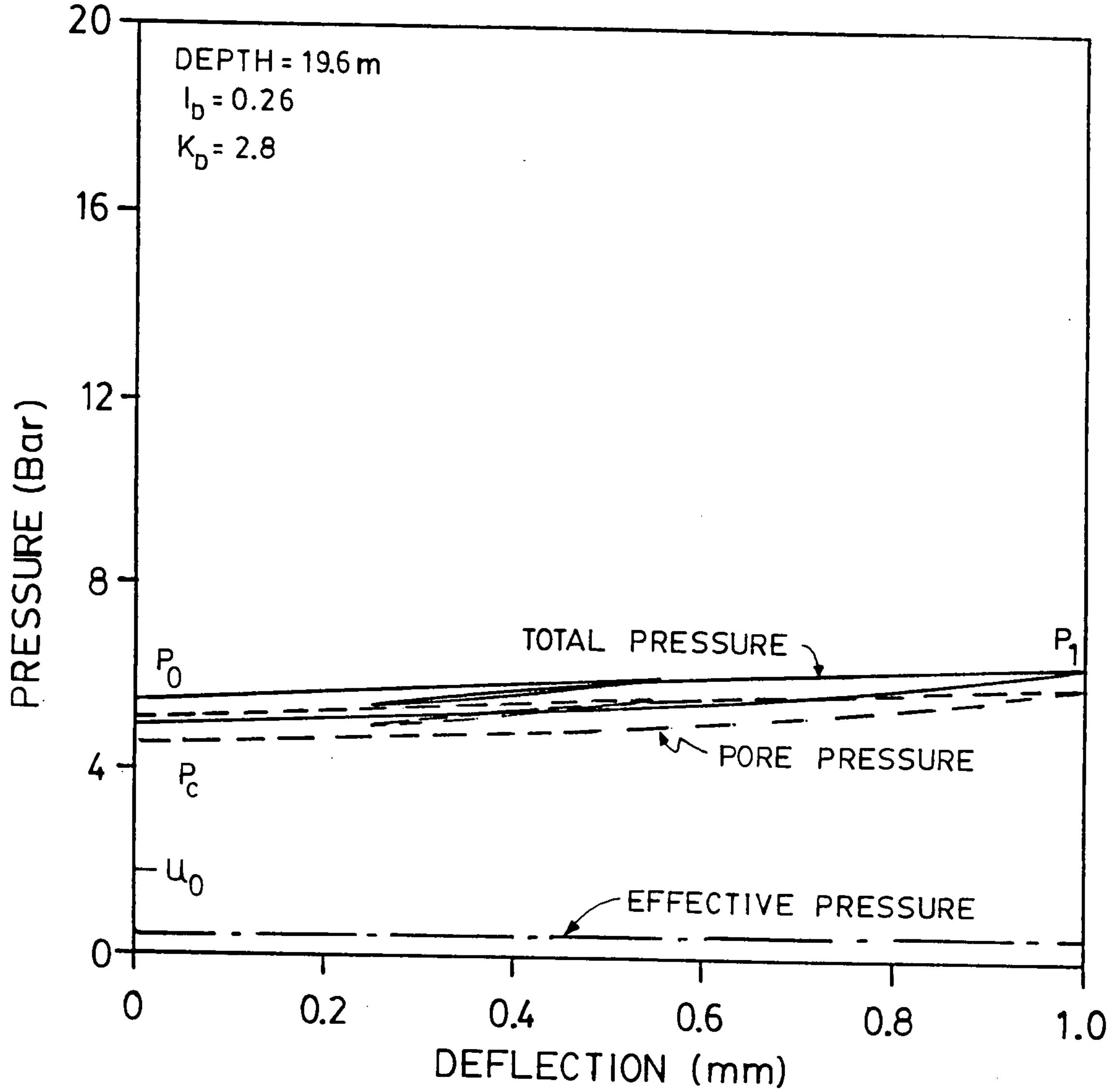


Figure 5.13 Typical Result of Research DMT at Lower 232nd St. Site - Silty Clay

expansion is much larger when comparing with the results in slightly overconsolidated to normally consolidated soft clayey deposits.

The results in the slightly overconsolidated to normally consolidated soft clayey deposits show that very large excess pore pressures are generated and that the effective stresses are very small during both the penetration and expansion phases of the tests. Though the deformation characteristics are similar for the deposits at the Langley sites and McDonald's Farm, they are not exactly the same.

Typical results at McDonald's Farm show that the effective stress adjacent to the center of the membrane increases slightly during the expansion and drops to a very small value, almost equal to zero, at closure. The pore pressure next to the membrane also increases slightly during the expansion phase, and decreases during unloading.

Typical test results in Langley show that the effective stress appears to remain unchanged throughout the pressure expansion and unloading phase of the test. The increase and decrease in total stress applied on the membrane is equally matched by an increase and decrease in the pore pressure.

The clayey silt deposit at McDonald's Farm has an average plasticity index (PI) value of 15 and average sensitivity of 5. It is not expected that the deformation characteristics of this material would have an identical behaviour of the soft silty clay at Langley which has a PI value of about 24 and sensitivity value of about 11.

Cavity expansion theories have shown that a limit pressure exists for undrained cavity expansion in soft clays. It appears that the penetration process during a DMT in soft clay is sufficient to induce pressures equivalent to some limit pressure. Because of the stress relief phenomena due to the location of the membrane relative to the blade tip, the lift-off pressure P_0 is less than the limit pressure. However, the expansion of 1mm would tend to re-establish the limit pressure. The shape of the pressure expansion curves obtained by the research dilatometer is therefore remarkably similar to the latter section of the pressure expansion curves from pressuremeter tests in soft clayey deposits.

Figure 5.14 and figure 5.15 give a comparison of the pressure measured at 1mm from dilatometer tests (P_1) to the limit pressures measured at 10% cavity strain from pressuremeter tests (P_L) at the McDonald's Farm site and Langley's B.C. Hydro Railway site, respectively. The P_1 values are slightly less than the P_L values at McDonald's

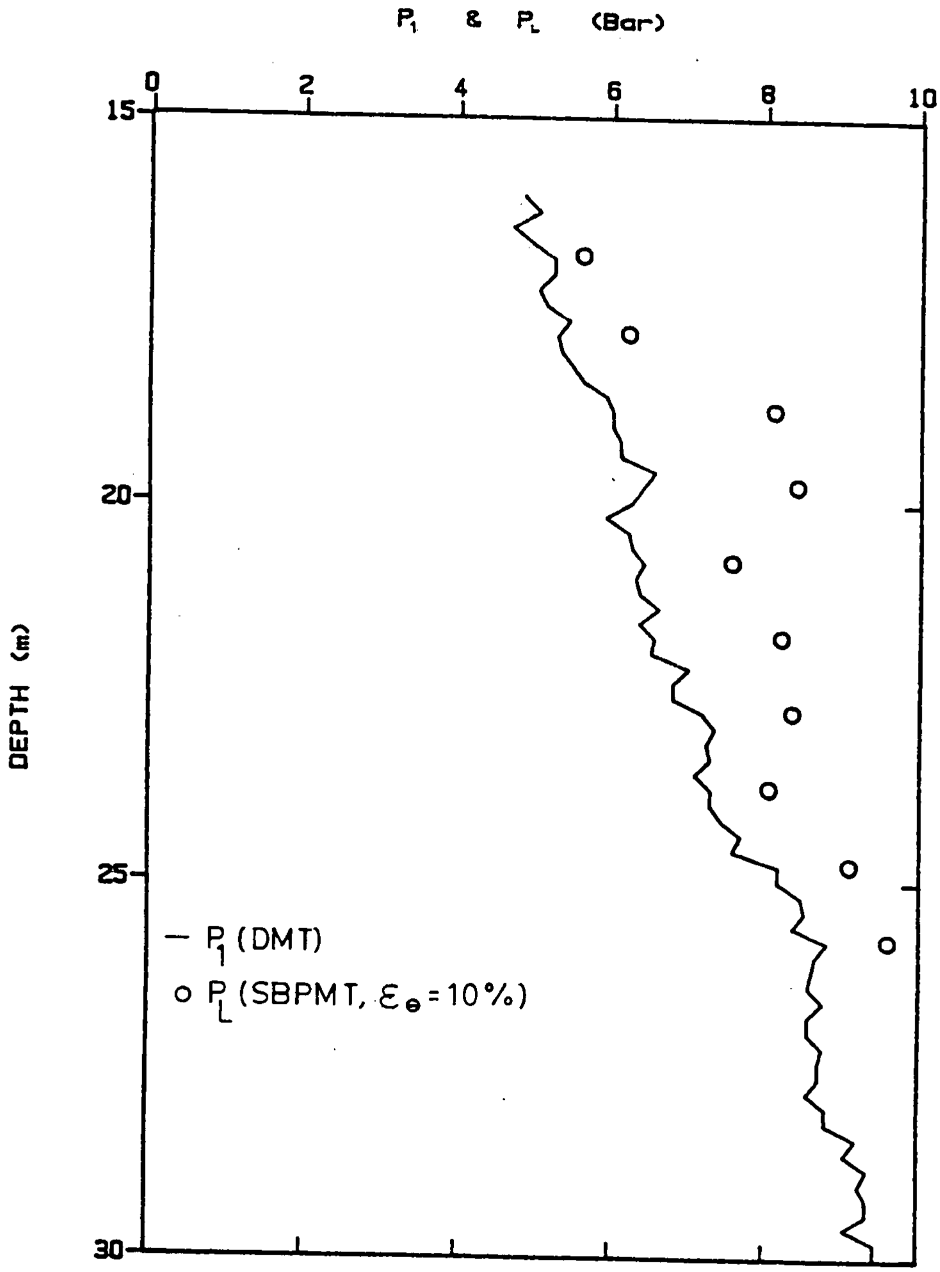


Figure 5.14 Comparison of P_1 and P_L at McDonald's Farm Site

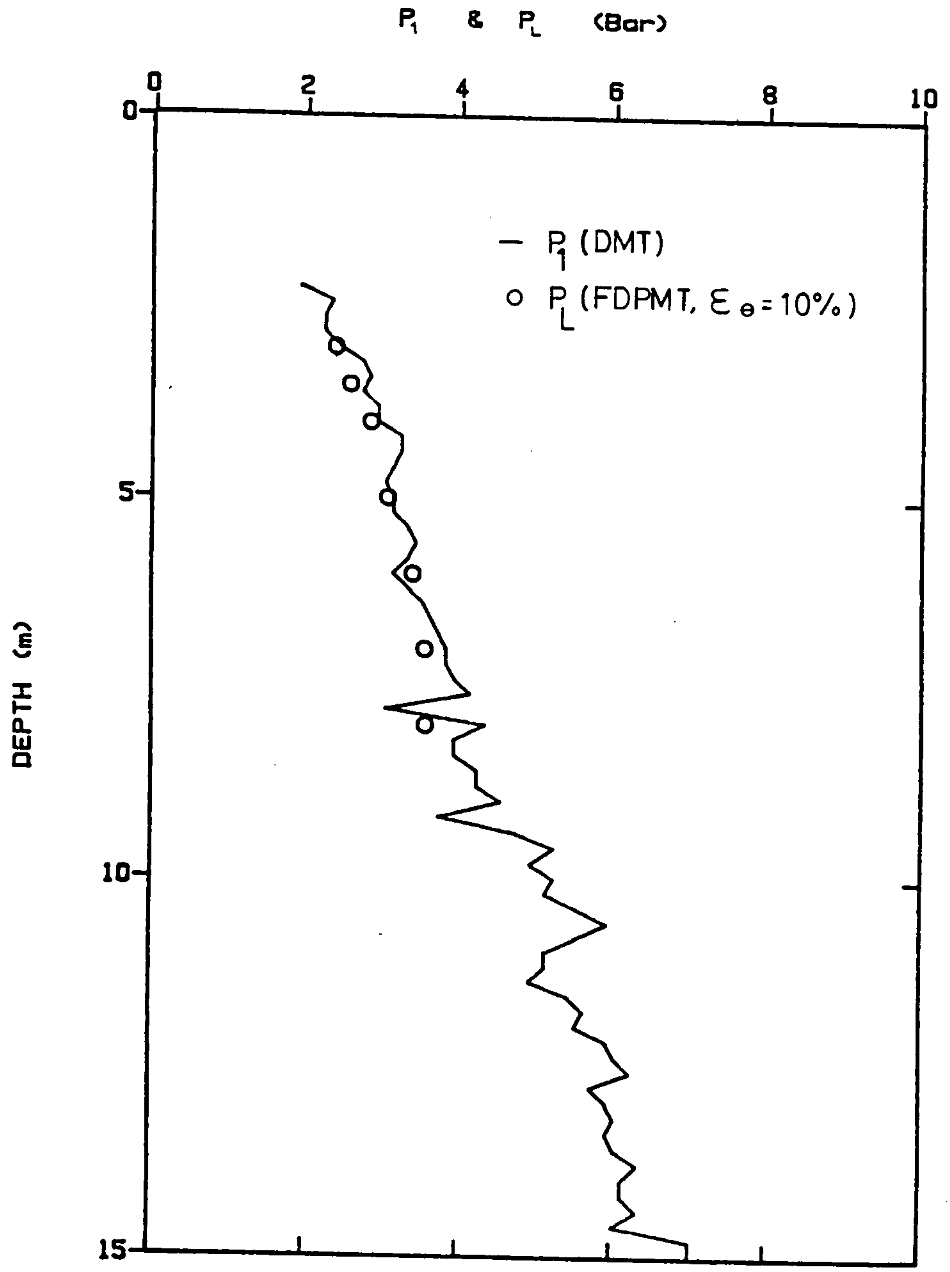


Figure 5.15 Comparison of P_1 and P_L at Langley Railway Site

Farm, but both are almost identical at Langley.

Also, it is interesting to note that the total pressure recorded as the membrane returned to its closed position is almost the same as the initial pore pressure at the start of the expansion test in slightly overconsolidated to normally consolidated soft clayey deposits. This is due to the fact that either the effective stress appears to remain unchanged throughout the test or the effective stress drops to almost zero at closure of the membrane. Therefore, it may be possible to estimate the initial pore pressure around the membrane immediately after penetration by recording the closing pressure when using Marchetti's standard dilatometer. This observation will be further illustrated in Section 5.4.

5.4 Pore Pressure Measurements

The results obtained with the research DMT shows that the pore pressure generated during the DMT penetration phase is very similar to that generated during the cone penetration test. Large pore pressures are generated in soft slightly overconsolidated to normally consolidated clay deposits and low or negative pore pressures are generated in stiff deposits with high over-consolidation ratio. The pore pressure measurements obtained during penetration of the research dilatometer and a piezometer cone at the four site studied are presented in figures 5.16 to 5.19.

The pore pressures recorded by the cone were measured just behind the cone tip which are generally smaller than the pore pressures measured on the face of the tip. The pore pressures recorded by the research dilatometer were measured on the center of the membrane. When comparing the two different pore pressure measurements recorded by the cone and dilatometer, it is observed that the pore pressure obtained by the research dilatometer are generally smaller than the pressure obtained by the cone.

Boghrat (1982) indicated that the volumetric strain and shear strain observed around the dilatometer during penetration were appreciably lower and more uniform than those occurring around the penetrating cone tip. On the basis of this observation, Boghrat concluded that the disturbance of the soil around the dilatometer is much less than that around the cone. However, Jamiolkowski et al (1985) reported that their experience had been somewhat different and that their dilatometer and cone results were very similar; hence the same level of disturbance might be expected. This writer feels that the level of soil disturbance around the dilatometer and the cone would depend on the stiffness, sensitivity and plasicity of the tested soil deposits and that this is the reason why the pore pressure recorded by the cone is larger than that by the

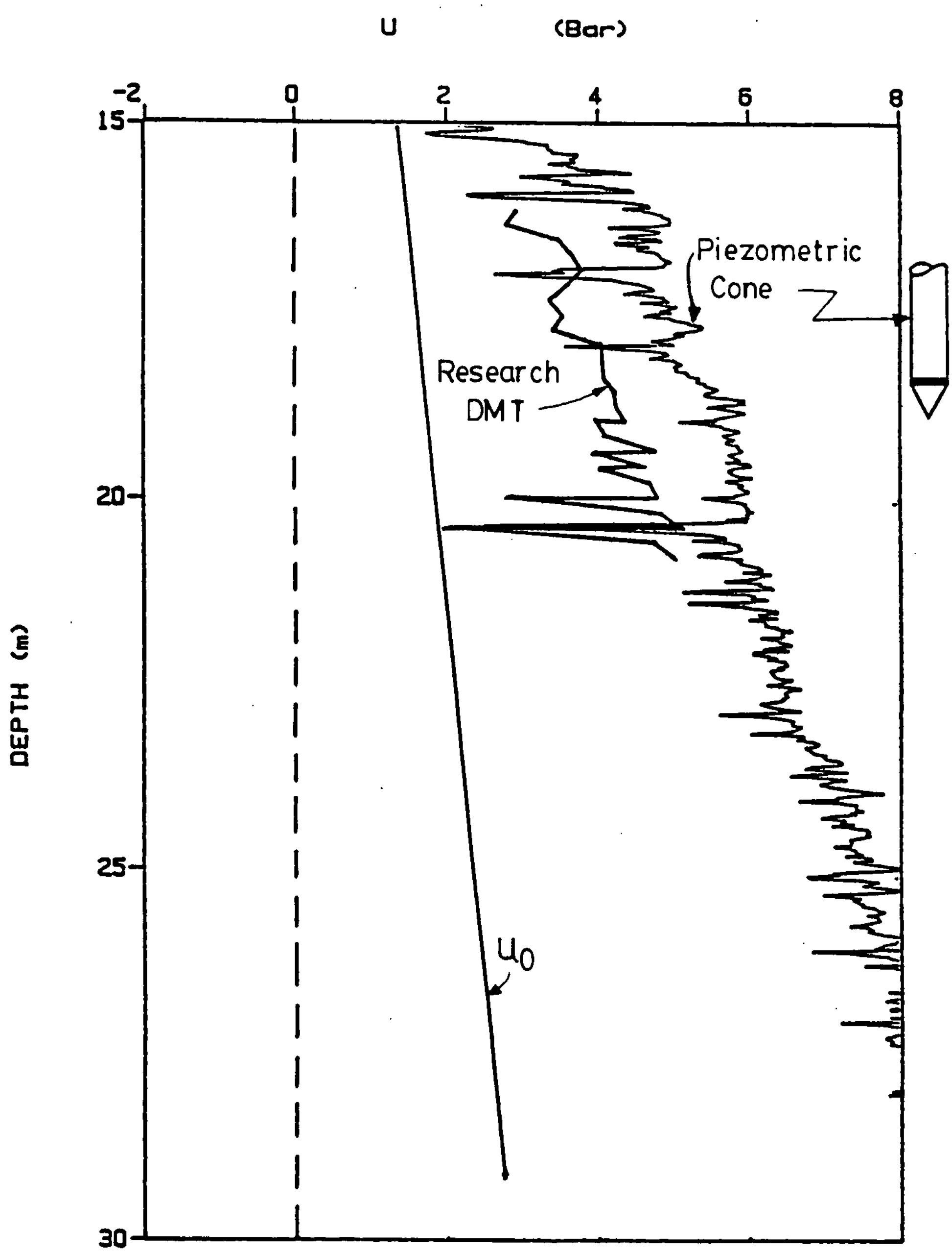


Figure 5.16 Pore Pressure During Penetration of Dilatometer and Cone Testings at McDonald's Farm Site

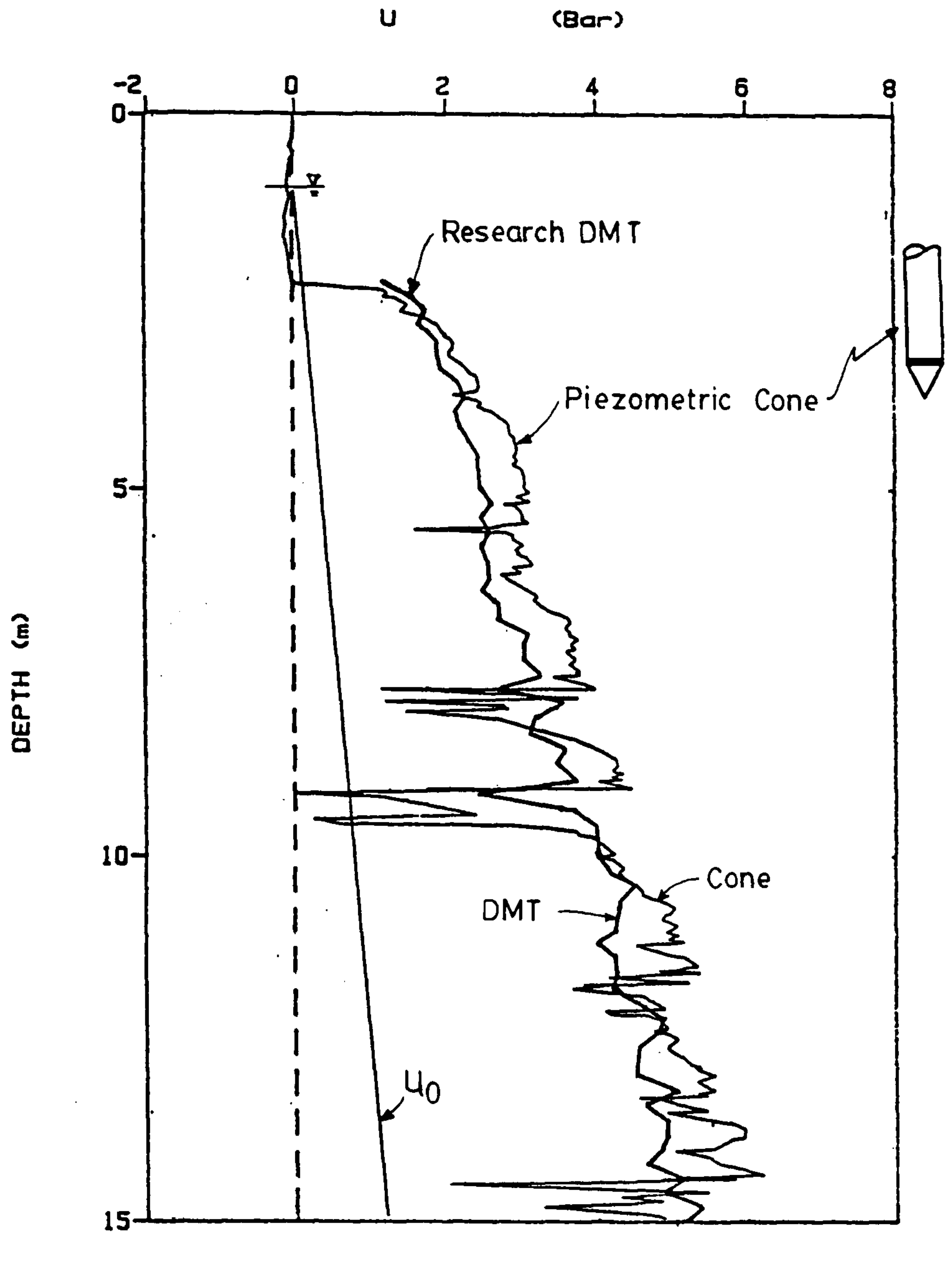


Figure 5.17 Pore Pressure During Penetration of Dilatometer and Cone Testings at Langley Railway Site

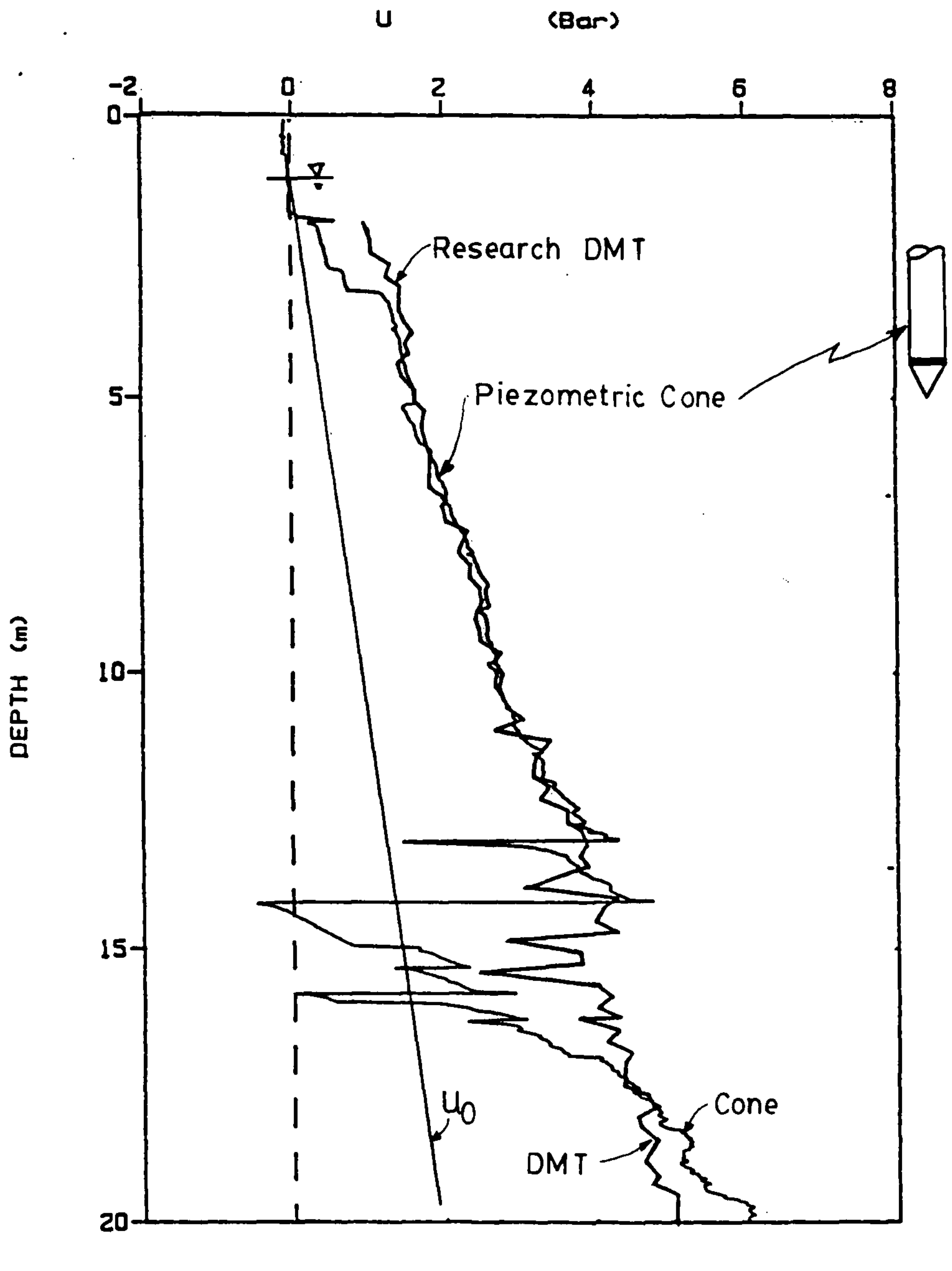


Figure 5.18 Pore Pressure During Penetration of Dilatometer and Cone Testings at Lower 232nd St. Site

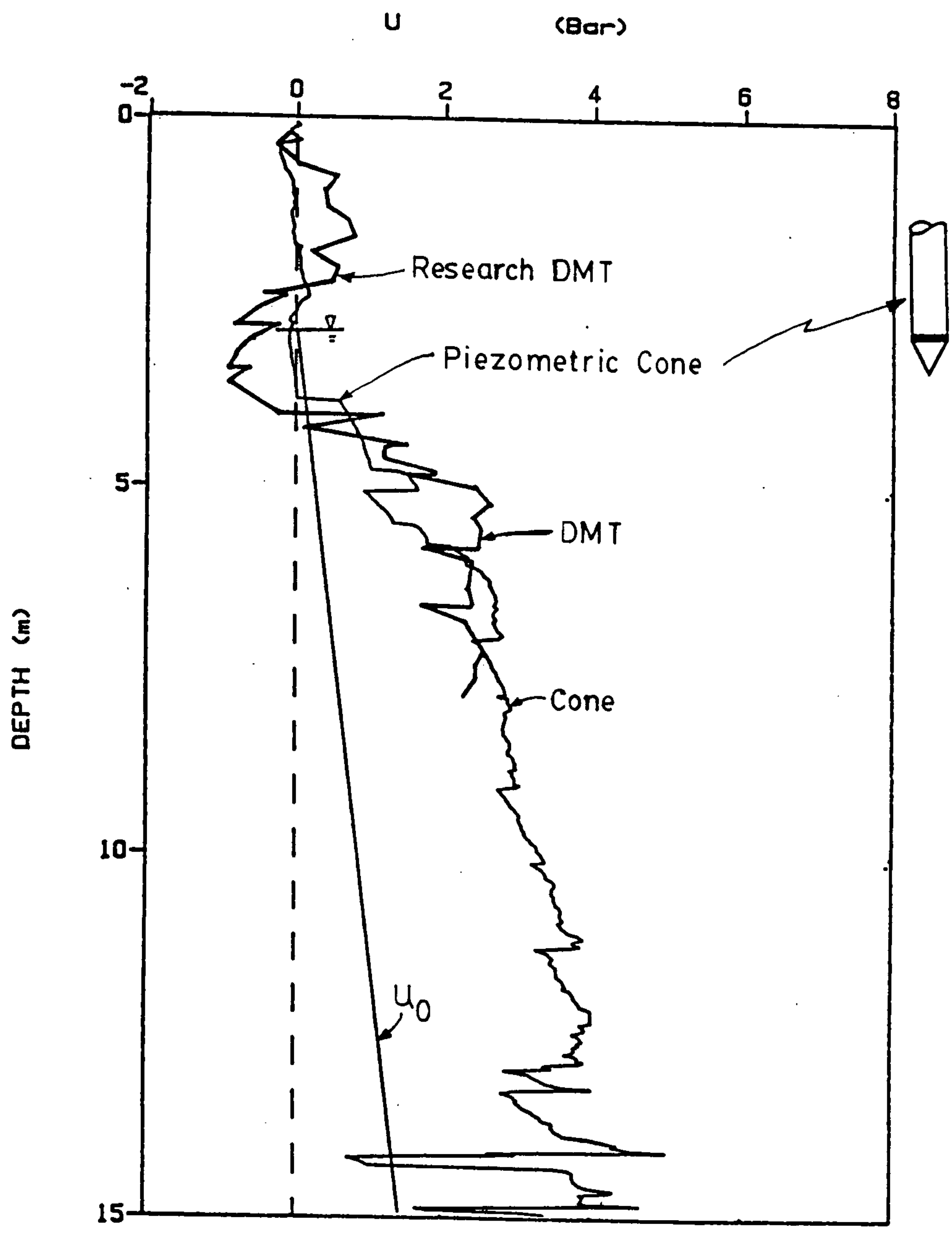


Figure 5.19 Pore Pressure During Penetration of Dilatometer and Cone Testings at Upper 232nd St. Site

dilatometer at McDonald's Farm and why the two measurements are almost identical at the Langley sites where sensitivity and PI values of the soil are much higher. Soil with high sensitivity will reach its failure state even under a very small disturbance.

Figure 5.20 presents the pore pressure dissipation phenomena around the research dilatometer and a piezometer cone, immediately after penetration, at McDonald's Farm. Figure 5.21 presents the same results in percentage of dissipation. The results of dissipation tests show that the rate of dissipation of excess pore pressure is slower around the flat dilatometer than around the cone, though the pore pressure generated next to the membrane is smaller. Time for 50% dissipation for the DMT is approximately twice that of a $10cm^2$ cone. The slower rate of dissipation around the dilatometer is probably related to the shape of the flat dilatometer blade.

When studying the soil deformation characteristics in Section 5.3, it was observed that the total pressure recorded at closure (P_C) in slightly overconsolidated to normally consolidated soft clayey deposits was very close to the initial pore pressure around the membrane before expansion (ie. the pore pressure during penetration). Figures 5.22 to 5.25 further illustrate this observation by comparing the pore pressure recorded by the research

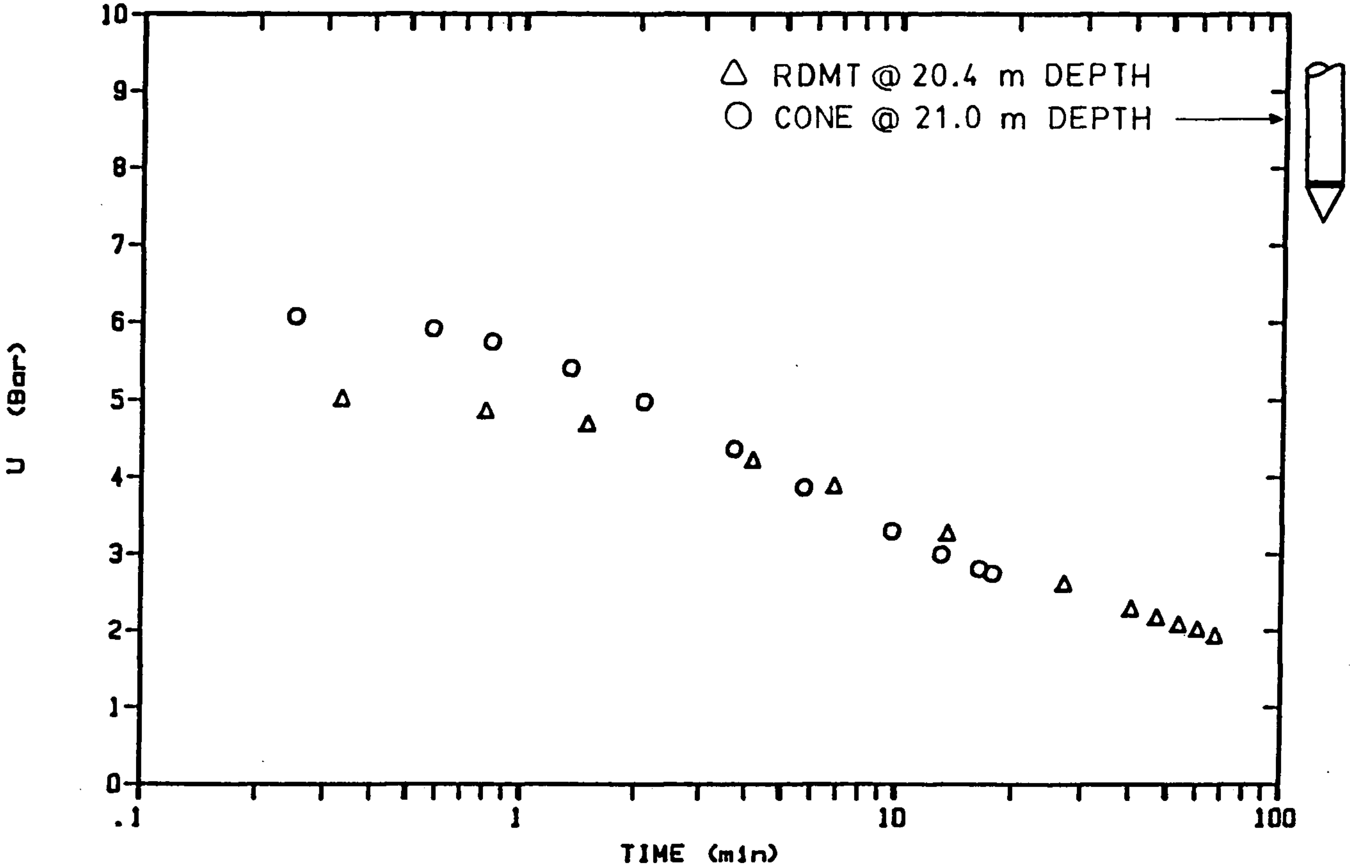


Figure 5.20 Dissipation of Pore Pressure Around Research Dilatometer and Piezometric Cone at McDonald's Farm Site

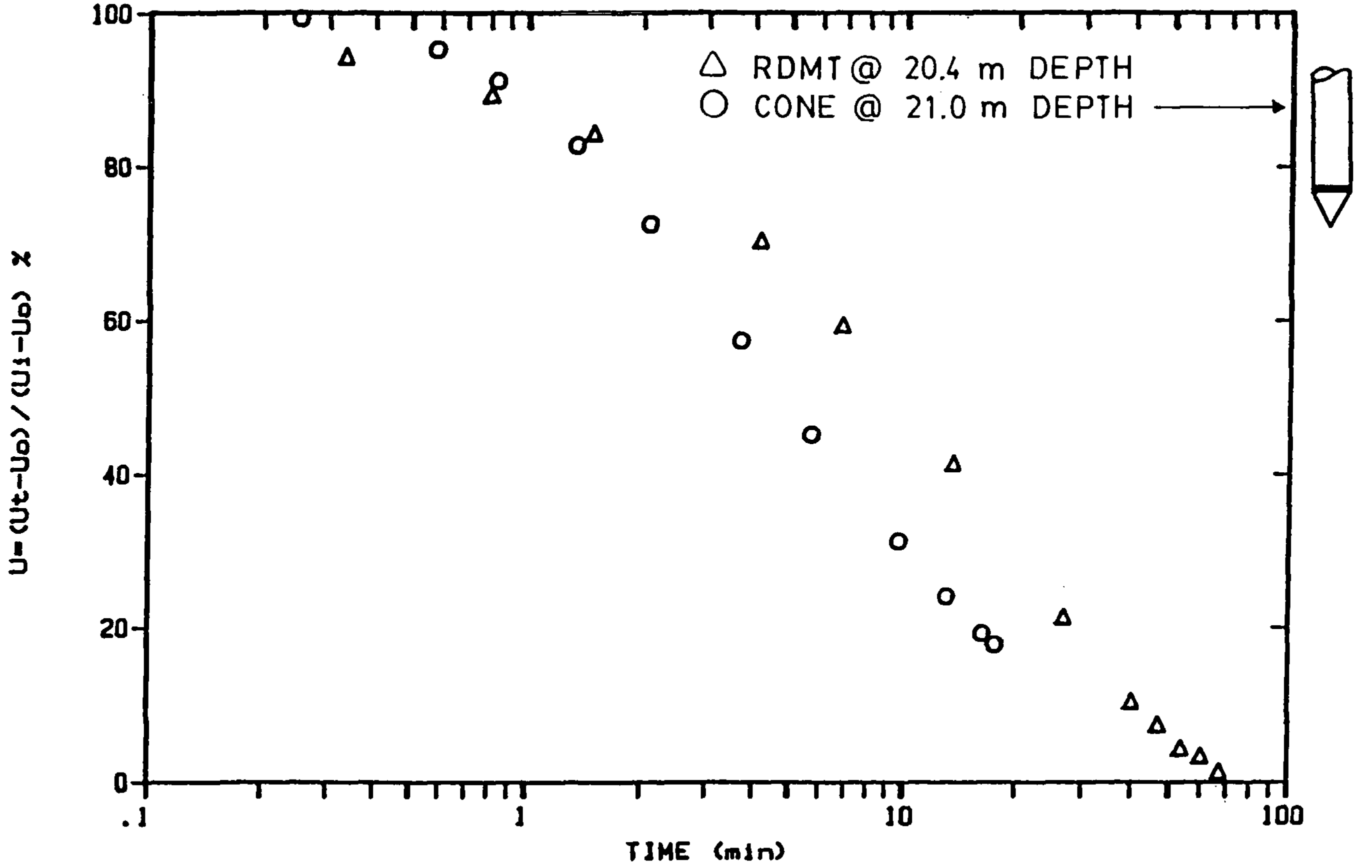


Figure 5.21 Degree of Dissipation Around Research Dilatometer and Piezometric Cone At McDonald's Farm Site

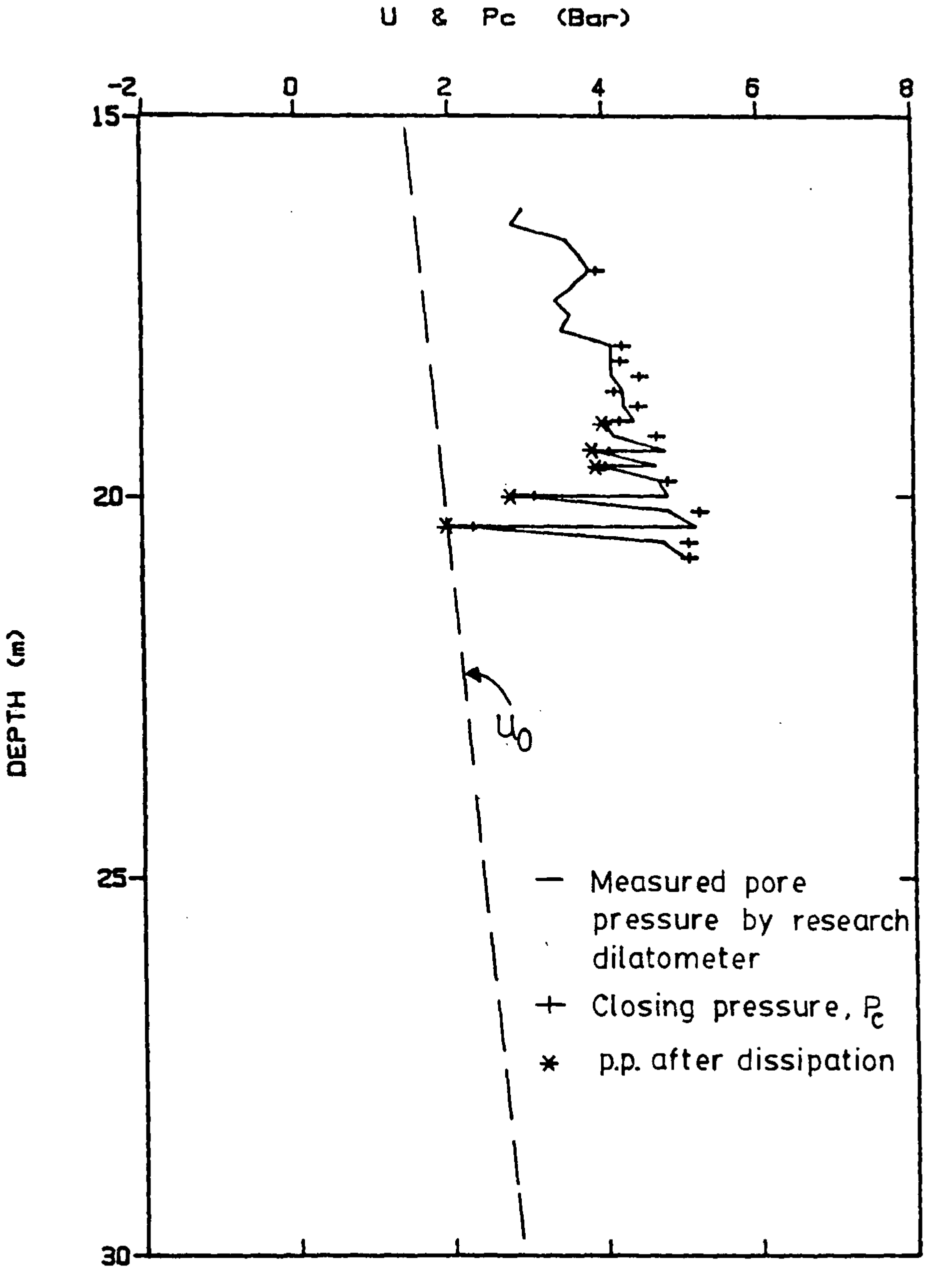


Figure 5.22 Comparison of Closing Pressure and Pore Pressure During Penetration of Dilatometer at McDonald's Farm Site

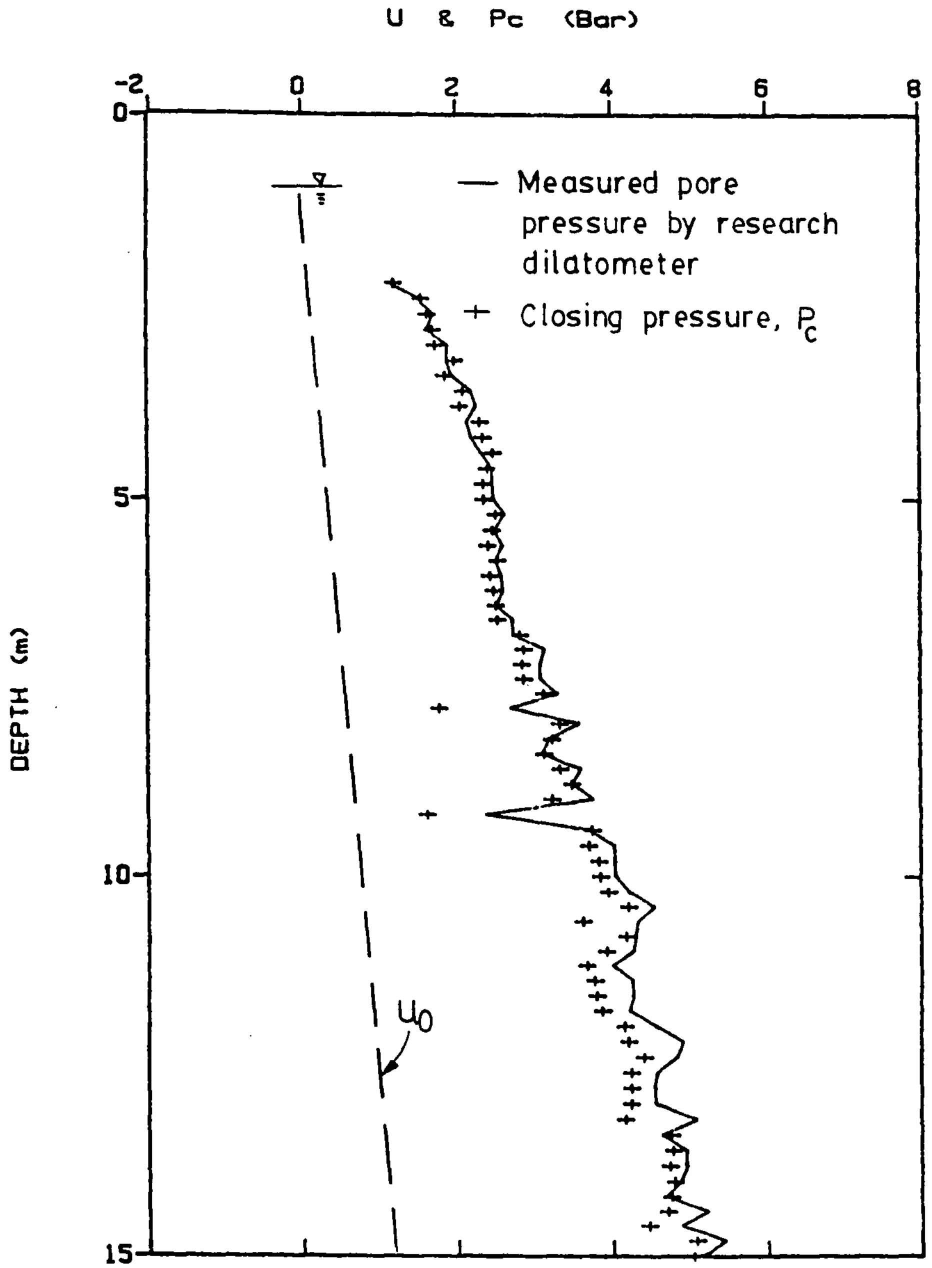


Figure 5.23 Comparison of Closing Pressure and Pore Pressure During Penetration of Dilatometer at Langley Railway Site

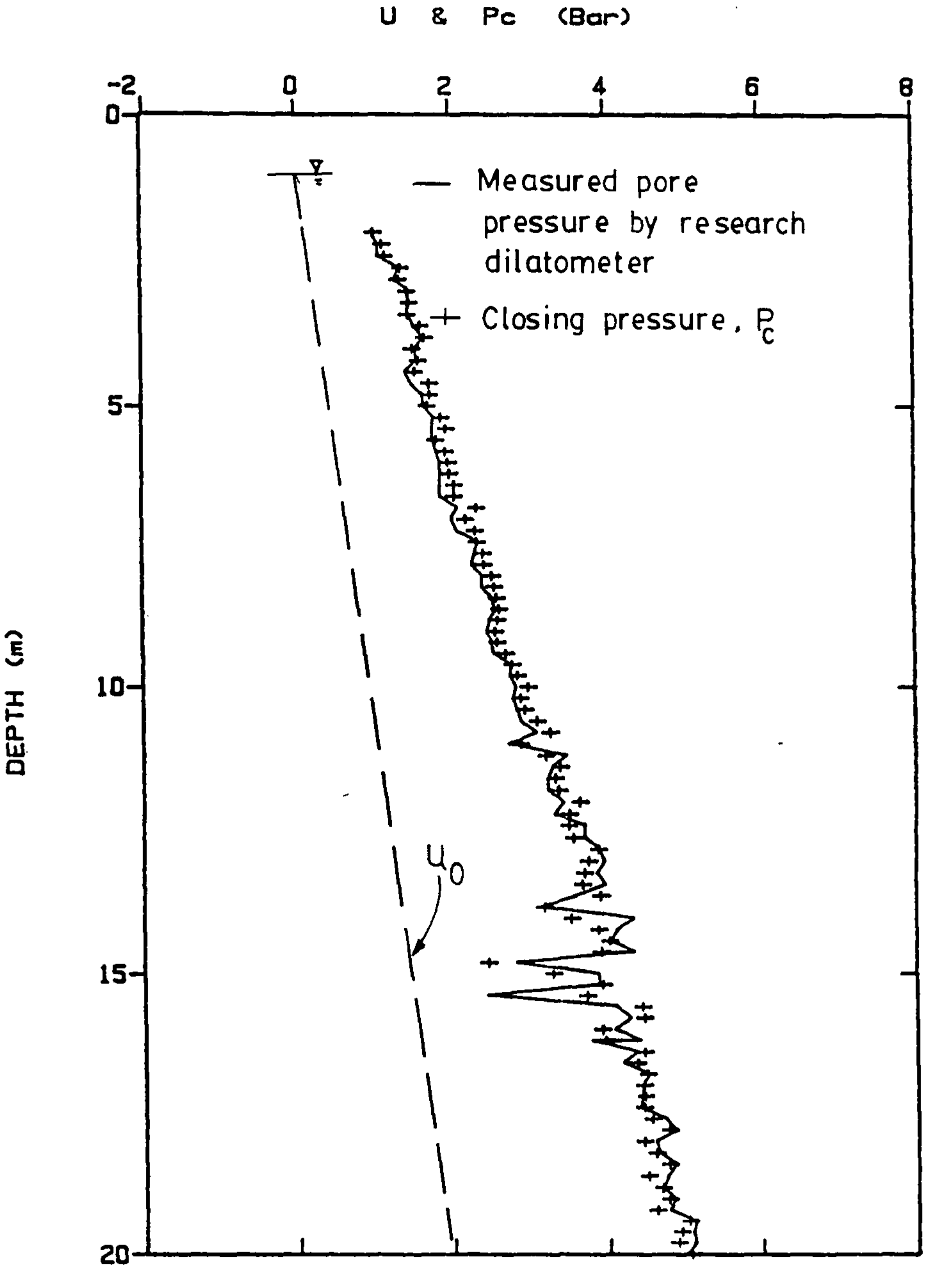


Figure 5.24 Comparison of Closing Pressure and Pore Pressure During Penetration of Dilatometer at Lower 232nd St. Site

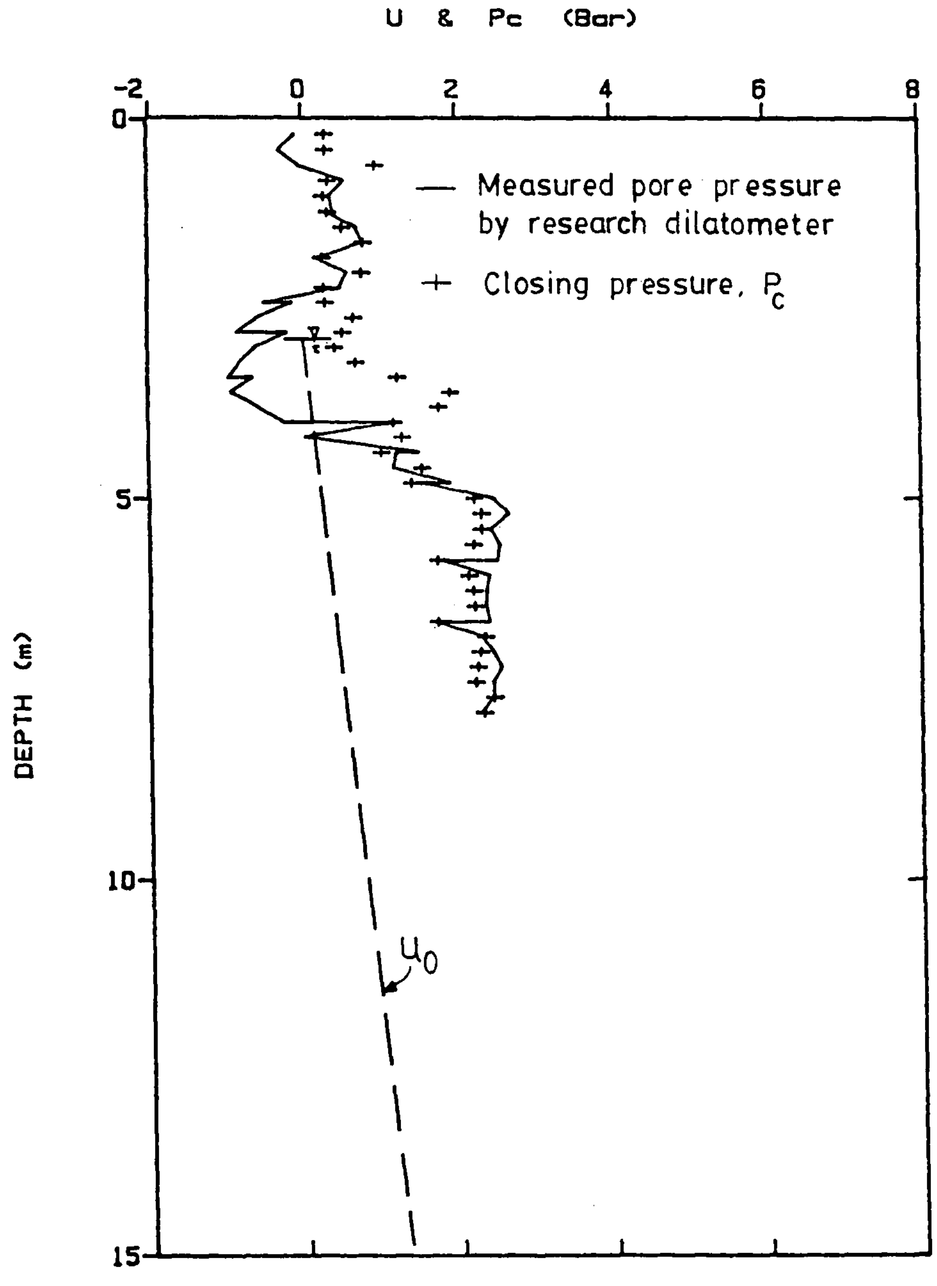


Figure 5.25 Comparison of Closing Pressure and Pore Pressure During Penetration of Dilatometer at Upper 232nd St. Site

dilatometer during penetration with the total pressure measured at closure, P_c, at each of the four studied sites.

The results in figures 5.22 to 5.25 and the results in figures 4.5 and 4.6 clearly show that, for the clean sand and soft clayey deposits tested, the DMT closing pressures (P_c) are very similar to the DMT penetration pore pressures and that these are similar to the pore pressures recorded during cone penetration. However, figure 5.25 shows that in stiff highly overconsolidated clayey soils, the measured pore pressures during DMT penetration can be negative and the closing pressure (P_c) highly positive.

5.5 Undrained Shear Strength

The undrained shear strength, Su, of the cohesive deposits at the four research sites have been investigated using the field vane shear test (FV). In addition, the strength of the clayey silt at McDonald's Farm has also been determined using the self-boring pressuremeter test (SBPMT). Figures 5.26 to 5.29 present these results together with the undrained shear strength determined from the DMT using the empirical correlation proposed by Marchetti (1980).

The field vane and self-boring pressuremeter test results produce similar values of Su at McDonald's Farm. The Su profiles determined by the field vane and the dilatometer

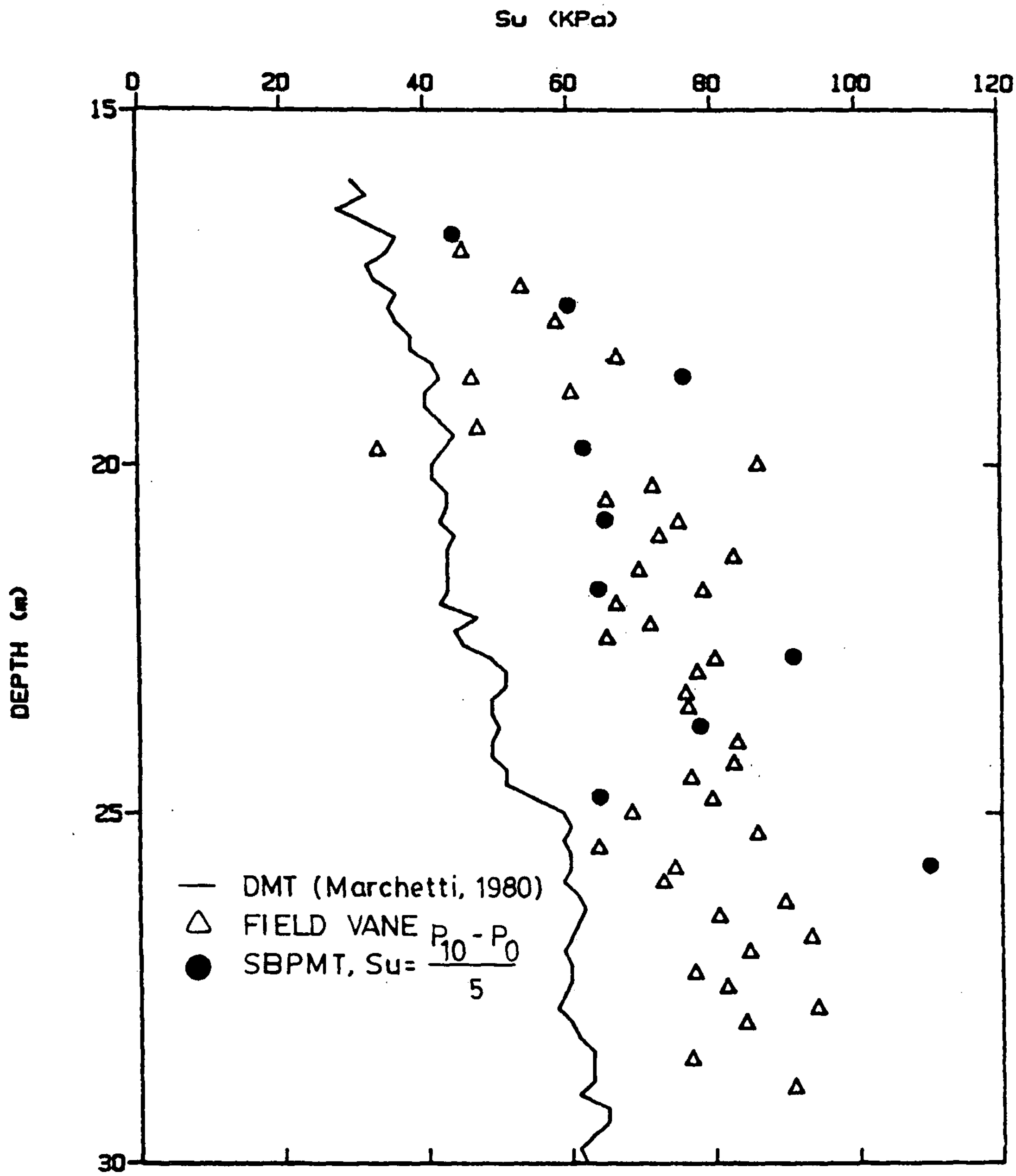


Figure 5.26 Comparison of Undrained Shear Strength From DMT and from Vane Test At McDonald's Farm Site

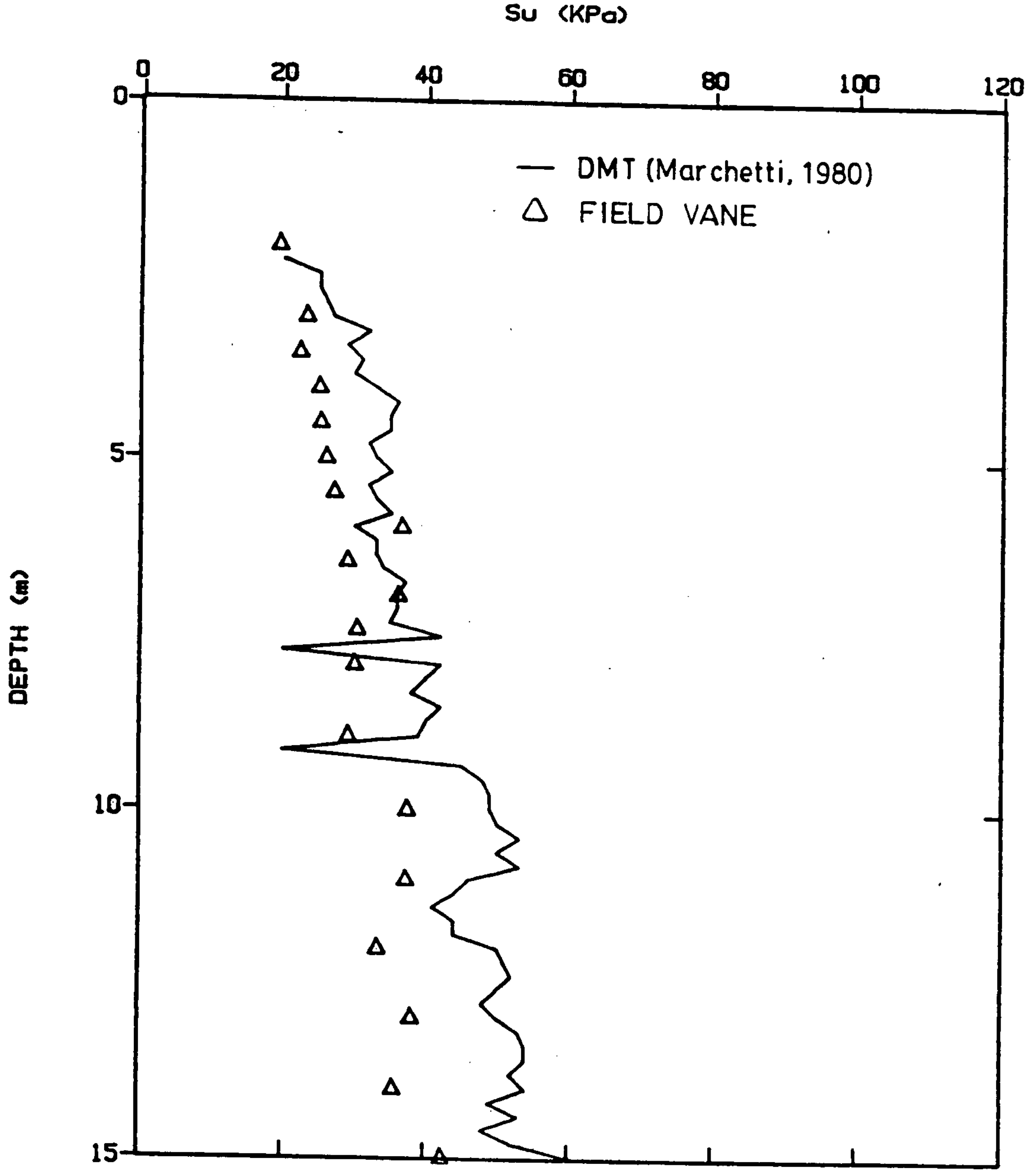


Figure 5.27 Comparison of Undrained Shear Strength From DMT and from Vane Test At Langley Railway Site

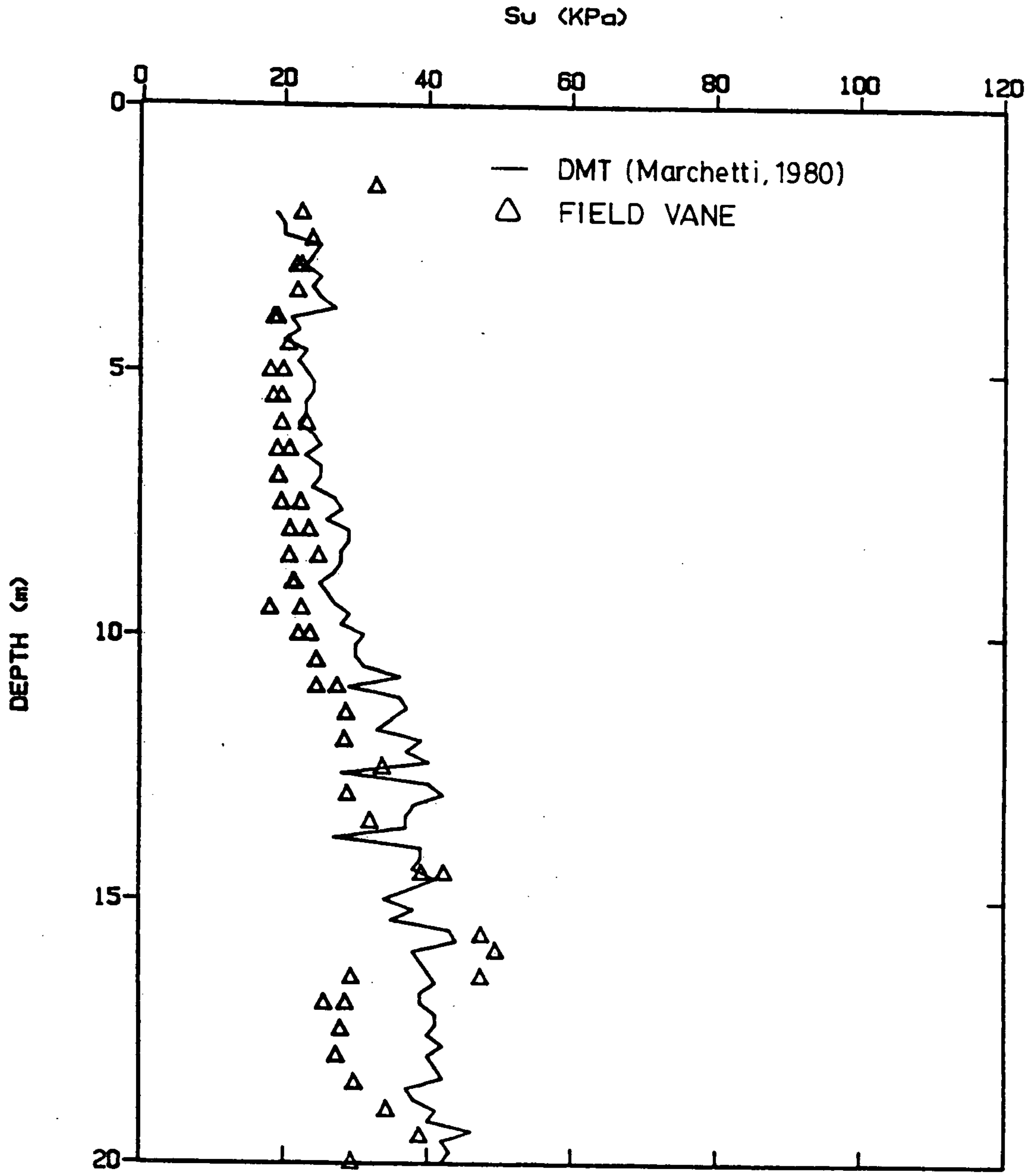


Figure 5.28 Comparison of Undrained Shear Strength From DMT and from Vane Test At Lower 232nd St. Site

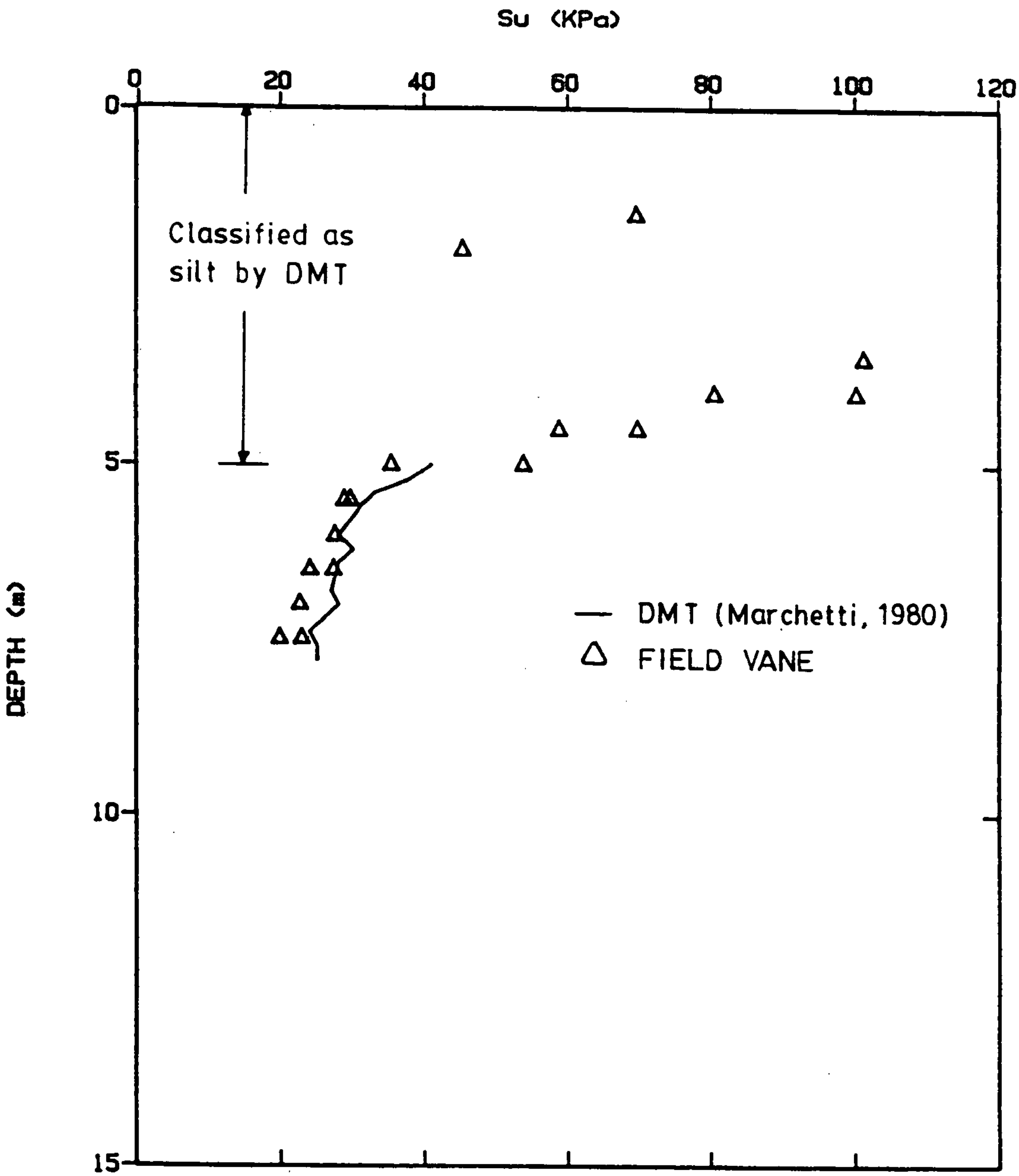
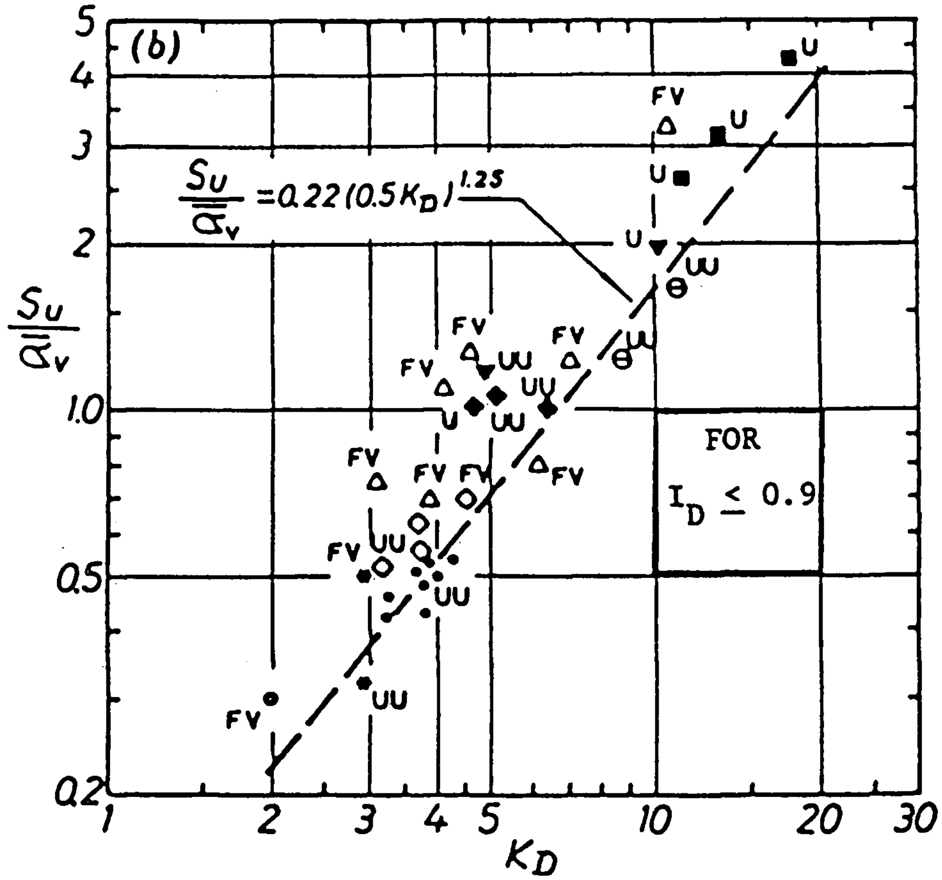


Figure 5.29 Comparison of Undrained Shear Strength From DMT and from Vane Test At Upper 232nd St. Site

are similar at all of the four studied sites. However, the DMT results are small than both the FV and SBPMT values by about 30% at McDonald's Farm and slightly larger than the FV values by about 25% at the three Langley sites. The comparisons shown in figures 5.26 to 5.29 do not give a clear and general picture of how the DMT Su values relate with the undrained shear strengths determined using the field vane.

Figure 5.30 shows Marchetti's (1980) empirical correlation between the Su/σ_v' and the horizontal stress index K_D. The correlation was based on the lower bound of a limited amount of data from field vane shear tests, unconfined compression tests and unconsolidated undrained tests in laboratory. The FV data were mainly from sites which have a sensitivity of about 1 to 3.

It appears that the relationship between Su & K_D might also depend on sensitivity since sensitivity can affect the pore pressure response of the soil at failure which consequently affects the values of P_0 and K_D. If this is the case, this may be the reason why the DMT results underestimated the Su at the McDonald's Farm site which has an average sensitivity of 5, and overestimated the Su at the Langley sites which have an average sensitivity values of 9 and 11 at the railway site and the upper & lower sites, respectively.



△ - FV with sensitivity = 1.5 to 2
◇ - FV with sensitivity = 2 to 3
FV = **Field Vane**
UU = **Undrained Unconsolidated Triaxial**
U = **Unconfined Compression**

Figure 5.30 Correlation between K_D and $Su/\sigma v'$ (Adapted from Marchetti, 1980)

Figure 5.31 presents the relationship between K_D and the Su/σ'_v ratio obtained from the field vane at the four research sites. A very good correlation is observed between the Su/σ'_v and K_D for the clay deposits at Langley. Also, it is interesting to note that there appears a good correlation between the data from McDonald's Farm and the data form the upper 5m of compacted clay at the upper site of Langley, which has a similar average sensitivity value of 5.

In Section 5.3, it has been shown that both P_0 and P_1 are dominated by the pore pressures developed during penetration in soft clayey deposits and are similar to the limit pressure for some form of cavity expansion. It is therefore not surprising that the horizontal stress index, K_D, derived from the measurement P_0, can be correlated to parameters such as undrained shear strength, stiffness and stress history as suggested by Marchetti in his (1980) paper. However, any correlation will not be unique for all soils, since factors such as sensitivity plays an important role.

Figure 5.32 shows both P_0/Su and P_1/Su profiles, using the Su determined by the field vane for the four sites. It is observed that no single factor can apply to determine the undrained shear strength directly either from P_0 or P_1. The two factors are about 10 and are relatively consistant with depth at McDonald's Farm where the clay is normally

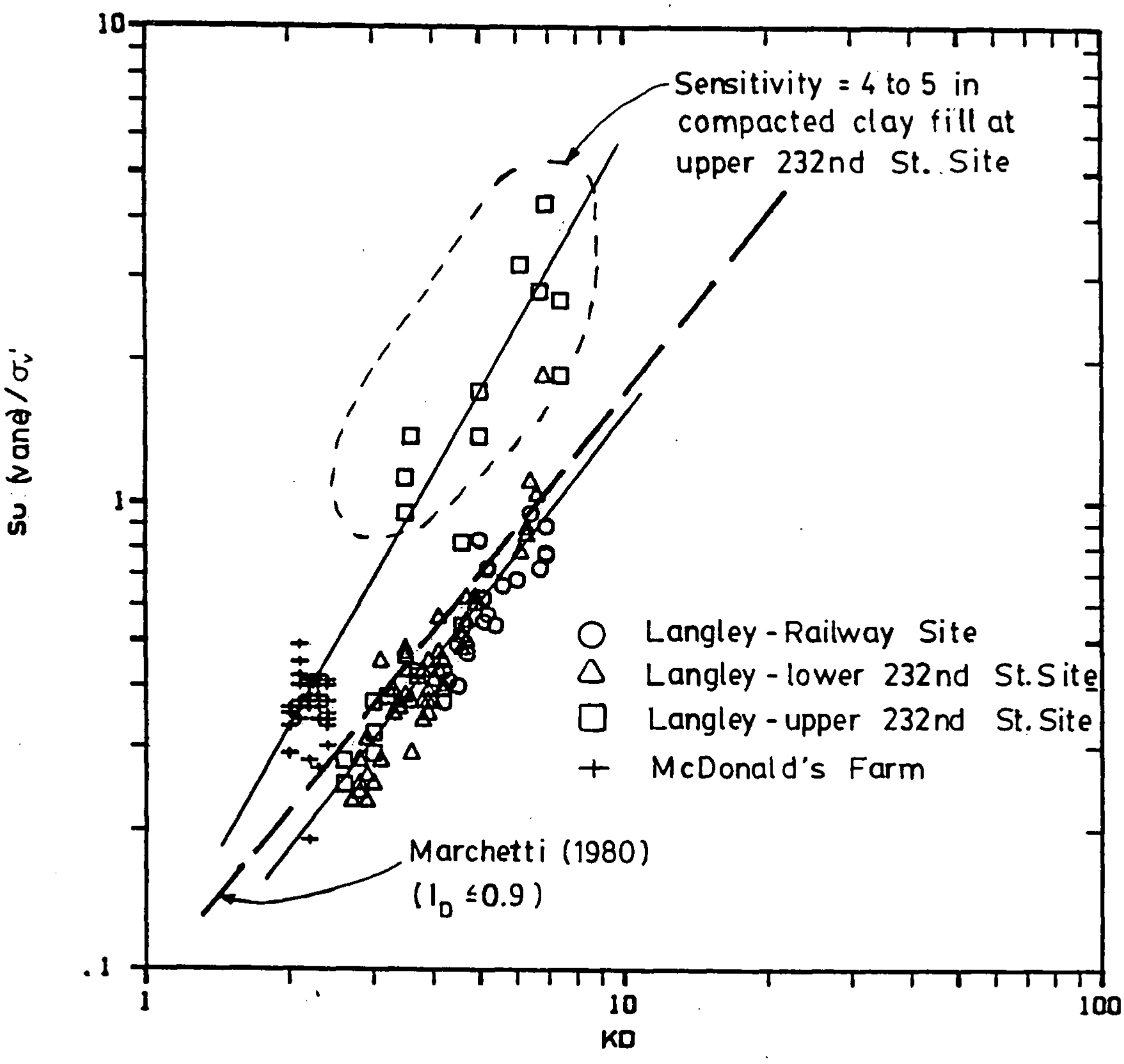


Figure 5.31 Relationship between K_D and Su(vane)/σ_v'

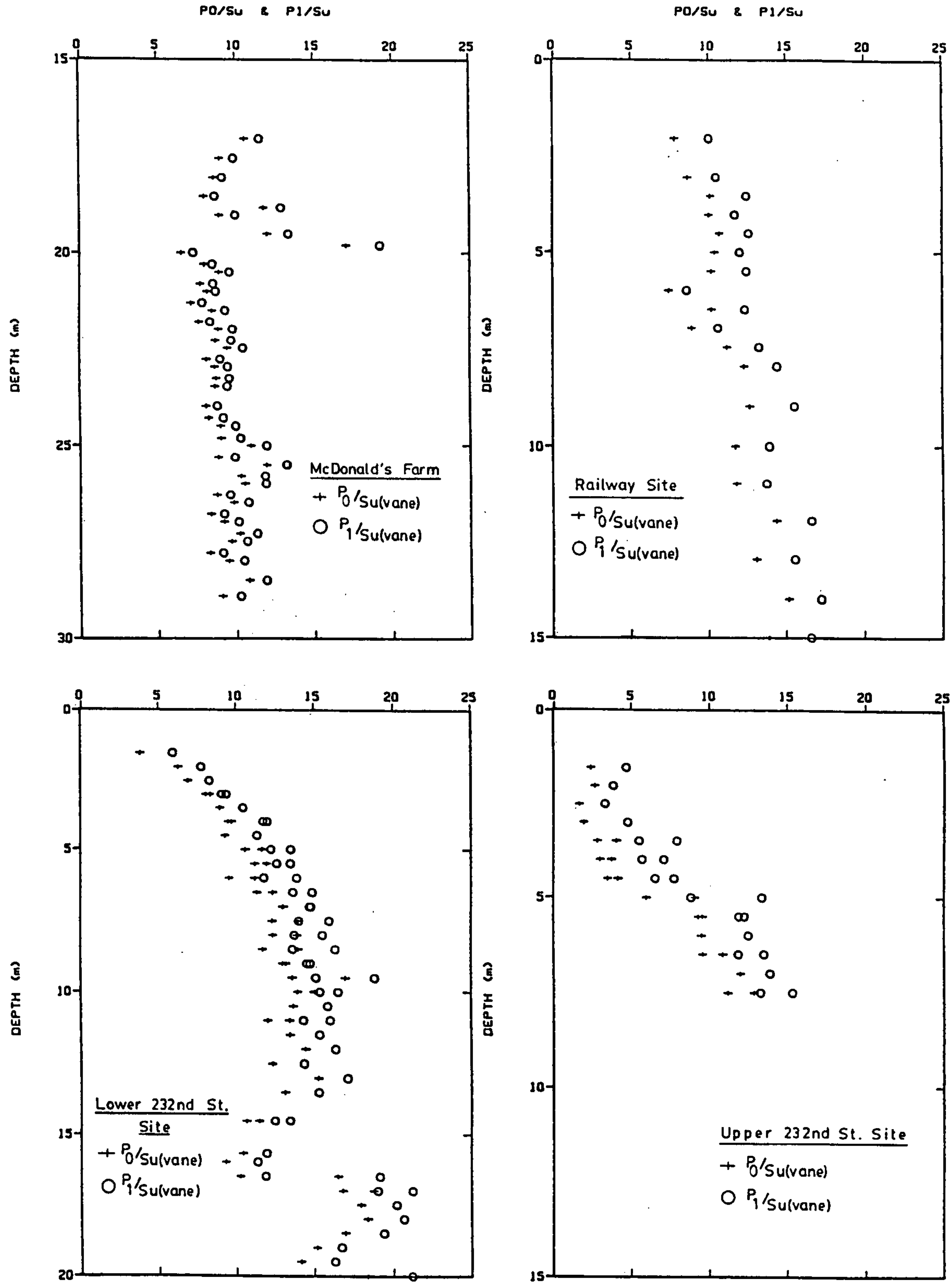


Figure 5.32 P_o/Su(vane) Profiles

consolidated. The factors at the Langley sites range from 5 to 20 and increase with depth as the deposits become slightly overconsolidated to normally consolidated. This observation suggests that the correlations between P_0 & Su and P_1 & Su could also depend on the stress history of the site.

5.6 Shear Modulus

As discussed in Section 4.4 for sands, shear moduli of the cohesive deposits at the four research sites were estimated from the dilatometer modulus, E_D using the equation:

$$G = 0.5*E_D*(1-\mu^2)/(1+\mu) \qquad (5.1)$$

with $\mu = 0.5$ for undrained condition.

Also, shear moduli were determined from unloaded and reload cycles during the expansion phase obtained with the research dilatometer. Details on the assumptions required were given in Section 4.4.

Figure 5.33 presents the computed and measured shear modulus profiles at the four research sites. The G values are in the range of 500 - 1000kPa at McDonald's Farm, and from 300 - 1000kPa with a maximum of approximately 4000kPa at the Langley sites. Theses values, however, are considerably smaller than the G_{max} values determined from

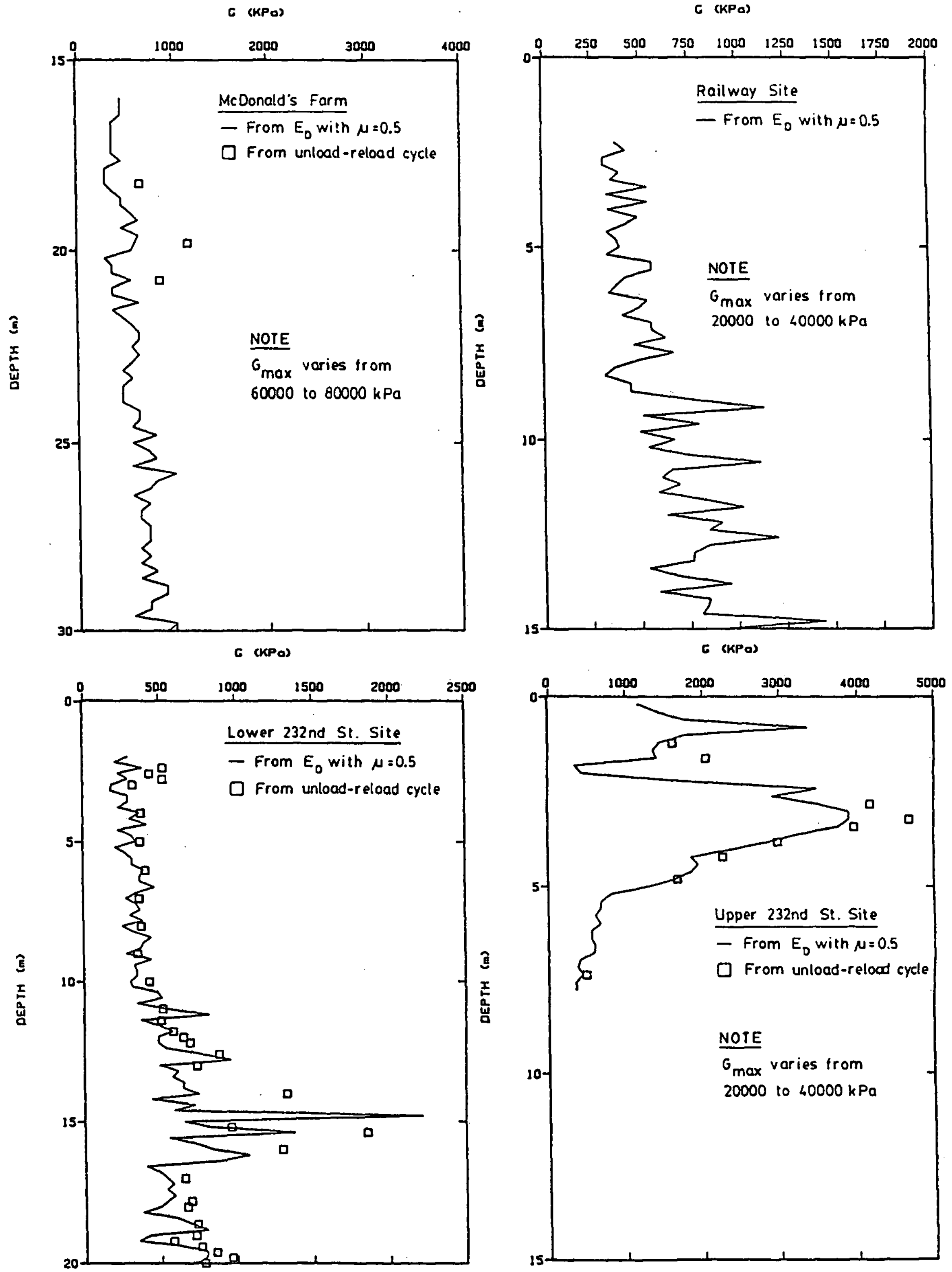


Figure 5.33 Estimated Shear Moduli from E_D and from Unload - Reload Cycle of Dilatometer Expansion Curve

the downhole seismic cone testing. The values of G_{max} at McDonald's Farm are approximately 60MPa at 15m depth and 80MPa at 30m depth. The value of G_{max} at the Langley sites are approximately 20MPa near the ground surface and 40MPa at 15m depth.

The shear modulus calculated from the dilatometer modulus or determined from the unload and reload cycle of the expansion curve is considerably smaller than the measured G_{max}. Since the soft cohesive clayey deposits next to the membrane are sheared to complete failure during penetration, with very large pore pressure generated and almost zero effective stress, it is not surprising that the membrane expansion test can not give a good estimate of the stiffness of the undisturbed soil.

5.7 OCR and K_0

Figure 5.34 presents the overconsolidation ratios, OCR, predicted by the dilatometer and field vane shear tests at the four sites. The OCR values derived from the FV results were based on Schmertmann's proposed correlation between normalized undrained shear strength ratio and overconsolidation ratio from laboratory tests. (Schmertmann, 1978)

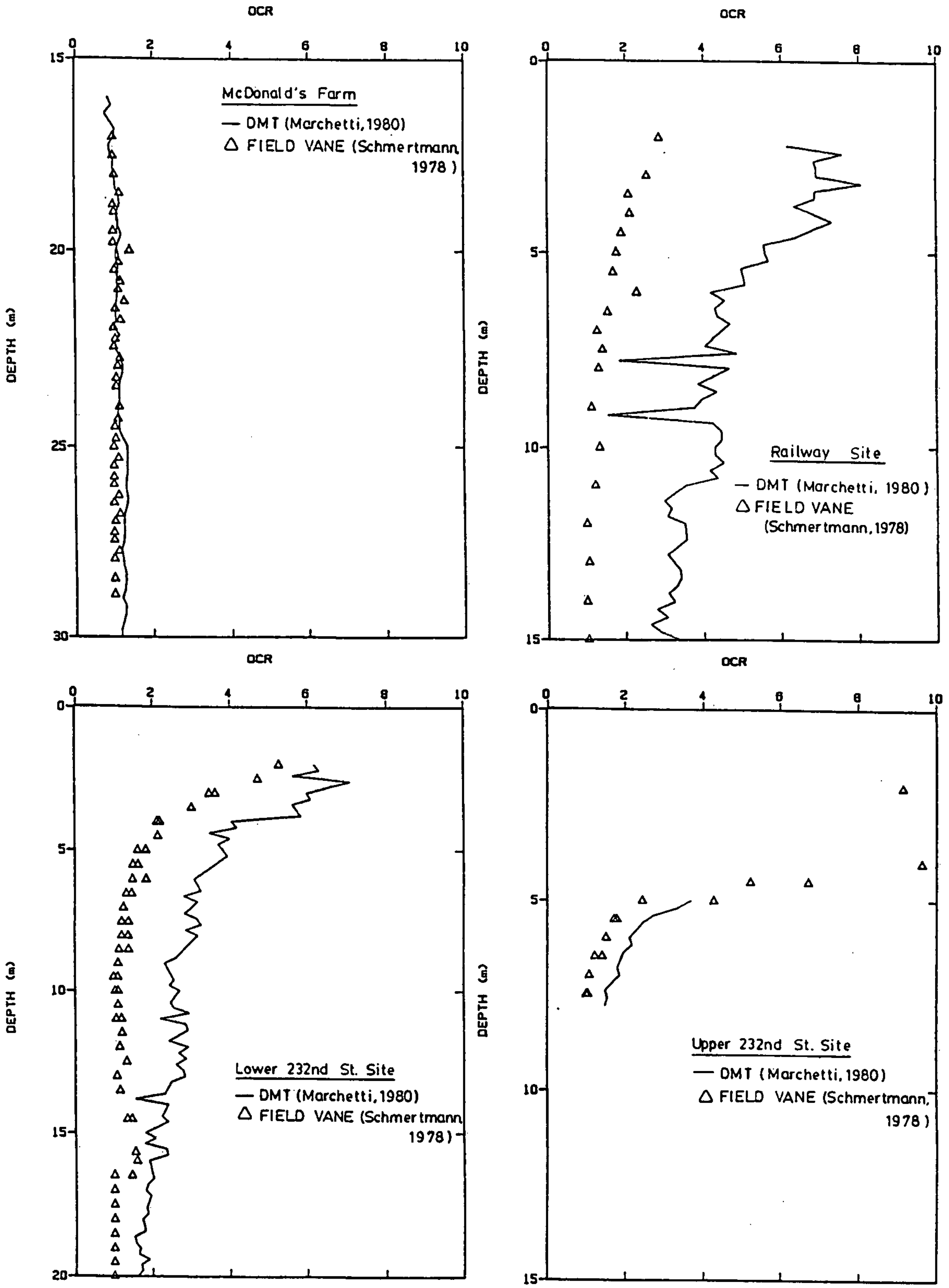


Figure 5.34 Overconsolidation Ratio Vs Depth

The geology of McDonald's Farm suggests that the clayey silt deposit is normally consolidated with an OCR equal to 1. Both the dilatometer and field vane results give a very good description of the stress history at McDonald's Farm.

The geology of the Langley sites suggests that the silty clay deposits in the upper approx. 10m is overconsolidated (or compacted at the upper site), and then slighty overconsolidated to normally consolidated with depth. The field vane results appear to give a good description of the stress history at the sites. The dilatometer results appear to overestimate the OCR and indicate that the deposit at 15m to 20m depth has an OCR of about 2. The reason for this discrepancy may stem from the fact that the horizontal stress index, K_D, is high, which leads to a high prediction of OCR for the deposit. The high K_D values appear to be due to the much higher pore pressures generated around the membrane as a result of the high soil sensitivity.

Based on the estimated OCR from the field vane tests and assumed PI values of the deposits, K_0 values of the four sites were estimated using Brooker and Ireland's proposed relationship (Brooker & Ireland, 1965). Figure 5.35 compares the above estimated K_0 with the values predicted by the dilatometer testing. A good comparison is obtained at McDonald's Farm. For the Langley sites, the values predicted

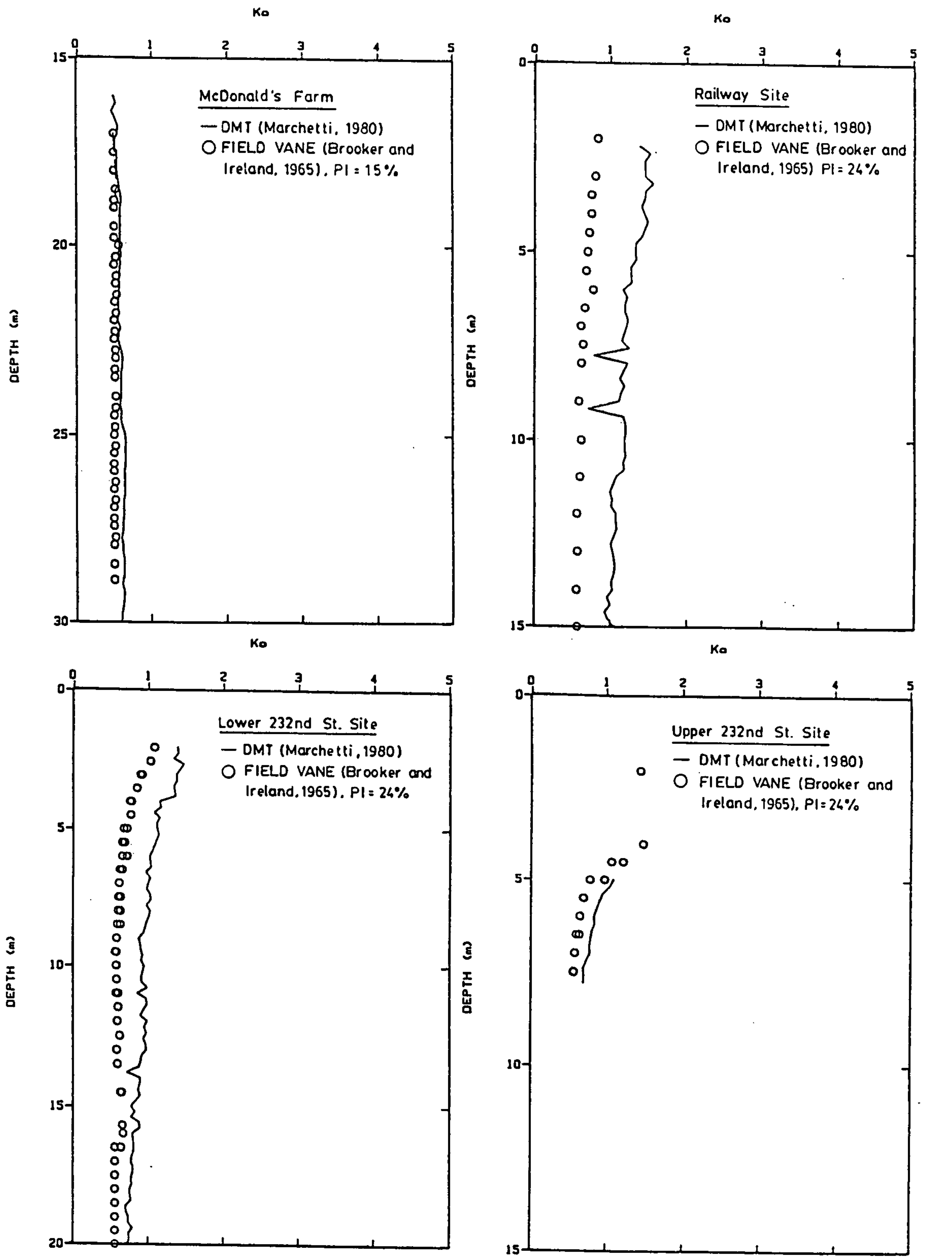


Figure 5.35 In-situ Earth Pressure Coefficient Vs Depth

by the dilatometer tests are slightly higher. This is because K_0 is also correlated to the high K_D.

Chapter 6

Summary and Conclusion

6.1 Observations

Data have been recorded and presented using the UBC research dilatometer. The measured pressure-deflection curves obtained during the dilatometer membrane expansion are very similar to the pressure expansion curves obtained from self-boring or full-displacement pressuremeter tests. Based on the results obtained with the UBC research DMT in clean sands and soft and stiff clayey soils, the following observation have been made:

1. Dilatometer tests in clean sands are drained during both the penetration and expansion phases, with almost no excess pore pressures generated.
2. Dilatometer tests in clayey deposits ($I_D < 0.6$) are undrained during both the penetration and expansion phases.
3. In soft, normally to slightly overconsolidated ($K_D < 3.0$) clayey soils, the DMT results (P_0, P_1) are dominated by large positive excess pore pressures and small effective stresses around the membrane.
4. In stiff, heavily overconsolidated clayey soils, negative pore pressures can be generated during penetration of the dilatometer.

5. The pore pressures generated during penetration of the dilatometer are very similar to the pore pressures generated during cone penetration.
6. The closing pressure from a DMT (P_c) is very similar to the DMT penetration pore pressure for clean sands and soft clayey deposits ($I_D < 0.6$, $K_D < 3.0$). In clean sands, almost no excess pore pressures are generated and the closing pressure represents a good approximation of the static equilibrium piezometric pressure (u_0).
7. The dissipaton of excess pore pressures during a stop in penetration is slower for a DMT than for a $10cm^2$ piezometer cone penetration test (CPTU). Time for 50% dissipation for the DMT is approximately twice that of a $10cm^2$ cone.
8. During the membrane expansion phase of a DMT, the soil adjacent to the membrane appears to deform plastically. However, elastic behaviour is observed during small unloading-reloading cycles.
9. The ϕ' values computed using the pushing force measured at the ground surface were only slightly higher than the ϕ' values calculated using the force measured directly behind the dilatometer (McDonald's Farm Site). This indicates that there is little rod friction after the friction reducer during dilatometer penetration in clean sands.

6.2 Predicted Properties of Sand

The dilatometer testing gave good estimates of the soil properties of the sand at McDonald's Farm.

The DMT clearly classifies the sand deposit for general logging purposes. The friction angle, K_0 and OCR determined using Schertmann's (1982,1983) correlations are in good agreement with values determined from other testing methods. Marchetti's (1980,1981) correlations gave a low estimate of friction angle and a high estimate on OCR and K_0. The results are similar to those reported in the literature (GPE, Inc., DMT Digest Series, and Bullock, 1983).

A good estimate of shear modulus can be computed from the dilatometer modulus (E_D), using a reasonable assumed value of poisson ratio.

6.3 Predicted Properties of Clayey Deposits

The dilatometer testing in general gave a rather poor estimate of the soil properties of the studied clayey deposits.

Although the DMT in general clearly identified the clayey deposits, it indicated the clayey silt as clay at McDonald's Farm, the compacted clay as silt at the Langley upper site, and occasionally the very soft clay as mud at the Langley railway and lower sites.

At the McDonald's Farm site, the DMT gave a very good estimate of OCR and K_0. The DMT, however underestimated the undrained shear strength when compared with the field vane (Su) since the Marchetti's (1980) correlation was based on the lower bound of some scattered data.

At the Langley sites, the DMT overestimated the OCR, K_0 and undrained shear strength. This might be related to the high sensitivity of the clay deposits at the Langley sites, since Marchetti's (1980) correlations were based on deposits of low sensitivity.

Since in soft clayey deposits the soil adjacent to the membrane is sheared to complete failure during penetration with very large pore pressure and almost zero effective stresses, the dilatometer modulus was very low in comparison to measured G_{max} values.

6.4 Suggestions for Future Research

1. It has been shown that a good estimate of the elastic shear modulus of sand can be measured from the unload-reload cycle of the expansion curve obtained with the research dilatometer. It appears that there exists a consistant relationship between the slope of the

unload-reload cycle and the slope of the straight expansion phase for DMT in sand. It is suggested to study the possibility of further establishing a relationship so that a shear modulus can be estimated from the slope of the straight expansion when using Marchetti's dilatometer.

2. It has been illustrated that E_D appears to be a useful parameter in sand and probably has a good correlation with the friction angle. Marchetti's (1981) correlation of ϕ' and E_D was unsuccessful, probably because of the limited available data. It is suggested to refine this correlation by including more up-to-date data. This can provide users an alternative method for estimating the friction angle of sand or as a comparison to Schmertmann's (1982) method.

3. It has been shown that the closing pressure of the membrane, P_C, is very close to the initial pore pressure before the expansion test. This provides a way of estimating the generated pore pressure during penetration of the dilatometer. Future work is recommended to further study this phenomenon and utilize the estimated pore pressure data to improve the correlations for dilatometer testings in clay, similar to the development of the piezometer cone in cone penetration testing.

4. Since the dilatometer testing is very similar to a full displacement pressuremeter testing, it is recommended

that the dilatometer testing can make use of the development in full displacement pressuremeter testing to sharpen the dilatometer correlations and better understand the dilatometer test.

5. Since the A reading (P_0) and C reading (P_C) are closely related to the penetration pore pressures in soft clay deposits, further work can be carried out to establish a procedure for performing dissipation tests using the DMT.

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APPENDIX I

Modification of Input Data of DILLY4

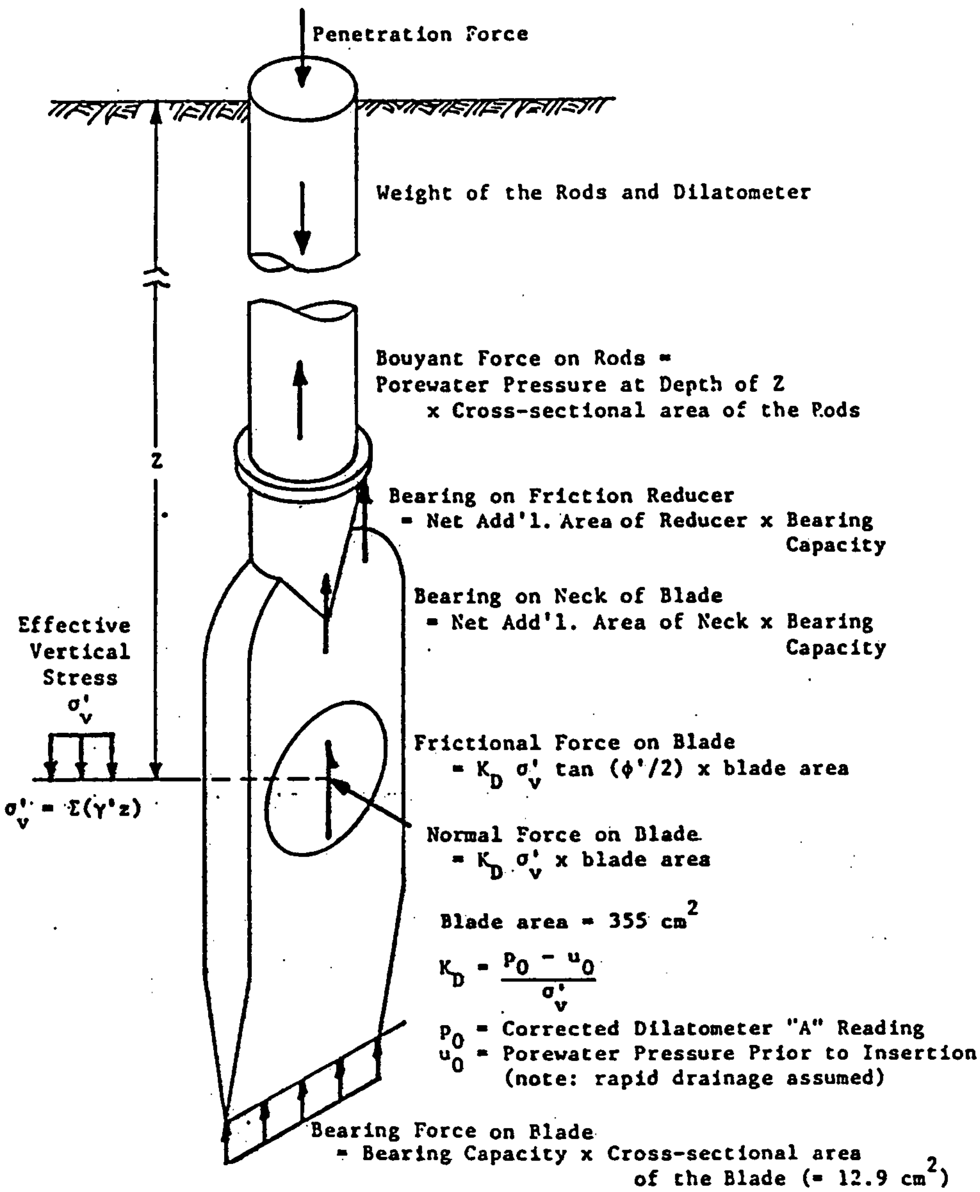
Modification of input data of DILLY4

The calculation of ϕ' in DILLY4 using Schmertmann's (1982) method is based on the force diagram and equation shown on the following page.

The load cell inside the research dilatometer is located immediately behind the neck of the blade. In order to determine the frictional force acting on the dilatometer blade using the penetration force measured behind the neck without changing the equations in the program, the following input data and modification are required:

1) Input data: Dia. of friction reducer = 0
   Dia. of pushing rod = 0
   wt. of pushing rod = 0
2) The bearing area of the dilatometer 19.2cm^2 (instead of 12.9cm^2) including additional area of neck.

Also, since the research dilatometer has a longer shoulder and stem, the blade area is 530cm instead of 355cm^2 for Marchetti's dilatometer, when using either the force measured at the ground surface or behind the blade for the computation.



$$\tan(\phi'_{ps}/2) = [\text{ THRUST} - (\pi/4) \times \text{RODIAM}^2 \times u_0 \times 1.019 - (\text{DMAREA} + (\pi/4) \times \text{DFRIC}^2 - \text{B} \times \text{DFRIC}) \times q_f + \text{RODWT} \times (\text{ZS} + 2)\ ] / F_H \qquad (6.4)$$

where:

- ϕ'_{ps} = Drained friction angle of the soil - plane strain
- THRUST = Insertion thrust (kg)
- RODIAM = Drill rod diameter (cm)
- u_0 = porewater pressure prior to insertion of the dilatometer (bars)
- DMAREA = Bearing area of the dilatometer (12.9 cm^2)
- B = Thickness of the dilatometer (1.37 cm)
- DFRIC = Diameter of the friction reducer (cm)
- q_f = Durgunoglu and Mitchell bearing capacity (kg/cm^2) - see following explanation
- RODWT = Drill rod weight per unit length (kg/m)
- ZS = Test depth (m) - Note: 2 m added in equation to account for rods above ground
- F_H = Horizontal force normal to the dilatometer blade, $(p_0 - u_0)$ x blade area (= 355 cm^2) x 1.019
- p_0 = Corrected dilatometer "A" reading (bars)

(Adapted from Bullock, 1983)

APPENDIX II

Computer Output

U.B.C.INSITU TESTING RESEARCH GROUP.

File Name:MRD-1X
Location:MCDONALD'S FARM

Record of Dilatometer test No:MRD-1
Date:MAR 21 84

Calibration Information:DA= 0.20 Bars DB= 0.27 Bars ZM= 0.0 Bars ZW= 1.00 metres

Gamma=Bulk unit weight
Sv =Effective over.stress
Uo =Pore pressure
Id =Material index
Ed =Dilatometer modulus
Kd =Horizontal stress index

INTERPRETED GEOTECHNICAL PARAMETERS
Ko =Insitu earth press.coeff.
OCR=Overconsolidation Ratio
M =Constrained modulus
Cu =Undrained cohesion(cohesive)
PHI=Friction Angle(cohesionless)

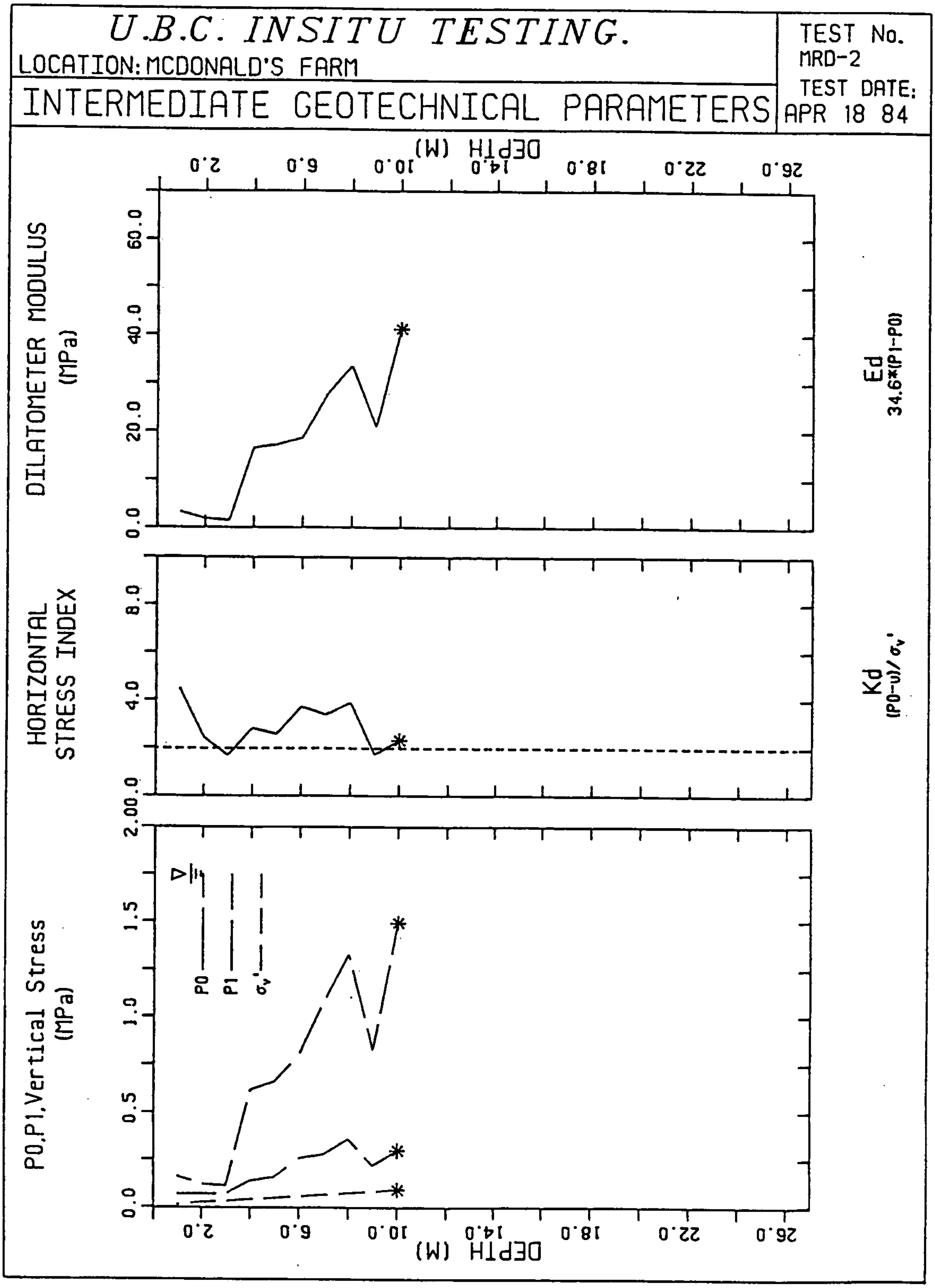
Z (m)	PO (Bar)	R1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)
0.20	1.10	3.53	84.	0.0	2.21	1.70	0.031	35.5	*****	13.17	3.82		35.4	311.	SILTY SAND	CEMENTED	0.20
0.40	0.70	2.33	56.	0.0	2.33	1.70	0.065	10.8	43.58	2.83	1.93		33.0	145.	SILTY SAND	LOOSE	0.40
0.60	0.60	1.53	32.	0.0	1.55	1.60	0.097	6.2	8.77	0.85	1.35		28.9	66.	SANDY SILT	COMPRESSIBLE	0.60
0.80	0.70	1.33	22.	0.0	0.90	1.60	0.129	5.4	4.74	0.61	1.23	0.10		41.	SILT	COMPRESSIBLE	0.80
1.00	0.90	1.73	29.	0.0	0.92	1.60	0.161	5.6	4.97	0.80	1.26			55.	SILT	COMPRESSIBLE	1.00
1.20	0.60	1.13	18.	0.02	0.91	1.60	0.173	3.4	2.24	0.39	0.86			26.	SILT	COMPRESSIBLE	1.20
1.60	0.70	1.13	15.	0.06	0.67	1.60	0.197	3.2	2.13	0.42	0.84	0.08		20.	CLAYEY SILT	COMPRESSIBLE	1.60
1.80	0.70	1.33	22.	0.08	1.02	1.60	0.209	3.0	1.85	0.39	0.78			28.	SILT	COMPRESSIBLE	1.80
2.00	0.80	2.03	43.	0.10	1.76	1.60	0.221	3.2	3.36	0.74	0.82		27.9	60.	SANDY SILT	COMPRESSIBLE	2.00
2.20	0.80	2.63	63.	0.12	2.69	1.70	0.235	2.9	3.54	0.83	0.76		29.8	89.	SILTY SAND	LOOSE	2.20
2.40	1.10	3.03	67.	0.14	2.01	1.70	0.249	3.9	6.13	1.53	0.96		29.0	108.	SILTY SAND	LOOSE	2.40
2.60	0.90	2.43	53.	0.16	2.07	1.70	0.263	2.8	3.36	0.88	0.74		28.4	70.	SILTY SAND	LOOSE	2.60
2.80	1.20	2.83	56.	0.18	1.60	1.60	0.275	3.7	3.83	1.05	0.93		27.9	87.	SANDY SILT	COMPRESSIBLE	2.80
3.00	0.90	3.03	74.	0.20	3.04	1.70	0.289	2.4	2.52	0.73	0.65		29.9	93.	SILTY SAND	LOOSE	3.00
3.20	1.40	4.73	115.	0.22	2.82	1.80	0.305	3.9	6.17	1.88	0.96		30.9	192.	SILTY SAND	LOW RIGIDITY	3.20
3.40	1.40	5.43	139.	0.24	3.47	1.80	0.321	3.6	5.41	1.74	0.91		32.1	225.	SAND	LOW RIGIDITY	3.40
3.60	1.50	6.63	177.	0.26	4.14	1.80	0.337	3.7	5.60	1.89	0.92		33.7	290.	SAND	LOW RIGIDITY	3.60
3.80	2.10	8.33	216.	0.28	3.42	1.80	0.353	5.2	10.67	3.77	1.19		33.4	415.	SAND	LOW RIGIDITY	3.80
4.00	1.70	6.73	174.	0.30	3.59	1.80	0.369	3.8	5.94	2.19	0.95		32.6	289.	SAND	LOW RIGIDITY	4.00
4.20	1.70	6.43	164.	0.32	3.43	1.80	0.385	3.6	5.33	2.05	0.91		32.0	263.	SAND	LOW RIGIDITY	4.20
4.40	1.30	4.73	119.	0.34	3.57	1.80	0.401	2.4	2.47	0.99	0.65		30.9	149.	SAND	LOW RIGIDITY	4.40
4.60	1.90	5.83	136.	0.36	2.55	1.80	0.417	3.7	5.64	2.35	0.93		30.1	218.	SILTY SAND	LOW RIGIDITY	4.60
4.80	1.50	5.33	133.	0.38	3.42	1.80	0.433	2.6	2.86	1.24	0.69		30.8	176.	SAND	LOW RIGIDITY	4.80
5.00	2.00	6.63	160.	0.40	2.89	1.80	0.449	3.6	5.27	2.37	0.90		30.8	256.	SILTY SAND	LOW RIGIDITY	5.00
5.20	1.80	6.43	160.	0.42	3.36	1.80	0.465	3.0	3.72	1.73	0.78		31.2	231.	SAND	LOW RIGIDITY	5.20
5.40	1.80	7.43	195.	0.44	4.14	1.80	0.481	2.8	3.39	1.63	0.75		32.5	273.	SAND	LOW RIGIDITY	5.40
5.60	2.30	8.53	216.	0.46	3.39	1.80	0.497	3.7	5.67	2.82	0.93		32.0	353.	SAND	LOW RIGIDITY	5.60
5.80	2.30	8.13	202.	0.48	3.20	1.80	0.513	3.5	5.23	2.68	0.90		31.5	323.	SILTY SAND	LOW RIGIDITY	5.80
6.00	1.90	6.63	164.	0.50	3.38	1.80	0.529	2.6	2.99	1.58	0.71		30.8	220.	SAND	LOW RIGIDITY	6.00
6.20	1.80	6.73	171.	0.52	3.85	1.80	0.545	2.3	2.38	1.30	0.63		31.3	212.	SAND	LOW RIGIDITY	6.20
6.40	2.10	9.73	264.	0.54	4.89	1.80	0.561	2.8	3.28	1.84	0.74		33.9	367.	SAND	LOW RIGIDITY	6.40
6.60	3.00	11.63	299.	0.56	3.54	1.90	0.579	4.2	7.26	4.20	1.02		32.9	522.	SAND	MEDIUM RIGIDITY	6.60
Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)

Sounding MRD-1 (DIL.RED)

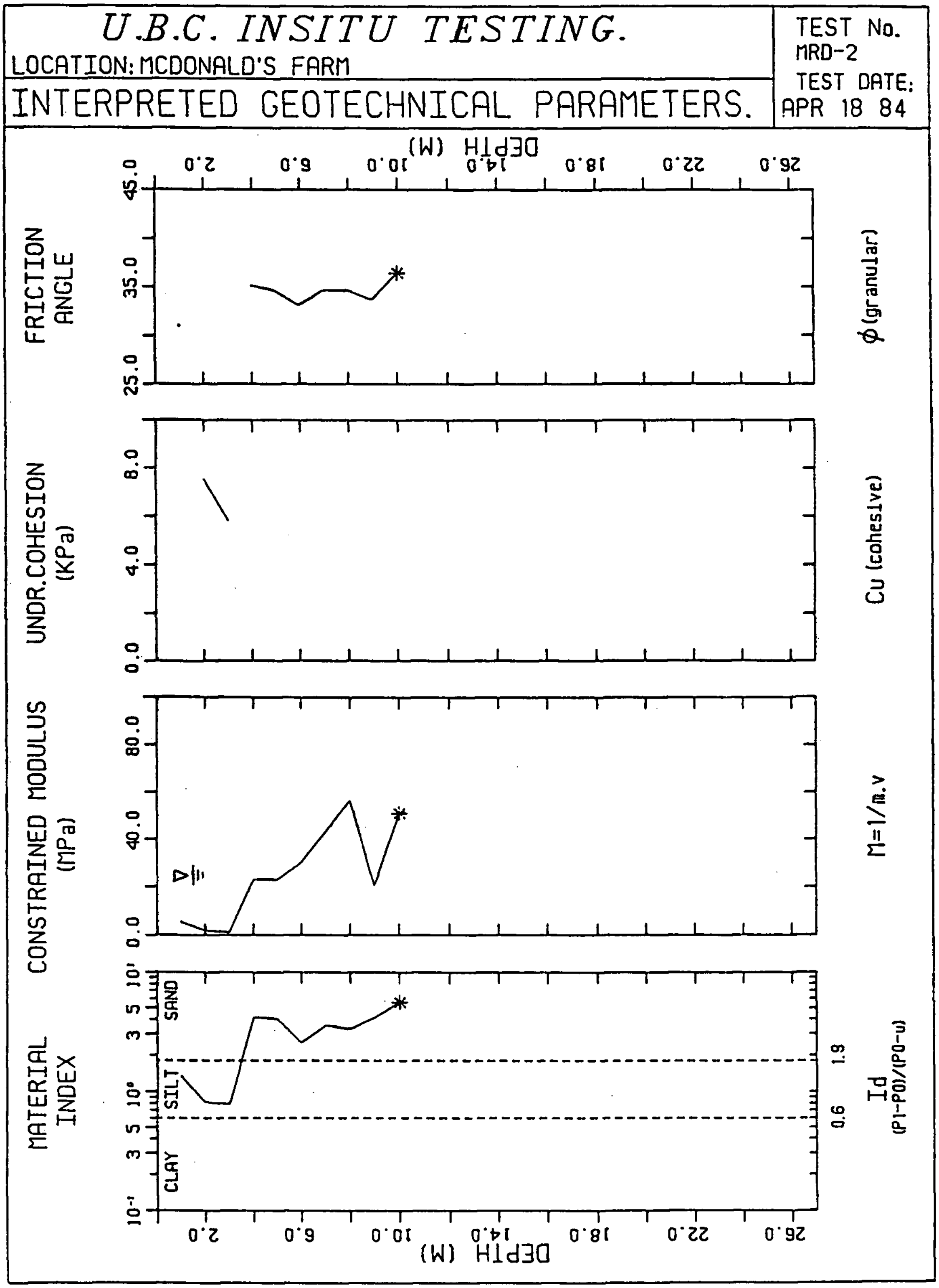
Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)
6.80	2.80	9.33	226.	0.58	2.94	1.90	0.597	3.7	5.72	3.41	0.93		31.0	370.	SILTY SAND	MEDIUM RIGIDITY	6.80
7.00	2.80	10.23	257.	0.60	3.38	1.90	0.615	3.6	5.31	3.27	0.90		31.9	413.	SAND	MEDIUM RIGIDITY	7.00
7.20	2.90	11.03	281.	0.62	3.57	1.90	0.633	3.6	5.38	3.41	0.91		32.3	454.	SAND	MEDIUM RIGIDITY	7.20
7.40	5.30	17.53	423.	0.64	2.62	2.00	0.653	7.1	19.86	12.87	1.48		32.6	930.	SILTY SAND	RIGID	7.40
7.60	4.40	16.83	430.	0.66	3.32	2.00	0.673	5.6	12.32	8.29	1.25		33.5	856.	SAND	RIGID	7.60
8.00	4.00	14.53	364.	0.70	3.19	1.90	0.709	4.7	8.78	6.22	1.10		32.5	669.	SILTY SAND	MEDIUM RIGIDITY	8.00
8.60	2.90	11.33	292.	0.76	3.94	1.90	0.763	2.8	3.34	2.55	0.74		32.1	407.	SAND	MEDIUM RIGIDITY	8.60
9.00	3.20	13.23	347.	0.80	4.18	1.90	0.799	3.0	3.80	3.04	0.79		32.9	505.	SAND	MEDIUM RIGIDITY	9.00
9.60	4.00	17.33	461.	0.86	4.25	1.90	0.853	3.7	5.61	4.78	0.92		33.9	753.	SAND	MEDIUM RIGIDITY	9.60
10.00	6.60	17.53	378.	0.90	1.92	2.00	0.893	6.4	14.49	12.94	1.38		30.1	786.	SILTY SAND	RIGID	10.00
10.60	4.40	18.43	485.	0.96	4.08	1.90	0.947	3.6	5.47	5.18	0.92		33.5	787.	SAND	MEDIUM RIGIDITY	10.60
11.00	3.10	12.73	333.	1.00	4.59	1.90	0.983	2.1	1.98	1.95	0.58		32.2	386.	SAND	MEDIUM RIGIDITY	11.00
11.60	2.50	6.63	143.	1.06	2.87	1.80	1.031	1.4	0.88	0.91	0.37		28.3	121.	SILTY SAND	LOW RIGIDITY	11.60
11.80	3.40	11.63	285.	1.08	3.55	1.90	1.049	2.2	2.12	2.22	0.60		30.6	339.	SAND	MEDIUM RIGIDITY	11.80
12.00	5.20	17.93	440.	1.10	3.10	2.00	1.069	3.8	6.07	6.48	0.95		31.5	735.	SILTY SAND	RIGID	12.00
12.20	6.10	18.63	434.	1.12	2.52	2.00	1.089	4.6	8.49	9.24	1.09		30.7	779.	SILTY SAND	RIGID	12.20
12.40	3.90	14.93	382.	1.14	4.00	1.90	1.107	2.5	2.66	2.95	0.67		31.8	494.	SAND	MEDIUM RIGIDITY	12.40
12.60	3.90	16.43	434.	1.16	4.57	1.90	1.125	2.4	2.55	2.87	0.66		32.7	552.	SAND	MEDIUM RIGIDITY	12.60
12.80	4.30	19.13	513.	1.18	4.75	1.90	1.143	2.7	3.17	3.62	0.72		33.6	704.	SAND	MEDIUM RIGIDITY	12.80
13.00	5.80	18.63	444.	1.20	2.79	2.00	1.163	4.0	6.43	7.48	0.98		30.9	747.	SILTY SAND	RIGID	13.00
13.40	4.90	18.43	468.	1.24	3.70	2.00	1.203	3.0	3.90	4.69	0.79		32.0	686.	SAND	RIGID	13.40
13.80	2.90	7.73	167.	1.28	2.98	1.80	1.235	1.3	0.78	0.97	0.34		28.3	142.	SILTY SAND	LOW RIGIDITY	13.80
14.00	5.20	16.43	389.	1.30	2.88	1.90	1.253	3.1	4.07	5.10	0.81		30.4	574.	SILTY SAND	MEDIUM RIGIDITY	14.00
14.20	4.30	13.53	319.	1.32	3.10	1.90	1.271	2.3	2.37	3.01	0.63		29.9	396.	SILTY SAND	MEDIUM RIGIDITY	14.20
14.40	3.50	12.63	316.	1.34	4.23	1.90	1.289	1.7	1.25	1.61	0.45		30.8	300.	SAND	MEDIUM RIGIDITY	14.40
14.60	3.50	11.13	264.	1.36	3.57	1.90	1.307	1.6	1.19	1.56	0.44		29.7	245.	SAND	MEDIUM RIGIDITY	14.60
14.80	3.60	10.53	240.	1.38	3.12	1.90	1.325	1.7	1.25	1.65	0.45		29.1	227.	SILTY SAND	MEDIUM RIGIDITY	14.80
15.00	3.50	11.53	278.	1.40	3.82	1.90	1.343	1.6	1.09	1.47	0.42		30.0	247.	SAND	MEDIUM RIGIDITY	15.00
15.20	4.00	10.03	209.	1.42	2.34	1.90	1.361	1.9	1.58	2.15	0.52		28.1	205.	SILTY SAND	MEDIUM RIGIDITY	15.20
16.00	3.40	4.23	29.	1.50	0.44	1.60	1.409	1.3	0.54	0.76	0.35	0.19		24.	SILTY CLAY	SOFT	16.00
17.00	4.30	4.93	22.	1.60	0.23	1.60	1.469	1.8	0.88	1.29	0.50	0.29		19.	CLAY	SOFT	17.00
18.00	4.70	5.13	15.	1.70	0.14	1.60	1.529	2.0	0.97	1.48	0.53	0.33		13.	CLAY	SOFT	18.00
18.20	4.80	5.23	15.	1.72	0.14	1.60	1.541	2.0	1.00	1.54	0.54	0.34		13.	CLAY	SOFT	18.20
18.40	4.90	5.33	15.	1.74	0.14	1.60	1.553	2.0	1.03	1.60	0.55	0.35		13.	CLAY	SOFT	18.40
18.60	4.70	5.23	18.	1.76	0.18	1.60	1.565	1.9	0.91	1.42	0.51	0.32		16.	CLAY	SOFT	18.60
18.80	5.00	5.63	22.	1.78	0.20	1.70	1.579	2.0	1.03	1.63	0.56	0.36		19.	CLAY	LOW CONSISTENCY	18.80
19.00	4.70	5.43	25.	1.80	0.25	1.70	1.593	1.8	0.86	1.38	0.50	0.31		21.	CLAY	LOW CONSISTENCY	19.00
19.20	5.30	6.13	29.	1.82	0.24	1.70	1.607	2.2	1.13	1.82	0.59	0.39		27.	CLAY	LOW CONSISTENCY	19.20
19.40	4.50	5.33	29.	1.84	0.31	1.70	1.621	1.6	0.73	1.19	0.44	0.28		24.	CLAY	LOW CONSISTENCY	19.40
19.60	4.70	5.43	25.	1.86	0.26	1.70	1.635	1.7	0.80	1.31	0.47	0.30		21.	CLAY	LOW CONSISTENCY	19.60
19.80	5.30	6.13	29.	1.88	0.24	1.70	1.649	2.1	1.06	1.75	0.56	0.38		25.	CLAY	LOW CONSISTENCY	19.80
20.00	3.80	5.03	43.	1.90	0.65	1.70	1.663	1.1	0.42	0.69	0.28	0.18		36.	CLAYEY SILT	LOW DENSITY	20.00
20.20	5.60	6.23	22.	1.92	0.17	1.70	1.677	2.2	1.16	1.94	0.60	0.41		21.	CLAY	LOW CONSISTENCY	20.20
20.40	3.20	5.13	67.	1.94	1.53	1.60	1.689	0.7	0.23	0.39	0.12		25.0	57.	SANDY SILT	COMPRESSIBLE	20.40
20.60	5.50	6.33	29.	1.96	0.23	1.70	1.703	2.1	1.06	1.81	0.57	0.39		26.	CLAY	LOW CONSISTENCY	20.60
20.80	5.80	6.33	18.	1.98	0.14	1.70	1.717	2.2	1.18	2.03	0.60	0.43		18.	CLAY	LOW CONSISTENCY	20.80
Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)

NOTES: 1. For 0.9>Id>1.2 neither Cu nor Phi calculated.
2. 1Bar=100KPa
3. # =1mm Deflection not reached.

Sounding MRD-1 (DIL.RED), Continued



Sounding MRD-2 (DIL.RED)



Sounding MRD-2 (DIL.RED), Continued

U.B.C. INSITU TESTING RESEARCH GROUP.

File Name:MRD-2X
Location:MCDONALD'S FARM

Record of Dilatometer test No:MRD-2
Date:APR 18 84

Calibration Information:DA= 0.20 Bars   DB= 0.27 Bars   ZM= 0.0 Bars   ZW= 1.50 metres

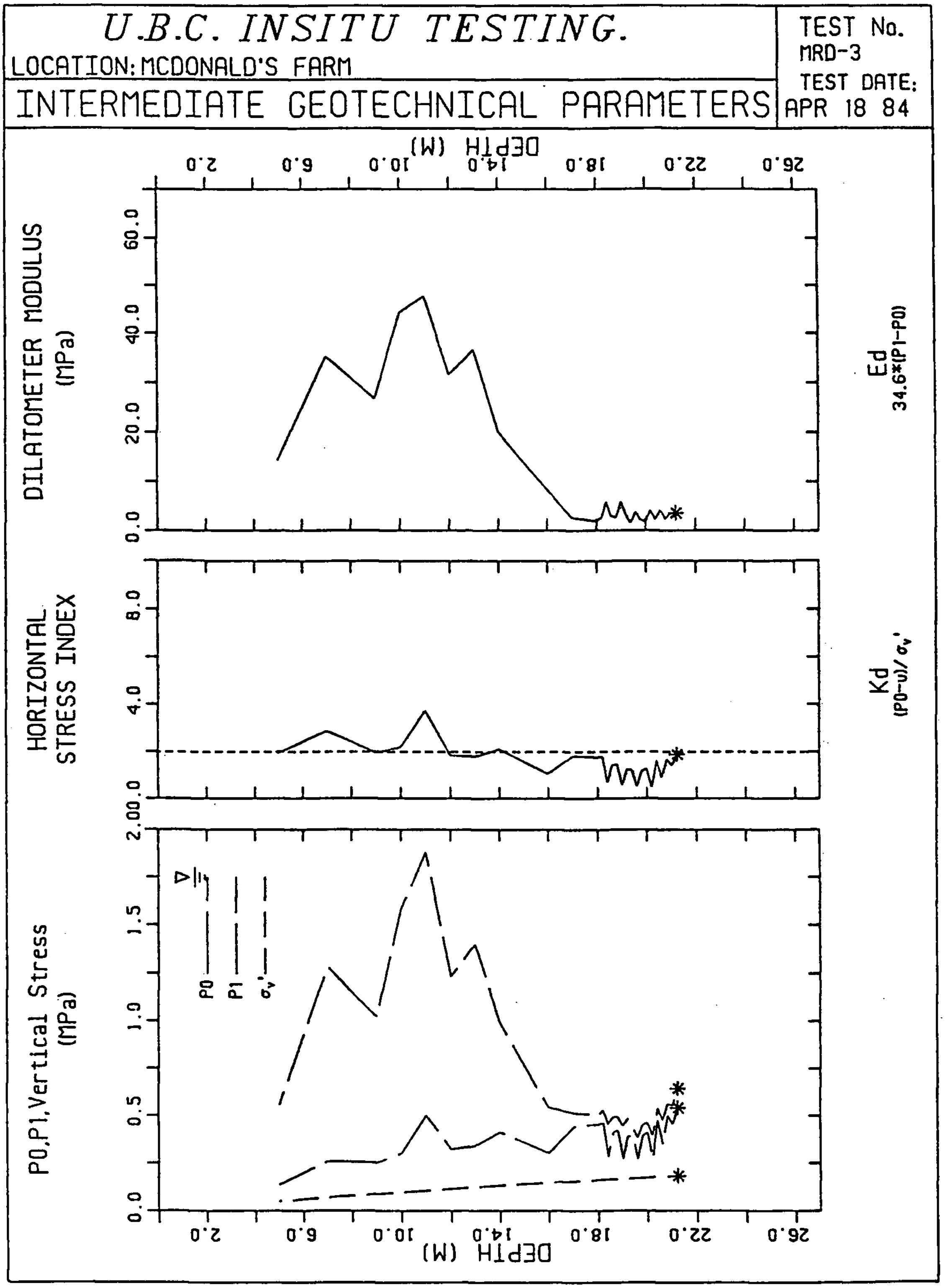
Gamma=Bulk unit weight
Sv =Effective over.stress
Uo =Pore pressure
Id =Material index
Ed =Dilatometer modulus
Kd =Horizontal stress index

INTERPRETED GEOTECHNICAL PARAMETERS
Ko =Insitu earth press.coeff.
OCR=Overconsolidation Ratio
M =Constrained modulus
Cu =Undrained cohesion(cohesive)
PHI=Friction Angle(cohesionless)

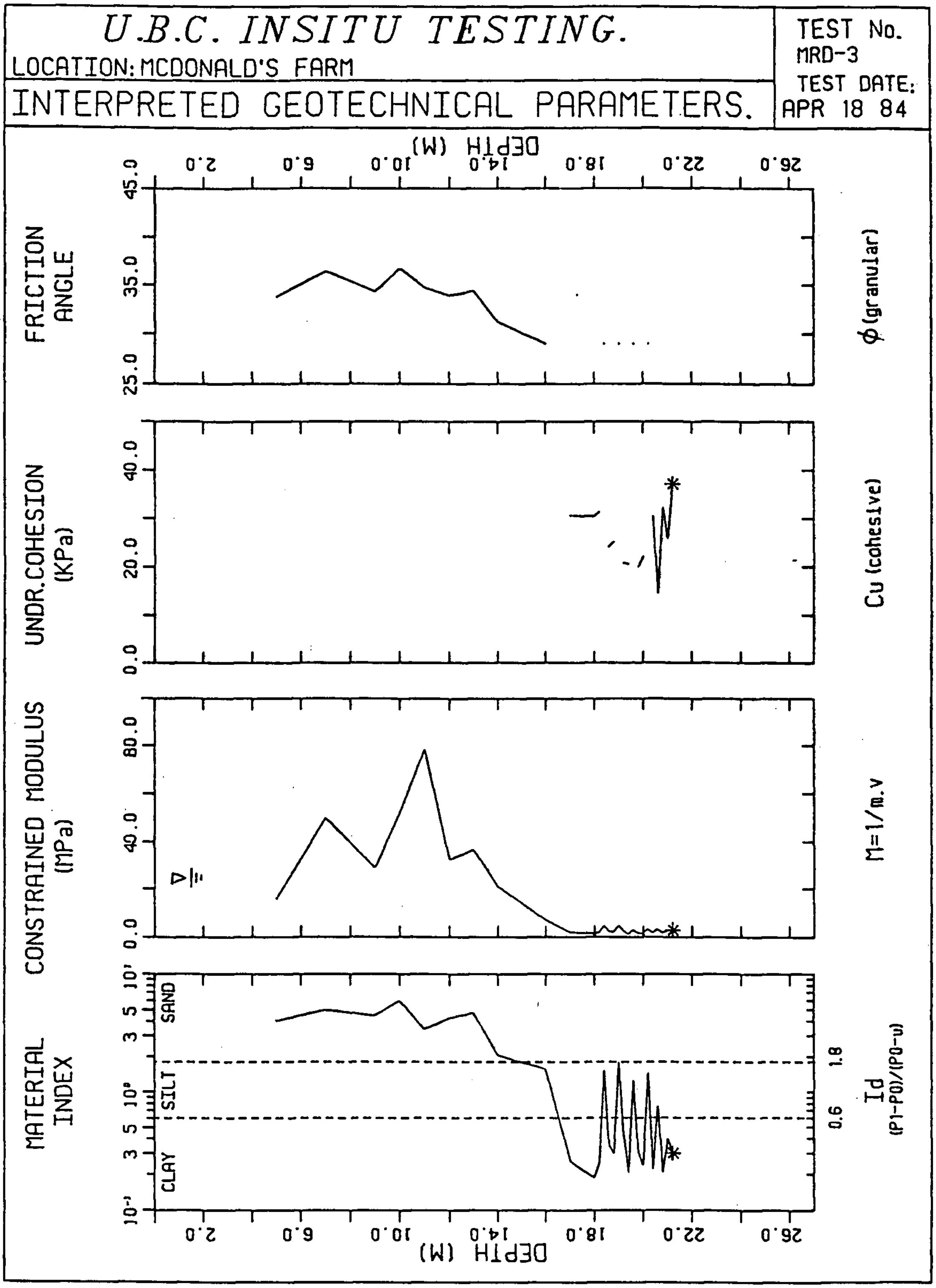
Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)
1.00	0.70	1.63	32.	0.0	1.33	1.60	0.157	4.5	3.98	0.63	1.07		27.5	55.	SANDY SILT	COMPRESSIBLE	1.00
2.00	0.70	1.23	18.	0.05	0.82	1.60	0.267	2.4	1.36	0.36	0.66	0.08		20.	SILT	COMPRESSIBLE	2.00
3.00	0.70	1.13	15.	0.15	0.78	1.60	0.327	1.7	0.76	0.25	0.46	0.06		13.	CLAYEY SILT	COMPRESSIBLE	3.00
4.00	1.40	6.23	167.	0.25	4.20	1.80	0.407	2.8	3.38	1.38	0.75		32.7	234.	SAND	LOW RIGIDITY	4.00
5.00	1.60	6.63	174.	0.35	4.02	1.80	0.487	2.6	2.82	1.37	0.69		32.0	230.	SAND	LOW RIGIDITY	5.00
6.00	2.60	8.03	188.	0.45	2.53	1.90	0.577	3.7	5.74	3.31	0.93		30.1	303.	SILTY SAND	MEDIUM RIGIDITY	6.00
7.00	2.80	10.83	278.	0.55	3.57	1.90	0.667	3.4	4.75	3.17	0.86		32.1	432.	SAND	MEDIUM RIGIDITY	7.00
8.00	3.60	13.33	337.	0.65	3.30	1.90	0.757	3.9	6.25	4.73	0.97		32.0	566.	SILTY SAND	MEDIUM RIGIDITY	8.00
9.00	2.20	8.23	209.	0.75	4.16	1.80	0.837	1.7	1.33	1.11	0.47		30.8	204.	SAND	LOW RIGIDITY	9.00
10.00	3.00	14.93	413.	0.85	5.55	1.90	0.927	2.3	2.32	2.15	0.63		34.3	508.	SAND	MEDIUM RIGIDITY	10.00
Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)

NOTES:1.For 0.9>Id>1.2 neither Cu nor Phi calculated.
2.1Bar=100KPa
3.# =1mm Deflection not reached.

Sounding MRD-2 (DIL.RED), Continued



Sounding MRD-3 (DIL. RED)



Sounding MRD-3 (DIL.RED), Continued

U.B.C. INSITU TESTING RESEARCH GROUP.

File Name:MRD-3X
Location:MCDONALD'S FARM

Record of Dilatometer test No:MRD-3
Date:APR 18 84

Calibration Information:DA= 0.20 Bars DB= 0.27 Bars ZM= 0.0 Bars ZW= 1.50 metres

Gamma=Bulk unit weight
Sv =Effective over.stress
Uo =Pore pressure
Id =Material index
Ed =Dilatometer modulus
Kd =Horizontal stress index

INTERPRETED GEOTECHNICAL PARAMETERS
Ko =Insitu earth press.coeff.
OCR=Overconsolidation Ratio
M =Constrained modulus
Cu =Undrained cohesion(cohesive)
PHI=Friction Angle(cohesionless)

Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)
5.00	1.40	5.63	146.	0.35	4.03	1.80	0.533	2.0	1.70	0.91	0.54		31.0	159.	SAND	LOW RIGIDITY	5.00
7.00	2.60	12.63	354.	0.55	4.99	1.90	0.713	2.9	3.50	2.49	0.76		34.3	502.	SAND	MEDIUM RIGIDITY	7.00
9.00	2.50	10.23	267.	0.75	4.42	1.90	0.893	2.0	1.68	1.50	0.53		31.6	290.	SAND	MEDIUM RIGIDITY	9.00
10.00	3.00	15.83	444.	0.85	5.97	1.90	0.983	2.2	2.07	2.04	0.59		34.7	524.	SAND	MEDIUM RIGIDITY	10.00
11.00	5.00	18.83	479.	0.95	3.41	2.00	1.083	3.7	5.78	6.26	0.94		32.1	787.	SAND	RIGID	11.00
12.00	3.20	12.33	316.	1.05	4.25	1.90	1.173	1.8	1.48	1.74	0.50		31.1	324.	SAND	MEDIUM RIGIDITY	12.00
13.00	3.40	14.03	368.	1.15	4.72	1.90	1.263	1.8	1.40	1.77	0.48		31.8	368.	SAND	MEDIUM RIGIDITY	13.00
14.00	4.10	9.93	202.	1.25	2.05	1.90	1.353	2.1	1.93	2.61	0.57		27.7	212.	SILTY SAND	MEDIUM RIGIDITY	14.00
16.00	3.00	5.43	84.	1.45	1.57	1.70	1.493	1.0	0.42	0.62	0.24		25.0	71.	SANDY SILT	LOW DENSITY	16.00
17.00	4.40	5.13	25.	1.55	0.26	1.70	1.563	1.8	0.87	1.35	0.50	0.31		21.	CLAY	LOW CONSISTENCY	17.00
18.00	4.50	5.03	18.	1.65	0.19	1.60	1.623	1.8	0.82	1.32	0.48	0.30		16.	CLAY	SOFT	18.00
18.20	4.60	5.33	25.	1.67	0.25	1.70	1.637	1.8	0.84	1.38	0.49	0.31		21.	CLAY	LOW CONSISTENCY	18.20
18.40	2.80	4.53	60.	1.69	1.56	1.60	1.649	0.7	0.20	0.32	0.09		25.0	51.	SANDY SILT	COMPRESSIBLE	18.40
18.60	4.10	4.93	29.	1.71	0.35	1.60	1.661	1.4	0.60	0.99	0.38	0.24		24.	SILTY CLAY	SOFT	18.60
18.80	4.20	4.93	25.	1.73	0.30	1.60	1.673	1.5	0.62	1.04	0.39	0.25		21.	CLAY	SOFT	18.80
19.00	2.70	4.43	60.	1.75	1.82	1.70	1.687	0.6	0.15	0.25	0.03		25.0	51.	SILTY SAND	LOOSE	19.00
19.20	3.90	4.83	32.	1.77	0.44	1.60	1.699	1.3	0.48	0.82	0.32	0.21		27.	SILTY CLAY	SOFT	19.20
19.40	3.90	4.23	15.	1.79	0.20	1.60	1.711	1.2	0.47	0.80	0.31	0.21		13.	CLAY	SOFT	19.40
19.60	2.70	3.83	39.	1.81	1.27	1.60	1.723	0.5	0.12	0.21	0.01		25.0	33.	SANDY SILT	COMPRESSIBLE	19.60
19.80	3.90	4.53	22.	1.83	0.30	1.60	1.735	1.2	0.45	0.77	0.30	0.20		19.	CLAY	SOFT	19.80
20.00	4.10	4.63	18.	1.85	0.24	1.60	1.747	1.3	0.50	0.88	0.33	0.22		16.	CLAY	SOFT	20.00
20.20	2.70	3.93	43.	1.87	1.48	1.60	1.759	0.5	0.11	0.19	-.02		25.0	36.	SANDY SILT	COMPRESSIBLE	20.20
20.40	4.80	5.43	22.	1.89	0.22	1.60	1.771	1.6	0.74	1.30	0.44	0.30		19.	CLAY	SOFT	20.40
20.60	3.50	4.73	43.	1.91	0.77	1.60	1.783	0.9	0.28	0.51	0.18	0.14		36.	CLAYEY SILT	COMPRESSIBLE	20.60
20.80	5.00	5.63	22.	1.93	0.21	1.70	1.797	1.7	0.78	1.41	0.46	0.32		19.	CLAY	LOW CONSISTENCY	20.80
21.00	4.50	5.53	36.	1.95	0.40	1.70	1.811	1.4	0.58	1.05	0.37	0.26		30.	SILTY CLAY	LOW CONSISTENCY	21.00
21.20	5.40	6.43	36.	1.97	0.30	1.70	1.825	1.9	0.91	1.66	0.51	0.37		30.	CLAY	LOW CONSISTENCY	21.20
Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)

NOTES: 1. For 0.9>Id>1.2 neither Cu nor Phi calculated.
2. 1Bar=100KPa
3. # =1mm Deflection not reached.

Sounding MRD-3 (DIL.RED), Continued

U.B.C. INSITU TESTING RESEARCH GROUP.

File Name:LRD-2X
Location:LANGLEY-RAILWAY

Record of Dilatometer test No:LRD-2
Date:OCT 7 83

Calibration Information:DA= 0.20 Bars DB= 0.27 Bars ZM= 0.0 Bars ZW= 1.00 metres

Gamma=Bulk unit weight
Sv =Effective over.stress
Uo =Pore pressure
Id =Material index
Ed =Dilatometer modulus
Kd =Horizontal stress index

INTERPRETED GEOTECHNICAL PARAMETERS
Ko =Insitu earth press.coeff.
OCR=Overconsolidation Ratio
M =Constrained modulus
Cu =Undrained cohesion(cohesive)
PHI=Friction Angle(cohesionless)

Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)
2.20	1.50	1.93	15.	0.12	0.31	1.60	0.215	6.4	6.17	1.33	1.38	0.20		30.	CLAY	SOFT	2.20
2.40	1.80	2.33	18.	0.14	0.32	1.60	0.227	7.3	7.56	1.72	1.51	0.25		40.	CLAY	SOFT	2.40
2.60	1.80	2.23	15.	0.16	0.26	1.60	0.239	6.9	6.84	1.64	1.44	0.25		31.	CLAY	SOFT	2.60
2.80	1.90	2.23	11.	0.18	0.19	1.50	0.249	6.9	6.91	1.72	1.45	0.26		24.	MUD		2.80
3.00	2.00	2.43	15.	0.20	0.24	1.60	0.261	6.9	6.90	1.80	1.45	0.27		32.	CLAY	SOFT	3.00
3.20	2.30	2.73	15.	0.22	0.21	1.60	0.273	7.6	8.06	2.20	1.55	0.32		33.	CLAY	SOFT	3.20
3.40	2.20	2.83	22.	0.24	0.32	1.60	0.285	6.9	6.87	1.96	1.45	0.29		46.	CLAY	SOFT	3.40
3.60	2.30	2.73	15.	0.26	0.21	1.60	0.297	6.9	6.85	2.04	1.44	0.31		31.	CLAY	SOFT	3.60
3.80	2.30	2.93	22.	0.28	0.31	1.60	0.309	6.5	6.34	1.96	1.40	0.30		45.	CLAY	SOFT	3.80
4.00	2.50	2.93	15.	0.30	0.20	1.60	0.321	6.9	6.83	2.19	1.44	0.33		31.	CLAY	SOFT	4.00
4.20	2.70	3.23	18.	0.32	0.22	1.60	0.333	7.1	7.29	2.43	1.48	0.36		40.	CLAY	SOFT	4.20
4.40	2.70	3.23	18.	0.34	0.22	1.60	0.345	6.8	6.81	2.35	1.44	0.35		39.	CLAY	SOFT	4.40
4.60	2.70	3.13	15.	0.36	0.18	1.60	0.357	6.6	6.37	2.27	1.40	0.35		31.	CLAY	SOFT	4.60
4.80	2.60	3.03	15.	0.38	0.19	1.60	0.369	6.0	5.57	2.06	1.32	0.32		29.	CLAY	SOFT	4.80
5.00	2.70	3.13	15.	0.40	0.19	1.60	0.381	6.0	5.60	2.13	1.32	0.33		29.	CLAY	SOFT	5.00
5.20	2.80	3.13	11.	0.42	0.14	1.50	0.391	6.1	5.68	2.22	1.33	0.35		23.	MUD		5.20
5.40	2.70	3.33	22.	0.44	0.28	1.60	0.403	5.6	4.99	2.01	1.26	0.32		42.	CLAY	SOFT	5.40
5.60	2.80	3.43	22.	0.46	0.27	1.60	0.415	5.6	5.04	2.09	1.26	0.33		42.	CLAY	SOFT	5.60
5.80	2.90	3.33	15.	0.48	0.18	1.60	0.427	5.7	5.08	2.17	1.27	0.35		29.	CLAY	SOFT	5.80
6.00	2.70	3.13	15.	0.50	0.20	1.60	0.439	5.0	4.19	1.84	1.16	0.30		27.	CLAY	SOFT	6.00
6.20	2.90	3.33	15.	0.52	0.18	1.60	0.451	5.3	4.54	2.05	1.21	0.33		27.	CLAY	SOFT	6.20
6.40	2.90	3.53	22.	0.54	0.27	1.60	0.463	5.1	4.30	1.99	1.18	0.33		39.	CLAY	SOFT	6.40
6.60	3.00	3.63	22.	0.56	0.26	1.60	0.475	5.1	4.36	2.07	1.18	0.34		40.	CLAY	SOFT	6.60
6.80	3.20	3.73	18.	0.58	0.20	1.60	0.487	5.4	4.68	2.28	1.22	0.37		34.	CLAY	SOFT	6.80
7.00	3.20	3.83	22.	0.60	0.24	1.60	0.499	5.2	4.45	2.22	1.20	0.36		40.	CLAY	SOFT	7.00
7.20	3.20	3.83	22.	0.62	0.24	1.60	0.511	5.0	4.24	2.17	1.17	0.36		39.	CLAY	SOFT	7.20
7.40	3.20	3.93	25.	0.64	0.29	1.60	0.523	4.9	4.04	2.11	1.14	0.35		45.	CLAY	SOFT	7.40
7.60	3.60	4.13	18.	0.66	0.18	1.60	0.535	5.5	4.84	2.59	1.24	0.42		35.	CLAY	SOFT	7.60
7.80	2.30	3.03	25.	0.68	0.45	1.60	0.547	3.0	1.84	1.01	0.78	0.20		32.	SILTY CLAY	SOFT	7.80
8.00	3.70	4.33	22.	0.70	0.21	1.60	0.559	5.4	4.66	2.61	1.22	0.42		41.	CLAY	SOFT	8.00
8.20	3.60	3.93	11.	0.72	0.11	1.50	0.569	5.1	4.26	2.42	1.17	0.40		21.	MUD		8.20
8.40	3.50	3.93	15.	0.74	0.16	1.60	0.581	4.8	3.86	2.24	1.12	0.38		26.	CLAY	SOFT	8.40
Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)

Sounding LRD-2 (DIL.RED)

Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)
8.60	3.80	4.23	15.	0.76	0.14	1.60	0.593	5.1	4.34	2.57	1.18	0.42		27.	CLAY	SOFT	8.60
8.80	3.70	4.23	18.	0.78	0.18	1.60	0.605	4.8	3.95	2.39	1.13	0.40		32.	CLAY	SOFT	8.80
9.00	3.70	4.53	29.	0.80	0.29	1.70	0.619	4.7	3.77	2.34	1.11	0.39		49.	CLAY	LOW CONSISTENCY	9.00
9.20	2.50	3.73	43.	0.82	0.73	1.60	0.631	2.7	1.56	0.99	0.71	0.20		49.	CLAYEY SILT	COMPRESSIBLE	9.20
9.40	4.10	4.73	22.	0.84	0.19	1.70	0.645	5.1	4.25	2.74	1.17	0.45		39.	CLAY	LOW CONSISTENCY	9.40
9.60	4.30	5.23	32.	0.86	0.27	1.70	0.659	5.2	4.47	2.94	1.20	0.48		59.	CLAY	LOW CONSISTENCY	9.60
9.80	4.40	4.93	18.	0.88	0.15	1.70	0.673	5.2	4.48	3.02	1.20	0.49		34.	CLAY	LOW CONSISTENCY	9.80
10.00	4.40	5.23	29.	0.90	0.24	1.70	0.687	5.1	4.30	2.85	1.18	0.49		52.	CLAY	LOW CONSISTENCY	10.00
10.20	4.50	5.13	22.	0.92	0.18	1.70	0.701	5.1	4.32	3.03	1.18	0.50		39.	CLAY	LOW CONSISTENCY	10.20
10.40	4.70	5.53	29.	0.94	0.22	1.70	0.715	5.3	4.52	3.23	1.20	0.53		53.	CLAY	LOW CONSISTENCY	10.40
10.60	4.60	5.93	46.	0.96	0.37	1.70	0.729	5.0	4.17	3.04	1.16	0.50		82.	SILTY CLAY	LOW CONSISTENCY	10.60
10.80	4.80	5.53	25.	0.98	0.19	1.70	0.743	5.1	4.36	3.24	1.18	0.53		46.	CLAY	LOW CONSISTENCY	10.80
11.00	4.40	5.13	25.	1.00	0.21	1.70	0.757	4.5	3.53	2.67	1.07	0.46		42.	CLAY	LOW CONSISTENCY	11.00
11.20	4.30	5.13	29.	1.02	0.25	1.70	0.771	4.3	3.25	2.50	1.03	0.44		47.	CLAY	LOW CONSISTENCY	11.20
11.40	4.20	4.93	25.	1.04	0.23	1.70	0.785	4.0	2.98	2.34	0.99	0.41		40.	CLAY	LOW CONSISTENCY	11.40
11.60	4.40	5.43	36.	1.06	0.31	1.70	0.799	4.2	3.16	2.52	1.02	0.44		57.	CLAY	LOW CONSISTENCY	11.60
11.80	4.40	5.63	43.	1.08	0.37	1.70	0.813	4.1	3.05	2.48	1.00	0.44		67.	SILTY CLAY	LOW CONSISTENCY	11.80
12.00	4.80	5.53	25.	1.10	0.20	1.70	0.827	4.5	3.51	2.90	1.07	0.50		42.	CLAY	LOW CONSISTENCY	12.00
12.20	4.90	5.93	36.	1.12	0.27	1.70	0.841	4.5	3.54	2.97	1.07	0.51		60.	CLAY	LOW CONSISTENCY	12.20
12.40	5.00	6.03	36.	1.14	0.27	1.70	0.855	4.5	3.56	3.04	1.08	0.52		60.	CLAY	LOW CONSISTENCY	12.40
12.60	4.90	6.23	46.	1.16	0.36	1.70	0.869	4.3	3.31	2.87	1.04	0.50		75.	SILTY CLAY	LOW CONSISTENCY	12.60
12.80	4.80	5.73	32.	1.18	0.26	1.70	0.883	4.1	3.06	2.71	1.00	0.48		51.	CLAY	LOW CONSISTENCY	12.80
13.00	5.00	5.93	32.	1.20	0.24	1.70	0.897	4.2	3.22	2.89	1.03	0.50		52.	CLAY	LOW CONSISTENCY	13.00
13.20	5.20	6.03	29.	1.22	0.21	1.70	0.911	4.4	3.38	3.08	1.05	0.53		47.	CLAY	LOW CONSISTENCY	13.20
13.40	5.30	5.93	22.	1.24	0.16	1.70	0.925	4.4	3.41	3.15	1.06	0.54		36.	CLAY	LOW CONSISTENCY	13.40
13.60	5.30	6.03	25.	1.26	0.18	1.70	0.939	4.3	3.30	3.10	1.04	0.54		41.	CLAY	LOW CONSISTENCY	13.60
13.80	5.20	6.33	39.	1.28	0.29	1.70	0.953	4.1	3.08	2.94	1.01	0.52		62.	CLAY	LOW CONSISTENCY	13.80
14.00	5.40	6.13	25.	1.30	0.18	1.70	0.967	4.2	3.23	3.12	1.03	0.54		41.	CLAY	LOW CONSISTENCY	14.00
14.20	5.10	6.13	36.	1.32	0.27	1.70	0.981	3.9	2.78	2.73	0.96	0.49		54.	CLAY	LOW CONSISTENCY	14.20
14.40	5.40	6.33	32.	1.34	0.23	1.70	0.995	4.1	3.04	3.03	1.00	0.53		51.	CLAY	LOW CONSISTENCY	14.40
14.60	5.10	6.03	32.	1.36	0.25	1.70	1.009	3.7	2.62	2.64	0.93	0.48		48.	CLAY	LOW CONSISTENCY	14.60
14.80	5.40	7.03	56.	1.38	0.41	1.70	1.023	3.9	2.87	2.93	0.97	0.52		87.	SILTY CLAY	LOW CONSISTENCY	14.80
15.00	5.90	7.03	39.	1.40	0.25	1.70	1.037	4.3	3.35	3.47	1.05	0.60		64.	CLAY	LOW CONSISTENCY	15.00

Z (m) | PO (Bar) | P1 (Bar) | Ed (Bar) | Uo (Bar) | Id | Gamma (T/CM) | Sv (Bar) | Kd | OCR | Pc (Bar) | KO | Cu (Bar) | PHI (Deg) | M (Bar) | Soil Type | Description | Z (m)

NOTES: 1. For 0.9>Id>1.2 neither Cu nor Phi calculated.
2. 1Bar=100KPa
3. # =1mm Deflection not reached.

Sounding LRD-2 (DIL.RED), Continued

U.B.C.INSITU TESTING RESEARCH GROUP.

File Name:LRD-3X
Location:LANGLEY-232 ST(LOWER)

Record of Dilatometer test No:LRD-3
Date:JUN 20 84

Calibration Information:DA= 0.20 Bars DB= 0.27 Bars ZM= 0.0 Bars ZW= 1.00 metres

Gamma=Bulk unit weight
Sv =Effective over.stress
Uo =Pore pressure
Id =Material index
Ed =Dilatometer modulus
Kd =Horizontal stress index

INTERPRETED GEOTECHNICAL PARAMETERS
Ko =Insitu earth press.coeff.
OCR=Overconsolidation Ratio
M =Constrained modulus
Cu =Undrained cohesion(cohesive)
PHI=Friction Angle(cohesionless)

Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)
1.00	1.10	2.13	36.	0.0	0.94	1.60	0.152	7.2	7.44	1.13	1.50			78.	SILT	COMPRESSIBLE	1.00
2.00	1.40	1.73	11.	0.10	0.25	1.50	0.202	6.4	6.19	1.25	1.38	0.19		23.	MUD		2.00
2.20	1.50	1.73	8.	0.12	0.17	1.50	0.212	6.5	6.30	1.34	1.39	0.20		16.	MUD		2.20
2.40	1.50	1.93	15.	0.14	0.32	1.60	0.224	6.1	5.65	1.27	1.33	0.20		30.	CLAY	SOFT	2.40
2.60	1.80	2.03	8.	0.16	0.14	1.50	0.234	7.0	7.07	1.65	1.46	0.25		17.	MUD		2.60
2.80	1.80	2.13	11.	0.18	0.20	1.50	0.244	6.6	6.50	1.59	1.41	0.24		24.	MUD		2.80
3.00	1.80	2.03	8.	0.20	0.14	1.50	0.254	6.3	5.99	1.52	1.36	0.23		16.	MUD		3.00
3.20	1.90	2.03	4.	0.22	0.08	1.50	0.264	6.4	6.08	1.61	1.37	0.25		9.	MUD		3.20
3.40	1.90	2.23	11.	0.24	0.20	1.50	0.274	6.1	5.63	1.54	1.33	0.24		23.	MUD		3.40
3.60	2.00	2.33	11.	0.26	0.19	1.50	0.284	6.1	5.73	1.63	1.34	0.25		23.	MUD		3.60
3.80	2.10	2.33	8.	0.28	0.13	1.50	0.294	6.2	5.83	1.71	1.35	0.27		16.	MUD		3.80
4.00	1.80	2.23	15.	0.30	0.29	1.60	0.306	4.9	4.05	1.24	1.14	0.21		26.	CLAY	SOFT	4.00
4.20	1.90	2.23	11.	0.32	0.21	1.50	0.316	5.0	4.18	1.32	1.16	0.22		20.	MUD		4.20
4.40	1.80	2.33	18.	0.34	0.36	1.60	0.328	4.5	3.48	1.14	1.07	0.20		31.	SILTY CLAY	SOFT	4.40
4.60	2.00	2.33	11.	0.36	0.20	1.50	0.338	4.9	3.99	1.35	1.14	0.23		20.	MUD		4.60
4.80	2.00	2.43	15.	0.38	0.27	1.60	0.350	4.6	3.70	1.30	1.10	0.22		25.	CLAY	SOFT	4.80
5.00	2.10	2.43	11.	0.40	0.19	1.50	0.360	4.7	3.82	1.38	1.11	0.23		20.	MUD		5.00
5.20	2.20	2.43	8.	0.42	0.13	1.50	0.370	4.8	3.93	1.45	1.13	0.24		14.	MUD		5.20
5.40	2.20	2.43	8.	0.44	0.13	1.50	0.380	4.6	3.71	1.41	1.10	0.24		14.	MUD		5.40
5.60	2.20	2.53	11.	0.46	0.19	1.50	0.390	4.5	3.50	1.36	1.07	0.23		19.	MUD		5.60
5.80	2.20	2.63	15.	0.48	0.25	1.60	0.402	4.3	3.28	1.32	1.04	0.23		24.	CLAY	SOFT	5.80
6.00	2.20	2.73	18.	0.50	0.31	1.60	0.414	4.1	3.07	1.27	1.01	0.22		29.	CLAY	SOFT.	6.00
6.20	2.30	2.73	15.	0.52	0.24	1.60	0.426	4.2	3.16	1.34	1.02	0.24		24.	CLAY	SOFT	6.20
6.40	2.40	2.83	15.	0.54	0.23	1.60	0.438	4.2	3.24	1.42	1.03	0.25		24.	CLAY	SOFT	6.40
6.60	2.30	2.83	18.	0.56	0.30	1.60	0.450	3.9	2.80	1.26	0.96	0.23		28.	CLAY	SOFT	6.60
6.80	2.50	2.83	11.	0.58	0.17	1.50	0.460	4.2	3.15	1.45	1.02	0.25		18.	MUD		6.80
7.00	2.50	2.83	11.	0.60	0.17	1.50	0.470	4.0	3.00	1.41	0.99	0.25		18.	MUD		7.00
7.20	2.50	2.93	15.	0.62	0.23	1.60	0.482	3.9	2.83	1.37	0.97	0.24		23.	CLAY	SOFT	7.20
7.40	2.70	3.13	15.	0.64	0.21	1.60	0.494	4.2	3.15	1.55	1.02	0.27		24.	CLAY	SOFT	7.40
7.60	2.80	3.13	11.	0.66	0.15	1.50	0.504	4.2	3.24	1.63	1.03	0.28		19.	MUD		7.60
7.80	2.70	3.13	15.	0.68	0.21	1.60	0.516	3.9	2.85	1.47	0.97	0.26		23.	CLAY	SOFT	7.80
8.00	2.90	3.23	11.	0.70	0.15	1.50	0.526	4.2	3.16	1.66	1.02	0.29		18.	MUD		8.00
Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)

Sounding LRD-3 (DIL.RED)

Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)
8.20	2.90	3.33	15.	0.72	0.20	1.60	0.538	4.1	3.01	1.62	1.00	0.29		23.	CLAY	SOFT	8.20
8.40	2.90	3.43	18.	0.74	0.25	1.60	0.550	3.9	2.87	1.58	0.97	0.28		28.	CLAY	SOFT	8.40
8.60	2.90	3.33	15.	0.76	0.20	1.60	0.562	3.8	2.73	1.53	0.95	0.28		22.	CLAY	SOFT	8.60
8.80	2.90	3.33	15.	0.78	0.20	1.60	0.574	3.7	2.60	1.49	0.93	0.27		22.	CLAY	SOFT	8.80
9.00	2.80	3.13	11.	0.80	0.16	1.50	0.584	3.4	2.31	1.35	0.87	0.25		16.	MUD		9.00
9.20	2.90	3.43	18.	0.82	0.25	1.60	0.596	3.5	2.38	1.42	0.89	0.26		26.	CLAY	SOFT	9.20
9.40	3.00	3.33	11.	0.84	0.15	1.50	0.606	3.6	2.46	1.49	0.90	0.27		16.	MUD		9.40
9.60	3.10	3.43	11.	0.86	0.15	1.50	0.616	3.6	2.54	1.57	0.92	0.29		17.	MUD		9.60
9.80	3.10	3.53	15.	0.88	0.19	1.60	0.628	3.5	2.43	1.53	0.90	0.28		21.	CLAY	SOFT	9.80
10.00	3.30	3.63	11.	0.90	0.14	1.50	0.638	3.8	2.68	1.71	0.94	0.31		17.	MUD		10.00
10.20	3.30	3.73	15.	0.92	0.18	1.60	0.650	3.7	2.57	1.67	0.92	0.30		22.	CLAY	SOFT	10.20
10.40	3.30	3.83	18.	0.94	0.22	1.60	0.662	3.6	2.46	1.63	0.90	0.30		26.	CLAY	SOFT	10.40
10.60	3.40	3.93	18.	0.96	0.22	1.60	0.674	3.6	2.52	1.70	0.91	0.31		27.	CLAY	SOFT	10.60
10.80	3.70	4.03	11.	0.98	0.12	1.50	0.684	4.0	2.92	2.00	0.98	0.36		18.	MUD		10.80
11.00	3.30	3.93	22.	1.00	0.27	1.60	0.696	3.3	2.19	1.52	0.85	0.29		30.	CLAY	SOFT	11.00
11.20	3.80	4.73	32.	1.02	0.33	1.70	0.710	3.9	2.85	2.02	0.97	0.36		50.	SILTY CLAY	LOW CONSISTENCY	11.20
11.40	3.90	4.33	15.	1.04	0.15	1.60	0.722	4.0	2.90	2.10	0.98	0.37		23.	CLAY	SOFT	11.40
11.60	3.80	4.43	22.	1.06	0.23	1.60	0.734	3.7	2.65	1.94	0.93	0.35		32.	CLAY	SOFT	11.60
11.80	3.70	4.33	22.	1.08	0.24	1.60	0.746	3.5	2.41	1.80	0.89	0.33		31.	CLAY	SOFT	11.80
12.00	4.10	4.63	18.	1.10	0.18	1.60	0.758	4.0	2.90	2.20	0.98	0.39		28.	CLAY	SOFT	12.00
12.20	4.00	4.53	18.	1.12	0.18	1.60	0.770	3.7	2.66	2.04	0.94	0.37		27.	CLAY	SOFT	12.20
12.40	4.20	4.73	18.	1.14	0.17	1.60	0.782	3.9	2.85	2.23	0.97	0.40		28.	CLAY	SOFT	12.40
12.60	4.10	4.93	29.	1.16	0.28	1.70	0.796	3.7	2.60	2.07	0.93	0.38		42.	CLAY	LOW CONSISTENCY	12.60
12.80	4.30	5.33	36.	1.18	0.33	1.70	0.810	3.9	2.78	2.25	0.96	0.40		54.	SILTY CLAY	LOW CONSISTENCY	12.80
13.00	4.40	4.93	18.	1.20	0.17	1.60	0.822	3.9	2.83	2.32	0.97	0.42		28.	CLAY	SOFT	13.00
13.20	4.20	4.83	22.	1.22	0.21	1.60	0.834	3.6	2.47	2.06	0.90	0.38		32.	CLAY	SOFT	13.20
13.40	4.20	4.83	22.	1.24	0.21	1.60	0.846	3.5	2.39	2.02	0.89	0.37		31.	CLAY	SOFT	13.40
13.60	4.20	4.93	25.	1.26	0.25	1.70	0.860	3.4	2.31	1.98	0.87	0.37		35.	CLAY	LOW CONSISTENCY	13.60
13.80	3.60	4.33	25.	1.28	0.31	1.60	0.872	2.7	1.56	1.36	0.71	0.27		29.	CLAY	SOFT	13.80
14.00	4.40	5.23	29.	1.30	0.27	1.70	0.886	3.5	2.39	2.12	0.89	0.39		41.	CLAY	LOW CONSISTENCY	14.00
14.20	4.40	4.93	18.	1.32	0.17	1.60	0.898	3.4	2.32	2.08	0.88	0.39		26.	CLAY	SOFT	14.20
14.40	4.40	5.23	29.	1.34	0.27	1.70	0.912	3.4	2.24	2.04	0.86	0.38		40.	CLAY	LOW CONSISTENCY	14.40
14.60	4.60	5.33	25.	1.36	0.23	1.70	0.926	3.5	2.39	2.22	0.89	0.41		36.	CLAY	LOW CONSISTENCY	14.60
14.80	3.90	6.43	88.	1.38	1.00	1.70	0.940	2.7	1.58	1.48	0.71			104.	SILT	LOW DENSITY	14.80
15.00	4.20	4.93	25.	1.40	0.26	1.70	0.954	2.9	1.82	1.74	0.77	0.34		31.	CLAY	LOW CONSISTENCY	15.00
15.20	4.50	5.43	32.	1.42	0.30	1.70	0.968	3.2	2.06	2.00	0.82	0.38		43.	CLAY	LOW CONSISTENCY	15.20
15.40	4.30	5.93	56.	1.44	0.57	1.70	0.982	2.9	1.80	1.77	0.77	0.35		70.	SILTY CLAY	LOW CONSISTENCY	15.40
15.60	4.90	5.53	22.	1.46	0.18	1.70	0.996	3.5	2.35	2.34	0.88	0.43		31.	CLAY	LOW CONSISTENCY	15.60
15.80	5.00	5.83	29.	1.48	0.24	1.70	1.010	3.5	2.38	2.40	0.89	0.44		41.	CLAY	LOW CONSISTENCY	15.80
16.00	4.60	5.63	36.	1.50	0.33	1.70	1.024	3.0	1.91	1.96	0.79	0.38		45.	SILTY CLAY	LOW CONSISTENCY	16.00
16.20	4.50	5.73	43.	1.52	0.41	1.70	1.038	2.9	1.76	1.82	0.76	0.36		52.	SILTY CLAY	LOW CONSISTENCY	16.20
16.40	4.80	5.83	36.	1.54	0.32	1.70	1.052	3.1	1.98	2.08	0.81	0.40		46.	CLAY	LOW CONSISTENCY	16.40
16.60	4.90	5.43	18.	1.56	0.16	1.60	1.064	3.1	2.02	2.15	0.81	0.41		24.	CLAY	SOFT	16.60
16.80	4.80	5.43	22.	1.58	0.20	1.70	1.078	3.0	1.87	2.02	0.78	0.39		27.	CLAY	LOW CONSISTENCY	16.80
17.00	4.80	5.43	22.	1.60	0.20	1.70	1.092	2.9	1.81	1.98	0.77	0.39		27.	CLAY	LOW CONSISTENCY	17.00
17.20	5.00	5.63	22.	1.62	0.19	1.70	1.106	3.1	1.94	2.14	0.80	0.41		28.	CLAY	LOW CONSISTENCY	17.20

Z (m) | PO (Bar) | P1 (Bar) | Ed (Bar) | Uo (Bar) | Id | Gamma (T/CM) | Sv (Bar) | Kd | OCR | Pc (Bar) | KO | Cu (Bar) | PHI (Deg) | M (Bar) | Soil Type | Description | Z (m)

Sounding LRD-3 (DIL.RED), Continued

Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)
17.40	5.00	5.53	18.	1.64	0.16	1.60	1.118	3.0	1.89	2.11	0.79	0.41		23.	CLAY	SOFT	17.40
17.60	5.00	5.73	25.	1.66	0.22	1.70	1.132	3.0	1.83	2.08	0.77	0.40		32.	CLAY	LOW CONSISTENCY	17.60
17.80	5.10	5.73	22.	1.68	0.18	1.70	1.146	3.0	1.87	2.14	0.78	0.42		27.	CLAY	LOW CONSISTENCY	17.80
18.00	5.00	5.63	22.	1.70	0.19	1.70	1.160	2.8	1.73	2.01	0.75	0.40		26.	CLAY	LOW CONSISTENCY	18.00
18.20	5.10	5.53	15.	1.72	0.13	1.60	1.172	2.9	1.77	2.07	0.76	0.41		18.	CLAY	SOFT	18.20
18.40	5.20	5.83	22.	1.74	0.18	1.70	1.186	2.9	1.80	2.14	0.77	0.42		27.	CLAY	LOW CONSISTENCY	18.40
18.60	4.90	5.73	29.	1.76	0.26	1.70	1.200	2.6	1.52	1.83	0.70	0.37		32.	CLAY	LOW CONSISTENCY	18.60
18.80	5.00	5.43	15.	1.78	0.13	1.60	1.212	2.7	1.56	1.89	0.71	0.38		17.	CLAY	SOFT	18.80
19.00	5.20	5.73	18.	1.80	0.16	1.60	1.224	2.8	1.67	2.04	0.74	0.41		22.	CLAY	SOFT	19.00
19.20	5.20	5.53	11.	1.82	0.10	1.50	1.234	2.7	1.63	2.02	0.73	0.40		13.	MUD		19.20
19.40	5.60	6.33	25.	1.84	0.19	1.70	1.248	3.0	1.90	2.36	0.79	0.46		32.	CLAY	LOW CONSISTENCY	19.40
19.60	5.40	6.33	32.	1.86	0.26	1.70	1.262	2.8	1.70	2.14	0.74	0.42		39.	CLAY	LOW CONSISTENCY	19.60
19.80	5.50	6.33	29.	1.88	0.23	1.70	1.276	2.8	1.73	2.20	0.75	0.43		35.	CLAY	LOW CONSISTENCY	19.80
20.00	5.40	6.23	29.	1.90	0.24	1.70	1.290	2.7	1.61	2.08	0.72	0.42		33.	CLAY	LOW CONSISTENCY	20.00
Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)

NOTES:1.For 0.9>Id>1.2 neither Cu nor Phi calculated.
2.1Bar=100KPa
3.# =1mm Deflection not reached.

Sounding LRD-3 (DIL.RED), Continued

U.B.C. INSITU TESTING RESEARCH GROUP.

File Name:LRD-4X
Location:LANGLEY-232 ST(UPPER)

Record of Dilatometer test No:LRD-4
Date:MAR 2 84

Calibration Information:DA= 0.20 Bars DB= 0.27 Bars ZM= 0.0 Bars ZW= 3.00 metres

Gamma=Bulk unit weight
Sv =Effective over.stress
Uo =Pore pressure
Id =Material index
Ed =Dilatometer modulus
Kd =Horizontal stress index

INTERPRETED GEOTECHNICAL PARAMETERS
Ko =Insitu earth press.coeff.
OCR=Overconsolidation Ratio
M =Constrained modulus
Cu =Undrained cohesion(cohesive)
PHI=Friction Angle(cohesionless)

Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)
0.20	0.90	2.23	46.	0.0	1.48	1.60	0.031	29.0	*****	3.36	3.43		32.4	161.	SANDY SILT	CEMENTED	0.20
0.40	1.40	3.03	56.	0.0	1.16	1.60	0.063	22.2	42.79	2.70	2.95			184.	SILT	COMPRESSIBLE	0.40
0.60	2.40	4.43	70.	0.0	0.85	1.70	0.097	24.7	50.60	4.91	3.13	0.50		236.	SILT	LOW DENSITY	0.60
0.80	2.80	6.63	133.	0.0	1.37	1.80	0.133	21.1	52.32	6.96	2.86		31.3	425.	SANDY SILT	MEDIUM DENSITY	0.80
1.00	1.40	3.43	70.	0.0	1.45	1.70	0.167	8.4	12.95	2.16	1.65		29.3	164.	SANDY SILT	LOW DENSITY	1.00
1.20	1.20	2.83	56.	0.0	1.36	1.60	0.199	6.0	6.71	1.34	1.32		28.2	113.	SANDY SILT	COMPRESSIBLE	1.20
1.40	1.50	3.03	53.	0.0	1.02	1.60	0.231	6.5	6.28	1.45	1.39			110.	SILT	COMPRESSIBLE	1.40
1.60	1.80	3.43	56.	0.0	0.91	1.70	0.265	6.8	6.74	1.78	1.43			119.	SILT	LOW DENSITY	1.60
1.80	0.90	1.33	15.	0.0	0.48	1.60	0.297	3.0	1.91	0.57	0.79	0.11		19.	SILTY CLAY	SOFT	1.80
2.00	1.20	1.73	18.	0.0	0.44	1.60	0.329	3.6	2.55	0.84	0.92	0.15		27.	SILTY CLAY	SOFT	2.00
2.20	1.30	3.23	67.	0.0	1.48	1.60	0.361	3.6	3.26	1.18	0.91		27.5	101.	SANDY SILT	COMPRESSIBLE	2.20
2.40	2.00	6.03	139.	0.0	2.01	1.80	0.397	5.0	10.21	4.05	1.17		29.7	259.	SILTY SAND	LOW RIGIDITY	2.40
2.60	3.40	6.73	115.	0.0	0.98	1.80	0.433	7.9	8.44	3.66	1.58			260.	SILT	MEDIUM DENSITY	2.60
2.80	2.80	6.83	139.	0.0	1.44	1.80	0.469	6.0	7.26	3.40	1.31		28.4	279.	SANDY SILT	MEDIUM DENSITY	2.80
3.00	3.10	7.63	157.	0.0	1.46	1.80	0.505	6.1	7.80	3.94	1.34		28.6	318.	SANDY SILT	MEDIUM DENSITY	3.00
3.20	3.40	7.83	153.	0.02	1.31	1.80	0.521	6.5	7.15	3.72	1.39		28.2	318.	SANDY SILT	MEDIUM DENSITY	3.20
3.40	3.50	7.83	150.	0.04	1.25	1.80	0.537	6.4	6.59	3.54	1.38		28.0	310.	SANDY SILT	MEDIUM DENSITY	3.40
3.60	4.30	8.03	129.	0.06	0.88	1.80	0.553	7.7	8.14	4.50	1.55	0.65		288.	SILT	MEDIUM DENSITY	3.60
3.80	3.50	6.83	115.	0.08	0.97	1.80	0.569	6.0	5.57	3.17	1.32			229.	SILT	MEDIUM DENSITY	3.80
4.00	2.70	5.43	94.	0.10	1.05	1.70	0.583	4.5	3.49	2.04	1.07			160.	SILT	LOW DENSITY	4.00
4.20	2.50	4.53	70.	0.12	0.85	1.70	0.597	4.0	2.93	1.75	0.98	0.31		110.	SILT	LOW DENSITY	4.20
4.40	2.30	4.53	77.	0.14	1.03	1.70	0.611	3.5	2.43	1.49	0.90			113.	SILT	LOW DENSITY	4.40
4.60	2.40	4.53	74.	0.16	0.95	1.70	0.625	3.6	2.48	1.55	0.91			108.	SILT	LOW DENSITY	4.60
4.80	2.40	4.33	67.	0.18	0.87	1.70	0.639	3.5	2.37	1.51	0.88	0.28		96.	SILT	LOW DENSITY	4.80
5.00	3.20	4.73	53.	0.20	0.51	1.70	0.653	4.6	3.66	2.39	1.09	0.41		90.	SILTY CLAY	LOW CONSISTENCY	5.00
5.20	3.10	4.03	32.	0.22	0.32	1.70	0.667	4.3	3.32	2.22	1.04	0.38		53.	CLAY	LOW CONSISTENCY	5.20
5.40	2.80	3.53	25.	0.24	0.29	1.60	0.679	3.8	2.69	1.83	0.94	0.33		38.	CLAY	SOFT	5.40
5.60	2.70	3.53	29.	0.26	0.34	1.60	0.691	3.5	2.43	1.68	0.80	0.31		41.	SILTY CLAY	SOFT	5.60
5.80	2.10	2.73	22.	0.28	0.35	1.60	0.703	2.6	1.50	1.05	0.69	0.21		24.	SILTY CLAY	SOFT	5.80
6.00	2.60	3.43	29.	0.30	0.36	1.60	0.715	3.2	2.10	1.50	0.83	0.28		38.	SILTY CLAY	SOFT	6.00
6.20	2.70	3.33	22.	0.32	0.26	1.60	0.727	3.3	2.16	1.57	0.84	0.30		30.	CLAY	SOFT	6.20
6.40	2.60	3.23	22.	0.34	0.28	1.60	0.739	3.1	1.94	1.43	0.80	0.28		28.	CLAY	SOFT	6.40
Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)

Sounding LRD-4 (DIL.RED)

Z (m)	PO (Bar)	P1 (Bar)	Ed (Bar)	Uo (Bar)	Id	Gamma (T/CM)	Sv (Bar)	Kd	OCR	Pc (Bar)	KO	Cu (Bar)	PHI (Deg)	M (Bar)	Soil Type	Description	Z (m)
6.60	2.10	2.73	22.	0.36	0.36	1.60	0.751	2.3	1.26	0.94	0.63	0.20		22.	SILTY CLAY	SOFT	6.60
6.80	2.60	3.23	22.	0.38	0.28	1.60	0.763	2.9	1.79	1.37	0.77	0.27		27.	CLAY	SOFT	6.80
7.00	2.70	3.13	15.	0.40	0.19	1.60	0.775	3.0	1.85	1.43	0.78	0.28		19.	CLAY	SOFT	7.00
7.20	2.60	3.03	15.	0.42	0.20	1.60	0.787	2.8	1.66	1.31	0.73	0.26		18.	CLAY	SOFT	7.20
7.40	2.50	3.03	18.	0.44	0.26	1.60	0.799	2.6	1.49	1.19	0.69	0.24		20.	CLAY	SOFT	7.40
7.60	2.60	3.03	15.	0.46	0.20	1.60	0.811	2.6	1.54	1.25	0.70	0.25		17.	CLAY	SOFT	7.60
7.80	2.60	3.03	15.	0.48	0.20	1.60	0.823	2.6	1.48	1.22	0.69	0.25		17.	CLAY	SOFT	7.80

Z (m) PO (Bar) P1 (Bar) Ed (Bar) Uo (Bar) Id Gamma (T/CM) Sv (Bar) Kd OCR Pc (Bar) KO Cu (Bar) PHI (Deg) M (Bar) Soil Type Description Z (m)

NOTES: 1. For 0.9>Id>1.2 neither Cu nor Phi calculated.
2. 1Bar=100KPa
3. # =1mm Deflection not reached.

Sounding LRD-4 (DIL.RED), Continued

SCHMERTMANN & CRAPPS, INC.
FILE NAME: RESEARCH DMT TESTING
FILE NUMBER: MRD-1

TEST NO. R.DMT SOUNDING NO.1

RECORD OF DILATOMETER TEST NO. R.DMT SOUNDING NO.1
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: MCDONALD'S FARM
PERFORMED - DATE: MAR 21 1984
BY: C. TSANG

CALIBRATION INFORMATION:
DA= 0.20 BARS DB= 0.27 BARS ZM= 0.0 BARS ZW= 1.00 METERS VSO= 0.031 BARS
ROD DIA.= 3.50 CM FRICTION RED. DIA.= 4.38 CM ROD WEIGHT= 6.59 KG/M DELTA/PHI= 0.50

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H2O UNIT WEIGHT = 1.000 T/M3

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
*****	******	*****	*****	*****	*****	*****	******	******	******	*****	*****	*****	*****	*****	*****	************
0.20	347.	0.90	3.80	84.	2.21	35.48	0.0	1.70	0.031	4.20	*****	4.34		35.1	312.	SILTY SAND
0.40	511.	0.50	2.60	57.	2.33	10.88	0.0	1.70	0.064	0.64	9.92	1.14		41.6	146.	SILTY SAND
0.60	551.	0.40	1.80	32.	1.55	6.27	0.0	1.60	0.096	0.33	3.46	0.67		40.8	66.	SANDY SILT
0.80	541.	0.50	1.60	22.	0.90	5.50	0.0	1.60	0.127	0.62	4.85	1.24	0.10		42.	CLAYEY SILT
1.00	531.	0.70	2.00	29.	0.92	5.68	0.0	1.60	0.159	0.81	5.09	1.27			56.	SILT
1.20	408.	0.40	1.40	18.	0.91	3.41	0.020	1.60	0.170	0.39	2.30	0.87			26.	SILT
1.60	347.	0.50	1.40	15.	0.67	3.31	0.059	1.60	0.194	0.42	2.19	0.85	0.08		20.	CLAYEY SILT
1.80	306.	0.50	1.60	22.	1.01	3.02	0.079	1.60	0.206	0.39	1.90	0.79			29.	SILT
2.00	327.	0.60	2.30	43.	1.75	3.23	0.098	1.60	0.217	0.51	2.34	0.64		31.5	61.	SANDY SILT
2.20	490.	0.60	2.90	64.	2.68	2.95	0.118	1.70	0.231	0.39	1.70	0.52		35.3	90.	SILTY SAND
2.40	603.	0.90	3.30	67.	2.00	3.93	0.137	1.70	0.245	0.63	2.57	0.63		35.6	109.	SILTY SAND
2.60	613.	0.70	2.70	53.	2.06	2.87	0.157	1.70	0.259	0.39	1.50	0.48		36.6	71.	SILTY SAND
2.80	633.	1.00	3.10	57.	1.59	3.78	0.177	1.60	0.270	0.67	2.47	0.62		35.5	89.	SANDY SILT
3.00	674.	0.70	3.30	74.	3.03	2.48	0.196	1.70	0.284	0.33	1.16	0.42		37.2	95.	SILTY SAND
3.20	827.	1.20	5.00	116.	2.81	3.95	0.216	1.80	0.300	0.73	2.43	0.61		37.0	194.	SILTY SAND
3.40	1052.	1.20	5.70	140.	3.46	3.69	0.236	1.80	0.316	0.58	1.85	0.52		38.9	228.	SAND
3.60	1400.	1.30	6.90	178.	4.12	3.76	0.255	1.80	0.331	0.50	1.50	0.45		40.9	294.	SAND
3.80	1318.	1.90	8.60	216.	3.41	5.26	0.275	1.80	0.347	1.23	3.55	0.72		38.8	420.	SAND
4.00	1083.	1.50	7.00	175.	3.58	3.88	0.294	1.80	0.363	0.81	2.23	0.58		38.0	293.	SAND
4.20	991.	1.50	6.70	164.	3.41	3.66	0.314	1.80	0.378	0.83	2.19	0.58		37.1	267.	SAND
4.40	868.	1.10	5.00	119.	3.55	2.45	0.334	1.80	0.394	0.48	1.22	0.44		37.0	152.	SAND
4.60	786.	1.70	6.10	136.	2.54	3.77	0.353	1.80	0.410	1.11	2.72	0.67		34.2	222.	SILTY SAND
4.80	909.	1.30	5.60	133.	3.40	2.65	0.373	1.80	0.426	0.61	1.42	0.48		36.7	170.	SAND
5.00	1001.	1.80	6.90	161.	2.88	3.64	0.393	1.80	0.441	1.04	2.36	0.61		36.1	259.	SILTY SAND
5.20	1083.	1.60	6.70	161.	3.34	3.04	0.412	1.80	0.457	0.76	1.67	0.51		37.2	235.	SAND
5.40	1522.	1.60	7.70	195.	4.11	2.90	0.432	1.80	0.473	0.55	1.15	0.40		40.0	278.	SAND
5.60	1635.	2.10	8.80	216.	3.37	3.79	0.451	1.80	0.488	0.96	1.96	0.53		39.5	358.	SAND
5.80	1236.	2.10	8.40	202.	3.19	3.63	0.471	1.80	0.504	1.13	2.25	0.59		37.0	328.	SILTY SAND
6.00	1165.	1.70	6.90	164.	3.36	2.71	0.491	1.80	0.520	0.74	1.43	0.48		37.3	224.	SAND
6.20	1338.	1.60	7.00	171.	3.82	2.41	0.510	1.80	0.535	0.57	1.06	0.40		38.6	216.	SAND
6.40	2084.	1.90	10.00	265.	4.86	2.85	0.530	1.80	0.551	0.49	0.89	0.34		41.6	373.	SAND
6.60	2146.	2.80	11.90	299.	3.52	4.31	0.550	1.90	0.569	1.33	2.35	0.58		40.2	530.	SAND
6.80	1778.	2.60	9.60	227.	2.93	3.80	0.569	1.90	0.586	1.26	2.14	0.56		38.9	375.	SILTY SAND
7.00	1982.	2.60	10.50	258.	3.36	3.66	0.589	1.90	0.604	1.13	1.87	0.52		39.8	419.	SAND
7.20	3127.	2.70	11.30	282.	3.55	3.69	0.608	1.90	0.622	0.68	1.09	0.37		43.3	461.	SAND
7.40	3679.	5.10	17.80	424.	2.62	7.28	0.628	2.00	0.641	3.67	5.72	0.89		41.6	941.	SILTY SAND
7.60	3015.	4.20	17.10	431.	3.31	5.68	0.648	2.00	0.661	2.48	3.75	0.72		40.9	866.	SAND
8.00	2555.	3.80	14.80	365.	3.18	4.74	0.687	1.90	0.698	2.06	2.95	0.65		39.9	677.	SILTY SAND
8.60	1941.	2.70	11.60	293.	3.91	2.87	0.746	1.90	0.751	1.07	1.42	0.47		38.9	414.	SAND
9.00	2044.	3.00	13.50	348.	4.15	3.07	0.785	1.90	0.787	1.26	1.60	0.50		38.8	513.	SAND
9.60	3505.	3.80	17.60	463.	4.22	3.76	0.844	1.90	0.840	1.31	1.56	0.46		42.1	763.	SAND
10.00	5764.	6.40	17.80	379.	1.91	6.52	0.883	2.00	0.877	3.46	3.95	0.72		43.6	796.	SILTY SAND
10.60	3853.	4.20	18.70	487.	4.06	3.71	0.942	1.90	0.933	1.42	1.53	0.45		42.2	797.	SAND
11.00	2381.	2.90	13.00	334.	4.55	2.19	0.981	1.90	0.968	0.89	0.92	0.37		39.6	394.	SAND

CONTINUED ON NEXT PAGE

Sounding MRD-1 (DILLY4)
(Thrust measured at ground surface)

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
11.60	1226.	2.30	6.90	143.	2.83	1.43	1.040	1.80	1.018	0.93	0.91	0.42		34.7	122.	SILTY SAND
11.80	2544.	3.20	11.90	286.	3.52	2.26	1.060	1.90	1.036	1.01	0.97	0.38		39.6	345.	SAND
12.00	3474.	5.00	18.20	442.	3.09	3.90	1.079	2.00	1.056	2.25	2.13	0.56		40.4	743.	SILTY SAND
12.20	3515.	5.90	18.90	435.	2.51	4.65	1.099	2.00	1.075	3.28	3.05	0.67		39.7	787.	SILTY SAND
12.40	3393.	3.70	15.20	383.	3.87	2.55	1.119	1.90	1.093	1.02	0.93	0.36		41.3	502.	SAND
12.60	4241.	3.70	16.70	435.	4.54	2.49	1.138	1.90	1.110	0.68	0.61	0.28		43.0	561.	SAND
12.80	5314.	4.10	19.40	515.	4.72	2.79	1.158	1.90	1.128	0.55	0.49	0.24		44.4	715.	SAND
13.00	6111.	5.60	18.90	445.	2.78	4.03	1.178	2.00	1.148	1.51	1.31	0.40		44.2	755.	SILTY SAND
13.40	4936.	4.70	18.70	469.	3.67	3.10	1.217	2.00	1.187	1.13	0.96	0.35		43.1	696.	SAND
13.80	2136.	2.70	8.00	168.	2.94	1.34	1.256	1.80	1.222	0.77	0.63	0.33		38.2	142.	SILTY SAND
14.00	3311.	5.00	16.70	390.	2.86	3.16	1.276	2.00	1.242	2.06	1.66	0.50		39.6	580.	SILTY SAND
14.20	3004.	4.10	13.80	320.	3.07	2.39	1.295	1.90	1.260	1.39	1.10	0.41		39.5	402.	SILTY SAND
14.40	2636.	3.30	12.90	317.	4.18	1.71	1.315	1.90	1.277	0.95	0.74	0.34		39.2	306.	SAND
14.60	2565.	3.30	11.40	265.	3.52	1.67	1.335	1.90	1.295	0.97	0.75	0.35		38.9	251.	SAND
14.80	2616.	3.40	10.80	240.	3.09	1.71	1.354	1.90	1.313	1.01	0.77	0.35		38.9	232.	SILTY SAND
15.00	2371.	3.30	11.80	279.	3.78	1.60	1.374	1.90	1.330	1.03	0.78	0.36		38.2	253.	SAND
15.20	2156.	3.80	10.30	209.	2.31	1.93	1.394	1.90	1.348	1.48	1.10	0.44		36.9	209.	SILTY SAND
16.00	572.	3.20	4.50	29.	0.43	1.37	1.472	1.60	1.407	0.78	0.55	0.36	0.19		24.	SILTY CLAY
17.00	572.	4.10	5.20	22.	0.23	1.86	1.570	1.60	1.466	1.31	0.89	0.51	0.29		19.	CLAY
18.00	572.	4.50	5.40	15.	0.14	1.99	1.668	1.60	1.525	1.51	0.99	0.54	0.33		13.	CLAY
18.20	572.	4.60	5.50	15.	0.14	2.03	1.688	1.60	1.536	1.57	1.02	0.55	0.34		13.	CLAY
18.40	572.	4.70	5.60	15.	0.13	2.06	1.708	1.60	1.548	1.62	1.05	0.56	0.35		13.	CLAY
18.60	572.	4.50	5.50	18.	0.18	1.91	1.727	1.60	1.560	1.45	0.93	0.52	0.32		16.	CLAY
18.80	572.	4.80	5.90	22.	0.19	2.07	1.747	1.70	1.574	1.66	1.05	0.56	0.36		19.	CLAY
19.00	572.	4.50	5.70	25.	0.25	1.85	1.766	1.70	1.587	1.40	0.88	0.50	0.32		22.	CLAY
19.20	572.	5.10	6.40	29.	0.24	2.19	1.786	1.70	1.601	1.85	1.16	0.60	0.40		27.	CLAY
19.40	572.	4.30	5.60	29.	0.31	1.67	1.806	1.70	1.615	1.22	0.75	0.45	0.28		24.	CLAY
19.60	572.	4.50	5.70	25.	0.25	1.77	1.825	1.70	1.629	1.34	0.82	0.48	0.31		22.	CLAY
19.80	572.	5.10	6.40	29.	0.24	2.10	1.845	1.70	1.642	1.78	1.08	0.57	0.38		26.	CLAY
20.00	572.	3.60	5.30	43.	0.64	1.17	1.865	1.70	1.656	0.72	0.43	0.29	0.19		36.	CLAYEY SILT
20.20	572.	5.40	6.50	22.	0.17	2.23	1.884	1.70	1.670	1.97	1.18	0.60	0.42		21.	CLAY
20.40	572.	3.00	5.40	67.	1.49	0.77	1.904	1.60	1.682	1.73	1.03	0.56		26.2	57.	SANDY SILT
20.60	572.	5.30	6.60	29.	0.23	2.11	1.923	1.70	1.695	1.84	1.09	0.57	0.40		26.	CLAY
20.80	572.	5.60	6.60	18.	0.14	2.26	1.943	1.70	1.709	2.06	1.21	0.61	0.44		18.	CLAY

END OF SOUNDING

Sounding MRD-1 (DILLY4), Continued
(Thrust measured at ground surface)

SCHMERTMANN & CRAPPS, INC. TEST NO. DMT SOUNDING NO.2
FILE NAME: RESEARCH DMT TEST
FILE NUMBER: MRD-2

RECORD OF DILATOMETER TEST NO. DMT SOUNDING NO.2
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: MCDONALD'S FARM
PERFORMED - DATE: APR 18 1984
BY: C. TSANG

CALIBRATION INFORMATION:
DA= 0.20 BARS DB= 0.27 BARS ZM= 0.0 BARS ZW= 1.50 METERS VSO= 0.157 BARS
ROD DIA.= 3.50 CM FRICTION RED. DIA.= 4.38 CM ROD WEIGHT= 6.59 KG/M DELTA/PHI= 0.50

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H2O UNIT WEIGHT = 1.000 T/M3

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
1.00	449.	0.50	1.90	32.	1.33	4.46	0.0	1.60	0.157	0.46	2.95	0.67		35.9	55.	SANDY SILT
2.00	235.	0.50	1.50	18.	0.81	2.46	0.049	1.60	0.265	0.37	1.38	0.66	0.08		20.	CLAYEY SILT
3.00	163.	0.50	1.40	15.	0.78	1.71	0.147	1.60	0.324	0.25	0.78	0.46	0.06		13.	CLAYEY SILT
4.00	1308.	1.20	6.50	168.	4.18	2.94	0.245	1.80	0.393	0.45	1.14	0.40		40.0	241.	SAND
5.00	1246.	1.40	6.90	175.	4.00	2.67	0.343	1.80	0.471	0.57	1.21	0.43		38.6	236.	SAND
6.00	2044.	2.40	8.30	188.	2.52	3.89	0.442	1.90	0.554	1.06	1.92	0.52		40.4	311.	SILTY SAND
7.00	1941.	2.60	11.10	279.	3.55	3.52	0.540	1.90	0.643	1.18	1.84	0.52		39.3	444.	SAND
8.00	3004.	3.40	13.60	338.	3.28	4.05	0.638	1.90	0.731	1.39	1.90	0.51		41.5	579.	SILTY SAND
9.00	2003.	2.00	8.50	209.	4.12	1.80	0.736	1.80	0.815	0.52	0.64	0.31		39.8	211.	SAND
10.00	4292.	2.80	15.20	414.	5.51	2.41	0.834	1.90	0.898	0.21	0.23	0.16		44.7	524.	SAND

END OF SOUNDING

Sounding MRD-2 (DILLY4)
(Thrust measured at ground surface)

SCHMERTMANN & CRAPPS, INC.
FILE NAME: RESEARSH DMT TEST
FILE NUMBER: MRD-3

TEST NO. DMT SOUNDING NO.3

RECORD OF DILATOMETER TEST NO. DMT SOUNDING NO.3
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: MCDONALD'S FARM
PERFORMED - DATE: APR 18 1984
BY: C. TSANG

CALIBRATION INFORMATION:
DA= 0.20 BARS DB= 0.27 BARS ZM= 0.0 BARS ZW= 1.50 METERS VSO= 0.883 BARS
ROD DIA.= 3.50 CM FRICTION RED. DIA.= 4.38 CM ROD WEIGHT= 6.59 KG/M DELTA/PHI= 0.50

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H20 UNIT WEIGHT = 1.000 T/M3

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
5.00	1042.	1.20	5.90	147.	4.00	1.96	0.343	1.80	0.540	0.52	0.96	0.40		37.0	159.	SAND
7.00	3086.	2.40	13.10	355.	4.97	2.92	0.540	1.90	0.706	0.50	0.71	0.30		43.0	508.	SAND
9.00	1921.	2.30	10.50	268.	4.38	2.00	0.736	1.90	0.883	0.79	0.89	0.38		38.7	295.	SAND
10.00	3965.	2.80	16.10	445.	5.92	2.23	0.834	1.90	0.971	0.34	0.35	0.21		43.6	533.	SAND
11.00	4721.	4.80	19.10	480.	3.40	3.82	0.932	2.00	1.065	1.61	1.51	0.45		42.8	799.	SAND
12.00	2555.	3.00	12.60	317.	4.21	1.87	1.030	1.90	1.158	0.92	0.80	0.35		39.3	331.	SAND
13.00	3229.	3.20	14.30	369.	4.68	1.82	1.129	1.90	1.246	0.77	0.62	0.30		40.8	377.	SAND
14.00	2779.	3.90	10.20	202.	2.03	2.15	1.227	1.90	1.334	1.40	1.05	0.41		38.8	216.	SILTY SAND
16.00	1410.	2.80	5.70	84.	1.54	1.06	1.423	1.70	1.491	1.18	0.79	0.40		34.0	72.	SANDY SILT
17.00	572.	4.20	5.40	25.	0.25	1.85	1.521	1.70	1.560	1.38	0.88	0.50	0.31		22.	CLAY
18.00	572.	4.30	5.30	18.	0.18	1.77	1.619	1.60	1.624	1.35	0.83	0.48	0.31		16.	CLAY
18.20	572.	4.40	5.60	25.	0.25	1.81	1.639	1.70	1.638	1.40	0.85	0.49	0.32		22.	CLAY
18.40	572.	2.60	4.80	60.	1.52	0.69	1.658	1.60	1.649	1.60	0.97	0.54		26.5	51.	SANDY SILT
18.60	572.	3.90	5.20	29.	0.34	1.46	1.678	1.60	1.661	1.01	0.61	0.39	0.25		24.	CLAY
18.80	572.	4.00	5.20	25.	0.29	1.50	1.698	1.60	1.673	1.06	0.64	0.40	0.26		22.	CLAY
19.00	572.	2.50	4.70	60.	1.76	0.58	1.717	1.60	1.685	1.52	0.90	0.53		26.7	51.	SANDY SILT
19.20	572.	3.70	5.10	32.	0.43	1.27	1.737	1.60	1.697	0.84	0.50	0.33	0.21		27.	SILTY CLAY
19.40	572.	3.70	4.60	15.	0.20	1.25	1.757	1.60	1.708	0.83	0.48	0.32	0.21		13.	CLAY
19.60	572.	2.50	4.10	39.	1.22	0.54	1.776	1.60	1.720	1.50	0.87	0.52		26.8	33.	SANDY SILT
19.80	572.	3.70	4.80	22.	0.30	1.21	1.796	1.60	1.732	0.80	0.46	0.31	0.20		19.	CLAY
20.00	572.	3.90	4.90	18.	0.23	1.31	1.816	1.60	1.744	0.90	0.52	0.34	0.23		16.	CLAY
20.20	572.	2.50	4.20	43.	1.42	0.49	1.835	1.60	1.755	1.49	0.85	0.52		26.8	36.	SANDY SILT
20.40	572.	4.60	5.70	22.	0.21	1.67	1.855	1.60	1.767	1.33	0.75	0.45	0.31		19.	CLAY
20.60	572.	3.30	5.00	43.	0.76	0.91	1.874	1.60	1.779	0.52	0.29	0.19	0.15		36.	CLAYEY SILT
20.80	572.	4.80	5.90	22.	0.20	1.73	1.894	1.70	1.793	1.43	0.80	0.47	0.33		19.	CLAY
21.00	572.	4.30	5.80	36.	0.40	1.43	1.914	1.70	1.806	1.07	0.59	0.38	0.26		30.	SILTY CLAY
21.20	572.	5.20	6.70	36.	0.30	1.90	1.933	1.70	1.820	1.69	0.93	0.52	0.38		30.	CLAY

END OF SOUNDING

Sounding MRD-3 (DILLY4)
(Thrust measured at ground surface)

SCHMERTMANN & CRAPPS, INC. TEST NO. R.DMT SOUNDING NO.1
FILE NAME: RESEARCH DMT TESTING
FILE NUMBER: MRD-1

RECORD OF DILATOMETER TEST NO. R.DMT SOUNDING NO.1
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: MCDONALD'S FARM
PERFORMED - DATE: MAR 21 1984
BY: C. TSANG

CALIBRATION INFORMATION:
DA= 0.20 BARS DB= 0.27 BARS ZM= 0.0 BARS ZW= 1.00 METERS VSO= 0.031 BARS
ROD DIA.= 0.0 CM FRICTION RED. DIA.= 0.0 CM ROD WEIGHT= 0.0 KG/M DELTA/PHI= 0.50

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H2O UNIT WEIGHT = 1.000 T/M3

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
0.20	299.	0.90	3.80	84.	2.21	35.48	0.0	1.70	0.031	4.57	*****	4.41		32.7	312.	SILTY SAND
0.40	377.	0.50	2.60	57.	2.33	10.88	0.0	1.70	0.064	0.79	12.29	1.30		38.4	146.	SILTY SAND
0.60	204.	0.40	1.80	32.	1.55	6.27	0.0	1.60	0.096	0.60	6.31	1.00		30.2	66.	SANDY SILT
0.80	125.	0.50	1.60	22.	0.90	5.50	0.0	1.60	0.127	0.62	4.85	1.24	0.10		42.	CLAYEY SILT
1.00	188.	0.70	2.00	29.	0.92	5.68	0.0	1.60	0.159	0.81	5.09	1.27			56.	SILT
1.20	173.	0.40	1.40	18.	0.91	3.41	0.020	1.60	0.170	0.39	2.30	0.87			26.	SILT
1.60	196.	0.50	1.40	15.	0.67	3.31	0.059	1.60	0.194	0.42	2.19	0.85	0.08		20.	CLAYEY SILT
1.80	165.	0.50	1.60	22.	1.01	3.02	0.079	1.60	0.206	0.39	1.90	0.79			29.	SILT
2.00	212.	0.60	2.30	43.	1.75	3.23	0.098	1.60	0.217	0.62	2.83	0.75		26.4	61.	SANDY SILT
2.20	362.	0.60	2.90	64.	2.68	2.95	0.118	1.70	0.231	0.45	1.97	0.58		32.8	90.	SILTY SAND
2.40	440.	0.90	3.30	67.	2.00	3.93	0.137	1.70	0.245	0.72	2.93	0.70		32.9	109.	SILTY SAND
2.60	472.	0.70	2.70	53.	2.06	2.87	0.157	1.70	0.259	0.45	1.72	0.53		34.7	71.	SILTY SAND
2.80	487.	1.00	3.10	57.	1.59	3.78	0.177	1.60	0.270	0.74	2.75	0.68		33.3	89.	SANDY SILT
3.00	519.	0.70	3.30	74.	3.03	2.48	0.196	1.70	0.284	0.39	1.36	0.47		35.4	95.	SILTY SAND
3.20	668.	1.20	5.00	116.	2.81	3.95	0.216	1.80	0.300	0.80	2.65	0.65		35.5	194.	SILTY SAND
3.40	920.	1.20	5.70	140.	3.46	3.69	0.236	1.80	0.316	0.61	1.93	0.53		38.5	229.	SAND
3.60	1251.	1.30	6.90	178.	4.12	3.76	0.255	1.80	0.331	0.51	1.53	0.45		40.8	294.	SAND
3.80	1164.	1.90	8.60	216.	3.41	5.26	0.275	1.80	0.347	1.27	3.65	0.73		38.4	420.	SAND
4.00	912.	1.50	7.00	175.	3.58	3.88	0.294	1.80	0.363	0.86	2.38	0.60		37.1	293.	SAND
4.20	834.	1.50	6.70	164.	3.41	3.66	0.314	1.80	0.378	0.88	2.33	0.61		36.2	267.	SAND
4.40	739.	1.10	5.00	119.	3.55	2.45	0.334	1.80	0.394	0.52	1.31	0.46		36.2	152.	SAND
4.60	661.	1.70	6.10	136.	2.54	3.77	0.353	1.80	0.410	1.18	2.88	0.70		32.9	222.	SILTY SAND
4.80	779.	1.30	5.60	133.	3.40	2.65	0.373	1.80	0.426	0.64	1.51	0.50		35.9	179.	SAND
5.00	857.	1.80	6.90	161.	2.88	3.64	0.393	1.80	0.441	1.10	2.48	0.64		35.2	259.	SILTY SAND
5.20	944.	1.60	6.70	161.	3.34	3.04	0.412	1.80	0.457	0.80	1.75	0.53		36.6	235.	SAND
5.40	1330.	1.60	7.70	195.	4.11	2.90	0.432	1.80	0.473	0.57	1.21	0.42		39.7	278.	SAND
5.60	1361.	2.10	8.80	216.	3.37	3.79	0.451	1.80	0.488	1.04	2.12	0.56		38.7	358.	SAND
5.80	1007.	2.10	8.40	202.	3.19	3.63	0.471	1.80	0.504	1.22	2.43	0.63		35.7	328.	SILTY SAND
6.00	944.	1.70	6.90	164.	3.36	2.71	0.491	1.80	0.520	0.82	1.58	0.51		36.0	224.	SAND
6.20	1156.	1.60	7.00	171.	3.82	2.41	0.510	1.80	0.535	0.60	1.13	0.42		38.1	216.	SAND
6.40	1857.	1.90	10.00	265.	4.86	2.85	0.530	1.80	0.551	0.50	0.91	0.35		41.5	373.	SAND
6.60	1802.	2.80	11.90	299.	3.52	4.31	0.550	1.90	0.569	1.43	2.51	0.60		39.5	530.	SAND
6.80	1479.	2.60	9.60	227.	2.93	3.80	0.569	1.90	0.586	1.35	2.30	0.59		38.0	375.	SILTY SAND
7.00	1762.	2.60	10.50	258.	3.36	3.66	0.589	1.90	0.604	1.15	1.91	0.53		39.5	419.	SAND
7.20	2801.	2.70	11.30	282.	3.55	3.69	0.608	1.90	0.622	0.68	1.09	0.37		43.2	461.	SAND
7.40	3281.	5.10	17.80	424.	2.62	7.28	0.628	2.00	0.641	3.71	5.79	0.89		41.4	941.	SILTY SAND
7.60	2274.	4.20	17.10	431.	3.31	5.68	0.648	2.00	0.661	2.79	4.23	0.79		39.2	866.	SAND
8.00	2085.	3.80	14.80	365.	3.18	4.74	0.687	1.90	0.698	2.22	3.18	0.69		38.9	677.	SILTY SAND
8.60	1566.	2.70	11.60	293.	3.91	2.87	0.746	1.90	0.751	1.18	1.57	0.50		37.7	414.	SAND
9.00	1731.	3.00	13.50	348.	4.15	3.07	0.785	1.90	0.787	1.34	1.71	0.52		38.0	513.	SAND
9.60	2896.	3.80	17.60	463.	4.22	3.76	0.844	1.90	0.840	1.45	1.73	0.49		41.3	763.	SAND
10.00	4934.	6.40	17.80	379.	1.91	6.52	0.883	2.00	0.877	3.63	4.13	0.74		43.2	796.	SILTY SAND
10.60	3256.	4.20	18.70	487.	4.06	3.71	0.942	1.90	0.933	1.54	1.65	0.48		41.6	797.	SAND
11.00	1964.	2.90	13.00	334.	4.55	2.19	0.981	1.90	0.968	0.99	1.02	0.40		38.7	394.	SAND

CONTINUED ON NEXT PAGE

Sounding MRD-1 (DILLY4)

(Thrust measured immediately behind blade)

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
11.60	1084.	2.30	6.90	143.	2.83	1.43	1.040	1.80	1.018	0.97	0.95	0.43		34.1	122.	SILTY SAND
11.80	2107.	3.20	11.90	286.	3.52	2.26	1.060	1.90	1.036	1.11	1.07	0.41		38.8	345.	SAND
12.00	2924.	5.00	18.20	442.	3.09	3.90	1.079	2.00	1.056	2.40	2.27	0.58		39.7	743.	SILTY SAND
12.20	2960.	5.80	18.90	435.	2.51	4.65	1.099	2.00	1.075	3.45	3.21	0.70		38.9	787.	SILTY SAND
12.40	2852.	3.70	15.20	383.	3.97	2.55	1.119	1.90	1.093	1.12	1.02	0.39		40.6	502.	SAND
12.60	3423.	3.70	16.70	435.	4.54	2.49	1.138	1.90	1.110	0.84	0.76	0.32		42.1	561.	SAND
12.80	4269.	4.10	19.40	515.	4.72	2.79	1.158	1.90	1.128	0.76	0.67	0.29		43.5	715.	SAND
13.00	4899.	5.60	18.90	445.	2.78	4.03	1.178	2.00	1.148	1.81	1.58	0.45		43.3	755.	SILTY SAND
13.40	3915.	4.70	18.70	469.	3.67	3.10	1.217	2.00	1.187	1.38	1.17	0.40		42.1	696.	SAND
13.80	1770.	2.70	8.00	168.	2.94	1.34	1.256	1.80	1.222	0.86	0.70	0.35		37.4	142.	SILTY SAND
14.00	2478.	5.00	16.70	390.	2.86	3.16	1.276	2.00	1.242	2.38	1.92	0.56		37.8	580.	SILTY SAND
14.20	2243.	4.10	13.80	320.	3.07	2.39	1.295	1.90	1.260	1.65	1.31	0.47		37.8	402.	SILTY SAND
14.40	1987.	3.30	12.90	317.	4.18	1.71	1.315	1.90	1.277	1.14	0.89	0.39		37.5	306.	SAND
14.60	1790.	3.30	11.40	265.	3.52	1.67	1.335	1.90	1.295	1.24	0.95	0.41		36.6	251.	SAND
14.80	1770.	3.40	10.80	240.	3.09	1.71	1.354	1.90	1.313	1.31	1.00	0.42		36.3	232.	SILTY SAND
15.00	1711.	3.30	11.80	279.	3.78	1.60	1.374	1.90	1.330	1.27	0.95	0.42		36.1	253.	SAND
15.20	1554.	3.80	10.30	209.	2.31	1.93	1.394	1.90	1.348	1.74	1.29	0.49		34.5	209.	SILTY SAND
16.00	275.	3.20	4.50	29.	0.43	1.37	1.472	1.60	1.407	0.78	0.55	0.36	0.19		24.	SILTY CLAY
17.00	275.	4.10	5.20	22.	0.23	1.86	1.570	1.60	1.466	1.31	0.89	0.51	0.29		19.	CLAY
18.00	275.	4.50	5.40	15.	0.14	1.99	1.668	1.60	1.525	1.51	0.99	0.54	0.33		13.	CLAY
18.20	275.	4.60	5.50	15.	0.14	2.03	1.688	1.60	1.536	1.57	1.02	0.55	0.34		13.	CLAY
18.40	275.	4.70	5.60	15.	0.13	2.06	1.708	1.60	1.548	1.62	1.05	0.56	0.35		13.	CLAY
18.60	275.	4.50	5.50	18.	0.18	1.91	1.727	1.60	1.560	1.45	0.93	0.52	0.32		16.	CLAY
18.80	275.	4.80	5.90	22.	0.19	2.07	1.747	1.70	1.574	1.66	1.05	0.56	0.36		19.	CLAY
19.00	275.	4.50	5.70	25.	0.25	1.85	1.766	1.70	1.587	1.40	0.88	0.50	0.32		22.	CLAY
19.20	275.	5.10	6.40	29.	0.24	2.19	1.786	1.70	1.601	1.85	1.16	0.60	0.40		27.	CLAY
19.40	275.	4.30	5.60	29.	0.31	1.67	1.806	1.70	1.615	1.22	0.75	0.45	0.28		24.	CLAY
19.60	275.	4.50	5.70	25.	0.25	1.77	1.825	1.70	1.629	1.34	0.82	0.48	0.31		22.	CLAY
19.80	275.	5.10	6.40	29.	0.24	2.10	1.845	1.70	1.642	1.78	1.08	0.57	0.38		26.	CLAY
20.00	275.	3.60	5.30	43.	0.64	1.17	1.865	1.70	1.656	0.72	0.43	0.29	0.19		36.	CLAYEY SILT
20.20	275.	5.40	6.50	22.	0.17	2.23	1.884	1.70	1.670	1.97	1.18	0.60	0.42		21.	CLAY
20.40	275.	3.00	5.40	67.	1.49	0.77	1.904	1.60	1.682	2.29	1.36	0.76		16.9	57.	SANDY SILT
20.60	275.	5.30	6.60	29.	0.23	2.11	1.923	1.70	1.695	1.84	1.09	0.57	0.40		26.	CLAY
20.80	275.	5.60	6.60	18.	0.14	2.26	1.943	1.70	1.709	2.06	1.21	0.61	0.44		18.	CLAY

END OF SOUNDING

Sounding MRD-1 (DILLY4), Continued
(Thrust measured immediately behind blade)

SCHMERTMANN & CRAPPS, INC. TEST NO. DMT SOUNDING NO.2
FILE NAME: RESEARCH DMT TEST
FILE NUMBER: MRD-2

RECORD OF DILATOMETER TEST NO. DMT SOUNDING NO.2
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: MCDONALD'S FARM
PERFORMED - DATE: APR 18 1984
BY: C. TSANG

CALIBRATION INFORMATION:
DA= 0.20 BARS DB= 0.27 BARS ZM= 0.0 BARS ZW= 1.50 METERS VSO= 0.157 BARS
ROD DIA.= 0.0 CM FRICTION RED. DIA.= 0.0 CM ROD WEIGHT= 0.0 KG/M DELTA/PHI= 0.50

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H2O UNIT WEIGHT = 1.000 T/M3

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
1.00	157.	0.50	1.90	32.	1.33	4.46	0.0	1.60	0.157	0.76	4.83	0.95		23.3	55.	SANDY SILT
2.00	102.	0.50	1.50	18.	0.81	2.46	0.049	1.60	0.265	0.37	1.38	0.66	0.08		20.	CLAYEY SILT
3.00	86.	0.50	1.40	15.	0.78	1.71	0.147	1.60	0.324	0.25	0.78	0.46	0.06		13.	CLAYEY SILT
4.00	1149.	1.20	6.50	168.	4.18	2.94	0.245	1.80	0.393	0.47	1.19	0.41		39.7	241.	SAND
5.00	1070.	1.40	6.90	175.	4.00	2.67	0.343	1.80	0.471	0.61	1.29	0.44		38.0	236.	SAND
6.00	1731.	2.40	8.30	188.	2.52	3.89	0.442	1.90	0.554	1.14	2.05	0.54		39.8	311.	SILTY SAND
7.00	1574.	2.60	11.10	279.	3.55	3.52	0.540	1.90	0.643	1.30	2.02	0.56		38.2	444.	SAND
8.00	2424.	3.40	13.60	338.	3.28	4.05	0.638	1.90	0.731	1.55	2.12	0.55		40.5	579.	SILTY SAND
9.00	1589.	2.00	8.50	209.	4.12	1.80	0.736	1.80	0.815	0.63	0.77	0.35		38.6	211.	SAND
10.00	3337.	2.80	15.20	414.	5.51	2.41	0.834	1.90	0.898	0.39	0.44	0.23		43.5	524.	SAND

END OF SOUNDING

Sounding MRD-2 (DILLY4)
(Thrust measured immediately behind blade)

SCHMERTMANN & CRAPPS, INC. TEST NO. DMT SOUNDING NO.3
FILE NAME: RESEARSH DMT TEST
FILE NUMBER: MRD-3

RECORD OF DILATOMETER TEST NO. DMT SOUNDING NO.3
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: MCDONALD'S FARM
PERFORMED - DATE: APR 18 1984
BY: C. TSANG

CALIBRATION INFORMATION:
DA= 0.20 BARS DB= 0.27 BARS ZM= 0.0 BARS ZW= 1.50 METERS VSO= 0.883 BARS
ROD DIA.= 0.0 CM FRICTION RED. DIA.= 0.0 CM ROD WEIGHT= 0.0 KG/M DELTA/PHI= 0.50

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H2O UNIT WEIGHT = 1.000 T/M3

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
5.00	952.	1.20	5.90	147.	4.00	1.96	0.343	1.80	0.540	0.52	0.97	0.40		36.9	159.	SAND
7.00	2715.	2.40	13.10	355.	4.97	2.92	0.540	1.90	0.706	0.52	0.74	0.31		42.9	508.	SAND
9.00	1668.	2.30	10.50	268.	4.38	2.00	0.736	1.90	0.883	0.83	0.94	0.39		38.2	295.	SAND
10.00	3274.	2.80	16.10	445.	5.92	2.23	0.834	1.90	0.971	0.45	0.46	0.24		43.0	533.	SAND
11.00	3714.	4.80	19.10	480.	3.40	3.82	0.932	2.00	1.065	1.89	1.77	0.50		41.7	799.	SAND
12.00	2046.	3.00	12.60	317.	4.21	1.87	1.030	1.90	1.158	1.05	0.91	0.39		38.2	331.	SAND
13.00	2526.	3.20	14.30	369.	4.68	1.82	1.129	1.90	1.246	0.94	0.75	0.34		39.6	377.	SAND
14.00	1936.	3.90	10.20	202.	2.03	2.15	1.227	1.90	1.334	1.73	1.29	0.48		36.3	216.	SILTY SAND
16.00	787.	2.80	5.70	84.	1.54	1.06	1.423	1.70	1.491	1.62	1.08	0.53		28.7	72.	SANDY SILT
17.00	267.	4.20	5.40	25.	0.25	1.85	1.521	1.70	1.560	1.38	0.88	0.50	0.31		22.	CLAY
18.00	267.	4.30	5.30	18.	0.18	1.77	1.619	1.60	1.624	1.35	0.83	0.48	0.31		16.	CLAY
18.20	267.	4.40	5.60	25.	0.25	1.81	1.639	1.70	1.638	1.40	0.85	0.49	0.32		22.	CLAY
18.40	267.	2.60	4.80	60.	1.52	0.69	1.658	1.60	1.649	2.11	1.28	0.74		17.3	51.	SANDY SILT
18.60	267.	3.90	5.20	29.	0.34	1.46	1.678	1.60	1.661	1.01	0.61	0.39	0.25		24.	CLAY
18.80	267.	4.00	5.20	25.	0.29	1.50	1.698	1.60	1.673	1.06	0.64	0.40	0.26		22.	CLAY
19.00	267.	2.50	4.70	60.	1.76	0.58	1.717	1.60	1.685	1.98	1.18	0.72		17.7	51.	SANDY SILT
19.20	267.	3.70	5.10	32.	0.43	1.27	1.737	1.60	1.697	0.84	0.50	0.33	0.21		27.	SILTY CLAY
19.40	267.	3.70	4.60	15.	0.20	1.25	1.757	1.60	1.708	0.83	0.48	0.32	0.21		13.	CLAY
19.60	267.	2.50	4.10	39.	1.22	0.54	1.776	1.60	1.720	1.96	1.14	0.71		17.8	33.	SANDY SILT
19.80	267.	3.70	4.80	22.	0.30	1.21	1.796	1.60	1.732	0.80	0.46	0.31	0.20		19.	CLAY
20.00	267.	3.90	4.90	18.	0.23	1.31	1.816	1.60	1.744	0.90	0.52	0.34	0.23		16.	CLAY
20.20	267.	2.50	4.20	43.	1.42	0.49	1.835	1.60	1.755	1.94	1.11	0.70		17.8	36.	SANDY SILT
20.40	267.	4.60	5.70	22.	0.21	1.67	1.855	1.60	1.767	1.33	0.75	0.45	0.31		19.	CLAY
20.60	267.	3.30	5.00	43.	0.76	0.91	1.874	1.60	1.779	0.52	0.29	0.19	0.15		36.	CLAYEY SILT
20.80	267.	4.80	5.90	22.	0.20	1.73	1.894	1.70	1.793	1.43	0.80	0.47	0.33		19.	CLAY
21.00	267.	4.30	5.80	36.	0.40	1.43	1.914	1.70	1.806	1.07	0.59	0.38	0.26		30.	SILTY CLAY
21.20	267.	5.20	6.70	36.	0.30	1.90	1.933	1.70	1.820	1.69	0.93	0.52	0.38		30.	CLAY

END OF SOUNDING

Sounding MRD-3 (DILLY4)
(Thrust measured immediately behind blade)

APPENDIX III

Measurements Recorded with the UBC Research Dilatometer

MEASUREMENTS RECORDED WITH UBC RESEARCH DILATOMETER

TESTING NO.: MRD-1 DATE: MAR 21,84
LOCATION : MCDONALD'S FARM

CALIBRATION INFORMATION: DA= 0.20 BARS DB= 0.27 BARS
ZM= 0.00 BARS ZW= 1.00 METRES

DEPTH (M)	A (BAR)	B (BAR)	C (BAR)	A' (BAR)	B' (BAR)	C' (BAR)
0.2	0.85	3.77	0.11	0.46	2.10	0.00
0.4	0.53	2.58	0.11	0.27	1.82	0.00
0.6	0.42	1.82	0.06	0.09	0.73	-0.19
0.8	0.53	1.61	0.06	0.00	0.73	-0.19
1.0	0.75	2.04	0.06	0.35	1.35	-0.20
1.2	0.42	1.39	0.06	0.00	0.81	-0.19
1.6	0.53	1.39	0.11	0.17	0.99	-0.20
1.8	0.53	1.61	0.11	0.08	1.08	-0.20
2.0	0.64	2.26	0.11	0.27	1.82	-0.19
2.2	0.64	2.90	0.22	0.46	2.55	-0.19
2.4	0.85	3.34	0.22	0.46	2.92	-0.19
2.6	0.75	2.69	0.22	0.36	2.29	-0.19
2.8	0.96	3.12	0.22	0.55	2.65	-0.19
3.0	0.75	3.34	0.22	0.32	2.87	-0.19
3.2	1.18	4.95	0.32	0.73	4.47	-0.09
3.4	1.18	5.71	0.43	0.73	5.20	0.00
3.6	1.29	6.90	0.49	0.82	6.44	0.09
3.8	1.93	8.62	0.65	1.46	8.21	0.19
4.0	1.50	7.00	0.49	1.19	6.52	0.09
4.2	1.50	6.68	0.49	1.10	6.30	0.09
4.4	1.07	4.95	0.43	0.55	4.51	-0.09
4.6	1.72	6.14	0.54	1.10	5.66	0.00
4.8	1.29	5.60	0.43	0.91	5.11	0.09
5.0	1.82	6.90	0.54	1.37	6.39	0.09
5.2	1.61	6.68	0.54	1.19	6.20	0.09
5.4	1.61	7.65	0.71	1.00	7.11	0.19
5.6	2.15	8.84	0.76	1.64	8.30	0.19
5.8	2.15	8.35	0.65	1.64	7.85	0.09
6.0	1.72	6.90	0.54	1.28	6.47	0.09
6.2	1.61	7.00	0.54	1.10	6.47	0.09
6.4	1.93	10.03	0.97	1.46	9.49	0.36
6.6	2.80	11.86	0.86	2.37	11.50	0.46
6.8	2.58	9.59	0.86	2.01	9.04	0.27
7.0	2.58	10.46	0.97	1.82	9.85	0.27

Sounding MRD-1

DEPTH (M)	A (BAR)	B (BAR)	C (BAR)	A' (BAR)	B' (BAR)	C' (BAR)
7.2	2.69	11.32	0.86	2.19	10.76	0.36
7.4	5.06	17.80	1.50	4.47	17.25	0.73
7.6	4.20	17.15	0.97	4.11	17.06	0.64
8.0	3.77	14.77	0.97	3.56	14.51	0.55
8.6	2.69	11.64	0.97	2.29	11.31	0.46
9.0	3.01	13.48	1.08	2.37	12.86	0.36
9.6	3.77	17.58	1.61	3.20	17.06	0.69
10.0	6.36	17.80	2.15	5.75	17.15	1.29
10.6	4.20	18.66	1.72	3.37	17.97	0.73
11.0	2.90	13.05	1.39	1.91	12.22	0.36
11.6	2.26	6.90	1.08	1.28	5.94	0.09
11.8	3.23	11.86	1.50	2.29	10.95	0.36
12.0	4.95	18.23	1.61	4.20	17.61	0.64
12.2	5.93	18.87	1.82	4.84	18.16	0.73
12.4	3.66	15.21	1.61	2.83	14.51	0.64
12.6	3.66	16.72	1.82	2.83	15.97	0.82
12.8	4.09	19.41	1.93	3.20	18.71	0.82
13.0	5.60	18.87	1.82	5.02	18.25	1.00
13.4	4.74	18.66	1.82	3.92	18.06	1.00
13.6	1.82	7.65	1.39	0.64	6.57	0.27
13.8	2.69	7.98	0.76	1.37	6.66	0.00
14.0	4.95	16.72	1.72	3.92	15.78	0.64
14.2	4.09	13.80	1.29	3.10	13.05	0.46
14.4	3.34	12.94	1.08	2.01	11.77	0.09
14.6	3.34	11.43	1.08	2.19	10.50	0.19
14.8	3.44	10.78	1.29	2.19	9.76	0.27
15.0	3.34	11.75	1.29	2.10	10.67	0.27
15.2	3.77	10.35	1.29	2.65	9.21	0.36
16.0	3.23	4.52	2.47	0.73	1.46	0.19
17.0	4.15	5.23	3.72	0.53	1.12	0.12
18.0	4.49	5.39	4.04	0.53	1.03	0.30
18.2	4.60	5.49	4.01	0.59	1.17	0.26
18.4	4.69	5.60	4.28	0.65	1.13	0.30
18.6	4.52	5.49	3.93	0.58	1.08	0.15
18.8	4.80	5.89	4.26	0.58	1.15	0.19
19.0	4.47	5.66	4.01	0.54	1.04	0.18
19.2	5.09	6.44	4.49	0.87	1.49	0.37
19.4	4.31	5.55	3.83	0.45	0.93	0.00
19.6	4.49	5.66	3.83	5.54	1.09	0.18
19.8	5.12	6.39	4.63	0.58	1.17	0.26
20.0	3.58	5.36	2.90	0.70	1.27	0.10
20.2	5.34	6.52	4.85	0.69	1.10	0.34
20.4	2.96	5.39	2.10	0.88	1.73	0.01
20.6	5.34	6.63	4.91	0.61	1.18	0.45
20.8	5.55	6.57	4.91	0.58	1.03	0.30

Sounding MRD-1, Continued

MEASUREMENTS RECORDED WITH UBC RESEARCH DILATOMETER

TESTING NO.: MRD-2 DATE: APR 18,84
LOCATION : MCDONALD'S FARM

CALIBRATION INFORMATION: DA= 0.20 BARS DB= 0.27 BARS
ZM= 0.00 BARS ZW= 1.50 METRES

DEPTH (M)	A (BAR)	B (BAR)	C (BAR)	A' (BAR)	B' (BAR)	C' (BAR)
1.0	0.51	1.85	0.11	0.00	1.16	-0.20
2.0	0.51	1.54	0.11	0.07	1.07	-0.20
3.0	0.51	1.43	0.41	0.00	0.90	-0.09
4.0	1.24	6.53	0.52	0.79	6.03	0.00
5.0	1.44	6.90	0.73	0.79	6.31	0.09
6.0	2.36	8.34	0.82	1.78	7.81	0.09
7.0	2.57	11.12	1.03	1.95	10.57	0.26
8.0	3.39	13.60	1.33	2.76	13.22	0.62
9.0	1.95	8.54	0.82	1.16	7.90	0.00
10.0	2.78	15.24	1.44	2.04	14.50	0.44

Sounding MRD-2

MEASUREMENTS RECORDED WITH UBC RESEARCH DILATOMETER

TESTING NO.: MRD-3 DATE: APR 18,84
LOCATION : MCDONALD'S FARM

CALIBRATION INFORMATION: DA= 0.20 BARS DB= 0.27 BARS
ZM= 0.00 BARS ZW= 1.50 METRES

DEPTH (M)	A (BAR)	B (BAR)	C (BAR)	A' (BAR)	B' (BAR)	C' (BAR)
5.0	1.24	5.87	0.44	0.51	5.22	-0.20
7.0	2.36	13.08	1.03	1.78	12.69	0.44
9.0	2.27	10.51	1.03	1.61	9.86	0.36
10.0	2.78	16.07	1.97	2.10	15.69	1.13
11.0	4.84	19.05	2.16	3.92	18.31	0.90
12.0	2.98	12.57	1.65	2.20	11.97	0.61
13.0	3.19	14.31	1.75	2.43	13.79	0.75
14.0	3.91	10.19	0.73	2.84	8.96	0.17
16.0	2.80	5.71	1.39	1.32	4.42	0.41
17.0	4.20	5.39	3.77	0.34	0.98	-0.20
18.0	4.28	5.34	3.90	0.45	1.09	0.18
18.2	4.41	5.55	4.01	0.53	1.20	0.08
18.4	2.58	4.82	1.85	0.88	1.71	-0.19
18.6	3.93	5.20	3.61	0.46	1.14	0.02
18.8	4.04	5.17	3.55	0.47	1.04	-0.03
19.0	2.53	4.66	1.72	0.86	1.78	-0.19
19.2	3.72	5.06	3.39	0.37	1.35	-0.11
19.4	3.74	4.60	3.26	0.42	0.97	0.06
19.6	2.47	4.09	2.07	0.60	1.44	-0.20
19.8	3.72	4.77	3.36	0.44	1.18	-0.01
20.0	3.93	4.93	3.61	0.44	1.03	-0.02
20.2	2.50	4.20	2.12	0.61	1.54	-0.20
20.4	4.55	5.66	4.15	0.56	1.20	-0.01
20.6	3.29	5.03	2.75	0.62	1.31	-0.20
20.8	4.85	5.93	4.49	0.38	1.02	-0.03
21.0	4.34	5.79	3.83	0.39	0.94	-0.20
21.2	5.17	6.71	4.82	0.41	1.14	-0.09

Sounding MRD-3

MEASUREMENTS RECORDED WITH UBC RESEARCH DILATOMETER

TESTING NO.: LRD-2 DATE: OCT 3,83
LOCATION : LANGLEY-RAILWAY SITE

CALIBRATION INFORMATION: DA= 0.20 BARS DB= 0.27 BARS
ZM= 0.00 BARS ZW= 1.00 METRES

DEPTH (M)	A (BAR)	B (BAR)	C (BAR)	A' (BAR)	B' (BAR)	C' (BAR)
2.2	1.29	2.19	1.00	0.07	0.46	-0.10
2.4	1.59	2.55	1.36	0.04	0.47	-0.13
2.6	1.65	2.47	1.44	0.00	0.42	-0.18
2.8	1.72	2.54	1.51	0.00	0.47	-0.10
3.0	1.78	2.70	1.54	0.00	0.44	-0.15
3.2	2.08	2.95	1.80	0.06	0.41	-0.10
3.4	2.00	3.09	1.67	0.07	0.48	-0.14
3.6	2.11	2.95	1.90	0.00	0.43	-0.12
3.8	2.13	3.22	1.85	0.00	0.36	-0.09
4.0	2.33	3.19	2.11	0.05	0.42	-0.04
4.2	2.47	3.50	2.16	0.08	0.58	-0.07
4.4	2.52	3.47	2.29	0.06	0.51	0.01
4.6	2.52	3.36	2.21	0.00	0.44	-0.13
4.8	2.41	3.32	2.16	0.00	0.34	-0.12
5.0	2.47	3.39	2.16	0.00	0.48	-0.15
5.2	2.60	3.44	2.32	0.00	0.37	-0.15
5.4	2.52	3.63	2.27	0.01	0.45	-0.07
5.6	2.57	3.68	2.21	0.00	0.47	-0.16
5.8	2.70	3.65	2.33	0.10	0.59	-0.09
6.0	2.52	3.42	2.24	0.00	0.33	-0.17
6.2	2.70	3.55	2.29	0.05	0.35	-0.18
6.4	2.68	3.76	2.32	0.01	0.54	-0.14
6.6	2.83	3.86	2.33	0.04	0.42	-0.15
6.8	3.03	3.96	2.62	0.14	0.40	-0.05
7.0	3.03	4.14	2.68	0.00	0.42	-0.14
7.2	3.03	4.14	2.65	0.00	0.54	-0.12
7.4	3.03	4.22	2.68	0.00	0.44	-0.12
7.6	3.39	4.39	2.93	0.00	0.35	-0.18
7.8	2.06	3.30	1.57	0.00	0.91	0.00
8.0	3.52	4.55	3.14	0.05	0.36	-0.10
8.2	3.36	4.25	3.03	0.09	0.34	-0.10
8.4	3.35	4.17	2.93	0.11	0.48	-0.05
8.6	3.55	4.53	3.14	0.00	0.37	-0.18
8.8	3.52	4.50	3.30	0.01	0.43	0.01

Sounding LRD-2

DEPTH (M)	A (BAR)	B (BAR)	C (BAR)	A' (BAR)	B' (BAR)	C' (BAR)
9.0	3.50	4.84	3.03	0.00	0.56	-0.18
9.2	2.27	4.04	1.41	0.14	1.51	0.05
9.4	3.91	4.96	3.55	0.06	0.45	-0.03
9.6	4.12	5.50	3.50	0.08	0.55	0.00
9.8	4.19	5.22	3.63	0.13	0.43	-0.02
10.0	4.22	5.45	3.65	0.07	0.45	-0.14
10.2	4.33	5.41	3.76	0.05	0.36	-0.04
10.4	4.53	5.84	4.01	0.12	0.51	0.06
10.6	4.42	6.18	3.42	0.51	0.95	0.51
10.8	4.55	5.77	3.98	0.00	0.52	0.00
11.0	4.25	5.41	3.73	0.00	0.48	-0.05
11.2	4.09	5.36	3.47	0.01	0.43	-0.10
11.4	4.01	5.15	3.57	0.00	0.44	-0.08
11.6	4.25	5.66	3.60	0.00	0.46	-0.15
11.8	4.25	5.90	3.68	0.11	0.51	0.11
12.0	4.58	5.77	3.96	0.05	0.40	-0.03
12.2	4.68	6.20	4.01	0.00	0.55	-0.07
12.4	4.84	6.28	4.22	0.01	0.50	-0.06
12.6	4.66	6.51	4.04	0.30	0.86	0.30
12.8	4.60	6.04	4.04	0.00	0.48	-0.16
13.0	4.81	6.15	4.04	0.15	0.38	-0.09
13.2	4.96	6.31	3.96	0.08	0.47	-0.14
13.4	5.07	6.61	4.53	0.11	0.38	-0.05
13.6	5.07	6.33	4.58	0.00	0.37	-0.07
13.8	5.04	6.61	4.53	0.00	0.55	0.00
14.0	5.22	6.36	4.60	0.00	0.60	0.00
14.2	4.91	6.36	4.55	0.11	0.43	0.00
14.4	5.17	6.59	4.50	0.00	0.52	0.00
14.6	4.91	6.31	4.27	0.02	0.26	-0.16
14.8	5.15	7.28	4.89	1.08	1.54	0.48
15.0	5.71	7.26	4.84	0.34	0.55	0.13

Sounding LRD-2, Continued

MEASUREMENTS RECORDED WITH UBC RESEARCH DILATOMETER

TESTING NO.: LRD-3 DATE: JAN 20,84
LOCATION : LANGLEY-LOWER SITE

CALIBRATION INFORMATION: DA= 0.20 BARS DB= 0.27 BARS
ZM= 0.00 BARS ZW= 1.00 METRES

DEPTH (M)	A (BAR)	B (BAR)	C (BAR)	A' (BAR)	B' (BAR)	C' (BAR)
1.0	0.85	2.42	0.31	0.36	1.26	-0.17
2.0	1.16	1.96	0.82	0.15	0.81	-0.20
2.2	1.29	1.99	0.93	0.15	0.66	-0.20
2.4	1.31	2.23	0.96	0.22	0.69	-0.04
2.6	1.56	2.29	1.18	0.24	0.71	-0.06
2.8	1.56	2.36	1.15	0.24	0.68	-0.11
3.0	1.64	2.32	1.26	0.24	0.69	-0.06
3.2	1.67	2.33	1.29	0.23	0.54	-0.07
3.4	1.67	2.47	1.26	0.20	0.56	-0.10
3.6	1.78	2.58	1.42	0.25	0.61	-0.09
3.8	1.85	2.58	1.47	0.22	0.57	0.22
4.0	1.61	2.50	1.31	0.12	0.59	0.12
4.2	1.69	2.50	1.39	0.08	0.56	0.08
4.4	1.64	2.58	1.34	0.20	0.69	0.11
4.6	1.82	2.55	1.53	0.27	0.65	0.12
4.8	1.82	2.66	1.53	0.18	0.60	0.00
5.0	1.85	2.72	1.50	0.23	0.65	0.14
5.2	2.01	2.72	1.69	0.26	0.52	0.07
5.4	1.96	2.75	1.75	0.18	0.64	0.07
5.6	1.96	2.80	1.61	0.27	0.61	0.07
5.8	2.04	2.87	1.75	0.24	0.60	0.05
6.0	2.04	2.96	1.78	0.20	0.63	0.18
6.2	2.12	3.01	1.80	0.28	0.62	0.08
6.4	2.23	3.12	1.85	0.35	0.65	0.15
6.6	2.15	3.15	1.85	0.28	0.69	0.12
6.8	2.29	3.15	2.15	0.21	0.58	0.21
7.0	2.33	3.12	1.99	0.33	0.66	0.15
7.2	2.32	3.18	2.12	0.24	0.59	0.24
7.4	2.50	3.39	2.15	0.21	0.56	0.03
7.6	2.58	3.39	2.23	0.31	0.61	0.07
7.8	2.53	3.44	2.23	0.26	0.70	0.09
8.0	2.72	3.47	2.33	0.33	0.71	0.16
8.2	2.72	3.55	2.36	0.32	0.68	0.15
8.4	2.75	3.72	2.39	0.26	0.68	0.07
8.6	2.72	3.63	2.42	0.16	0.56	0.01
8.8	2.66	3.55	2.39	0.20	0.65	0.07
9.0	2.61	3.39	2.36	0.16	0.62	0.08
9.2	2.72	3.69	2.39	0.20	0.65	0.08
9.4	2.77	3.61	2.50	0.24	0.66	0.14
9.6	2.87	3.74	2.58	0.25	0.55	0.09
9.8	2.90	3.77	2.66	0.26	0.68	0.19
10.0	3.09	3.90	2.80	0.29	0.70	0.29

Sounding LRD-3

DEPTH (M)	A (BAR)	B (BAR)	C (BAR)	A' (BAR)	B' (BAR)	C' (BAR)
10.2	3.15	3.98	2.69	0.33	0.69	0.16
10.4	3.07	4.09	2.75	0.20	0.55	0.07
10.6	3.18	4.23	2.90	0.30	0.69	0.23
10.8	3.47	4.34	3.07	0.34	0.66	0.24
11.0	3.15	4.23	2.69	0.30	0.76	0.12
11.2	3.55	4.95	3.01	0.29	0.98	0.22
11.4	3.66	4.55	3.20	0.35	0.75	0.21
11.6	3.63	4.66	3.12	0.39	0.77	0.18
11.8	3.50	4.63	3.18	0.31	0.76	0.23
12.0	3.90	4.92	3.44	0.38	0.81	0.32
12.2	3.83	4.85	3.31	0.38	0.79	0.29
12.4	3.95	5.03	3.31	0.22	0.54	0.04
12.6	3.90	5.25	3.36	0.30	0.72	0.19
12.8	4.06	5.63	3.69	0.19	0.92	0.19
13.0	4.20	5.23	3.55	0.26	0.56	0.09
13.2	3.95	5.12	3.50	0.24	0.68	0.08
13.4	4.01	5.14	3.47	0.04	0.56	-0.08
13.6	3.98	5.20	3.72	0.23	0.72	0.23
13.8	3.39	4.60	2.98	0.27	0.74	0.07
14.0	4.20	5.52	3.33	0.24	0.79	0.05
14.2	4.20	5.17	3.69	0.11	0.55	0.00
14.4	4.23	5.52	3.83	0.31	1.00	0.28
14.6	4.41	5.55	3.72	0.37	0.50	0.01
14.8	3.72	6.74	2.26	1.34	4.38	0.27
15.0	3.98	5.20	3.09	0.21	0.77	0.07
15.2	4.34	5.64	3.74	0.22	0.96	0.22
15.4	4.12	6.17	3.52	1.17	2.86	1.17
15.6	4.69	5.79	4.26	0.22	0.70	0.22
15.8	4.77	6.06	4.28	0.15	0.68	0.15
16.0	4.44	5.88	3.72	0.28	0.51	0.05
16.2	4.28	5.98	3.77	0.26	0.69	0.02
16.4	4.58	6.06	4.28	0.18	0.64	0.18
16.6	4.74	5.66	4.17	0.00	0.45	-0.07
16.8	4.63	5.66	4.31	0.00	0.28	-0.03
17.0	4.63	5.71	4.26	0.20	0.55	0.20
17.2	4.77	5.90	4.28	0.26	0.62	0.18
17.4	4.77	5.85	4.26	0.24	0.48	0.13
17.6	4.85	5.98	4.37	0.17	0.39	0.02
17.8	4.91	5.98	4.58	0.00	0.45	0.00
18.0	4.85	5.88	4.26	0.05	0.56	0.05
18.2	4.89	5.79	4.41	0.04	0.37	-0.04
18.4	4.98	6.14	4.58	0.22	0.51	0.13
18.6	4.74	6.00	4.31	0.00	0.64	0.00
18.8	4.82	5.74	4.49	0.07	0.52	0.07
19.0	5.03	5.98	4.58	0.31	0.61	0.16
19.2	4.95	5.82	4.41	0.17	0.70	0.08
19.4	5.40	6.60	4.85	0.42	0.66	0.28
19.6	5.25	6.63	4.74	0.17	0.69	0.17
19.8	5.28	6.65	4.69	0.20	0.63	0.06
20.0	5.23	6.52	4.88	0.22	0.66	0.22

Sounding LRD-3, Continued

MEASUREMENTS RECORDED WITH UBC RESEARCH DILATOMETER

TESTING NO.: LRD-4 DATE: MAR 2,84
LOCATION : LANGLEY-UPPER SITE

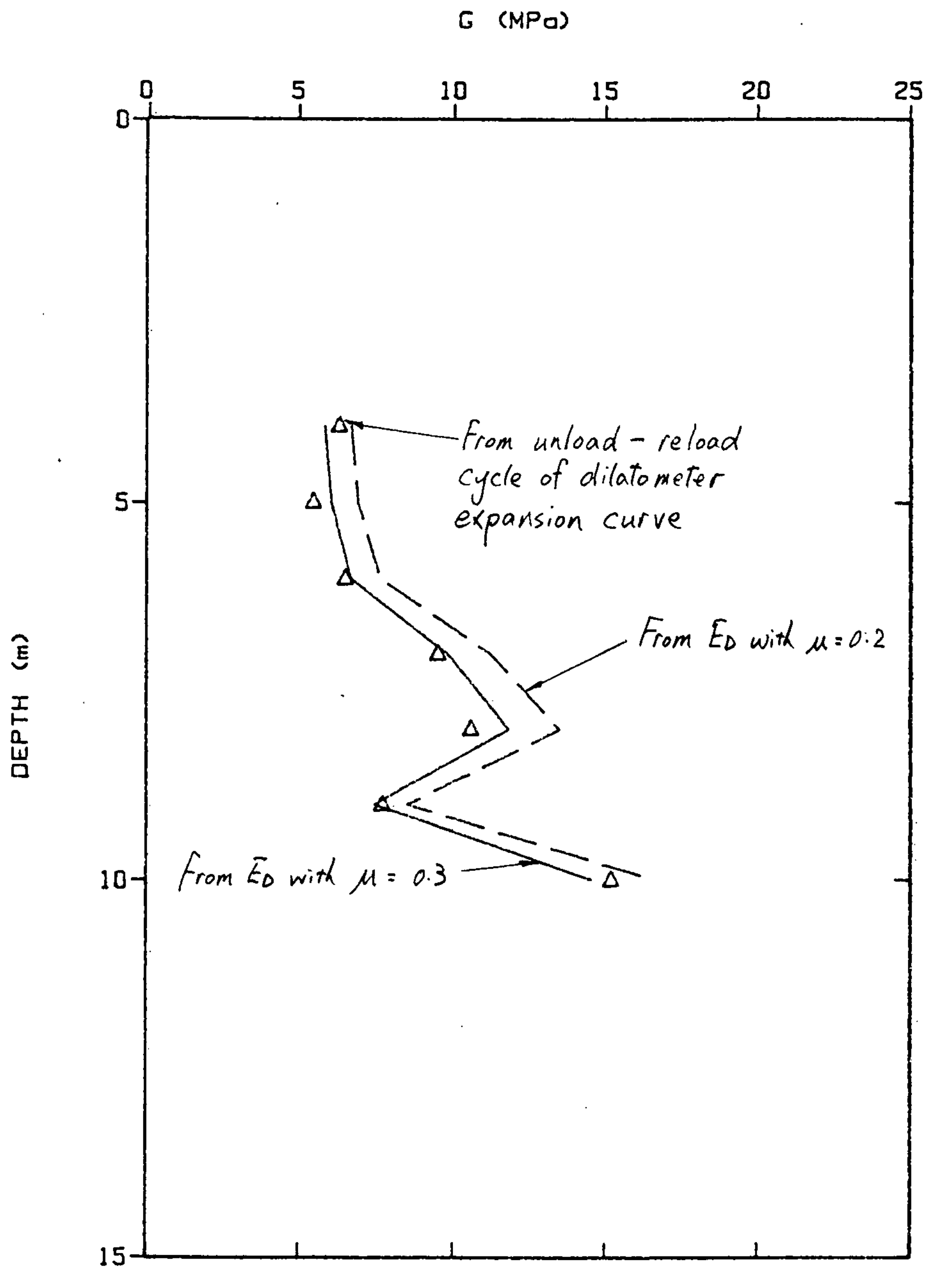
CALIBRATION INFORMATION: DA= 0.20 BARS DB= 0.27 BARS
ZM= 0.00 BARS ZW= 3.00 METRES

DEPTH (M)	A (BAR)	B (BAR)	C (BAR)	A' (BAR)	B' (BAR)	C' (BAR)
0.2	0.67	2.47	0.11	0.59	2.37	0.19
0.4	1.24	3.33	0.11	1.51	3.36	0.37
0.6	2.23	4.71	0.76	2.07	3.33	0.31
0.8	2.58	6.93	0.14	1.75	3.66	0.13
1.0	1.21	3.72	0.08	0.66	1.82	-0.16
1.2	0.96	3.07	0.14	0.52	2.28	0.06
1.4	1.29	3.31	0.32	0.51	1.37	-0.11
1.6	1.64	3.72	0.60	0.67	1.77	0.10
1.8	0.75	1.61	0.06	0.47	1.04	0.06
2.0	0.99	1.96	0.57	0.35	1.24	-0.08
2.2	1.10	3.52	0.08	0.47	2.43	0.07
2.4	1.80	6.28	0.11	1.83	4.39	0.80
2.6	3.18	7.00	0.46	3.45	6.77	0.72
2.8	2.58	7.06	0.32	2.70	5.62	0.42
3.0	2.90	7.87	0.22	3.54	8.28	0.72
3.2	3.18	8.14	0.49	4.06	8.85	1.19
3.4	3.29	8.08	1.03	3.93	8.22	1.20
3.6	4.09	8.30	1.72	4.89	8.63	1.97
3.8	3.33	7.11	1.56	3.68	4.95	0.39
4.0	2.53	5.75	0.97	1.30	2.30	-0.20
4.2	2.26	4.85	1.08	1.81	2.06	-0.02
4.4	2.10	4.80	0.81	0.99	1.72	-0.20
4.6	2.21	1.50	1.34	0.63	4.80	-0.20
4.8	2.23	4.58	1.21	0.61	1.32	-0.20
5.0	3.01	4.95	2.01	0.24	0.96	-0.20
5.2	2.90	4.31	2.10	0.08	0.77	-0.20
5.4	2.58	3.83	2.10	0.00	0.67	-0.16
5.6	2.53	3.77	1.99	0.03	0.60	-0.16
5.8	1.88	3.04	1.53	0.05	0.55	-0.19
6.0	2.42	3.66	1.93	0.00	0.53	-0.12
6.2	2.53	3.63	1.99	0.09	0.66	-0.05
6.4	2.42	3.52	2.01	0.12	0.59	-0.02
6.6	1.85	3.01	1.53	0.09	0.52	-0.03
6.8	2.36	3.50	2.15	0.07	0.66	0.07
7.0	2.47	3.39	2.07	0.00	0.48	0.00
7.2	2.44	3.34	2.04	0.00	0.39	-0.09
7.4	2.33	3.31	2.01	0.00	0.50	0.00
7.6	2.44	3.31	2.26	0.03	0.46	0.03
7.8	2.42	3.29	2.12	0.12	0.58	0.07

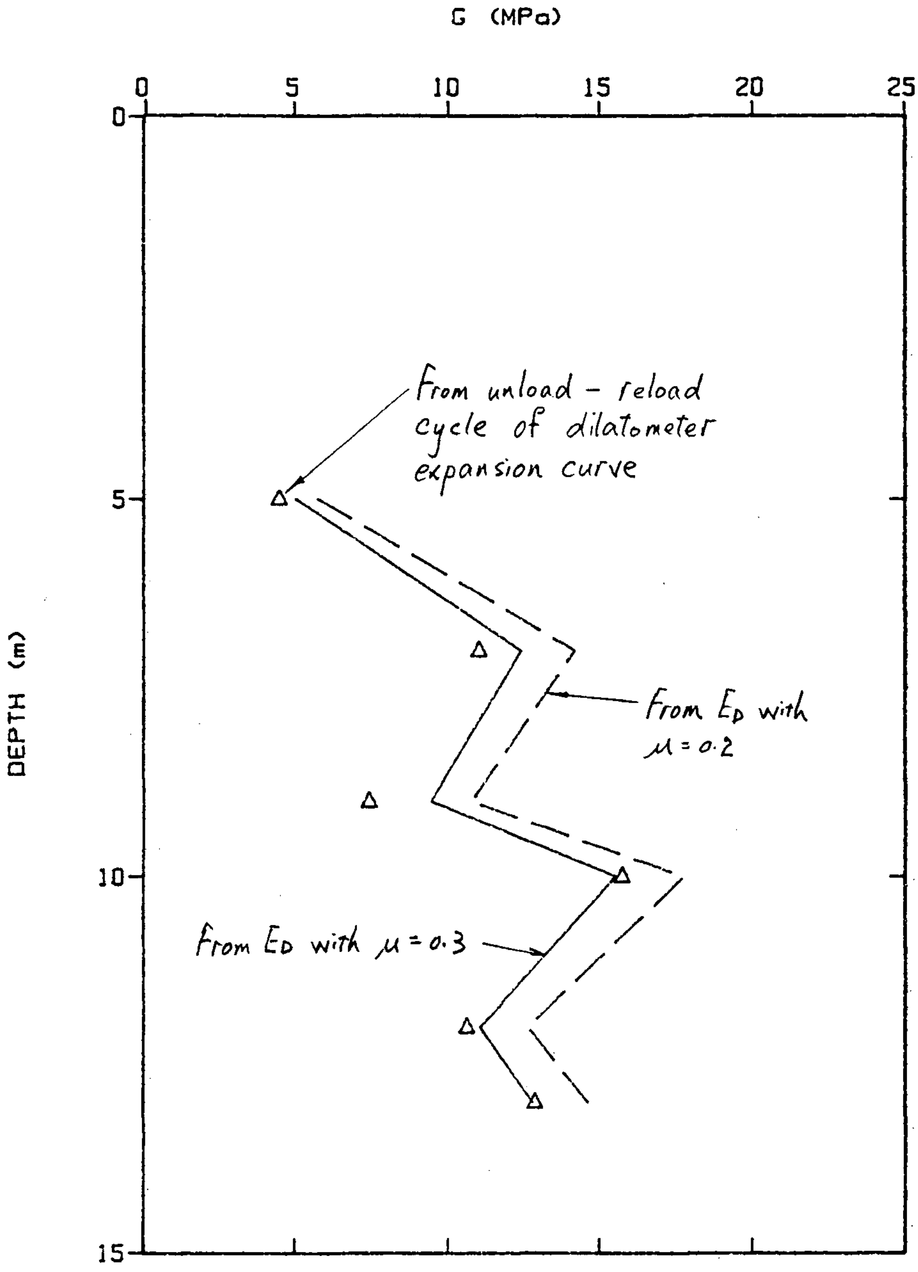
Sounding LRD-4

APPENDIX IV

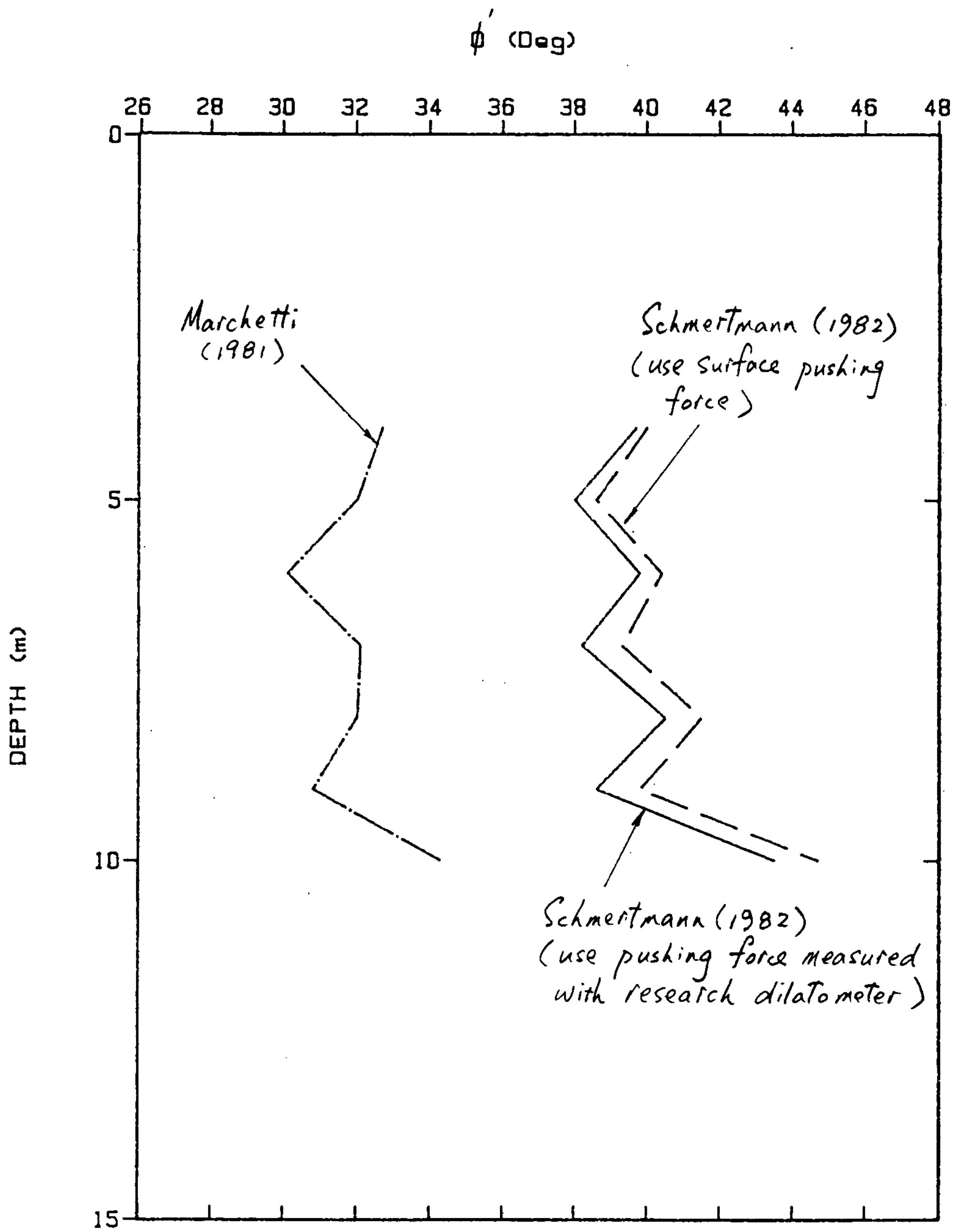
Additional Figures for Testing in Sand at McDonald's Farm Site



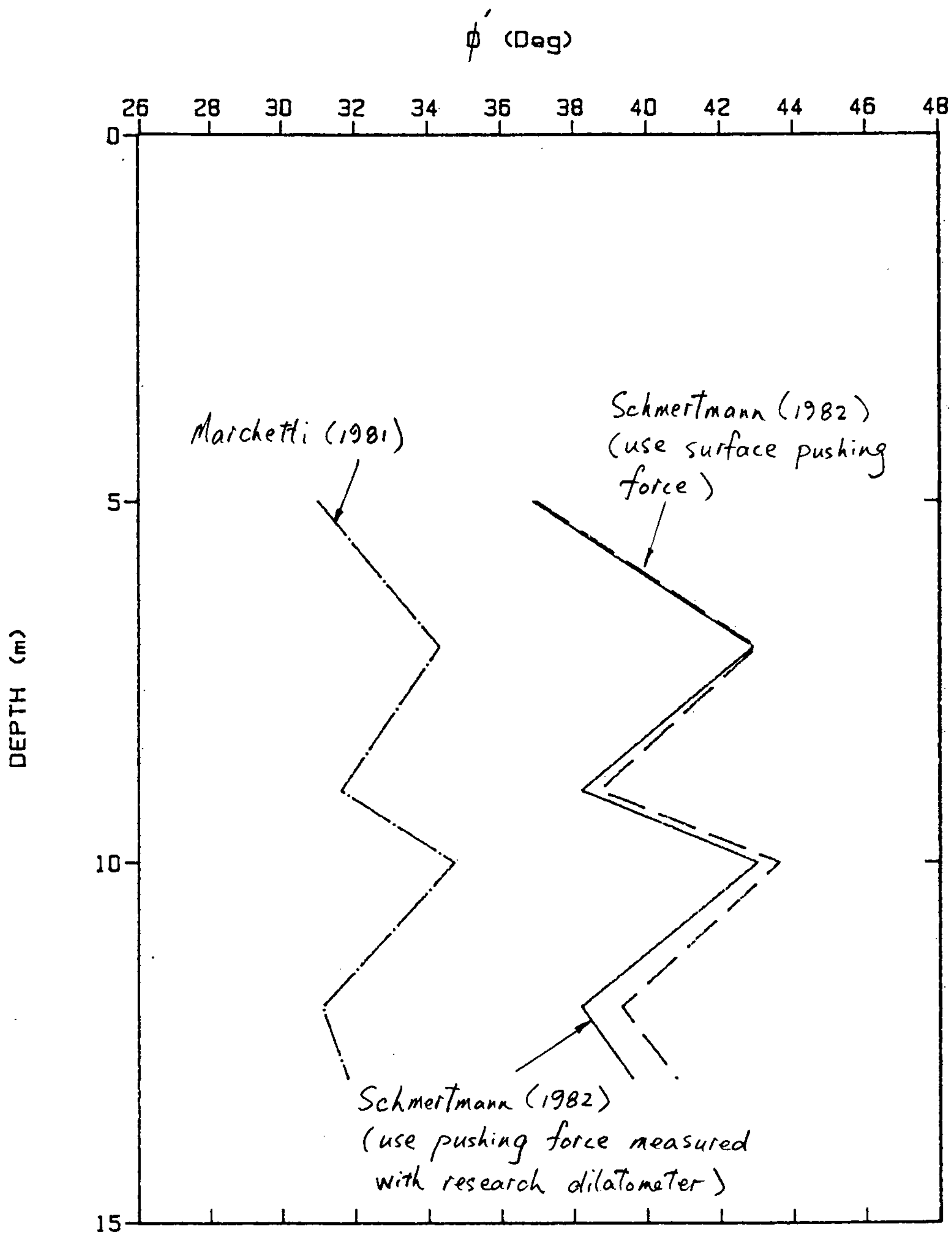
Comparison of Shear Moduli From E_D and from Unload - Reload Cycle of Dilatometer Expansion Curve (Sounding MRD-2)



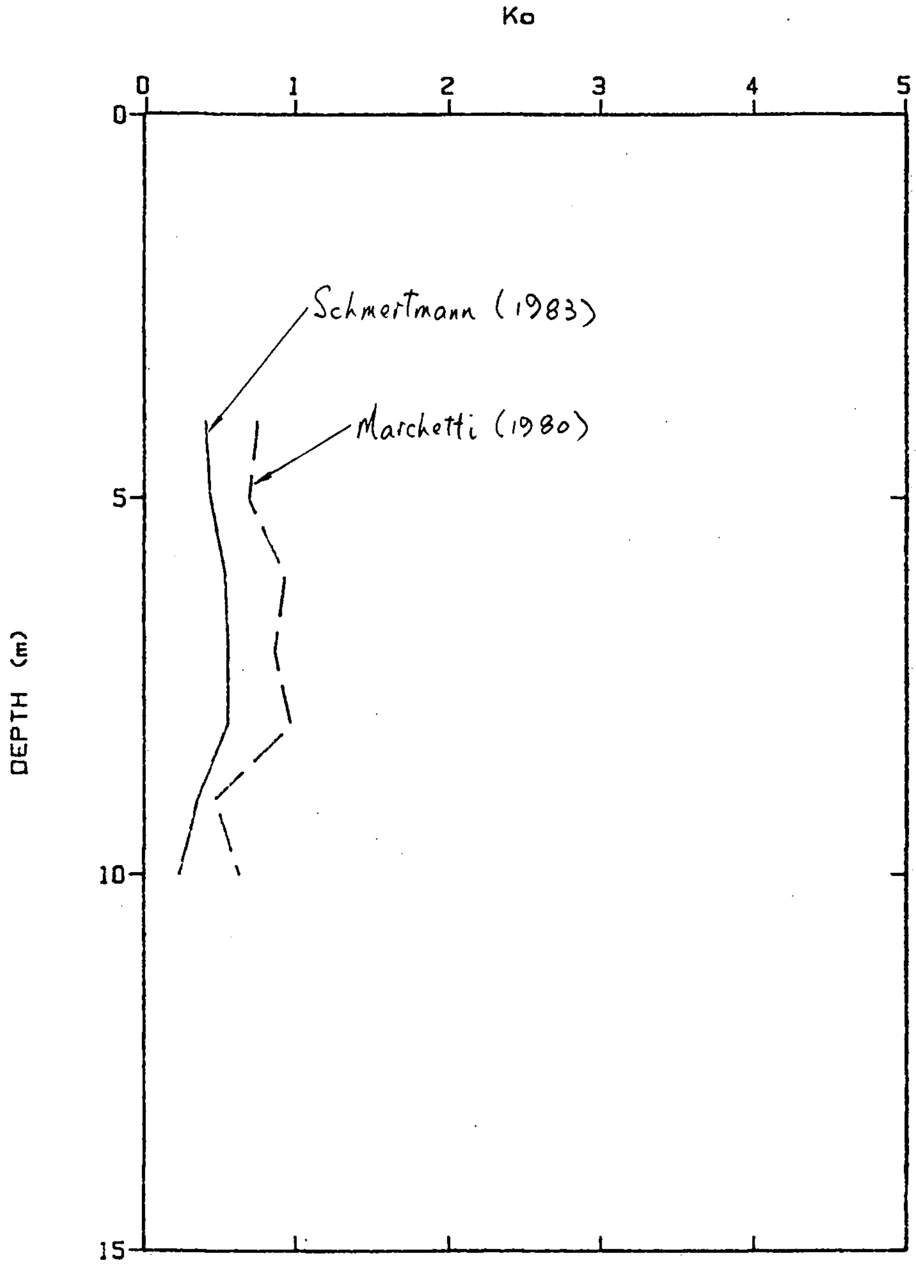
Comparison of Shear Moduli from E_D and from Unload - Reload Cycle of Dilatometer Expansion Curve (Sounding MRD-3)



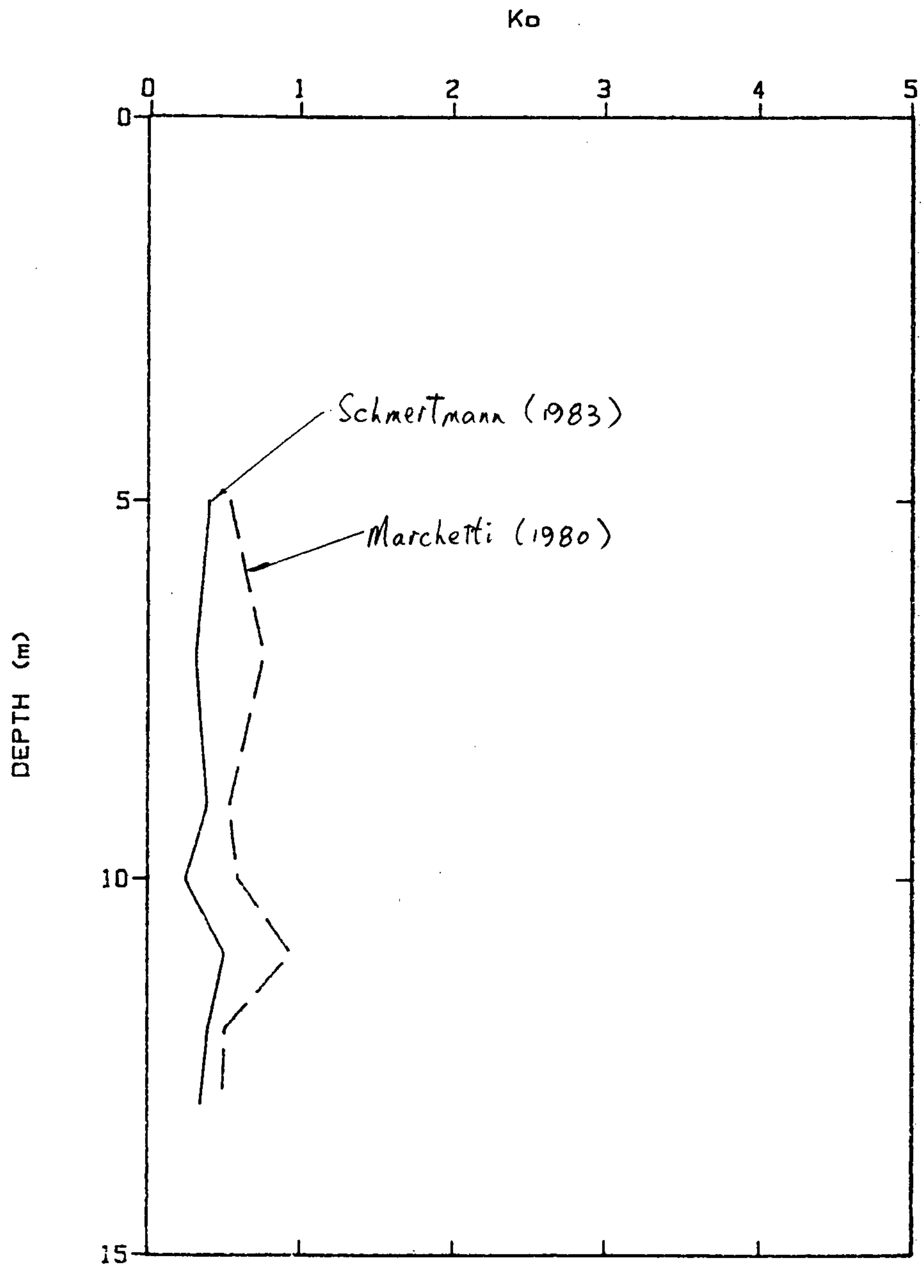
Friction Angles Estimated by DMT Results (Sounding MRD-2)



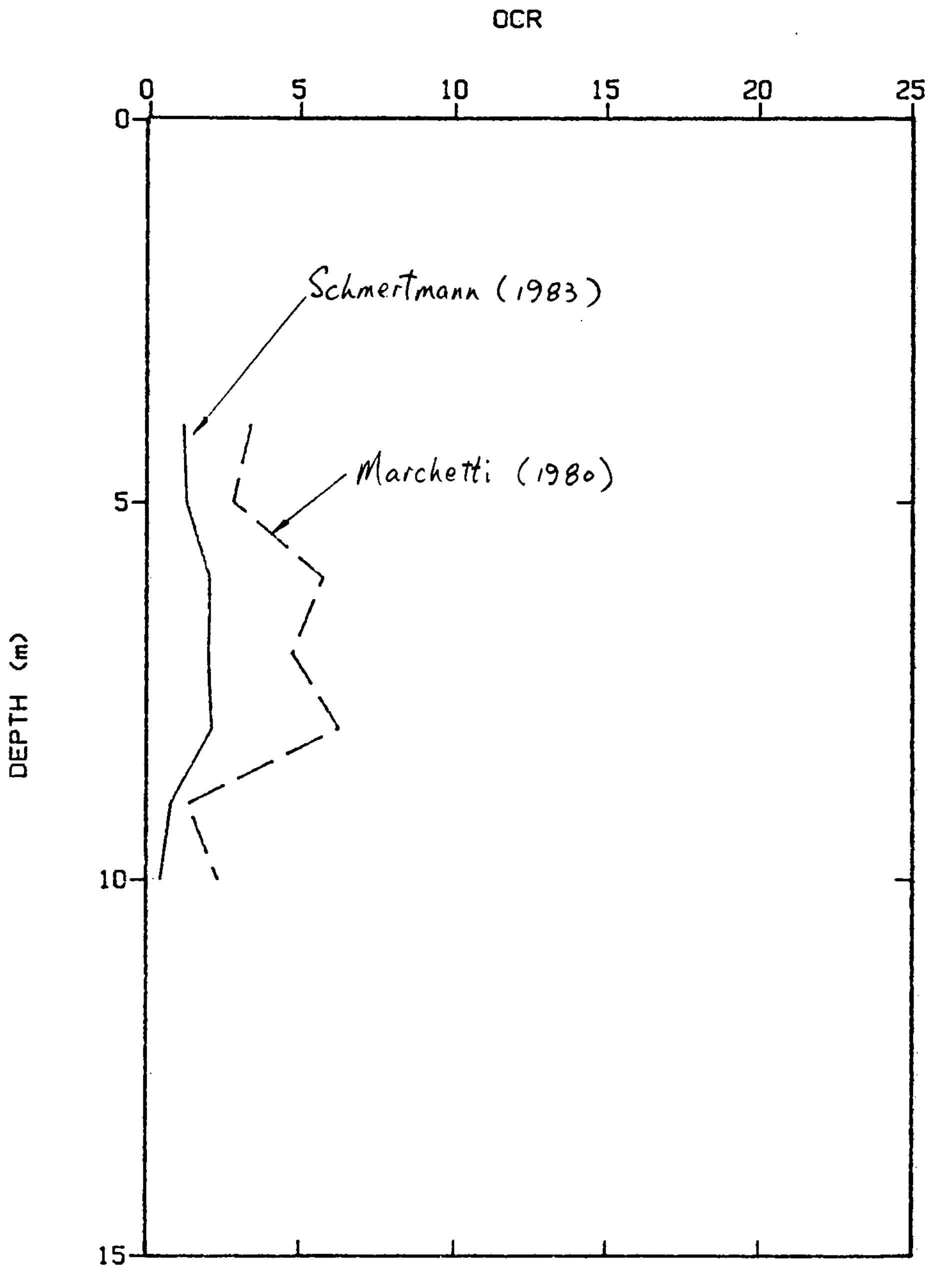
Friction Angles Estimated by DMT Results (Sounding MRD-3)



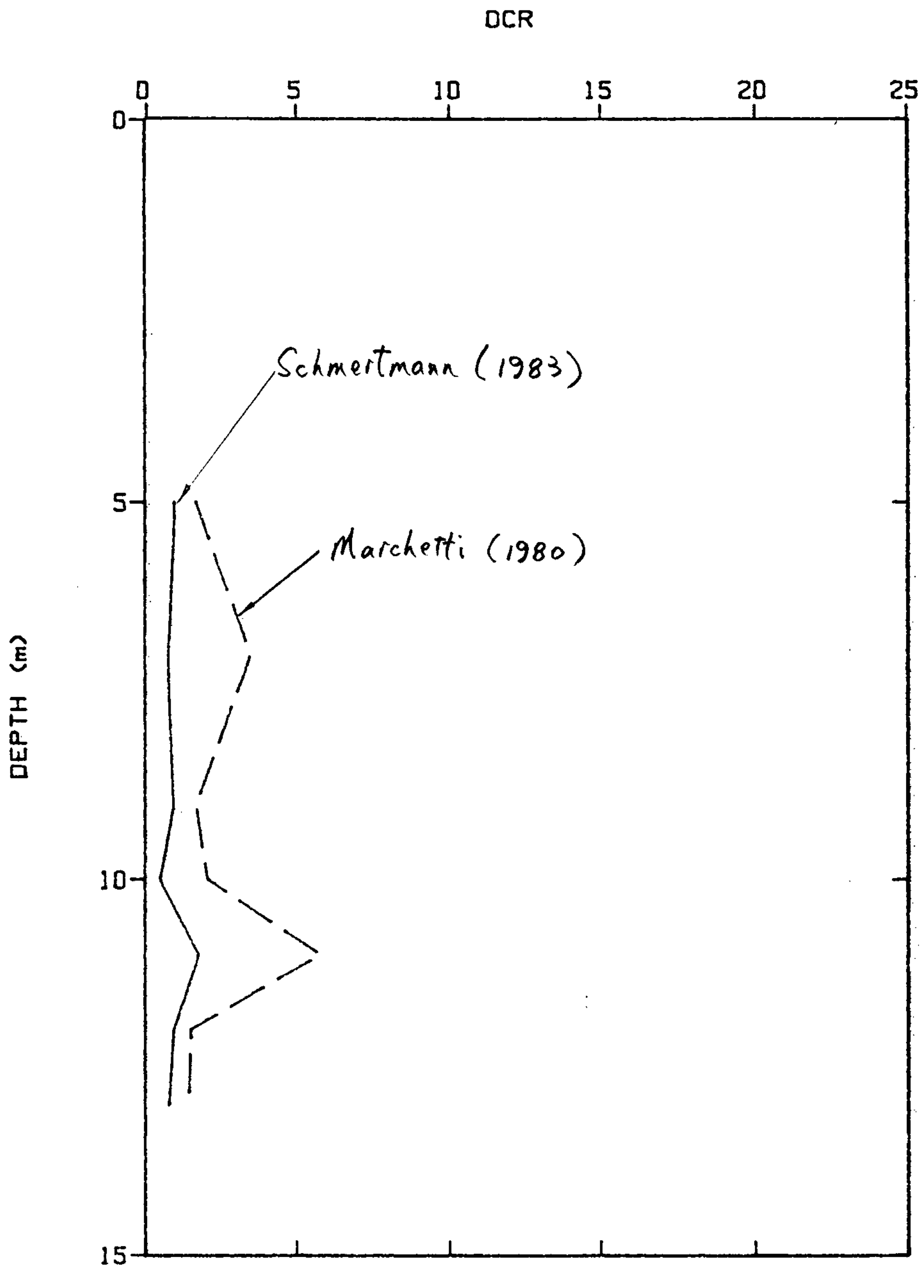
In-situ Earth Pressure Coefficient
Vs Depth (Sounding MRD-2)



In-situ Earth Pressure Coefficient
Vs Depth
(Sounding MRD-3)



Overconsolidation Ratio Vs Depth
(Sounding MRD-2)



Overconsolidation Ratio Vs Depth
(Sounding MRD-3)