THE UNIVERSITY OF MANITOBA

RATE EFFECTS AND LOW STRESS STRENGTH OF WINNIPEG CLAY

by

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ABSTRACT

The two principal purposes in this thesis are:

1. to investigate the influence of test duration and strain rate on the stress-strain behaviour of Lake Agassiz clay from Winnipeg.
2. to examine the strength of Winnipeg clay at low stress levels.

The study also investigated the Undrained Strength of the clay at Large Strains (USALS) and its relationship with the normally consolidated Coulomb-Mohr envelope.

Six drained stress-controlled triaxial tests on undisturbed samples were used to study the time-dependent aspects of the YLIGHT model of soil behaviour. Six non-standard and four strain-rate controlled oedometer tests were performed to examine the effects of time and strain rate on the preconsolidation pressure, p'_c. The samples were taken from 11.6 m depth, and the sample diameter was 76 mm.

The preconsolidation pressure p'_c decreased from 249 to 225 kPa as the duration of the load application increased from 0.1 to 100 days. This supports previous findings by Bjerrum (1967), Tavenas and Leroueil (1977). Strain controlled oedometer tests also show that the preconsolidation pressure is strain rate dependent.

Five 76 mm diameter undisturbed triaxial samples taken from 11.6 m, six 'fully-softened' and five 'freeze-thaw' triaxial samples taken from 8.7 m were tested to study the low stress strengths of Winnipeg clay. Data was obtained on both drained and undrained triaxial behaviour. The low stress strengths were the highest for undisturbed samples, followed by the 'fully-softened' and 'freeze-thaw' samples. These low stress strength envelopes were considerably curved and parallel to each other.

The Undrained Strength at Large Strains (USALS) obtained for all the undrained tests lay close to the normally consolidated Coulomb-Mohr envelope ($\phi' = 17.5^{o}$; $c' = 4$ kPa).

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LIST OF SYMBOLS

A, B - porewater pressure parameter (after Skempton, 1954)

A_f - value of A at failure

c' - effective cohesion intercept

C_c - compression index

c_v - coefficient of consolidation

C_α - coefficient of secondary compression

CAD - stress-controlled, consolidated anisotropically drained test

CAD(U) - strain-controlled, undrained compression test with porewater pressure measurements preceded by CAD test

CAU - strain-controlled, consolidated anisotropically undrained compression test

CRS - constant rate of strain oedometer test

e - voids ratio

e_o - initial voids ratio

e_f - final voids ratio

E_{50} - elastic modulus to 50 per cent of failure stress

G - shear modulus

G_s - specific gravity

G.W.L - groundwater table or phreatic surface

I_p - plasticity index

K_o - coefficient of earth pressure at rest

LSSV - Length of Stress Vector

OCR - overconsolidation ratio

p' - mean principal stress; $= (\sigma'_1 + \sigma'_2 + \sigma'_3)/3$

p'_c - effective preconsolidation pressure

p'_o - effective vertical overburden stress

q - principal stress difference; $= (\sigma_1 - \sigma_3)$

s_u - undrained strength; $= (\sigma_1 - \sigma_3)/2_{max}$

u - porewater pressure

V - specific volume; $= (1 + e)$

w - natural moisture content

w_i - initial moisture content

w_f - final moisture content

w_L - liquid limit

w_p - plastic limit

W_T - strain energy absorbed per unit volume

γ_{sat} - saturated unit weight

ε_1, ε_3 - major and minor principal strains (i.e. axial and radial strains in triaxial compression test)

ε - shear strain; $= 2(\sigma_1 - \sigma_3)/3$

ε_{1c}, ε_{3c} - ε_1 and ε_3 at the end of triaxial consolidation to σ'_{1c}, σ'_{3c}

ε_v - volumetric strain in triaxial compression test

ε_{vc} - ε_v at the end of triaxial consolidation to σ'_{1c}, σ'_{3c}

ε_{VR} - vertical strain for oedometer test

- average axial strain during relaxation test in undrained compression test

$\dot{\varepsilon}_1$ - axial strain rate

$\rho_{0.1}$ - strain rate effect parameter for undrained strength

$\eta_{0.1}$ - strain rate effect parameter for preconsolidation pressure p'_c

σ'_1, σ'_3 - major and minor effective principal stresses

σ'_{1c}, σ'_{3c} - σ'_1 and σ'_3 at the end of triaxial consolidation

σ_{oct} - total octahedral normal stress

σ'_{oct} - effective octahedral normal stress

σ'_v - effective vertical stress

ϕ' - effective angle of shearing resistance

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CHAPTER 1

INTRODUCTION

1.1 INFLUENCE OF TIME EFFECTS ON THE STRESS-STRAIN BEHAVIOUR OF SOIL

Before 1960 it was considered that time effects such as straining rate or test duration influenced stress-strain behaviour of soil in a relatively minor way, and could be included with other effects whose magnitude, could not be determined, but which produce compensating errors (Bishop and Henkel, 1957). Since Bjerrum (1967) introduced the "delayed compression" concept, more attention had been paid to time dependent and strain rate dependent properties of carefully sampled natural clay (Crooks and Graham, 1976). The "delayed compression" concept suggested that normally consolidated clay subjected to a constant overburden stress after a long period could be referred to as "aged normally consolidated clay" having a value of preconsolidation pressure p_c' greater than p_o' due to delayed compression. Delayed compression acts to reduce the void ratio and develop a more stable arrangement of soil particles. This leads to greater strength and reduced compressibility. A result of this delayed compression is the development of a reserve resistance against further consolidation. Since more load can be carried in addition to the overburden stress without significant volume change, the preconsolidation pressure p_c' appears to increase with time. By monitoring the settlements of five buildings in the Drammen area, Bjerrum (1967) further observed that the effect of the reserve resistance of the plastic clay on the settlement was most pronounced during the initial period after completion of the buildings. The effect of reserve resistance disappeared with long time increments.

Crooks and Graham (1976), working with the post-glacial organic silty clays of the Belfast area, showed that rate effects were also significant in the stress-strain behaviour of less sensitive, plastic clays. They reported that the undrained strength of samples increased by between 7 and 17 per cent for tenfold increases in strain rate.

Based on tests on sensitive clays from Eastern Canada, Crawford (1965), Conlon (1967) and Jarrett (1967) demonstrated that the time dependency of both undrained shear strength (s_u) and preconsolidation pressure (p_c') was significant. Recently tests on the compressibility and strength of Canadian natural clays, especially their creep behaviour under constant effective stress (Campanella and Vaid, 1974; Vaid et al., 1979; Tavenas et al., 1978) also indicated the pronounced influence of time and rate effects on the compressibility and strength of natural clays.

To provide more rational framework for understanding the stress-strain behaviour of natural lightly overconsolidated clay, Mitchell (1970), Crooks and Graham (1976), and Tavenas and Leroueil (1977) developed qualitative behavioural models based on consideration of yielding of these materials. A generally accepted definition for the yield envelope of a natural clay is a locus joining a set of yield points in the (p', q)* stress space, inside which strains, strain rates and porewater pressure generation were much higher. The locus depends on the stress history of the clay as expressed by its preconsolidation pressure p'_c, or voids ratio e. The practical significance of the limit-state concept in understanding the behaviour of clay and in the design of structures on clay foundations had been shown by Tavenas and Leroueil (1977); Tavenas et al. (1978 and 1979); and Tavenas (1979). Although yield envelopes for various clays had been found (Mitchell, 1970; Crooks and Graham, 1976), a general understanding of the nature of the yield envelope for a clay and the factors affecting it was not clear until the development of the YLIGHT model by Tavenas and Leroueil (1977). A description of the YLIGHT model has been given by Noonan (1980), and summarized by Lew (1981).

A particular feature of the YLIGHT model was that the magnitude of the preconsolidation pressure governed the position of the yield envelope in the (p', q) stress space (Tavenas and Leroueil, 1977). This was also shown by Graham (1974). Crawford (1964) and Bjerrum (1967) both demonstrated that the apparent preconsolidation pressure of a clay determined by oedometer tests was reduced if the rate of loading was reduced, or if the duration of loading was increased. Tavenas and Leroueil (1977), using oedometer tests and triaxial tests, confirmed the effect of rate, or duration of

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*Symbols are defined in LIST OF SYMBOLS on page vii loading, on the preconsolidation pressure and yield envelope. As special cases of more general behaviour, they showed that the preconsolidation pressure of a clay was reduced if the duration of loading was increased. Similarly, undrained triaxial tests at different strain rates indicated a reduction in strength as the strain rate decreased. More importantly, the displacement of the yield envelope indicated a homothetic movement inwards with time. On this basis Tavenas and Leroueil (1977) concluded that the known effects of aging and strain rate on p'_c applied to the entire yield envelope.

The applicability of the limit-state or yield concept has been part of a larger investigation by the geotechnical group at the University of Manitoba into the geotechnical properties of the glacial Lake Agassiz clay which underlies the Winnipeg area. This work was initiated by Dr. J. Graham in 1976 at the University of Manitoba. The testing program consisted of 76 mm diameter samples, trimmed using equipment specially designed to minimize disturbance, and tested in large diameter, rotating-bush triaxial cells. Samples were taken from 6 m to 12 m depth at the University of Manitoba campus using the block sampler devised by Domaschuk (1977). Preliminary information was presented by Baracos et al. (1980), Noonan (1980) and Lew (1981). Yield envelopes were found from intact overconsolidated clay samples taken from various depths. A summary of the existing information is presented in Figure 1.1.

It should be noted that the yield envelope defined by Lew (1981) was based on two sets of samples taken from different boreholes at different times. Samples T303 to T313 were taken from borehole 4 (Figure 1.1) in July, 1980; samples T315 to T319 were taken from borehole 5 (Figure 1.1) in January, 1981. Lew (1981) suggested that the p'_c values for the two sets of sample were the same and an average value of $p'_c = 218$ kPa was used for normalizing test results. However, in studies on the elastic and limit-state properties, Dr. J. Graham (1982) has shown that the shear and bulk moduli of the two sets of samples were different (Graham and Houlsby, 1982; Graham et al., 1982b). Samples T315 to T319 appeared to be stiffer than samples T302 to T314. He therefore modified the yield envelope proposed by Lew (1981) by using different values of p'_c for the two sets of samples. Values of p'_c equal to 191 kPa and 241 kPa were used for samples T302 to T314 and T315 to T319 respectively. This modified normalized yield envelope was transformed back to the (p', q) stress space in Figure 1.2 by using p'_c equal 241 kPa. The modified yield envelope in this figure therefore corresponds to p'_c equal 241 kPa. The modified yield envelope and the modified normalized yield envelope are shown in Figure 1.2 and Figure 1.3 respectively.

Lew (1981) began the study of time effects on the yield envelope for clays taken from 11.5 m. He concluded that the yield envelope was displaced towards reduced preconsolidation pressures and shear strengths as the load duration increased. However, this conclusion was based on a limited number of tests and the time and rate effects on the preconsolidation pressure p'_c had not been examined in previous work. One major purpose of the present study is to continue the study of time effects on the yield envelope initiated by Lew (1981), and especially the effects of time and straining rate on the preconsolidation pressure p'_c.

1.2 LOW STRESS STRENGTHS

The properties of the lacustrine clays underlying Winnipeg continue to cause problems for geotechnical engineers. Natural riverbank slopes are often marginally stable at slopes as flat as 8:1; compacted clay fills will occasionally fail in shallow planar slides at moderate inclinations; and excavation stability is lower than implied by measured unconfined compression strengths. In an investigation of the yielding and rupture of Winnipeg clay, Baracos et al. (1980) proposed a 3-section strength envelope for the full depth of the blue clay (Figure 1.4):

Section 1 (low pressure $\sigma'_{1c} < 60$ kPa)

$c' = 6$ kPa; $\phi' = 31.7^{\circ}$

Section 2 (intermediate pressure $60 \text{ kPa} \leq \sigma'_{1c} \leq 200$ kPa)

$c' = 33$ kPa; $\phi' = 13.0^{\circ}$

Section 3 (high pressure $\sigma'_{1c} > 200$ kPa)

$c' = 3$ kPa; $\phi' = 22.5^{\circ}$

They postulated that the strength of the soil at low effective stresses was largely controlled by a highly fissured and nuggety clay structure which was easily observed in shallow excavations. Mitchell (1970) identified similar behaviour in Leda (Champlain Sea) clay, and concluded that failure would be accompanied by strong dilation of a nodular or prismatic granular structure behaving as an essentially cohesionless material. Crawford (1964), using samples from the Greater Winnipeg Floodway Test Pit, reported a substantial reduction in strength when the soil was allowed to swell. After the investigation of landslide problems in Winnipeg, Baracos and Graham (1980) stated:

> "At low effective stresses, Winnipeg clays behave as cohesionless, softened materials, a fact that must be adequately considered for low effective stress zone, such as the submerged toe of a riverbank, or to shallow depth beneath the faces of all slopes, (excavated or embankments) subject to snow-melt, rainfall, etc."

They further suggested that low-stress strengths were applicable for first-time shallow slides such as those induced by erosion at the toe of riverbanks, or shallow planar slides paralleling the face of a slope. It was necessary to use the concept of "fully-softened strength", with conservatively assumed zero cohesion. Further attention will be paid in a later section to the strength of Winnipeg clay at low stresses.

The climate in Winnipeg is "continental", with temperatures varying over wide extremes through the year. The average daily temperature curve is at its lowest ($-20^{\circ}C$)

during the period January 17 to 27 and its highest (22°C) from July 19 to 27 (Environment Canada, 1980). Therefore Winnipeg clay at low effective stress zones near the ground surface are susceptible to alternating cycles of freeze and thaw. Nuggets and fissures are frequently formed due to the effects of freezing and thawing. The accompanying destruction of the intact clay structure may lead to a reduction in strength. This effect will also be examined in a later section.

By studying the behaviour of a test embankment founded on a well-instrumented foundation of soft Champlain clay at Saint-Alban, LaRochelle et al. (1974) showed that the strength mobilized at failure under the test fill was approximately equal to the "undrained residual strength", a term hitherto used to designate the undrained strength at large strains (USALS), from undrained (CIU) or unconsolidated, undrained (UU) tests at strains of about 15 per cent. Lefebvre (1981) successfully demonstrated that the use of 'post peak' or large strain strengths allowed a reasonable estimate of the stability of natural or man-made slopes in Champlain Sea clays.

By studying case histories of failure of water-retaining structures on highly plastic clay, Rivard and Lu (1978) concluded that the intact strength of the clay did not reliably predict the stability condition. A study of the foundation conditions revealed the presence of structural discontinuities such as nugget and blocky structures, joints, fissures and slickensides. These structural discontinuities were probably caused by weathering. They further suggested that embankments on soft highly plastic clay soils with structural discontinuities should be designed using the normally consolidated strength, as suggested by Skempton and Hutchinson (1969) for stiff fissured clays.

With these points in mind therefore, the second major purpose of the present study was to investigate the low stress strengths of Winnipeg clay under several sets of controlled conditions. The changes in strength from the natural "undisturbed" strengths studied by Baracos et al., 1980; Noonan, 1980 and Lew, 1981 were investigated when the soil was a) allowed to swell freely, and b) was subjected to a series of 'freeze-thaw' cycles. Undrained strengths at large strains (USALS) (LaRochelle, 1974) and their relationship with the normally consolidated strength (Rivard and Lu, 1978) were also examined.

1.3 OUTLINE OF THESIS

The previous section (1.1) showed that although preliminary work on the time-dependent aspects of the YLIGHT model on yielding was studied by Lew (1981), only a limited number of tests were performed. Time and rate effects on the preconsolidation pressure p'_c measured by oedometer, were not examined. The low stress strength envelope shown by Baracos et al. (1980) was based on limited data and further examination of this envelope was required.

As mentioned previously, the two major topics for investigation in the present study were:

1. Examination of test duration and strain rate effects on the yield envelope for Lake Agassiz (Winnipeg) clay.
2. Investigation of low stress strengths including 'fully-softened' strengths and 'freeze-thaw' strengths for Winnipeg clay.

More specifically the aims of this thesis were:

1. To examine the time-dependent aspects of the YLIGHT model for yielding of clays as they applied to Winnipeg clay.
2. To examine the effect of time and strain rate on the preconsolidation pressure, p'_c.
3. To investigate the low stress strengths of Winnipeg clay, and to study the effects of swelling and freeze-thaw degradation on them.
4. To examine the undrained strength at large strains in Winnipeg clay using the USALS method described by LaRochelle et al. (1974), and by implication by Rivard and Lu (1978).
5. To study the effects of changes of strain rate on undrained shear strength.

Large diameter (76 mm) samples were used for all the triaxial tests and oedometer tests performed in the present study. Samples used for the study of time effects and undisturbed low stress strengths were taken from 11.6 m.

'Fully-softened' and 'freeze-thaw' samples were taken from 8.7 m, preparation of these samples will be described in Chapter 2. Six drained stress-controlled tests with two samples running on the same stress path but with different load durations (1 day and 5 days) for each load increment were used to examine the time effects on the yield envelope. Six non-standard oedometer tests similar to those performed by Tavenas et al. (1977) were used to examine the time effects on the preconsolidation pressure p'_c. Four strain-controlled oedometer tests (Sallfors, 1975; Bell, 1977) were employed to investigate rate effects on p'_c. The undisturbed low stress strengths were examined using three undrained strain-controlled and two drained stress-controlled triaxial tests. Three drained stress-controlled and three undrained strain-controlled triaxial tests were performed on the 'fully-softened' samples to examine the effect of swelling on the low stress strengths. Finally, three undrained strain-controlled and two drained stress-controlled triaxial tests were applied to the 'freeze-thaw' samples to study the effect of freeze-thaw degradation on the low stress strengths. The laboratory testing program will be described in detail in Chapters 3 and 4.

Samples which were not stressed to rupture during the drained portion of the triaxial test were tested to failure in undrained shear. The undrained part of the test allowed examination of the following characteristics of clay behaviour: the influence of consolidation history on porewater pressure generation and elastic moduli; the effects of changes of strain rate on the undrained shear strength; the normally consolidated strength for samples consolidated to stresses well past p_c'; the low stress strength envelope and the undrained strength at large strains (USALS).

The thesis begins with a review of the general properties of the lacustrine clays and test procedures (Chapter 2). It continues with the results for time and rate effects (Chapter 3) and low stress strengths (Chapter 4). Discussion of results are presented in Chapter 5. Finally, conclusions and suggestions for further research are presented in Chapter 6.

CHAPTER 2

DESCRIPTION OF GENERAL SOIL PROFILE AND TEST PROCEDURES

2.1 INTRODUCTION

Winnipeg clay was deposited by glacial Lake Agassiz as the last ice-sheet retreated northwards. The samples of Winnipeg clay used in the present study were taken from 8.7 m and 11.6 m depths in borehole 6 at the University of Manitoba campus. The location of borehole 6 is shown on Figure 2.1 and is on the site of the new Physical Education Building which is currently under construction. The borehole was drilled on April, 1981 using a 760 mm diameter power auger. The block sampler devised by Domaschuk (1977) was used to ensure that high quality samples were attained. This chapter provides a brief description of the general properties of the Lake Agassiz lacustrine clays and the testing procedures used in the project.

2.2 SOIL PROFILE AND PROPERTIES

The general soil profile for clay samples taken from the University of Manitoba campus has been described in detail by Baracos et al. (1980), Noonan (1980) and Lew (1981). Samples used in the present study were taken from 8.7 m and 11.6 m depth in the blue-clay layer identified by Baracos et al. (1980). The clay is medium - to highly - plastic

(CH), and has medium-stiff to stiff consistency. Fissures are not normally visible in the blue clay but it contains numerous pockets of grey silt, pebbles and occasional cobbles. Some localized brown stainings were found in samples taken at 8.7 m for the present study.

Basic soil properties of the clay samples are presented in Tables 2.1 and 2.2 and are in general agreement with results from Noonan (1980) and Lew (1981). Test procedures for the basic soil properties were described by Lew (1981) and will not be described here. Additional information on the soil profile obtained from the present study have been added to the average borehole log presented by Lew (1981). This revised borehole log is shown as Figure 1.3 in this thesis.

2.3 SAMPLE PREPARATION

Except for a new series of constant-rate-of-strain oedometer tests, the preparation of samples for consolidated-drained and undrained triaxial tests, and stress-controlled oedometer tests were described in detail by Noonan (1980) and Lew (1981). Only a brief outline of the procedures will be given here. To minimize disturbance during trimming, samples were trimmed using equipment which has been designed and constructed at the University of Manitoba (see Lew 1981, Figure 3.3). The equipment is similar in principle to equipment described by Landva (1964). The trimming and building-in procedures for triaxial samples can be briefly outlined as follows: The cell pedestal was deaired by flushing water through the pedestal by means of burettes attached to the pedestal drainage leads. The base plate was placed on the cell base and was adjusted until the cutting cylinder was accurately centered over the pedestal base. The trimming table was then attached to the base plate. The trimming equipment was lubricated with silicone oil to reduce friction. A roughly trimmed sample was then placed centrally on the trimming table; a greased cutting cylinder with a sharp leading edge was pushed carefully into the soil to a depth of slightly less than the full length of the cutting edge. The excess clay outside the cutting edge was then removed using a piece of cutting wire. This process was repeated until soil protruded from the top of the cylinder. The cutting cylinder was removed from the uprights and placed on a glass plate. The ends of the sample were then trimmed across the top and bottom of the cutting cylinder. A saturated deaired filter stone in a holder was attached to one end of the sample. The sample was then lowered on to the cell pedestal, the top cap was located firmly by a central rod, and the cutting cylinder was removed. The height and the diameter of the sample were measured. A thin coat of silicone stopcock grease was applied to the side of the pedestal and the top cap. Lateral drains were provided by applying saturated filter strips, approximately 1 cm wide, longitudinally around the circumference of the sample. Two membranes, separated by a layer of silicone oil, were placed over the sample, together with two O-rings on the top cap and three O-rings on the pedestal. The cell top was then fitted very carefully on to the cell base and screwed down. The loading piston was lowered until contact was made with the sample. The piston was then locked in place. The cell was filled with deaired distilled water and a 2 cm layer of engine oil added through the top of the cell to reduce leakage of cell water and friction between the piston and bushing. Air trapped in the pedestal and drainage leads were then removed by passing water between two burettes attached to the pedestal drainage leads. The pressure tranducers were re-zeroed to correspond with the water level at mid-height of sample. Finally, the rotating bush drive coupling was attached, the vertical dial gauge was put in place and zeroed; and the ball bearing and loading hanger were placed in position on top of the loading piston.

Oedometer samples were prepared using similar trimming equipment to the triaxial samples, but with some minor modification. The building-in procedure for the stress-controlled oedometer tests was the same as the conventional oedometer tests.

For the constant rate of strain (CRS) oedometer test, a modified oedometer cell was used. This modified cell is shown and described in Figure 2.3. A photograph of the CRS test apparatus is shown in Figure 2.4. Before placing the oedometer onto the cell base, the water system was flushed thoroughly with deaired water to get rid of entrapped air. Then the oedometer was fastened to the cell base. The O-ring around the edge of the ring acted as a seal, making the bottom impermeable. The water system was left open to avoid large excess pressures in the water system during mounting. The top cap was then placed in position, the reservoir was flooded with water, and the oedometer was transferred to a Wykeham Farrance IT compression machine.

2.4 TEST PROCEDURES

Consolidated-drained stress-controlled triaxial tests (CAD(D) tests), undrained shear tests (CAU tests), non-standard stress controlled oedometer tests and constant-rate-of-strain (CRS) oedometer tests were performed in the present study of rate effects and low stress strengths of Winnipeg clay. Testing procedures for CAD(D) tests and CAU tests for undisturbed samples are briefly summarized in this section. Noonan (1980) and Lew (1981) have given detailed descriptions of the testing procedures used in the Soil Mechanics laboratories in University of Manitoba. For the investigation of low stress strengths, CAD(D) tests and CAU tests were also performed on 'fully-softened' samples and samples subjected to 'freeze-thaw' cycles. The 'fully-softened' samples were allowed to swell and the 'freeze-thaw' samples were subjected to several freeze-thaw cycles before reconsolidation. Thus the actual procedures during testing for the CAD(D) tests and CAU tests of the 'fully-softened' and 'freeze-thaw' samples were the same as described by previous workers (Noonan, 1980; Lew, 1981) for undisturbed samples. In addition, this section also describes test procedures which have not previously been used in the research at University of Manitoba for:

1. 'fully-softened' samples
2. 'freeze and thaw' samples
3. non-standard stress-controlled oedometer tests
4. constant rate of strain (CRS) oedometer tests

2.4.1 Undisturbed Samples

2.4.1.1 Triaxial Consolidation and Drained Stress Controlled Triaxial Tests for Undisturbed Samples

The undisturbed samples were first consolidated to desired axial stress levels: $p_o'/3$, $2p_o'/3$, p_o' where p_o' is the in-situ stress level. A constant stress ratio ($\sigma_{3c}'/\sigma_{1c}'$) of 0.65 was used during the reconsolidation phase of the present study. The effective overburden stress for each sample was calculated assuming the phreatic surface at a depth of 3 m and an average unit weight of 17.5 kN/m^3. Detailed discussion on the use and implications of this method was described by Noonan (1980).

The consolidation stages of the undrained triaxial tests and the drained stress-controlled tests were both carried out on a steel loading frame, the general arrangement of which is shown in Figure 3.5 of Lew's thesis (Lew, 1981). Up to three rotating bush cells could be used at one time. Dial gauges were used to measure the height changes of the samples and the volume changes were measured using burettes. Before each loading increment, water was flushed through the drainage leads to remove air which might have been trapped between the membrane and sample, together with any gas released by the sample (Noonan, 1980).

Cell pressure was applied through water in the cell, using compressed air to pressurize an external air-water tank. The cell pressures and porewater pressures were both monitored by pressure tranducers and were re-zeroed to atmospheric pressure at mid-height of sample before each load increment. Axial loading was applied by dead loads on a hanger which rested freely on the piston.

After the application of the stresses, axial and lateral stresses, axial dial gauge and burette readings were taken using standardized 'doubling' time intervals (that is, 1, 2, 4, 8, 15, 30 min; 1, 2, 4 hr etc.). Stress increments in triaxial consolidation, drained stress controlled tests were added at approximately 24 hour intervals, with the exceptions of those stress points that were in the vicinity of the proposed yield stresses, and in the 5 day loading tests (Samples T402, T404 and T406). These latter procedures will be described in detail in Chapter 3.

2.4.1.2 Undrained Shearing

After triaxial consolidation, samples which were to be subjected to undrained strain-controlled shearing were moved carefully from the consolidation frame to a 10 t compression frame. The axial load was reapplied in the compression frame using a proving ring (sensitivity = 4.156 N/div). The loading piston was clamped while the cell was being moved.

Prior to back-pressuring, the sample drainage system was again flushed to remove any air which had collected during the last consolidation increment. A back-pressure of approximately 210 kPa was used to achieve saturation in the sample. The back-pressuring process was usually continued for about 24 hours before checking for saturation. For research purposes, the acceptable value for the porewater parameter B is 98 per cent or greater. The B values obtained in the present study ranged from 97 to 100 per cent.

The strain rate used for undrained shearing was about 1 per cent/hour before the peak shear stress was reached. After reaching the peak shear stress, the sample was strained for a further 1 to 2 per cent axial strain, at which point a "relaxation test" was carried out to examine the effect of strain rate variation on the undrained strength. This procedure, developed by Kenney (1966), involves switching off the compression machine and noting changes with time in the axial deflection, proving ring, porewater pressure and cell pressure. Relaxation tests were usually continued overnight. After the relaxation test, the compression machine was switched on again and step-changing technique was applied to all of the samples. In this technique which was introduced by Richardson and Whitman (1963), the strain rate applied to a sample is step-changed during the test. Each strain rate is applied only long enough to establish the stress-strain relationship for that stage in the test. Stress-strain curves for different strain rates can then be interpolated between measured portions of the curves, and can be extrapolated to the region of failure strains. Relaxation tests at axial strains greater than 5 per cent were performed on some of the samples to examine the dependency of strain rate effects on the magnitude of strain. On completion of testing, the failed samples were removed from the triaxial cell and cut longitudinally. One-half of the sample was used for determining the final moisture content of the sample. The other half was normally used for visual examination; namely inspection of the failure plane and pecularities within the sample.

2.4.2 'Fully-Softened' Samples

The 'fully-softened' samples were trimmed from 'undisturbed' block samples, and built into the triaxial cell in the usual way. Prior to the reconsolidation, however, they were allowed to absorb as much water as possible under low applied stresses. A small cell pressure of 2 kPa and axial pressure of approximately 4 kPa were applied in order to keep the membrane and piston just in contact with the sample so that measurements for volume change and axial deformation could be made. Axial dial gauge and burette readings were taken using standard 'doubling' time intervals for the first 24 hours and daily readings were taken thereafter. It was observed that the volume of samples would become stable after 10 days. The volume and height were increased by about 6 and 3 per cent respectively for all the samples. The samples were then reconsolidated in the usual way and CAD(D) or CAU tests performed as described previously for undisturbed samples, except that an average unit weight of 16.7 kN/m^3 was used for the calculation of in-situ stresses in these tests. Based on the unit weights obtained for the samples tested in the present study (see Table 2.1, 2.2), and those tested by Noonan (Table 3.1, Noonan, 1980) and Lew (Table 1, Lew, 1981), the author suggests that the average unit weight of 17.5 kN/m^3 proposed by Baracos et al. (1980) was rather too high.

2.4.3 'Freeze and Thaw' Samples

The samples for examining the effects of 'freeze and thaw' cycling were again trimmed from undisturbed block samples. After the membranes were put on the sample, the sample and the cell base were transported into a temperature control chamber. Pressure transducers were disconnected from the cell base to facilitate the transportation. The freezing and thawing temperatures ranged from -5 to -25^{o}C and 20 to 25^{o}C respectively. Average duration of the freeze and thaw cycles was about 12 hours for samples T418 to T420, and 48 hours for samples T421 and T422. The temperatures, durations and the number of freeze-thaw cycles for which the samples were subjected to are shown in Table 2.3. Average axial compressive strains of 2.5 per cent were observed, for samples T418 to T420, and 6.5 per cent for samples T421 and T422.

No net volume change occured since the samples were 'freeze-thawed' under a closed system, that is, all drainage valves were closed during the freeze-thaw cycles. Figure 2.5 shows a typical 'freeze-thaw' sample T421 after completion of the freeze-thaw cycles. The sample was tilted from the vertical position and a rough outer surface had formed. The unit weights obtained for individual samples were used for the calculation of in-situ stresses. After the freeze and thaw cycles, the samples were reconsolidated, and CAD(D) or CAU tests were performed in the same way as the undisturbed samples.

2.4.4 Non-Standard Stress Controlled Oedometer Tests

The equipment and sample preparations for the six oedometer tests were the same as for standard oedometer tests. The six samples were trimmed and loaded at approximately the same time. Single, different loads were applied to each sample for periods of about 100 days. The loads were 480.4, 377.9, 280.4, 210.2, 150, 75 kPa for samples C401, C402, C403, C404, C405 and C406 respectively. For loads that were smaller than 220 kPa, the samples were loaded in one step. For those loads larger than 220 kPa, the loads were put on in steps of about 100 kPa at 30 minute intervals. This was done to avoid squashing of the samples due to high porewater pressure gradients causing flow of the clay past the top cap if the loads were applied too quickly. The threshold value for axial pressure of 220 kPa was used because the preconsolidation stress at this depth was estimated to be

240 kPa.

Axial deformations of each sample were measured using a dial gauge, with the readings being taken using standard 'doubling' time intervals for the first 24 hours. After the first day, readings were taken daily for the first month, after about every 4 days in the second month, and then irregularly the third month. The most important readings were those during the first 24 hours; and subsequently after 10, 30, 60, 100 days. The loads were allowed to stay on the samples for 100 days and during this period all the tests were performed under a controlled temperature of 21°C.

2.4.5 Constant Rate of Strain Oedometer Tests (CRS Tests)

The set of CRS oedometer tests performed in the present study was a pilot series in a new piece of equipment designed and manufactured in the University of Manitoba (Figures 2.1, 2.2).

After the sample had been built into the cell, the test was started by setting the compression machine into motion at a constant rate of straining. Up to a load of approximately 10 kPa the drainage system from the bottom of the cell was left open and when good contact was assured between the sample and the bottom of the cell, the drainage was shut off, making the base impermeable. Samples C409 and C410 were loaded initially to about 70 kPa to avoid swelling.

A type TYCO pressure transducer with a range of 0 to 980 kPa was used for measuring porewater pressure at the bottom of the sample. The vertical force was measured with a TYCO (JP 1000) force transducer, range 0 to 4,500 N. The deformation was measured with a LVDT, type HP 7DCDT-500. Readings were taken with the following accuracy:

Force	1.0 N
Pressure	0.1 kPa
Deformation	0.001 mm

Data were fed to conditioning units designed and built in the workshops at University of Manitoba, and recorded by a Consolidated Control Model 90MCI datalogger.

Strain rates used in this test series ranged from 0.0002 mm/min. to 0.0036 mm/min. After the strain rate was set, the compression machine was switched on, and readings of vertical force, pore pressure and deformation were taken every ten minutes during the first hour and every hour thereafter. Step changing tests (Bell, 1977) were performed on samples C408 and C409 after the p'_c values were reached.

The effective axial pressure was calculated based on a parabolic porewater pressure distribution throughout the sample (Sallfors, 1975). The effective pressure can then be calculated as:

$$\sigma'_v = \sigma_v - 2/3\ u_b$$

where σ'_v = effective vertical pressure

σ_v = total vertical pressure

u_b = porewater pressure at the bottom of the sample

The tests were run to an average axial strain of about 18 per cent.

The results of the time effects and low stress strengths for the present study will be presented in Chapters 3 and 4 respectively.

CHAPTER 3

TESTS TO EXAMINE TIME EFFECTS AND STRAIN RATE EFFECTS

3.1 INTRODUCTION

Three major types of laboratory tests, namely consolidated drained triaxial tests, non-standard stress-controlled oedometer tests and strain controlled oedometer tests were carried out to investigate the influence of time and strain rate on the stress-strain behaviour of Lake Agassiz lacustrine clay.

The series of consolidated drained triaxial tests examined the deterioration or shrinkage of the yield envelope towards the origin of the (p'. q) stress space with increased time of testing (Tavenas and Leroueil, 1977). The non-standard oedometer tests study the influence of time effects on the preconsolidation pressure, p'_c (Tavenas et al., 1977; Bjerrum, 1967). The effect of strain rate on p'_c was investigated using strain-controlled oedometer tests (Sallfors, 1975; Bell, 1977). Strain rate effects were also examined using relaxation tests (Kenney, 1966) and step-changing tests (Richardson and Whitman, 1963) on all the undrained shearing tests.

Standard classification tests (Atterberg limits, specific gravity, natural moisture content and hydrometer tests) were performed on the trimmings taken from the triaxial compression samples. Test results are listed along with sampling depths and test types in Tables 2.1 and 2.2. Swedish Fall Cone sensitivity tests were also performed on small intact cuttings from the block samples. Natural moisture contents were performed on all the oedometer samples. These results are shown later with the complete oedometer results in Table 3.5. Only one set of standard classification tests was performed because the oedometer samples were all trimmed from the same block sample of clay. The average results are as follows:

Liquid limit, w_L	75.8%
Plastic limit, w_p	26.6%
Plasticity index, I_p	49.2%
Average specific gravity, G_s	2.78
Clay fraction	66%
Sensitivity	3.0

These results are in general agreement with results from Lew (1981).

3.2 TESTING PROGRAM

3.2.1 Consolidated Drained Triaxial Tests

Six consolidated drained triaxial tests on samples T401 to T406 were used to investigate the shrinkage or degeneration of the yield envelope with time. The samples were first reconsolidated to their approximate in-situ stress levels (Crooks and Graham, 1976) in three stress increments. Once the triaxial samples were reconsolidated to the approximate in-situ stresses (Baracos et al., 1980), a series of three stress paths were used, with two samples for each stress path, to investigate the effect of time or test duration on the yield envelope. The three stress paths are shown in Figure 3.1. They can be further divided into the following categories:

1. T401, T402 (Figures 3.3, 3.4, 3.5)
   - Stress path of increasing effective octahedral normal stress and constant shear stress of $P_o'(1-K_o)$.
2. T403, T404 (Figures 3.6, 3.7, 3.8, 3.9, 3.10)
   - Stress path of effective octahedral normal stress and shear stress both increasing, with $\Delta q/\Delta p'$ being constant.
3. T405, T406 (Figures 3.11, 3.12, 3.13)
   - Stress path of decreasing effective octahedral normal stress and increasing shear stress.

Previous work by Lew (1981) defined an average yield envelope for samples taken from 11.5 m depth. Intersections of this average yield envelope with the proposed stress paths established the approximate yield stress level along each path (Figure 3.1). The incremental stress levels along each stress path were determined by allowing five equal increments between in-situ stresses and the expected approximate yield stresses. Each stress level was maintained for 24 hours. Detailed discussion of this method was given by Noonan (1980). However, for the steeply inclined stress paths along which the samples would eventually fail abruptly, the yield stresses were more difficult to define (Lew, 1981). Therefore, two more stress increments were added before and beyond the approximated yield stress level for samples T403 to T406 (Figure 3.1) to increase the 'sensitivity' of the tests at around yield stress level. Dr. J. Graham suggested reducing the load increment as well as the load duration by half of the original values in order to maintain constant strain rate. This will be discussed in more detail in Chapter 5.

The complete stress-strain results for the stress controlled portion of this study are tabulated in Appendix I and shown in Figures 3.3 to 3.13. The triaxial consolidation results at the end of the drained portion of the tests are summarized in Table 3.2.

Sample T402 was consolidated under constant shear stress to stresses higher than the yield stresses, and was then sheared to failure under undrained triaxial compression conditions. Additional stress-strain information for the clay was provided during undrained shearing. The undrained stress strain results for this sample will be presented in Chapter 4. It should perhaps be explained here why no undrained stress strain results for test T401 have been included. An procedural error was made in this first test during back pressuring for saturation. As a result, the effective lateral stress on the sample was decreased significantly. It was considered that an undrained test on this sample would be inappropriate.

3.2.2 Non-Standard One-Dimensional Oedometer Tests

Six oedometer tests were carried out using 76 mm diameter samples which had been carefully trimmed using equipment developed by Lew, 1981. Silicon grease was used to reduce friction between the sample and the oedometer ring. The procedure involved loading the six oedometer samples in one step to six different predetermined stress levels, namely 480.4, 377.9, 280.4, 210.2, 150.0, 75.0 kPa. Detailed description of the procedure can be found in Chapter 2. The development of vertical strains was monitored for a period of 100 days. The tests were performed under a controlled temperature of 21^{o}C.

The results of these tests are presented in Tables 3.5 to 3.7 and Figures 3.15 to 3.20.

3.2.3 Constant Rate of Strain Oedometer Tests

Four 76 mm diameter oedometer samples (C407-C410) were used in this pilot test series. The new piece of equipment designed and manufactured in the University of Manitoba has been described and shown in Figures 2.1 and 2.2.

The strain rate used for samples C407 to C410 were 0.0010 mm/min., 0.0036 mm/min., 0.0002 mm/min. and 0.0006 mm/

min. respectively.

Step changing tests (Bell, 1977) were performed on samples C408 and C409. Samples C408 to C410 were run to an average vertical strain of 18 per cent. Sample C407 was the first test and it was stopped at an axial pressure of 487 kPa because of the limited capacity of the load cell used in the test. The results of these tests are tabulated in Table 3.8 and are shown in Figures 3.21 to 3.22.

3.3 TRIAXIAL CONSOLIDATION AND DRAINED STRESS CONTROLLED TRIAXIAL TESTS

3.3.1 Reconsolidation to In-Situ Stresses

The triaxial samples that were used for the study of time effects (T401 to T406) were reconsolidated to in-situ stresses in three increments, with at least 24 hours between increments. A ratio of horizontal to vertical effective stress during restressing was taken as 0.65 (Baracos et al., 1980). The importance of reconsolidating samples anisotropically with respect to preserving the field structure of the clay was emphasized by Crooks and Graham (1976).

The stress-strain results of reconsolidating the samples to the estimated in-situ stresses are tabulated in Table 3.1. For samples T401 to T406, the axial strains to in-situ stresses ranged from 1.25 to 1.56 per cent. The lateral strains to in-situ stresses varied from 0.12 to 0.36 per cent. All of the samples except T406 had negative volumetric strains of 0.08 to 0.3 per cent during the first stress increment. Sample T406 had a positive volumetric strain of 0.1 per cent and it was trimmed from a different block of clay.

These strains can be considered small, and will not seriously affect the mechanical properties of the clay. They compare favourably with corresponding values obtained by Noonan (1980) and Lew (1981). The amount of straining which occured during restressing was in part a measure of the amount of sample disturbance. Crooks (1973) stated that a small degree of disturbance during sample preparation resulted in axial strain below 2 per cent at P'_o. Based on this statement, the axial strains of less than 1.6 per cent to P'_o for the present tests reflected acceptable level of disturbance. The volumetric stress strain behaviour during reconsolidation will be presented in more detail in Chapter 4.

3.3.2 Drained Compression Results

The proposed effective stress paths to be followed by the samples (T401 - T406) are shown in Figure 3.1. Figure 3.2 shows the actual effective stress paths and stress levels of the samples. The development of stresses and strains during each test is summarized in tabular form in Appendix I.

The yield or limit state stresses were identified by stress-strain criteria which depended on the stress path of the tests. For example, no yield stress could be obtained from a plot of $(\sigma_1 - \sigma_3)$ vs ε_1 for a test carried out at constant shear stress, or from a plot of σ'_{oct} vs ε_v for a test at constant octahedral normal stress. Yield stresses could be defined in a number of ways depending on the stress paths in question. Discussion on the application of different criteria for different stress paths were given by Baracos et al. (1980), Noonan (1980). Lew (1981) developed an "energy criterion" for yielding based on earlier work by Graham, 1974 and Noonan, 1980. This involved plotting W_T vs LSSV where:

W - strain energy absorbed per unit volume
LSSV - Length of Stress Vector (Lew, 1981)

In addition, the shear stress $(\sigma_1-\sigma_3)$ vs shear strain *ε plot was used to determine the yield stresses for the steeply inclined stress paths (samples T403 to T406). The $(\sigma_1-\sigma_3)$ vs ε plot is more meaningful and useful than the $(\sigma_1-\sigma_3)$ vs ε_1 plot. This is because the shear modulus of the triaxial samples can be identified as one-third the slope of the initial stiff section of the $(\sigma_1-\sigma_3)$ vs ε plot. For samples T401 and T402, yield stresses could only be determined by the σ'_{oct} vs ε_v, σ'_3 vs ε_3 and the W_T vs LSSV plots (Figures 3.3, 3.4, 3.5). The σ'_1 vs ε_1, σ'_{oct} vs ε_v, $(\sigma_1-\sigma_3)$ vs ε_1, $(\sigma_1-\sigma_3)$ vs ε and W_T vs LSSV plots were useful in determining yield stresses for samples T403 and T404 (Figures 3.6 to 3.10). The yield stresses obtained from the different graphs are indicated on the figures. Corresponding

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* $\varepsilon = 2/3\ (\varepsilon_1-\varepsilon_3)$

values of σ'_{oct} at yield are given in Table 3.4.

The stresses at rupture are interpreted as being the yield stresses for samples T405 and T406. Figures 3.11, 3.12, 3.13 show the σ'_3 vs ε_3, $(\sigma_1-\sigma_3)$ vs ε_s, W_T vs LSSV plots for these samples. The difficulties in defining yield stresses for stress paths of this type were pointed out by Lew (1981), and will be discussed in more detail in Chapter 5 of this thesis.

Except for samples T401 and T402, all the samples (T403 to T406) failed abruptly during the last loading increment with the drainage leads open. The undrained shearing results for sample T402 are presented in Chapter 4. As explained earlier in this chapter, no undrained shearing results were obtained from sample T401.

The yield stresses for samples T401 to T406 are presented in Figure 3.14. The results indicated that for the constant shear stress path, the yield stresses for sample T401 were greater than that of sample T402. Therefore, the yield stresses for the 5-day loading duration test (T402) were smaller than that of the 1-day loading duration test (401). This confirmed with observations in the YLIGHT model (Tavenas and Leroueil, 1977). However, for the other samples in this series, T403 to T406, the results were in contradiction with the YLIGHT model observations. The yield stresses for the 5-day loading duration tests (T403 and T405) were greater than that of the 1-day loading duration tests (T404 and T406). It should be pointed out that the stresses at rupture for sample T404 (5-day loading duration) were smaller than that of sample T403 (1-day loading duration). This set of results has presented difficulties during interpretation. The estimated yield stresses for samples T401 to T406 were predicted using the one-day yield envelope for 11.5 m depth proposed by Lew (1981). Figure 3.14 shows that the yield stresses for samples T401 to T404 are outside Lew's envelope; while the yield stresses for samples T405 and T406 are inside Lew's envelope. However, these results are in better agreement with the revised yield envelope by Graham (1982), described earlier in Chapter 1. Discussion of the results will be presented in Chapter 5.

3.4 NON-STANDARD OEDOMETER TESTS

Crawford (1964), Bjerrum (1967), Tavenas and Leroueil (1977) demonstrated that a reduction in the rate of loading or an increase in the duration of load application resulted in a reduction of p'_c.

In order to verify this point, six special oedometer tests (C401 to C406) were performed on the Winnipeg clay from 11.6 m depth. The load settlement curves (σ'_v vs ε_{VR} curves) observed after 0.1 day, 1 day, 10 days and 100 days are shown on Figure 3.15. The effective preconsolidation pressures p'_c were interpreted from bilinear fitting of the observed stress-strain results. Lew (1981) noted that all the graphs of ε_{VR} vs σ'_v revealed an initial straight section of low compressibility of the clay which changed to a higher compressibility at p'_c and for a range of stresses beyond p'_c. At higher pressures, strain-hardening behaviour was observed. Graham, Noonan and Lew, 1982 have suggested that this may indicate cementation in the clay. The plot was formed from the initial linear section of the ε_{VR} vs σ'_v plot and the straight line joining the first two points in the more compressible region. The p'_c values found in this way reduced from 249 to 225 kPa as the duration of the load application increased from 0.1 to 100 days. These results are tabulated in Table 3.5.

Figure 3.16 shows corresponding vertical strain ε_{VR} vs $\log\sigma'_v$ curves for the 0.1 to 100 days loading durations. In this case, the values of p'_c were difficult to determine using the Casagrande construction. Points of minimum radius of curvature were difficult to locate due to roundness of the ε_{VR} vs $\log\sigma'_v$ curves. The straight lines in the ε_{VR} vs σ'_v space in Figure 3.15 will appear to be curved in the ε_{VR} vs $\log\sigma'_v$ space (Graham et al., 1982a). Because of this, the p'_c values for these tests were defined using the ε_{VR} vs σ'_v curves in Figure 3.15. The p'_c-values defined using the ε_{VR} vs $\log\sigma'_v$ curves are also shown in Table 3.5.

The consolidation-time curves are shown in Figures 3.17 and 3.18. Sample C406 began to swell at about 20 minutes after the load application, and reached a constant value at about 40 hours. The initial compression of sample C404 was greater than that of C405 while sample C405 was subjected to a larger load. However, sample C405 became more compressible at about 40 minutes after loading. The 'S' shaped curves predicted by Terzaghi consolidation theory were generally observed except for sample C406.

Values of c_v, C_c, C_α, C_α/C_c were calculated for different stress levels at 24 hours and 240 hours and 2,400 hours load durations. Values of c_v were calculated using t_{50} from the empirical log(time) construction method. In all cases, the consolidation time curves indicated that all primary consolidation was completed within 24 hours after loading. The results are tabulated in Table 3.7. Figures 3.19 and 3.20 show the graphs of c_v, C_α/C_c, C_c, C_α and ε_{VR} vs $\log\sigma'_v$ for load durations of 24 and 240 hours respectively. The c_v vs $\log\sigma'_v$ plot for 240 hours load duration cannot be presented for reasons stated above.

The c_v vs $\log\sigma'_v$ plot in Figure 3.19 show that c_v peaked just before p'_c (250 kPa) and dropped until a vertical pressure of about 378 kPa was reached. C_α peaked at a value of 3.4 per cent at stress level of 378 kPa for load duration of 24 hours and decreased to a value of 1.6 per cent at the same stress level for a load duration of 240 hours. For the 24 hour C_c vs $\log\sigma'_v$ curve, C_c increased with increasing vertical stress, whereas the value of C_c peaked at vertical stress of 378 kPa. The C_α/C_c values also peaked just after p'_c and decreased with time.

The effect of strain rate on p'_c can be expressed as $\eta_{0.1}$ - the change in p'_c for a ten-fold change in vertical strain rate, expressed as a percentage of p'_c at a standard strain rate of 0.1 per cent/hour. The strain rate was estimated using the strain to p'_c, and divided by the corresponding time. The value of $\eta_{0.1}$ in this study was 3.6 per cent. This is rather lower than the normal range of $\eta_{0.1}$ is from 10 to 20 per cent (Graham, Crooks and Bell, 1982a).

3.5 CONSTANT RATE OF STRAIN OEDOMETER TESTS

The constant rate of strain oedometer tests performed in the present study form a pilot series. The equipment and test procedures are similar to those described by Sallfors (1975). Graphs of ε_{VR} vs σ'_v and ε_{VR} vs $\log\sigma'_v$ are shown in Figures 3.21 and 3.22. Although no sharp break was observed for any sample (C407-C410) in both plots, yielding could be identified with some certainty. The p'_c values are better defined using the ε_{VR} vs σ'_v plot. Table 3.8 shows the p'_c values obtained, and the corresponding strain rate for both plots. p'_c values are unusually high in tests in this study. The author suggests that this might be due to equipment problems, specifically the inability to back-pressurise the equipment to ensure saturation and meaningful porewater pressures. This could be expected to lead to low estimates of porewater pressure, and hence high estimates of effective stress. It has not been considered useful to calculate from these tests consolidation parameters such as C_c, C_α. Note that significant strain rate dependencies have been observed. These tests will be discussed further in Chapter 5.

CHAPTER 4

LOW STRESS TEST RESULTS

4.1 INTRODUCTION

The shear strength and stress-strain characteristics of the Winnipeg clay at low stresses (stresses less than or equal to the in-situ stresses p_o'), have been investigated using drained stress-controlled triaxial CAD(D) tests and undrained shear triaxial (CAU) tests. These tests were performed on five undisturbed samples (T407, T408, T415, T416, T417). The effect of swelling and freeze-thaw degradation on low stress strength of the Winnipeg clay were also examined using the same tests on six 'fully-softened' samples (T409 to T414) and five 'freeze-thaw' samples (T418 to T422). The testing program is described in detail in section 4.2.

Undisturbed samples tested in the present study were obtained from borehole 6 at the University of Manitoba campus (Figure 1.1) at 11.4 m depth. 'Fully-softened' and 'freeze-thaw' samples were obtained from the same borehole but at a depth of 8.7 m. Preparation of the 'fully-softened' and 'freeze-thaw' samples was described earlier in Chapter 2. Basic soil properties for these samples are listed in Tables 1 and 2.

Results from the CAD(D) tests and CAU tests are presented in sections 4.3 and 4.4 in this chapter. Strength results for sample T405 which have already been presented in

Chapter 3 are included again as part of the undisturbed CAD(D) test results in this chapter.

4.2 TESTING PROGRAM

Similar testing programs were carried out for the 'undisturbed', 'fully-softened' and 'freeze-thaw' samples. Pairs of samples were first consolidated to $p'_o/3$, $2p'_o/3$ and p'_o. In principle, CAD(D) and CAU tests were then run on each of these pairs at each consolidation stress level. However, because of a shortage of samples free of stone inclusions, CAD tests were not performed for the 'undisturbed' and 'freeze-thaw' samples consolidated to p'_o. Stress paths with increasing deviator stress $(\sigma_1-\sigma_3)$ and constant effective octahedral stress σ'_{oct} were followed in the CAD(D) tests. For samples that were consolidated to $2p'_o/3$ and p'_o, strain-controlled undrained shear tests were run before the corresponding drained tests so that their strengths could be used to estimate the peak strengths in the subsequent drained tests. For the CAD(D) tests on 'undisturbed' and 'freeze-thaw' samples consolidated to $p'_o/3$, a stress path with increasing $(\sigma_1-\sigma_3)$ and decreasing σ'_{oct} was followed (Figures 3.2 and 4.2). The approximate peak strengths for these tests were predicted using the low stress envelope proposed by Baracos et al. (1980). The incremental stress levels along each stress path for the CAD(D) tests were determined similar to that of the triaxial samples (T401 to T406) used in the study of time effects. In this test series, five stress increments were allowed between the estimated peak strengths and stresses at the end of consolidation ($p'_o/3$, $2p'_o/3$ and p'_o). Additional stress increments were inserted before and beyond the approximated peak strengths in the same way as described in Chapter 3.

4.3 TRIAXIAL CONSOLIDATION AND DRAINED STRESS CONTROLLED TESTS

4.3.1 Triaxial Consolidation

Samples tested in this series were reconsolidated anisotropically to $p'_o/3$, $2p'_o/3$ and p'_o with the ratio of σ'_3/σ'_1 equal to 0.65 (Baracos et al., 1980).

Stress-strain results for the reconsolidation phase of testing are tabulated in Tables 4.1 and 4.2. Swelling was observed for the 'undisturbed' samples consolidated to $p'_o/3$, that is, negative values for axial, lateral and volumetric strains were recorded (Tables 4.1 and 4.2). The axial strain (0.95 per cent) of the 'undisturbed' sample (T407) tested in this series was lower than the axial strains (ranging from 1.25 to 1.56 per cent) for the comparable samples T401 to T406 tested in the time effect series. The axial strains were always less than 2 per cent, therefore the sampling disturbance is acceptable for all these samples (T401 to T407) (Crooks, 1973) and is minimum for sample T407. The average axial strains for 'fully-softened' and 'freeze-thaw' samples both consolidated to p'_o were 3.73 and 10.58 per cent respectively. These axial strains were greater than 2 per cent which indicated that the samples had been "disturbed" considerably (Crooks, 1973). It is perhaps worth noting here, that "disturbance" in this context does not imply inattention to detail during sample preparation, rather that the test procedures themselves cause disturbance and changes to the fabric of the clay. The higher value of axial strain for the 'freeze-thaw' samples as compared to the 'fully-softened' samples indicate that their degree of disturbance was greater.

4.3.2 Drained Compression Results

The actual effective stress paths followed by the 'undisturbed', 'fully-softened' and 'freeze-thaw' samples are shown respectively in Figures 3.2, 4.1 and 4.2 respectively. The stresses and strains developed during each test are summarized and tabulated in Appendix I. The triaxial consolidation results at the end of the drained portion of the tests are summarized in Tables 3.2 and 3.3.

The determination of yield stresses was discussed earlier in Chapter 3 and similar techniques have been used for these tests, stress-strain curves are presented in Figure 4.3 to Figure 4.18. Yield points are shown on each graph and yield stresses defined from the various criteria are summarized in Table 4.3. Samples T415 and T417 were 'undisturbed' samples taken from borehole 6 (Figure 1.1) at 11.4 m depth. For yield determination, the σ_1' vs ε_1, $(\sigma_1 - \sigma_3)$ vs ε_1 and the $(\sigma_1 - \sigma_3)$ vs ε plots were useful for sample

T415 whereas the σ'_{oct} vs ε_v, σ'_3 vs ε_3, $(\sigma_1-\sigma_3)$ vs ε , W_T vs LSSV plots were useful for sample T417. Figures 4.3 to 4.8 show the yield determination for these samples.

'Fully-softened' and 'freeze-thaw' samples were also taken from borehole 6 (Figure 1.1) but from a depth of 8.7 m. For the 'fully-softened' samples (T410, T412 and T414), the σ'_1 vs ε_1, $(\sigma_1-\sigma_3)$ vs ε_1, σ'_3 vs ε_3, $(\sigma_1-\sigma_3)$ vs ε and W_T vs LSSV plots were all useful for yield determinations, with the exception of σ'_3 vs ε_3 plot for sample T412. The yield determinations of these samples are shown in Figure 4.9 to Figure 4.13.

Graphs for yield determinations for samples T419 and T421 are presented in Figure 4.14 to Figure 4.18. For the 'freeze-thaw' samples (T419 and T421), the $(\sigma_1-\sigma_3)$ vs ε_1, $(\sigma_1-\sigma_3)$ vs ε_s and W_T vs LSSV plots were useful in determining yield stresses for T419. σ'_1 vs ε_1, $(\sigma_1-\sigma_3)$ vs ε_1, σ'_3 vs ε_3, $(\sigma_1-\sigma_3)$ vs ε_s and W_T vs LSSV plots were used to determine yield stresses for sample T421.

Difficulties in determining yield stresses along steeply inclined stress paths were encountered by Lew (1981). The yield stresses of the samples tested in the present study for the investigation of low stress strengths were clearly defined, even for steeply-inclined stress paths. The yield stresses were considerably lower than the maximum shear stress $(\sigma_1-\sigma_3)$. This will be discussed in Chapter 5.

The drained strengths obtained from this section of testing are presented in Figures 3.14 and Figure 4.30.

4.4 UNDRAINED SHEAR TRIAXIAL TESTS

Undrained shear tests provided information on several further aspects of the soil's behaviour. They allowed the examination of stress-strain and porewater pressure generation characteristics of each sample. These include the porewater pressure parameter, A_f, the elastic modulus, E_{50}, and the strain-rate parameter, $\rho_{0.1}$. In addition, and perhaps most importantly, the failure stresses from the undrained tests in conjunction with the results from the drained stress-controlled tests permitted an evaluation of the shear strength of the blue clay (Baracos et al., 1980) at low consolidation pressures.

4.4.1 Stress-Strain Relationship

The stress-strain conditions for each sample prior to undrained shearing are summarized in Tables 5 and 6. Graphs of $(\sigma_1-\sigma_3)/2\sigma'_{1c}$, σ'_1/σ'_3 and $\Delta u/\sigma'_{1c}$ vs ε_1 are shown in Figure 4.19 to Figure 4.28. These stress strain curves appeared broken and stepped because of the relaxation and step-changing tests performed to investigate strain rate effects. These will be reviewed later. The effective stress paths in (p', q) stress space are shown in Figures 4.29, 4.1 and 4.2 for each test. The complete shear test results are summarized in Table 4.4.

Sample T402 was consolidated well past its yield state stresses prior to undrained shearing. Therefore the in-situ grain structure of the sample had been modified and some of the reserve resistance associated with overconsolidation had been destroyed. The stress-strain curve for sample T402 (Figure 4.19) indicates typical normally consolidated behaviour. No distinct sharp peak was observed from the $(\sigma_1-\sigma_3)/2\sigma'_{1c}$ plot, the deviator stress reached a maximum value at axial strain of 2.6 per cent and decreased gradually with increasing strain. The maximum principal stress ratio occured at an axial strain of 4.6 per cent. The $\Delta u/\sigma'_{1c}$ vs ε_1 plot showed that the porewater pressure increased fairly rapidly up to the maximum deviator stress and then flattened off becoming substantially constant at large strains. It should be noted that a mechanical problem with the compression machine was encountered after the first relaxation. The gears of the machine were running in the opposite direction such that the sample was extended instead of being compressed. The gears were readjusted at about 20 minutes after the machine was switched on. No major disturbance seems to have been caused to the stress-strain behaviour of the sample.

Stress-strain results for the undisturbed samples (T407, T408, T416) taken from 11.6 m depth are shown in Figures 4.19 to 4.22. The $(\sigma_1-\sigma_3)/2\sigma'_{1c}$ vs ε_1 plots indicated distinct sharp peaks and the value of $(\sigma_1-\sigma_3)/2\sigma'_{1c}$ increased with decreasing consolidation pressure. The $\Delta u/\sigma'_{1c}$ vs ε_1 plots showed that the porewater pressure rose rapidly to peak value and then dropped off with increasing strain. For samples consolidated to $2p'_o/3$ (T408) and $p'_o/3$ (T416), the porewater pressure decreased to negative values at large strains. For samples T408 and T416, the $\Delta u/\sigma'_{1c}$ value reached a maximum at a smaller strain than the σ'_1/σ'_3 ratio, followed by $(\sigma_1-\sigma_3)/2\sigma'_{1c}$ value. It should be noted that for sample T407, the $(\sigma_1-\sigma_3)/2\sigma'_{1c}$, σ'_1/σ'_3 and $\Delta u/\sigma'_{1c}$ values reached constant values at a very small axial strain (1.5 per cent).

The stress-strain behaviour of the 'fully-softened' samples (T409, T411, T413) during undrained shearing was very similar in a general sense to that of the undisturbed samples described earlier in this chapter. The results are shown in Table 4.4 and Figures 4.23 to 4.25. However the stress-strain behaviour of the 'freeze-thaw' samples were quite different from that of the 'undisturbed' and 'fully-softened' samples. The sharp peaks typical of the other test series were not observed from $(\sigma_1-\sigma_3)/2\sigma'_{1c}$, σ'_1/σ'_3, $\Delta u/\sigma'_{1c}$ vs ε_1 plots for any of the 'freeze-thaw' samples in Figures 4.26 to 4.28. These plots were very similar to that of sample T402 which was normally consolidated. However, one major difference between T402 and the 'freeze-thaw' samples was that the porewater pressure of the 'freeze-thaw' samples decreased during shear. The $\Delta u/\sigma'_{1c}$ vs ε_1 plots for the 'freeze-thaw' samples showed that $\Delta u/\sigma'_{1c}$ value decreased with increasing strain and became constant at large axial strain while the $\Delta u/\sigma'_{1c}$ value for T402 remained constant. Thus the 'freeze-thaw' samples exhibited some degree of overconsolidation. These results will be discussed in Chapter 5.

4.4.2 Effective Stress Paths

The effective stress paths plotted in terms of stress parameters, $(\sigma_1 - \sigma_3)$ and $(\sigma'_1 + 2\sigma'_3)/3$ for all undrained shear samples are shown in Figures 3.2 and 4.29; Figure 4.1; and Figure 4.2 for 'undisturbed', 'fully-softened' and 'freeze-thaw' samples respectively.

Sample T402 was consolidated with $\sigma'_{1c}/p'_c = 1.36$. The effective stress path was almost linear up to a large percentage of the maximum shear stress. After this point shear strains began to have a significant influence on the porewater pressures and the stress paths moved sharply to the left.

The influence of overconsolidation was clearly demonstrated by the effective stress paths of the CAU tests with $\sigma'_{1c}/P'_o \leq 1$ for the 'undisturbed' and 'fully-softened' samples. The initial sections of these stress paths were almost linear. The stress paths curved to the right before reaching the maximum shear stress because the porewater pressure began to decrease at that point. After reaching this peak stress, the samples tended to dilate on further straining. This is accompanied by a decrease in porewater pressure, and the shear stress dropped abruptly, drawing the effective stress paths vertically downward. Due to the smaller decreases in porewater pressure observed in the 'freeze-thaw' samples (Figure 4.2), the effective stress paths for these samples did not curve to the right as much as the 'undisturbed' (Figure 3.2) and 'fully-softened' samples (Figure 4.1). The effective stress paths for the undisturbed samples in the overconsolidated region were in close agreement with Lew's results (Figure 4.29).

The 'fully-softened' and 'freeze-thaw' strengths are presented in Figure 4.30. It should be pointed out that the yield envelope for 8.2 m depth proposed by Noonan (1980) did not extend into the overconsolidated region. However, the overconsolidated yield envelope is shown as dotted lines in Figure 4.30. This envelope was obtained by multiplying the coordinates of the revised normalized yield envelope (Figure 4.31) proposed by Graham et al. (1982b), by the value of p'_c equal to 380 kPa for samples taken from 8.2 m depth. This value of p'_c for the Winnipeg clay was based on the one-dimensional oedometer tests performed on samples taken from various depths at the same site. The variation of p'_c with depth has been shown in Figure 6.7 in Lew's thesis (1981). The results showed that the 'fully-softened' strengths were lower than the undisturbed strengths but higher than the 'freeze-thaw' strengths. The envelopes appeared to be curved and parallel to each other.

The drained and undrained strengths for the undisturbed, 'fully-softened' and 'freeze-thaw' samples are presented in Figures 4.32 and 4.33 respectively. They are also presented in the revised normalized stress space (Figure 4.31). The preconsolidation pressure (p'_c) of 241 kPa was used for samples taken from 11.4 m depth. This value was based on the one-dimensional oedometer tests performed by Lew (1981) for this particular series of samples (Graham et al., 1982b). The p'_c value of 400 kPa was used for samples taken from 8.7 m, based on Figure 6.7 in Lew's thesis.

It should be noted that the 'fully-softened' and 'freeze-thaw' procedures can be expected to affect not only the steep stress path strengths, but also the K_o-stress path strength and hence the value of p'_c. Therefore the normalized results for the 'fully-softened' and 'freeze-thaw' samples presented in Figure 4.31 may not be correct due to the changes in p'_c values. This will be further discussed in Chapter 5.

4.4.3 Porewater Pressure Generation

The relationships between $\Delta u/\sigma'_{1c}$ and ε_1 for the undrained shear samples are shown in Figures 4.19 to 4.28. For the overconsolidated 'undisturbed' and 'fully-softened' samples, the porewater pressures during undrained shear rose quickly to a maximum value before the maximum σ'_1/σ'_3 ratio and the maximum $(\sigma_1-\sigma_3)/2\sigma'_{1c}$ value were reached. Porewater pressures then dropped off quickly after the peak value was reached and approached a constant value at large strains.

For samples consolidated to $p_o'/3$ and $2p_o'/3$, the porewater pressures dropped off to negative values. Porewater pressure generation for the 'freeze-thaw' samples was similar to the 'undisturbed' and 'fully-softened' samples but the $\Delta u/\sigma_{1c}'$ vs ε_1 plots (Figures 4.26 to 4.28) for these samples were more rounded and the porewater pressure did not fall off to negative values.

The porewater pressure parameter $A = \Delta u/\Delta(\sigma_1 - \sigma_3)$ (Skempton, 1954), designated 'A_f' for failure conditions, is often used in practice. Values of A_f for the undrained tests are tabulated in Tables 4.4 and 4.5. The A_f values for overconsolidated 'undisturbed' samples ranged from 0.15 to 0.47. The range of A_f values for the 'fully-softened' samples was from 0.18 to 0.38. A_f values for the 'freeze-thaw' samples were quite constant, ranging from 0.52 to 0.56. The relationships of A_f plotted against $(1/\sigma_{1c}')$ (Baracos et al., 1980) and overconsolidation ratio (OCR) (Lew, 1981) are shown in Figure 4.34 and Figure 4.35 respectively. The A_f values for undisturbed samples decreased with increasing $1/\sigma_{1c}'$ value and OCR, the results were in good agreement with the results obtained by Baracos et al., 1980 and Lew, 1981.

A_f values for the 'fully-softened' and 'freeze-thaw' samples did not decrease with increasing $1/\sigma_{1c}'$ value and overconsolidation ratio. The results in Figure 4.35 indicate that the A_f values were low at low OCR, increased with increasing OCR; reaching a maximum at OCR of about 6 to 7 and dropped off with further increase of OCR. Figure 4.36

shows the A_f values vs the effective stress ratio $\sigma'_{3c}/\sigma'_{1c}$. The result for the normally consolidated sample (T402) used in the present study did not agree with Lew's values for normally consolidated samples (Lew, 1981). In the present study, A_f values for 'freeze-thaw' samples were the highest followed by the 'fully-softened' and 'undisturbed' samples. The value of the A_f parameter depended to a large extent on the stress history of the soil and particularly on the degree of overconsolidation. These results will be discussed further in Chapter 5.

Figures 4.37 to 4.42 show the normalized values of $\Delta u/\sigma'_{1c}$ vs $\Delta\sigma_{oct}/\sigma'_{1c}$ for all undrained strain-controlled tests. For 'undisturbed' samples consolidated to $2p'_o/3$ and p'_o (T407 and T408), the relationship was approximately linear up to a high percentage of the maximum stress (Figure 4.38). Thereafter the relationship became non-linear. The porewater pressure dropped off after $(\sigma_1-\sigma_3)_{max}$ value was reached. For the undisturbed sample consolidated to $p'_o/3$, the porewater pressure behaviour was similar to the 'fully-softened' samples (T409, T411, T413). The relationship for the initial stage was slightly curved and became distinctly non-linear thereafter. Porewater pressure dropped before the $(\sigma_1-\sigma_3)_{max}$ value was reached. The porewater pressure dropped to negative values for both the 'undisturbed' and 'fully-softened' samples consolidated to less than p'_o.

The initial porewater pressure response was linear for the 'freeze-thaw' samples. In each case, the porewater pressures decreased with decreasing σ_{oct} after the maximum deviator stress $(\sigma_1-\sigma_3)$. In the post-peak range for samples T420, T422, the ratio $\Delta u/\Delta \sigma_{oct}$ was lower than in the pre-peak range. This contrasts with the more usual behaviour shown for example in Figs. 4.38-4.40 for the "undisturbed" and "fully-softened" samples.

The slope of the linear relationship for the normally consolidated sample (T402) was greater than those obtained from the overconsolidated samples. However, for both the overconsolidated and normally consolidated cases, the initial response in porewater pressure change (Δu) was greater than the changes in total octahedral normal stress. Once the structure of the clay began to respond nonlinearly, however, the behaviour was very different in the two cases. Overconsolidated samples produced strongly decreasing porewater pressures, whereas normally consolidated samples gave increasing porewater pressures. The gradients of the linear section, m, are summarized in Table 4.4 and comparison of A_f and m values for overconsolidated 'undisturbed', 'fully-softened' and 'freeze-thaw' samples are shown in Table 4.5.

4.4.4 'E_{50}' Parameter

The non-linearity of the $(\sigma_1-\sigma_3)$ vs ε_1 curves from triaxial compression tests has been approximated by a secant modulus E_{50} from the end of consolidation to 50 per cent of the reserve resistance (Graham, 1974). Values of E_{50} have been normalized by dividing by the undrained strength $s_u = (\sigma_1-\sigma_3)/2_{max}$ to give what is known as the relative stiffness,

E_{50}/s_u. Table 4.4 summarizes all values of E_{50} and E_{50}/s_u. The results varied considerably with test type, and showed significant scatter. Figure 4.43 shows a plot of relative stiffness versus overconsolidation ratio (OCR) for the undrained tests. No clear relationship was observed. However, for the same overconsolidation ratio, the 'freeze-thaw' sample had the highest value of relative stiffness, followed by the 'fully-softened' and 'undisturbed' samples.

4.4.5 Strain Rate Effect

In the present study, the strain-rate effect was examined by using two procedures, namely, the step-changing procedure (Richardson and Whitman, 1963) and 'relaxation' procedure (Kenney, 1966). These procedures were described earlier in Chapter 2. The strain-rate effect can be represented by a parameter $\rho_{0.1}$, which describes the percentage change in shearing resistance produced by a tenfold change in strain rate, referred to the shearing resistance at a strain rate of 0.1 per cent/hour.

In this testing program, relaxation and step-changing procedures were performed on all the undrained shear tests. Relaxation tests were also performed at large axial strains on some of the samples to examine the dependency of strain rate effects on the magnitude of strain (Figures 4.19 to 4.28).

The normalized average undrained strength $(\sigma_1-\sigma_3)/2\sigma'_{1c}$ versus the axial strain rate from relaxation tests performed just after the sample had failed is shown in Figure 4.44. The $\rho_{0.1}$ values obtained from these tests are also tabulated in Table 4.4. Tables 4.6 and 4.7 show the $\rho_{0.1}$ values obtained from relaxation tests and step-changing tests respectively at various axial strains. The results showed that $\rho_{0.1}$ values obtained from relaxation tests were lower than those obtained from step-changing tests. The $\rho_{0.1}$ values obtained from both tests ranged from 6 to 10 per cent for all the 'undisturbed', 'fully-softened' and 'freeze-thaw' samples. In general, the $\rho_{0.1}$ values decreased with increasing axial strain. This confirms earlier work by Lew (1981), and Graham, Crooks and Bell (1982).

4.4.6 Undrained Strength at Large Strains

The use of the USALS method for slope stability analysis had been described by LaRochelle et al. (1974). Preliminary work on the Winnipeg clay has been reported by Lew (1981).

USALS obtained from the present study for the 'undisturbed', 'fully-softened' and 'freeze-thaw' samples are tabulated in Table 4.8. These results are also presented in Figures 4.31 to 4.33. The USALS values lie very close to the normally consolidated Coulomb Mohr Envelope. This will be discussed in more detail in Chapter 5.

CHAPTER 5

DISCUSSION OF RESULTS

5.1 INTRODUCTION

The main purposes for the present research were:

1. To examine the influence of time and rate effects on the yield behaviour of Winnipeg clay.
2. To investigate the low stress strengths of Winnipeg clay by means of 'undisturbed', 'fully-softened' and 'freeze-thaw' samples.

In the present study, the effect of time and strain rate effects on the yield envelope and preconsolidation pressure p_c' for Winnipeg clays taken from 11.6 m depth were studied. These had not been confirmed by previous researchers (Baracos et al., 1980; Noonan, 1980; Lew, 1981). Because of the low sensitivity of the Winnipeg clays, the extension of the time dependent aspects of the YLIGHT concept to include these clays is a significant step towards verifying the stress-strain (time) behaviour for all natural clays. (The YLIGHT concept was developed from tests on highly sensitive Champlain Sea clay).

Strengths at low stresses are thought to control the field behaviour in many small embankment, riverbank and excavation problems in the Winnipeg area (Baracos et al., 1980). However, the low stress strength of Winnipeg clay is still not fully understood. Low stress strengths for Winnipeg clay were investigated in the present study using undisturbed samples taken from 11.4 m depth, 'fully-softened' and 'freeze-thaw' samples taken from 8.7 m. Preparations for the 'fully-softened' and 'freeze-thaw' samples has been described in Chapter 2. Undrained strength at large strains (USALS) (La Rochelle et al., 1974) and their relationship with the normalized consolidated strength (Rivard and Lu, 1978) were examined. The influence of strain rate effects on the undrained strengths were also studied.

Results for the study of time and rate effects and low stress strengths obtained from the present study will be compared with those of the previous studies (Baracos et al., 1980; Noonan, 1980; Lew, 1981). In addition, some of the results for time and rate effects study are examined with reference to the YLIGHT model (Tavenas and Leroueil, 1977). Undrained shear results for the study of low stress strength are studied with reference to the USALS concept (LaRochelle et al., 1974). Furthermore, USALS obtained for the present study are compared with the normally consolidated strengths proposed by Baracos et al. (1980).

This chapter is further subdivided into sections 5-A and 5-B. Section 5-A emphasizes results for time and rate effects while section 5-B concentrates on the low stress strength results.

5-A TIME AND STRAIN RATE EFFECTS ON THE YIELD BEHAVIOUR OF WINNIPEG CLAY

5-A.1 Time Effects on Yield Stresses

As described in section 3.2.1, six consolidated drained triaxial tests on samples T401 to T406 were used to investigate the shrinkage or degeneration of the yield envelope with time. The stress paths used for this study were also described in section 3.2.1.

Due to the difficulties encountered for the interpretation of yield stresses along steeply inclined stress paths (Lew, 1981), the 'sensitivity' of these tests at around yield stress level was improved in the present study. This was done by inserting intermediate stress points before and after the expected yield stress level (Figure 3.1) to improve yield interpretations. The load increments for these intermediate stress points were reduced to half of the original value. However, in order to maintain a rather constant strain rate, Dr. J. Graham suggested that the load duration had to be reduced also by half of the original value, that is, from 24 hours to 12 hours. Standard 24 hour load duration tests had been adopted by previous researchers (for example, Graham (1974) and Tavenas et al. (1978)) to define yield envelopes. The assumption inherent in their work was that for small load increment ratio, the majority of the strains occuring in the first 24 hours were due to creep (not consolidation) and that the majority of the movements occurred during this period. Therefore, by further reducing the load increment ratio for the intermediate stress points the relative importance of primary consolidation was greatly diminished and the observed behaviour was essentially representative of creep (Leonards and Girault, 1961; Wahls, 1962; Tavenas et al., 1978). Therefore the strains occuring during the 12 hour load duration for the intermediate stress points should also be due to creep. A major portion of the strains should be completed within the 12 hour period. Strains at the end of the 24 hour load period for a particular load increment would be the same for samples loaded with or without the insertion of the intermediate stress point. The method of reducing both the load duration and load increment by half of the original values was therefore adopted in the present study. This hypothesis deserves further detailed study in carefully controlled tests.

The determination of yield stresses for samples T401 to T406 has been presented earlier in Chapter 3. It was pointed out in Chapter 3 that the interpretation for yield stresses along steeply inclined stress paths (T405 and T406) was quite difficult. The same problem was encountered by Lew (1981) who demonstrated that by examining the strain rates in the last two stress increments before rupture, namely the 5th and 6th stress increment in his Test T312, he was able to detect that the sample had in fact begun to yield at low strain rates during the 5th increment, and that the extra shearing resistance shown in the 6th increment simply reflected the influence of the strain rate parameter, $\rho_{0.1}$.

The same approach was employed by the author on test results for Tests T405 and T406 in the present study. Unfortunately in this case, the technique was not useful for determining the yield conditions. Irregular strain rate patterns were observed, and the method was not investigated further.

Noonan (1980) pointed out that in the overconsolidated region, limit state and rupture coincide. In the overconsolidated region, samples first reach a maximum deviator stress, which is a function of the in-situ grain structure of the soil, and which occurs at small strains. The maximum deviator stress, $(\sigma_1-\sigma_3)/2_{max}$, represents the structural strength of the soil's grain skeleton and is therefore a part of the 'yield' or 'limit state' surface. The stress level at rupture is therefore interpreted as yield stresses for the steeply inclined stress paths in the overconsolidated region. These included Tests T405, T406, T410, T412, T414, T415, T417, T419, T421. Moreover, Bjerrum and Kenney (1967) state that the maximum shear strength rupture criterion for undrained shear is associated with the quasi-static yielding of the grain structure of a soil at small strains; whereas the maximum stress ratio rupture criterion for undrained shear represents the dynamic yielding of the clay structure at large strains once a statically constant condition of sliding friction between soil particles has been obtained (Graham, 1974). Consequently, in undrained shear the maximum shear stress reached at small strains by an overconsolidated sample is a function of its particle structure and represents a limit state condition. This has been used to define the yield envelopes shown in Figures 4.32 and 4.33. However, quasi-yield stress conditions at somewhat lower stresses were identified in the drained compression tests used for the investigation of low stress strengths (T410, T412, T414, T415, T417, T419, T421). This will be discussed later in section 5-B.

Yield stresses for samples T401 to T406 are shown in Figure 3.14. Results for samples T401 to T402 confirm with the observation in the YLIGHT model (Tavenas and Leroueil, 1977) that the yield stresses decrease with increasing load duration. Yield stresses for sample T401 are larger than those of sample T402 while its load duration is shorter. However, results for samples T403 to T406 are in contradiction with the time aspects of the YLIGHT model. The yield stresses from these tests are higher with longer load durations. The cause for this is still not clear following discussions with all members of the soil mechanics staff of the Civil Engineering Department, University of Manitoba. Dr. J. Graham has suggested that this set of results for samples T403 to T406 simply reflects the sample variability which is encountered in natural clays, and that no firm conclusions can be drawn because of the limited number of tests performed in the present study. The author recommends further testing of this type in the future, especially in the overconsolidated region, to investigate the shrinkage or degeneration of the yield envelope with time.

Figure 3.14 also shows the yield envelope proposed by Lew (1981) and the revised yield envelope by Graham (1982). Description along with the reason for the revision of Lew's envelope has been given in Chapter 1. The shape of the revised yield envelope is changed at the righthand side and it goes to higher value of σ'_{oct}. The yield stresses for sample T401 tested in the present study is in better agreement with the revised envelope. The average moisture content for samples taken from 11.6 m for the present study was 57.8 per cent and this value corresponds well with samples T315 to T319 tested by Lew (1981). Therefore p'_c value of 241 kPa determined by Lew (1981) was also used in the current study to normalize the test results. The normalized test results (T401 to T406) along with the normalized yield envelope proposed by Graham (1982) are shown in Figure 5.1. The results are in general agreement with the normalized yield envelope.

5-A.2 Influence of Time and Strain Rate Effects on the Preconsolidation Pressure p'_c

5-A.2.1 Non-Standard Oedometer Tests

Results from the six non-standard oedometer tests (C401 to C406) indicate that the preconsolidation pressure p'_c for Winnipeg clay decreases with increasing load duration. This confirms with the findings by previous researchers (Crawford, 1964; Bjerrum, 1967; Tavenas and Leroueil, 1977) and supports the suggestion in the previous paragraphs that non-systematic variability has affected the results of T401 to T406. The preconsolidation pressures are reduced from 243 to 225 kPa as the duration of the load application increases from 1.0 to 100 days, thus confirming the significant influence of time on p_c'. The p_c' values were interpreted using bilinear fitting of the observed stress-strain results. This was discussed earlier in Chapter 3.

The consolidation-time curves are shown in Figures 3.17 and 3.18. Except for sample C406, the 'S' shape curves predicted by Terzaghi consolidation theory were generally observed. Because the stress level on sample C406 is small, the majority of the strain occured for this sample is due to creep (Leonards and Girault, 1961), and the 'S' shape curve predicted by Terzaghi consolidation theory is not observed. It is interesting to observe that for samples loaded to stress levels higher than p_c' (C401 to C403), the consolidation time curves gradually become more and more parallel with the passage of time. This means that with time, the rates of secondary compression are becoming equal. Also this finding could imply that for stress levels higher than p_c', the rate of secondary compression is independent of the effective stress provided sufficient time has elapsed for the original loading conditions to disappear. Figures 3.17 and 3.18 show that the effect of the reserve resistance of the plastic clay on deformations is most pronounced during the initial period after the samples are loaded. The effect gradually disappears with time. Bjerrum (1967) observed similar behaviour for the sensitive Norwegian clay by monitoring settlements for five buildings in the Drammen area. He suggested that this is due to the diminishing reserve resistance of the clay with time.

Graphs of c_v, C_α/C_c, C_c, C_α* and ε_{VR} vs $\log\sigma'_v$ for load durations of 24 hours are shown in Figure 3.19. The value of c_v peaked just before p'_c (250 kPa) and dropped until a vertical pressure of about 378 kPa was reached. C_α increased sharply just after p'_c and peaked at stress level of 378 kPa. These results indicate that for a stress levels before p'_c, the deformation is mainly due to elastic compression, with a small creep component, whereas after p'_c, primary and secondary compressions become important. The porewater pressure dissipation rate increases gradually with increasing stress level until just before p'_c is reached, drops off quite sharply thereafter, and becomes essentially constant at stress levels higher than p'_c.

The $\log\sigma'_v$ vs ε_{VR} curves for 1 day, 10 day and 100 day load durations are shown in Figure 3.16. The instantaneous slopes for these curves when multiplied by the original specific volumes $(1+e_o)$, become the compression index values C_c. The slopes for these curves are quite parallel to each other in the stress range greater than p'_c. However,

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*C_α is here calculated in terms of changes in voids ratio. Note that in tests of 24 -hour load duration on these samples, the rate of secondary consolidation in log(time) is not fully established. The values of C_α in Fig. 3.19 have been calculated from the measured slope of the log(time) relationship at the end of the load increment, that is at 24 hour duration.

in the stress range smaller than p'_c, the slopes become steeper with time. This indicates that regardless of load increment duration and load increment ratio, C_c is approximately constant for any given stress level in the normally consolidated range, and increases with load duration in the reload range.

C_α/C_c values peaked just after p'_c for the 24 hour period and become rather constant with time (Figures 3.19 and 3.20). However, although C_α/C_c becomes constant in the reload and normal consolidation ranges of stresses, it is higher at stresses close to p'_c (Figure 3.20). Mesri and Godlewski (1977) concluded that during secondary compression of natural soils, there is a unique relationship between C_α and C_c for any given time, effective stress and void ratio. For a wide variety of clays, they found that C_α/C_c lies in a relatively narrow range between 0.03 and 0.09. They used the procedure of obtaining the C_c values from the slope of the e-logσ'_v curve corresponding to the end of primary consolidation and, C_α- values from the "linear slope" of the e-log t curve beyond the transition from primary to secondary compression. The "end of primary" consolidation C_α/C_c values for the present test series were calculated and are presented in Table 3.7. These values are rather low compared to the values proposed by Mesri and Godlewski (1977). Further research into this extensive topic is outside the scope of this thesis.

The strain rate parameter $\eta_{0.1}$ defining the relationship between p'_c and strain rate was described in Chapter 3.

The $\eta_{0.1}$ value for this study is 3.6 per cent. This is considerably lower than the normal range of $\eta_{0.1}$ (10 to 20 per cent) proposed by Graham et al. (1982b).

5-A.2.2 Strain-Controlled Oedometer Tests

The present pilot series of strain-controlled oedometer tests was designed only as a trial run to examine their applicability for defining p'_c and the influence of strain-rate effects on p'_c. Stress-strain relationship for the four strain-rate controlled oedometer tests are shown as ε_{VR} vs σ'_v and ε_{VR} vs $\log\sigma'_v$ plots in Figures 3.21 and 3.22 respectively. Slope discontinuities such as those reported by Sallfors (1975) and Vaid et al. (1979) could be observed from the arithmetic plot in Fig. 3.21, and p'_c values could be identified with some certainty. These p'_c values are unusually high when compared to the results obtained from standard oedometer tests (Lew, 1981). These higher values might because these tests were not performed under back pressure. Thus the samples were probably not fully saturated and the measured porewater pressure lower than the values inside the samples. This leads to high estimates of effective stress and high p'_c-values. However, the results obtained from the present series do indicate that p'_c is time dependent. Higher values of p'_c are obtained for higher strain rates (see Figures 3.21 and 3.22). The values of $\eta_{0.1}$ calculated from this series of tests is about 37 per cent which is obviously excessive if taken in isolation.

The author suggests that all further strain-rate controlled oedometer tests performed at the University of Manitoba should be run under a back pressure of approximately 200 kPa in order to ensure complete saturation and freedom from compliance effects in porewater pressure measurements. This means that new equipments should be used which will enable the back pressure to be applied. The strain rate effect on the undrained strengths along with the low stress strength results will be discussed in the next section 5-B.

5-B RESULTS FOR THE LOW STRESS STRENGTH INVESTIGATION

5-B.1 Triaxial Consolidation

These samples were reconsolidated anisotropically to $p'_o/3$, $2p'_o/3$ and p'_o with $\sigma'_{3c}/\sigma'_{1c}$ equal to 0.65.

Specific volume (V) versus σ'_{oct} curves for the 'undisturbed', 'fully-softened' and 'freeze-thaw' samples during reconsolidation are shown in Figure 5.2*. For comparison purpose, the reconsolidation results obtained by Noonan (1980) for 'undisturbed' samples taken from 8.2 m were recalculated and included. These results are also tabulated in Tables 5.1 and 5.2. The results showed that the 'undisturbed' samples swelled during the first load increment and were then compressed linearly to a smaller specific volume. The curves obtained for different samples were quite parallel to each other. The V versus σ'_{oct} plots for the 'fully-softened'

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*Fig. 5.2 shows the "undisturbed" and "fully-softened" tests starting at about the same specific volume V. Note that these two series came from slightly different depths, and had different initial moisture contents. The initial V for the 8.7 m samples is shown in Fig. 5.2.

and 'freeze-thaw' samples were rather non-linear with greater curvature for the 'freeze-thaw' samples. Figure 5.3 shows the V versus $\log\sigma'_{oct}$ for these results. The straight lines for the 'undisturbed' samples became non-linear in this figure. Also the non-linear curves for the 'fully-softened' and 'freeze-thaw' samples became bi-linear and linear straight lines respectively in this figure. The reconsolidation curve for 'undisturbed' samples taken from 11.6 m is the average of all the samples taken from this depth and is shown as a dotted line. The results indicate that the compressibility is largest for the 'freeze-thaw' samples, followed by the 'fully-softened' and 'undisturbed' samples since the slope of the reconsolidation curves for the 'freeze-thaw' samples is the steepest. This implies that sample disturbance caused by the 'freeze-thaw' procedure is greater than that of the 'fully-softened' procedure. It is interesting to observe that the 'fully-softened' samples appear to be stiffer at the beginning of loading until an average σ'_{oct} of 23 kPa is reached.

5-B.2 Drained Stress Controlled Triaxial Tests

The maximum $(\sigma_1-\sigma_3)$ values and the yield stresses for the 'undisturbed', 'fully-softened' and 'freeze-thaw' samples are shown in Figures 3.14 and 4.31 respectively. It has been discussed earlier in section 5-A that the maximum $(\sigma_1-\sigma_3)$ values are used as yield stresses for tests in the overconsolidated region. The difficulties of observing yield stresses for the steep stress paths in this region have also been discussed. However, early yield stresses were clearly identified for drained compression tests (T410, T412, T414, T415, T417, T419, T421). Yield determinations for these tests are shown in Figures 4.3 to 4.18. These results suggest that the sample exhibit an initial stiff behaviour, followed by a less stiff range before rupture. There is a threshold stress level before rupture for each stress path beyond which the sample will become rather compressible. This has a rather important implication in predicting stress-strain behaviour in the field. The early yield stresses for the 'undisturbed', 'fully-softened' and 'freeze-thaw' samples (Figures 3.14 and 4.31) are lower than the $(\sigma_1 - \sigma_3)_{max}$ values but higher than the normally consolidated Coulomb Mohr strengths. Also the early yield stresses for the 'fully-softened' samples are higher than the 'freeze-thaw' samples.

The early yield behaviour is yet to be understood. The author suggests that further research into this topic is required in order to fully understand the stress-strain behaviour of the Winnipeg clay in the overconsolidated region.

5-B.3 Low Stress Strengths

Low stress strengths obtained from the drained and undrained triaxial tests for samples taken from 11.6 m and 8.7 m depths are shown in Figures 4.30 and 4.32 respectively. The 'undisturbed' strengths and the 'fully-softened' strengths are close to the low stress envelope proposed by Baracos et al. (1980) up to about σ'_{oct} equal 60 kPa. Figure 4.32 shows that the 'fully-softened' and 'freeze-thaw' strength envelopes seem to be curved and parallel with the undisturbed yield envelope. For drained tests consolidated to $p'_o/3$ with stress path running in the decreasing σ'_{oct} direction (T417 and T419), the samples failed just before the no tension line.

To minimize stress history variability, these results are also shown in the normalized stress space (q/p'_c, p'/p'_c) in Figure 4.33. It can be observed that the undisturbed strengths are in general higher than the 'fully-softened' strengths, followed by the 'freeze-thaw' strengths. These strength envelopes are curved and parallel to each other. Therefore the low stress envelope proposed by Baracos et al. (1980) should probably be curved rather than a straight line.

The p'_c values used for the normalization of the 'fully-softened' and 'freeze-thaw' samples may not be justified. Since the 'fully-softened' and 'freeze-thaw' procedures modified the strength for the steeply inclined stress paths, therefore the strength along the K_o-line should be changed and hence the value of p'_c. The p'_c values would be the lowest for the 'freeze-thaw' samples, followed by the 'fully-softened' samples. The lower values of p'_c for these samples when used for normalization may raise their low stress strength envelopes back up to the 'undisturbed' envelope. This consideration only developed in the final stages of preparation of this thesis, and no testing on this point was possible.

5-B.4 Undrained Shearing Behaviour

5-B.4.1 Stress-Strain Behaviour

Stress-strain results for the undrained shearing tests have been presented in section 4.4.1. It was shown in that section that sample T402 (Figure 4.19) had a typically normally consolidated behaviour, whereas the 'undisturbed' samples (T407, T408, T416) (Figures 4.20 to 4.22) and 'fully-softened' samples (T409, T411, T413) (Figures 4.23 to 4.25) behaved in a typical overconsolidated fashion. In all these tests, the samples' stress-strain behaviour was brittle or strain-softening. The deviator stress and porewater pressure reached a peak at relatively low strains, after which they both fell off abruptly to a lower value. The degree of overconsolidation was also reflected by the decrease in the porewater pressure. The porewater pressure dropped off to a lower value for samples having higher overconsolidation ratio, that is, for samples consolidated to a lower stress level. It should be noted that for samples consolidated to the same stress level, the porewater pressure for the 'undisturbed' samples dropped off to a lower value than the 'fully-softened' samples. This could imply that the structure of the 'fully-softened' samples had been modified, and thus they behaved in a less overconsolidated fashion.

Section 4.4.1 also pointed out that the behaviour of the 'freeze-thaw' samples was intermediate between normally consolidated and overconsolidated behaviour. The

$(\sigma_1-\sigma_3)/2\sigma'_{1c}$, σ'_1/σ'_3 vs ε_1 plots (Figures 4.26 to 4.28) showed normally consolidated behaviour while the $\Delta u/\sigma'_{1c}$ vs ε_1 plot showed overconsolidated behaviour. This suggests that disturbance cause structural changes in the clay, creating a 'young' structure. However, some reserve resistance still exists in the clay perhaps due to remnants of cementation, and this is reflected in overconsolidated porewater pressure behaviour. The structural modification of the 'freeze-thaw' samples is greater than the 'fully-softened' samples, as indicated by the reconsolidation and the stress-strain behaviour. Figures 5.3 and 5.4 show the structure of the 'fully-softened' and 'freeze-thaw' samples after failure. A nuggety structure was generally observed for the 'freeze-thaw' samples. However, higher consolidation pressures tended to close the nuggets. Typical 'fully-softened' and 'freeze-thaw' samples after failure are shown in Figures 5.5 and 5.6. It should be noted that the failure plane was rather clearly defined for both the 'fully-softened' and 'freeze-thaw' samples.

5-B.5 'A_f' Parameter

Skempton's (1954) parameter 'A' is one of the most widely used porewater pressure parameters, and is known to be considerably affected by stress history. Henkel (1956) showed that the A-value at failure (A_f), is highly dependent on the overconsolidation ratio in general. Figure 4.35 shows the variation of A_f with overconsolidation ratio for the

Winnipeg clays. Also included in this figure are results obtained by Henkel (1956) and Crooks (1973) for remoulded Weald clay, and Belfast estuarine clay at the Kinnegar and Holywood sites respectively. The variation of A_f with OCR for the 'undisturbed' samples from the present study follows the expected pattern, that is the value of A_f decreases with increasing degree of overconsolidation. However, A_f values for the 'fully-softened' and 'freeze-thaw' samples do not follow the general trend. Their behaviour has been described earlier in section 4.4.3. These results indicate that maximum A_f values occured at OCR of about 6 to 7. The A_f values for 'freeze-thaw' samples were the highest followed by the 'fully-softened' and 'undisturbed' samples. Therefore greater sample disturbance would be expected to create higher A_f values and the sample would tend to behave towards the normally consolidated fashion. This has also been shown earlier for the stress-strain behaviour in section 5-B.4. Moreover, the A_f values for the 'freeze-thaw' samples are rather constant which could imply that for highly disturbed samples the A_f values would be constant and independent of OCR. This is in contradiction with Henkel's results (1956). Further research using remoulded samples is required to investigate this point. Finally, the p_c' values for the 'fully-softened' and 'freeze-thaw' samples may not be correct as discussed earlier in section 5-B.3. Lower values of p_c' would reduce the OCR for these samples. The A_f values may then be in better agreement with the undisturbed samples.

5-B.6 Strain Rate Effects

Results for strain rate effects have been presented earlier in section 4.4.5. The $\rho_{0.1}$ values obtained from relaxation tests (range from 5.9 to 10.1 per cent) for the present study are lower than those obtained by Lew (1981) who measured $\rho_{0.1}$ values ranging from 11 to 12.2 per cent. In comparing his results with earlier values by Noonan (1980), Lew pointed out that the relaxation tests for his study were performed at axial strains closer to the failure strains (that is, ε_1 at $(\sigma_1 - \sigma_3)_{max}$), and therefore show higher strain-rate effects. The samples are markedly strain softening. Perhaps for this reason, the $\rho_{0.1}$ values determined by the relaxation tests and step-changing tests in the present study are not equal. The $\rho_{0.1}$ values from relaxation tests are consistently lower than those from the step-changing tests.

The average $\rho_{0.1}$ value determined at large strains (ε_1 = 12 per cent) using step-changing techniques is about 6 per cent. Strain rate effects become therefore less significant with increasing axial strain.

Previous work summarized by Graham (1979) has suggested that the $\rho_{0.1}$ parameter is related to the plasticity index of a clay. The value of $\rho_{0.1}$ versus plasticity index for these tests have been plotted along with other data from Graham (1979) and is shown in Figure 5.8. This data suggests that no simple relationship exists between $\rho_{0.1}$ and I_p.

5-B.7 USALS

LaRochelle et al. (1974) showed that the USALS (undrained strength at large strains) approach offered some potential as a means of analyzing the stability of embankments on soft sensitive clay foundations. USALS obtained from the present study for the 'undisturbed', 'fully-softened' and 'freeze-thaw' samples are tabulated in Table 4.8. These results are also presented in Figures 4.31 to 4.33. The USALS values are very close to the normally consolidated Coulomb Mohr envelope (Critical State line) for all the 'undisturbed', 'fully-softened' and 'freeze-thaw' samples.

Since USALS is recognized as resulting from the sliding friction between particles, it should therefore be expected to be independent of sample disturbance. Lefebvre (1980) demonstrated this point by performing the same test on intact and pre-cut samples. The shear resistance on the pre-cut plane was gradually mobilized as axial deformation occured, and at large deformation became more or less equal to the post-peak strength. USALS obtained from the present study agrees with this concept.

Rivard and Lu (1978) studied the case histories of failure of water-retaining structures on highly plastic clays. Using the normally consolidated strength as suggested by Skempton and Hutchinson (1969), they obtained a more reliable prediction of the in-situ stability condition. They further suggested that for highly plastic clay soils with structural discontinuities, slopes and embankments should be designed using the normally consolidated strength, rather than the intact strength of the clay. Their study also includes natural slopes in Lake Agassiz clay. It is interesting to observe that the USALS obtained for the present study are very close to the normally consolidated strength. These results suggest that the USALS method proposed by LaRochelle (1974) could be valuable for prediction of slope stability of the weathered Lake Agassiz clay, as implied by Rivard and Lu (1978).

The $(\sigma_1 - \sigma_3)_{max}$ and USALS for the 'undisturbed', 'fully-softened' and 'freeze-thaw' samples are also plotted in Figure 5.3. It should be noted that the 'Isotropic Normally Consolidated Line', 'One-Dimensional Normally Consolidation Line' and the 'Critical State Line (CSL) are proposed by Graham, Noonan and Lew (1982b) based on previous results obtained for the Winnipeg clay. The USALS obtained for the 'undisturbed' samples are close to the CSL. For samples failing on the left hand side of the CSL, σ'_{oct} values move to the right from the $(\sigma_1 - \sigma_3)_{max}$ position towards the CSL until they reach USALS. For samples failing on the right hand side of the CSL, σ'_{oct} moves from the $(\sigma_1 - \sigma_3)_{max}$ position to the left towards CSL. This agrees with the critical state soil mechanics concept (Atkinson and Bransby, 1978). The USALS values lie close to the CSL in the stress space shown in Figures 4.32 and 4.33, but lie below it in the specific volume, $\log(\sigma'_{oct})$ space in Figure 5.3. This has also been observed in tests on remoulded overconsolidated clays, and is due to the non-uniformity of straining that occurs when failure planes develop in overconsolidated samples. Stresses on these planes can be measured. Only average strains or specific volume changes can be measured over the sample as a whole. Differences in σ'_{oct} values between $(\sigma_1 - \sigma_3)_{max}$ and USALS conditions decrease from 'undisturbed' to 'fully-softened' samples, followed by 'freeze-thaw' samples. In fact, σ'_{oct} values for $(\sigma_1 - \sigma_3)_{max}$ and USALS conditions are almost the same for the 'freeze-thaw' samples.

Conclusions and suggestion for further research will be presented in the next chapter.

CHAPTER 6

CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

6.1 CONCLUSIONS

1. The influence of time effects on the preconsolidation pressure (p_c') were examined by means of non-standard oedometer tests like those performed by Tavenas et al. (1977). The results show that the preconsolidation pressure (p_c') decreases with increasing load duration. This confirms the findings by previous researchers (Bjerrum, 1967; Tavenas and Leroueil, 1977).
2. Strain rate parameter $\eta_{0.1}$ defining the relationship between p_c' and strain rate was found to be 3.6 per cent. This is considerably lower than the normal range of $\eta_{0.1}$ (10 to 20 per cent) proposed by Graham et al. (1982).
3. Strain-controlled oedometer tests also indicate that p_c' is strain-rate dependent. Higher values of p_c' are obtained for higher strain rates.
4. Disturbance caused by subjecting the samples to 'freeze-thaw' procedures is greater than that caused by 'fully-softened' procedures.
5. The low stress strength envelope at 36 kPa $\leq \sigma_{1c}' \leq$ 117 kPa is curved rather than straight and rather lower than the envelope proposed by

Baracos et al. (1980).

6. The low stress strengths for the undisturbed samples are higher than those measured from samples after 'fully-softened' and 'freeze-thaw' procedures. The low stress strength envelopes for these samples are parallel to each other.
7. Undrained Strength at Large Strains (USALS) (LaRochelle et al., 1974) for the 'undisturbed', 'fully-softened' and 'freeze-thaw' samples are very close to the normally consolidated Coulomb-Mohr parameters, c' and ϕ' = 4 kPa and 17.5^{o} respectively.

6.2 SUGGESTIONS FOR FURTHER RESEARCH

1. The time-dependent aspects of the YLIGHT model on yielding has been investigated in this study, using drained stress-controlled triaxial tests. No firm conclusions can be drawn from the limited number of tests performed in the present study. The author recommends further testing of this type to confirm the shrinkage or degeneration of the yield envelope with time.
2. In the present study, the method of inserting intermediate stress points which involves reducing both the load duration and load increment by half of the original values, was used

to increase the sensitivity of the tests around the expected yield stress level. This method deserves further study. An investigation could be conducted with samples stressed along the same stress path. In one test, the sample could be stressed in five increments with one-day load duration to a certain stress level; whereas in the second test, both the load increment and load duration are reduced to half of the original values to reach the same stress level.

3. Further strain-rate controlled oedometer tests should be performed on the Winnipeg clay. These tests should be run under a back pressure of approximately 200 kPa in order to ensure complete saturation and freedom from compliance effects in the porewater pressure measurements.
4. Standard one-dimensional oedometer tests should be performed on 'fully-softened' and 'freeze-thaw' samples to further confirm the p'_c values for these samples. Thus the normalized yield stresses and the overconsolidation ratio for these samples can be made more meaningful.
5. Strain-rate effects on the undrained shear strengths and p'_c require further study. The strain-rate parameters ($\rho_{0.1}$ and $\eta_{0.1}$) values obtained at the same axial strain using the

relaxation and step-changing techniques should be carefully compared.

6. Early 'quasi-yield' behaviour was observed for drained stress-controlled tests in the overconsolidated region. Further research into this area is required to understand better the stress-strain behaviour of Winnipeg clay in the overconsolidated region. Also interpretation of yield stresses in the overconsolidated region requires further examination.
7. Further attention should be paid to the anisotropy and elasticity of the soil before yield. Further work should be done to examine the Bulk Modulus K and Shear Modulus G of the clay.
8. Work using remoulded Winnipeg clay samples is required to develop the classical Critical State Soil Mechanics parameters for this clay, and to allow comparisons with the modified Cam-clay model.

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TABLE 2.1 BASIC SOIL PROPERTIES

Test No.	T401	T402	T403	T404	T405	T406	T407	T408	T409	T410	T411
State	Undisturbed								'Fully-Softened'		
Test Type	CAD(U)	CAD(U)	CAD	CAD	CAD	CAD	CAU	CAU	CAU	CAD	CAU
Borehole No.	6	6	6	6	6	6	6	6	6	6	6
Block Sample No.	3	3	4	4	4	3	3	1	1	1	1
Depth (m)	11.6	11.6	11.6	11.6	11.6	11.4	11.4	11.4	8.7	8.7	8.7
Initial Moisture Content (%)	55.1	55.9	56.5	57.8	59.3	57.5	59.7	58.1	50.2	51.3	51.4
Final Moisture Content (%)	45.8	50.9	61.1	53.6	58.4	61.8	63.0	60.8	53.8	63.1	52.6
Liquid Limit (%)	72.2	80.4	74.8	80.2	74.5	76.8	81.4	77.8	70.0	72.0	69.2
Plastic Limit (%)	26.9	29.2	25.2	27.6	26.3	24.4	28.4	26.5	25.6	26.3	26.9
Plasticity Index (%)	45.3	51.2	49.6	52.6	48.2	52.4	53.0	51.3	44.4	45.7	42.3
Clay Content (%)	66.5	66.0	65.0	66.0	67.0	66.0	71.0	68.5	63.5	61.0	66.0
Specific Gravity	2.77	2.80	-	-	-	-	2.93	2.74	2.80	-	-
Unit Weight (kN/m^3)	16.6	16.6	16.5	16.5	16.5	16.6	16.5	16.4	17.2	16.9	17.0
Sensitivity	3.0	2.85	2.83	2.81	2.96	3.19	3.19	2.95	2.84	2.96	2.60

- Not obtained for this test

TABLE 2.2 BASIC SOIL PROPERTIES

Test No.	T412	T413	T414	T415	T416	T417	T418	T419	T420	T421	T422
State	'Fully-Softened'			'Undisturbed'			'Freeze-Thaw'				
Test Type	CAD	CAU	CAD	CAD	CAU	CAD	CAU	CAD	CAU	CAD	CAU
Borehole No.	6	6	6	6	6	6	6	6	6	6	6
Block Sample No.	1	2	2	4	4	4	2	2	2	1	1
Depth (m)	8.7	8.7	8.8	11.4	11.4	11.4	8.8	8.8	8.8	8.8	8.8
Initial Moisture Content (%)	50.9	52.2	50.2	59.7	58.8	57.4	49.5	48.8	49.4	51.2	51.4
Final Moisture Content (%)	54.2	56.1	54.7	58.9	58.9	65.9	47.1	43.3	42.5	42.9	40.5
Liquid Limit (%)	71.8	80.4	-	83.8	87.3	84.7	76.6	-	-	-	82.3
Plastic Limit (%)	24.9	23.7	-	27.9	28.7	26.8	27.0	-	-	-	25.0
Plasticity Index (%)	46.9	56.7	-	55.9	58.6	57.9	49.6	-	-	-	57.3
Clay Content (%)	61.0	65.0	64.0	68.0	66.0	68.0	-	-	-	-	-
Specific Gravity	-	2.811	-	-	-	2.760	-	-	-	-	-
Unit Weight (kN/m^3)	17.0	16.9	17.1	16.3	16.4	16.3	17.2	17.3	17.2	17.1	17.0
Sensitivity	2.78	2.75	2.47	2.70	3.35	2.82	2.24	2.96	-	-	-

- Not obtained for this test

TABLE 2.3 TEMPERATURE, DURATION AND NUMBER OF FREEZE-THAW CYCLES FOR 'FREEZE-THAW' SAMPLES

Sample Number	T418	T419	T420	T421	T422
Freezing Temperature (°C)	-5	-5	-5	-25	-25
Thawing Temperature (°C)	25	25	25	20	20
Average Freezing Duration (Hrs)	12	12	12	48	48
Average Thawing Duration (Hrs)	12	12	12	48	48
Number of Freezing and Thaw Cycles	5	5	5	6	6

TABLE 3.1 TRIAXIAL CONSOLIDATION RESULTS FOR RESTRESSING TO IN-SITU STRESSES

Test No.	T401	T402	T403	T404	T405	T406	T407	T411^{+}	T422^{++}
p'^{*}_{o} (kPa)	118.4	118.4	118.4	118.4	118.4	117.0	117.0	89.0	92.9
σ'_{c} (kPa)	118.7	118.9	118.9	118.8	117.8	116.9	117.8	88.8	93.0
σ'_{3c} (kPa)	77.2	77.2	77.3	77.2	76.9	75.9	76.7	57.4	60.2
p'^{**}_{c} (kPa)	241	241	241	241	241	241	241	400	400
σ'_{1c}/p'_{o}	1.0	1.0	1.0	1.0	0.99	1.0	1.01	1.0	1.0
p'_{c}/σ'_{1c}	2.03	2.03	2.03	2.03	2.05	2.06	2.05	4.50	4.30
$\sigma'_{3c}/\sigma'_{1c}$	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
ε_{1c} (%)	1.56	1.51	1.50	1.25	1.47	1.48	0.95	3.82	10.58
ε_{3c} (%)	0.22	0.28	0.12	0.36	0.24	0.36	0.23	1.15	1.62
ε_{vc} (%)	2.00	2.06	1.73	1.98	1.96	2.20	1.42	6.13	13.82
$\gamma^{\#}$ (kN/m^3)	17.5	17.5	17.5	17.5	17.5	17.5	17.5	16.7	17.0

* Based on GWT at 3.0 meters

** Based on one dimensional oedometer tests by Lew (1981)

\+ 'Fully-Softened' sample

\++ 'Freeze-Thaw' sample

\# γ_{sat} for calculating p'_{o}

TABLE 3.2 TRIAXIAL CONSOLIDATION RESULTS AT THE END OF STRESS-CONTROLLED TESTING FOR UNDISTURBED SAMPLES

Test No.	T401	T402^{o}	T403^{+}	T404^{+o}	T405^{+}	T406^{+o}	T407^{++}	T408	T415^{+}	T416	T417^{+}
p'^{*}_{o} (kPa)	118.4	118.4	118.4	118.4	118.4	117.0	117.0	117.0	117.0	117.0	117.0
σ'_{1c} (kPa)	482.4	326.8	272.7	268.9	122.1	120.6	117.8	78.0	115.3	39.4	35.4
σ'_{3c} (kPa)	441.4	285.4	128.7	128.7	43.8	39.8	76.7	50.7	31.9	26.0	3.7
$\sigma'_{3c}/\sigma'_{1c}$	0.91	0.87	0.47	0.48	0.36	0.33	0.65	0.65	0.28	0.66	0.10
ε_{1c} (%)	6.84	4.23	6.33	7.77	2.31	2.00	0.95	0.47	2.06	-0.36	0.61
ε_{3c} (%)	3.15	1.71	-1.06	-1.30	-0.13	-0.19	0.23	0.10	-0.63	-0.22	-1.64
ε_{vc} (%)	13.14	7.66	4.22	5.17	1.77	1.62	1.42	0.67	0.80	-0.80	-2.67
$\gamma^{\#}$ (kN/m^3)	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5

* Based on GWT at 3.0 meters

\+ Sample failed in drained shear at the value shown

++ Sample consolidated to in-situ stresses only

o Sample with 5 days load increment duration

\# γ_{sat} for calculating p'_o

TABLE 3.3 TRIAXIAL CONSOLIDATION RESULTS AT THE END OF STRESS-CONTROLLED TESTING FOR 'FULLY-SOFTENED' AND 'FREEZE-THAW' SAMPLES

	'Fully-Softened' Samples						'Freeze-And-Thaw' Samples				
Test No.	T409	T410^{+}	T411^{++}	T412^{+}	T413	T414^{+}	T418	T419^{+}	T420	T421^{+}	T422^{++}
$p_o'^{*}$ (kPa)	89.0	89.0	89.0	89.0	89.0	90.2	93.4	94.2	93.4	92.9	92.9
σ_{1c}' (kPa)	29.7	57.5	88.8	130.2	59.5	96.5	31.6	33.8	61.9	92.5	93.0
σ_{3c}' (kPa)	19.3	5.4	57.4	36.9	38.5	19.8	20.6	3.2	40.6	24.5	60.2
$\sigma_{3c}'/\sigma_{1c}'$	0.65	0.09	0.65	0.28	0.65	0.21	0.65	0.09	0.66	0.26	0.65
ε_{1c} (%)	1.54	3.651	3.82	6.21	2.70	4.40	4.30	7.66	7.13	12.24	10.58
ε_{3c} (%)	-0.37	-0.573	1.15	-0.18	0.82	-0.07	0.90	1.37	1.57	0.18	1.62
ε_{vc} (%)	0.80	2.51	6.13	5.85	4.35	4.26	6.09	10.41	10.26	12.60	13.82
$\gamma^{\#}$ (kN/m^3)	16.7	16.7	16.7	16.7	16.7	16.7	17.2	17.3	17.2	17.0	17.0

* Based on GWT at 3.0 meters

\+ Sample failed in drained shear at the value shown

++ Sample consolidated to in-situ stresses only

\# γ_{sat} for calculating p_o'

TABLE 3.4 YIELD STRESSES FROM DIFFERENT YIELD CRITERIA FOR UNDISTURBED SAMPLES CONSOLIDATED TO IN-SITU STRESS LEVEL

Test No.		T401	T402*	T403	T404*	T405	T406*
Plotted Perimeter	σ'_1 vs ε_1	-	-	136.0	146.0	69.9	66.8
	$(\sigma_1-\sigma_3)$ vs ε_1	-	-	136.5	145.5	69.9	66.8
	σ'_{oct} vs ε_v	234.0	177.3	142.0	147.5	69.9	66.8
	σ'_3 vs ε_3	211.8	177.3	-	-	69.9	66.8
	$(\sigma_1-\sigma_3)$ vs ε	-	-	134.9	142.0	69.9	66.8
	W_T vs LSSV	217.5	187.7	132.9	142.0	69.9	66.8

\- Not obtained for this test

* Sample with 5 day load increment duration

Note: The yield (or limit-state) stresses presented in this table have been put in terms of σ'_{oct} along the stress path for the test.

TABLE 3.5 RESULTS FOR NON-STANDARD OEDOMETER TESTS

Sample	C401	C402	C403	C404	C405	C406
Borehole No.	6	6	6	6	6	6
Block Sample No.	3	3	3	3	3	3
Depth (m)	11.6	11.6	11.6	11.6	11.6	11.6
Initial Moisture Content (%)	55.1	55.5	56.6	54.9	55.7	57.4
Initial Void Ratio e_i	1.53	1.54	1.58	1.53	1.55	1.60
Axial Pressure	480.4	377.9	280.4	210.2	150.0	75.0
$\varepsilon_{VR(0.1)}^{*}$	6.15	3.96	2.57	1.69	0.98	0.17
$\varepsilon_{VR(1.0)}^{*}$	8.58	6.04	3.36	1.89	1.21	0.18
$\varepsilon_{VR(10.0)}^{*}$	9.32	6.96	3.90	2.07	1.27	0.15
$\varepsilon_{VR(100.0)}^{*}$	9.87	7.54	4.34	2.24	1.34	0.16
Final Moisture Content (%)	46.6	49.1	52.5	53.2	55.0	62.4
Final Voids Ratio e_f	1.30	1.37	1.46	1.48	1.53	1.74

$^{*}\varepsilon_{VR(0.1)}$, $^{*}\varepsilon_{VR(1.0)}$, $^{*}\varepsilon_{VR(10.0)}$, $^{*}\varepsilon_{VR(100.0)}$ are vertical strains after 0.1 day, 1.0 day, 10.0 day and 100 days respectively.

G_s is assumed to be 2.78

TABLE 3.6 RELATIONSHIP BETWEEN p'_c AND LOAD DURATION FOR THE NON-STANDARD OEDOMETER TESTS

Criteria	ε_{VR} vs σ'_v				ε_{VR} vs $\log\sigma'_v$			
Load Duration (Hrs)	2.4	24	240	2400	2.4	24	240	2400
p'_c (kPa)	249	243	233	225	-	250	239	230

TABLE 3.7 RELATIONSHIP AMONG c_v, C_α, C_c, C_α/C_c AND TIME FOR THE NON-STANDARD OEDOMETER TESTS

		Load Duration = 24 Hrs				Load Duration = 240 Hrs			Load Duration = 2400 Hrs			'End of Primary'		
Axial Pressure (kPa)	t_{50} (s)	$c_v \times 10^{-4}$ (cm^2/s)	C_α (%)	C_c	C_α/C_c	C_α (%)	C_c	C_α/C_c	C_α (%)	C_c	C_α/C_c	C_α (%)	C_c	C_α/C_c
150.0	1080	2.95	0.38	0.088	0.043	0.21	0.095	0.022	0.21	0.1	0.021	0.21	0.087	0.024
210.2	600	5.22	0.41	0.12	0.034	0.30	0.14	0.021	0.30	0.16	0.019	0.30	0.087	0.035
280.4	1980	1.55	1.92	0.30	0.064	1.00	0.37	0.027	1.00	0.43	0.023	1.00	0.32	0.031
377.9	5100	0.58	3.42	0.53	0.065	1.61	0.60	0.027	1.61	0.63	0.026	1.61	0.59	0.027
480.4	3900	0.71	3.01	0.62	0.049	1.20	0.58	0.021	1.20	0.57	0.021	1.20	0.63	0.019

TABLE 3.8 CRS OEDOMETER TEST RESULTS

Sample	C407	C408	C409	C410
Borehole No.	6	6	6	6
Block Sample No.	3	3	3	3
Depth (m)	11.4	11.4	11.4	11.4
Initial Moisture Content (%)	57.7	58.0	56.9	55.6
Strain Rate (mm/min)	0.0010	0.0036	0.0002	0.0006
p'_c* (kPa)	396	383	285	328

* p'_c is defined using the ε_{VR} vs σ'_v plot

TABLE 4.1 TRIAXIAL RECONSOLIDATION RESULTS FOR LOW STRESS TESTS (UNDISTURBED SAMPLES)

Test No.	T407	T408	T415	T416	T417
$p_o'^{*}$ (kPa)	117.0	117.0	117.0	117.0	117.0
σ_{1c}' (kPa)	117.8	78.0	78.0	39.4	38.8
σ_{3c}' (kPa)	76.7	50.7	50.8	26.0	25.3
$p_c'^{**}$ (kPa)	241	241	241	241	241
σ_{1c}'/p_o'	1.01	0.67	0.67	0.34	0.33
p_c'/σ_{1c}'	2.05	3.09	3.09	6.12	6.21
$\sigma_{3c}'/\sigma_{1c}'$	0.65	0.65	0.65	0.66	0.65
ε_{1c} (%)	0.95	0.47	0.67	-0.36	-0.076
ε_{3c} (%)	0.23	0.10	0.05	-0.22	-0.14
ε_{vc} (%)	1.42	0.67	0.77	-0.80	-0.36
$\gamma^{\#}$ (kN/m^3)	17.5	17.5	17.5	17.5	17.5

* Based on GWT at 3.0 meters

** Based on one-dimensional oedometer tests by Lew (1981)

\# γ_{sat} for calculating p_o'

TABLE 4.2 TRIAXIAL RECONSOLIDATION RESULTS FOR LOW STRESS TESTS ('FULLY-SOFTENED' AND 'FREEZE-THAW' SAMPLES)

	'FULLY-SOFTENED' SAMPLES						'FREEZE-AND-THAW' SAMPLES				
Test No.	T409	T410	T411	T412	T413	T414	T418	T419	T420	T421	T422
$p_o'^{*}$ (kPa)	89.0	89.0	89.0	89.0	89.0	89.0	93.4	94.2	93.4	92.9	92.9
σ_{1c}' (kPa)	29.7	29.6	88.8	89.1	59.5	59.5	31.6	32.1	61.9	62.0	93.0
σ_{3c}' (kPa)	19.3	19.1	57.4	57.9	38.5	38.5	20.6	21.0	40.6	40.2	60.2
$p_c'^{**}$ (kPa)	400	400	400	400	400	400	400	400	400	400	400
σ_{1c}'/p_o'	0.33	0.33	1.0	1.0	0.67	0.67	0.34	0.34	0.66	0.67	1.0
p_c'/σ_{1c}'	13.5	13.5	4.50	4.50	6.72	6.72	12.7	12.5	6.46	6.45	4.30
$\sigma_{3c}'/\sigma_{1c}'$	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
ε_{1c} (%)	1.54	1.22	3.81	3.64	2.70	2.53	4.30	6.13	7.28	8.02	10.58
ε_{3c} (%)	0.54	0.38	1.16	1.05	0.83	0.78	0.89	0.96	1.50	1.63	1.62
ε_{vc} (%)	2.62	1.98	6.13	5.75	4.35	4.10	6.06	8.04	10.26	11.28	13.82
$\gamma^{\#}$ (kN/m^3)	16.7	16.7	16.7	16.7	16.7	16.7	17.2	17.3	17.2	17.0	17.0

* Based on GWT at 3.0 meters

** Based on p_c' vs Depth - Figure 6.7 in Lew's thesis (1981)

\# γ_{sat} for calculating p_o'

TABLE 4.3 QUASI-YIELD STRESSES FROM DIFFERENT YIELD CRITERIA FOR LOW STRESS TESTS

		'Undisturbed'		'Fully-Softened'			'Freeze-Thaw'	
	Test No.	T415	T417	T410	T412	T414	T419	T421
Plotted Perimeter	σ'_1 vs ε_1	58.8	-	32.2	75.2	63.9*	-	45.0
	$(\sigma_1-\sigma_3)$ vs ε_1	58.5	-	32.0	77.0	65.5*	23.0	44.6
	σ'_{oct} vs ε_v	-	24.9	-	-	-	-	-
	σ'_3 vs ε_3	-	25.1	32.0	-	58.2	-	46.1
	$(\sigma_1-\sigma_3)$ vs ε	57.8	23.3	33.0	79.0	56.2	22.8	45.0
	W_T vs LSSV	-	25.0	30.8	73.8	54.0	23.5	45.5

* Not included in averaging

\- Not obtained for this test

Note: The yield (or limit-state) stresses presented in this table have been put in terms of $(\sigma_1-\sigma_3)$ along the stress path for the test.

TABLE 4.4 SUMMARY OF UNDRAINED SHEAR TEST RESULTS

	Undisturbed				Fully-Softened			Freeze-Thaw		
Test Number	T416	T402	T407	T408	T409	T411	T413	T418	T420	T422
Test Type	CAU	CAD(U)	CAU	CAU	CAU	CAU	CAU	CAU	CAU	CAU
Borehole Number	6	6	6	6	6	6	6	6	6	6
Block Sample Number	4	3	3	1	1	1	2	2	2	1
Depth (m)	11.4	11.6	11.4	11.4	8.7	8.7	8.7	8.8	8.8	8.8
$p_o'^*$ (kPa)	117.0	118.4	117.0	117.0	89.0	89.0	89.0	93.4	93.4	92.9
σ_{1c}' (kPa)	39.4	326.8	117.8	78.0	29.7	88.8	59.5	31.6	61.9	93.0
$\sigma_{3c}'/\sigma_{1c}'$	0.66	0.87	0.65	0.65	0.65	0.65	0.65	0.65	0.66	0.65
σ_{1c}'/p_o'	0.34	2.76	1.01	0.67	0.33	1.0	0.67	0.34	0.66	1.00
$\sigma_{1c}'/p_c'^{**}$	0.16	1.36	0.49	0.32	0.08	0.22	0.15	0.08	0.15	0.23
$(\sigma_1-\sigma_3)/2_{max}$ (kPa)	35.9	86.0	49.8	44.8	28.4	47.0	33.9	16.4	27.3	37.9
$(\sigma_1-\sigma_3)/2\sigma_{1c\ max}'$	0.91	0.26	0.42	0.57	0.96	0.53	0.57	0.52	0.44	0.41
σ_{oct}' at $(\sigma_1-\sigma_3)/2_{max}$ (kPa)	41.2	230.0	80.8	59.6	28.7	70.1	41.5	19.4	39.5	59.4
ε_1 at $(\sigma_1-\sigma_3)/2_{max}$ (%)	1.99	2.58	0.61	1.68	2.94	2.48	1.92	3.14	2.71	5.22
$(\sigma_1'/\sigma_3')_{max}$	5.45	2.27	3.09	4.24	9.39	3.61	4.81	4.92	3.62	3.27
ε_1 at $(\sigma_1'/\sigma_3')_{max}$ (%)	1.30	4.57	0.61	1.39	1.73	1.88	1.63	3.03	2.71	4.35
E_{50} (MPa)	7.8	34.2	18.7	11.8	5.6	8.7	8.8	9.2	11.1	1.43
$E_{50}/(\sigma_1-\sigma_3)/2_{max}$	215.4	398	375.6	197.7	196.2	185.1	259.8	575.1	407.1	377.5
A_f	0.15	0.84	0.47	0.32	0.18	0.29	0.38	0.53	0.56	0.52
B (%)	98	97	98	100	99	98	99	98	98	97
$m = \Delta u/\Delta\sigma_{oct}$	1.54	2.0	1.61	1.47	1.43	1.72	1.92	1.67	1.82	1.67
$\rho_{0.1}$ at ε_ρ (%)	5.91	9.57	6.12	7.09	7.44	7.98	8.04	10.0	7.57	7.17
ε_ρ (%)	2.53	3.52	1.22	2.26	3.40	3.02	1.86	2.66	3.72	5.93
Initial Strain Rate ε (%/hr)	0.92	0.92	0.93	0.93	0.92	0.93	0.92	0.98	1.02	1.09
$\gamma^\#$ (kN/m^3)	17.5	17.5	17.5	17.5	16.7	16.7	16.7	17.2	17.2	17.0

* Based on GWT at 3 meters at $\gamma_{sat} = 17.5$ kN/m^3

** $p_c' = 241$ kPa for samples at 11.4 - 11.6 meters
$p_c' = 400$ kPa for samples at 8.7 - 8.8 meters

\# γ_{sat} for calculating p_o'

TABLE 4.5 COMPARISON OF A_f AND m VALUES FOR OVERCONSOLIDATED 'UNDISTURBED', 'FULLY-SOFTENED' AND 'FREEZE-THAW' SAMPLES

State	UND.+	F.S.+	F.T.+	UND.+	F.S.+	F.T.+	UND.+	F.S.+	F.T.+
σ'_{1c}/p'_o	0.34	0.33	0.34	0.67	0.67	0.66	1.01	1.00	1.00
Test No.	T416	T409	T418	T408	T413	T420	T407	T411	T422
A_f	0.15	0.18	0.53	0.32	0.38	0.56	0.47**	0.29	0.52
A_f* (%)	100	120	353	100	119	175	100	61.7	111
m	1.54	1.43	1.67	1.47	1.92	1.82	1.61	1.72	1.67
m* (%)	100	92.9	108	100	131	124	100	107	104

+ UND., F.S. and F.T. stands for 'Undisturbed', 'Fully-Softened' and 'Freeze-Thaw' samples respectively

* Percentage value of A_f referred to corresponding A_f for undisturbed sample at same σ'_{1c}

** This value appears high. Similar results from Lew (1981) and Noonan (1980) suggests A_f for $\sigma'_{1c} = p'_o$ is 0.35

TABLE 4.6 VALUES OF STRAIN RATE PARAMETER $\rho_{0.1}$ FOR VARIOUS AXIAL STRAINS FROM RELAXATION TESTS

	'Undisturbed'							
Sample	T402			T407	T408	T416		
ε_1 (%)	3.52	7.77	10.93	1.22	2.26	2.52	4.91	8.63
$\rho_{0.1}$ @ ε_1 (%)	9.6	3.0	2.9	6.1	7.1	5.9	2.5	2.9

	'Fully-Softened'										'Freeze-Thaw'		
Sample	T409			T411				T413			T418	T420	T422
ε_1 (%)	3.41	6.82	10.26	3.02	5.99	8.30	12.1	1.86	3.82	8.84	2.66	3.72	5.93
$\rho_{0.1}$ @ ε_1 (%)	7.4	4.1	2.4	8.0	3.2	3.1	2.2	8.0	3.1	4.2	10.0	7.6	7.2

TABLE 4.7 VALUES OF STRAIN RATE PARAMETER $\rho_{0.1}$ FOR VARIOUS AXIAL STRAINS FROM STEP-CHANGING TESTS

	'Undisturbed'				'Fully-Softened'			'Freeze-Thaw'		
	$\rho_{0.1}$ at ε_1 (%)				$\rho_{0.1}$ at ε_1 (%)			$\rho_{0.1}$ at ε_1 (%)		
ε_1 (%)	T402	T407	T408	T416	T409	T411	T413	T418	T420	T422
4	11.5	-	-	-	-	-	-	-	-	-
5	-	4.1*	11.0	-	10.5	6.6	-	-	-	-
6	10.3	6.3	-	-	-	-	6.3	-	8.9	-
8	4.3	-	6.8	7.7	-	-	-	9.9	-	-
9	-	-	-	-	10.3	-	-	-	-	-
10	-	6.1	-	-	-	-	-	-	5.1	6.7
11	-	-	-	5.8	-	9.9	-	-	-	-
12	-	5.9	5.9	-	-	-	6.3	10.9**	-	-

- Not included at this strain

* This value appears low

** This value appears high

TABLE 4.8 END OF TEST VALUES FOR UNDRAINED SHEAR TESTS

	'Undisturbed'				'Fully-Softened'			'Freeze-Thaw'		
Sample No.	T402	T407	T408	T416	T409	T411	T413	T418	T420	T422
$(\sigma_1-\sigma_3)/2\sigma'_{1c}$	0.15	0.26	0.29	0.58	0.50	0.30	0.34	0.36	0.303	0.25
σ'_1/σ'_3	1.66	1.90	1.85	2.1	2.20	1.95	2.07	0.26	2.25	1.95
$\Delta u/\sigma'_{1c}$	0.41	0.42	-0.085	-0.36	-0.19	0.0	-0.02	0.22	0.21	0.14
Depth (m)	11.6	11.4	11.4	11.4	8.7	8.7	8.7	8.8	8.8	8.8
p'^{*}_o (kPa)	118.4	117.0	117.0	117.0	89.0	89.0	89.0	93.4	93.4	92.9
σ'_{1c} (kPa)	326.8	117.8	78.0	39.4	29.7	88.8	59.5	31.6	61.9	93.0
$\sigma'_{3c}/\sigma'_{1c}$	0.87	0.65	0.65	0.66	0.65	0.65	0.65	0.65	0.66	0.65
σ'_{1c}/p'_o	2.76	1.01	0.67	0.34	0.33	1.00	0.67	0.34	0.66	1.00
σ'_{0ct} (kPa)	182.9	89.2	72.0	57.5	35.2	74.0	52.1	21.8	42.8	63.4
ν		2.59	2.56	2.62	2.43	2.40	2.45	2.20	2.10	2.07
$\gamma^{\#}$ (kN/m^3)	17.5	17.5	17.5	17.5	16.7	16.7	16.7	17.2	17.2	17.0

* Based on GWT at 3.0 meters

\# γ_{sat} for calculating p'_o

TABLE 5.1 RELATIONSHIP BETWEEN SPECIFIC VOLUME (ν) AND σ'_{oct} DURING SAMPLE RECONSOLIDATION FOR UNDISTURBED SAMPLES TAKEN FROM 11.6 m

Test No.	T401			T402			T403			T404			T405		
$p_o'^*$ (kPa)	118.4			118.4			118.4			118.4			118.4		
e_i	1.50			1.52			1.54			1.57			1.61		
ν_i	2.50			2.52			2.54			2.57			2.61		
σ'_{1c}/p'_o	0.34	0.72	1.00	0.34	0.67	1.00	0.33	0.67	1.0	0.34	0.67	1.0	0.34	0.67	0.99
ν	2.50	2.47	2.45	2.52	2.49	2.47	2.55	2.52	2.49	2.58	2.55	2.52	2.62	2.59	2.56
σ'_{oct} (kPa)	30.7	63.4	91.0	30.4	60.7	91.1	30.4	61.2	91.2	31.3	60.9	91.1	31.1	60.4	90.5

Test No.	T406			T407			T408		T415		T416	T417
$p_o'^*$ (kPa)	117.0			117.0			117.0		117.0		117.0	117.0
e_i	1.56			1.62			1.58		1.62		1.60	1.56
νi	2.56			2.62			2.58		2.62		2.60	2.56
σ'_{1c}/p'_o	0.33	0.66	1.00	0.34	0.50	1.01	0.33	0.67	0.33	0.67	0.34	0.33
ν	2.56	2.53	2.51	2.63	2.62	2.59	2.59	2.56	2.63	2.60	2.62	2.57
σ'_{oct} (kPa)	29.5	59.4	89.6	30.2	45.0	90.4	29.7	59.8	30.1	59.9	30.5	29.8

* Based on GWT at 3.0 meters depth

TABLE 5.2 RELATIONSHIP BETWEEN SPECIFIC VOLUME (ν) AND $'_{\text{oct}}$ DURING RECONSOLIDATION FOR SAMPLES TAKEN FROM 8.2 AND 8.7 m

' UNDISTURBED' SAMPLES AT 8.2 m (NOONAN, 1980)

Test No.	T201			T202			T203		
$p_o'^*$ (kPa)	91.0			91.0			91.0		
e_i	1.52			1.54			1.54		
ν_i	2.52			2.54			2.54		
σ_{1c}'/p_o'	0.49	0.71	1.0	0.49	0.71	1.0	0.48	0.72	1.0
ν	2.51	2.50	2.48	2.52	2.51	2.49	2.58	2.56	2.54
σ_{oct}' (kPa)	34.5	49.7	69.9	34.4	49.9	69.8	34.3	49.9	70.1

'FULLY-SOFTENED' SAMPLES AT 8.7 m

Test No.	T409	T410	T411			T412			T413		T414	
$p_o'^*$ (kPa)	89.0	89.0	89.0			89.0			89.0		89.0	
e_i	1.50	1.54	1.56			1.53			1.56		1.50	
ν_i	2.50	2.54	2.56			2.53			2.56		2.50	
σ_{1c}'/p_o'	0.33	0.33	0.33	0.67	1.0	0.33	0.67	1.0	0.33	0.67	0.33	0.66
ν	2.43	2.49	2.49	2.44	2.40	2.47	2.42	2.39	2.50	2.45	2.45	2.40
σ_{oct}' (kPa)	22.8	22.6	22.6	45.9	67.9	22.7	45.3	68.3	22.8	45.5	23.1	45.5

'FREEZE-AND-THAW' SAMPLES AT 8.7 m

Test No.	T418	T419	T420		T421		T422		
$p_o'^*$ (kPa)	93.4	94.2	93.4		92.9		92.9		
e_i	1.35	1.33	1.35		1.39		1.40		
ν_i	2.35	2.33	2.35		2.39		2.40		
σ_{1c}'/p_o'	0.34	0.34	0.34	0.66	0.35	0.67	0.34	0.67	1.0
ν	2.20	2.14	2.17	2.10	2.21	2.12	2.21	2.12	2.07
σ_{oct}' (kPa)	24.3	24.7	24.2	47.7	24.7	47.5	24.3	47.5	71.1

* Based on GWT at 3.0 meters

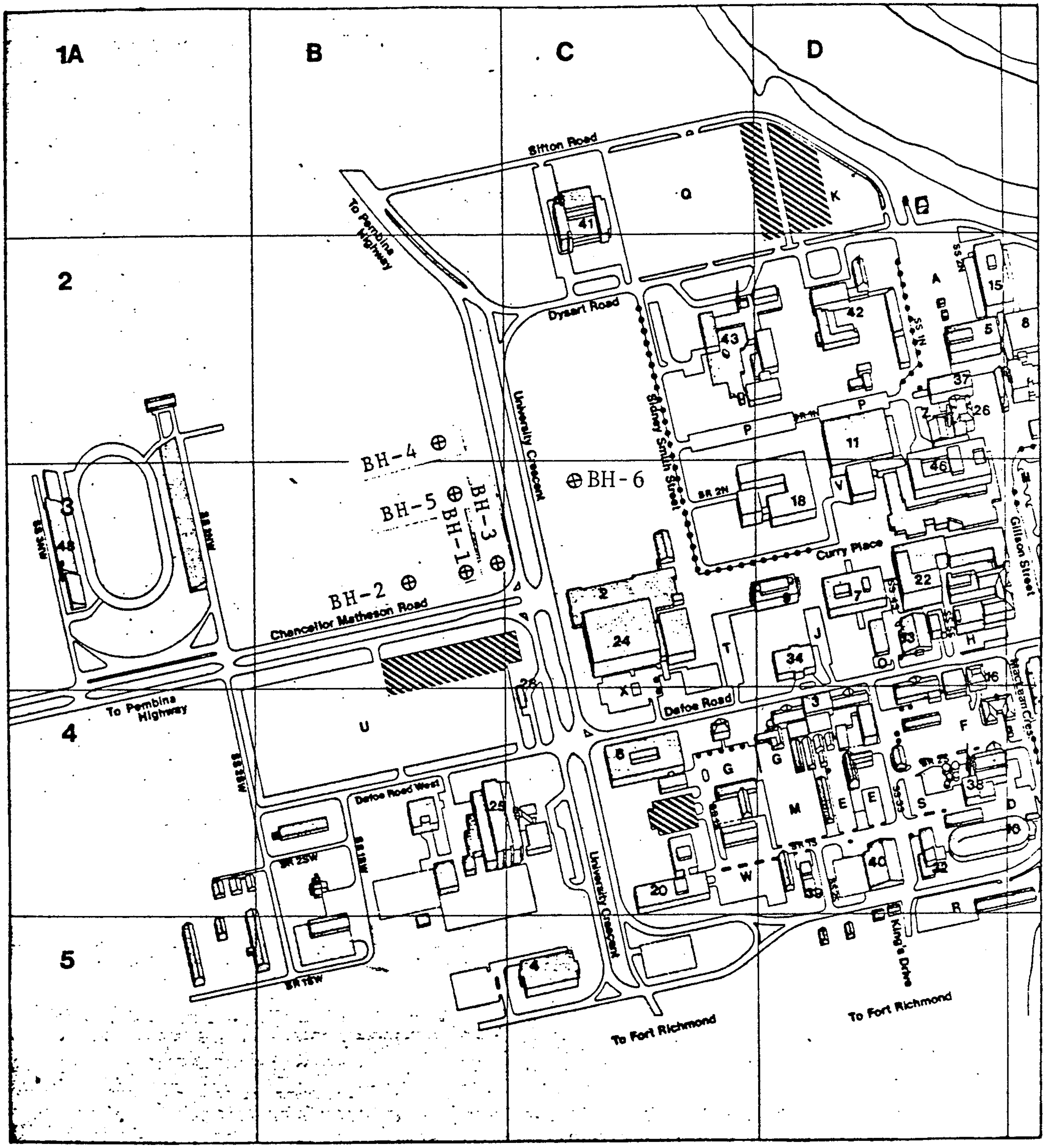


FIG. 1.1 SITE PLAN AND LOCATION OF BOREHOLES 6

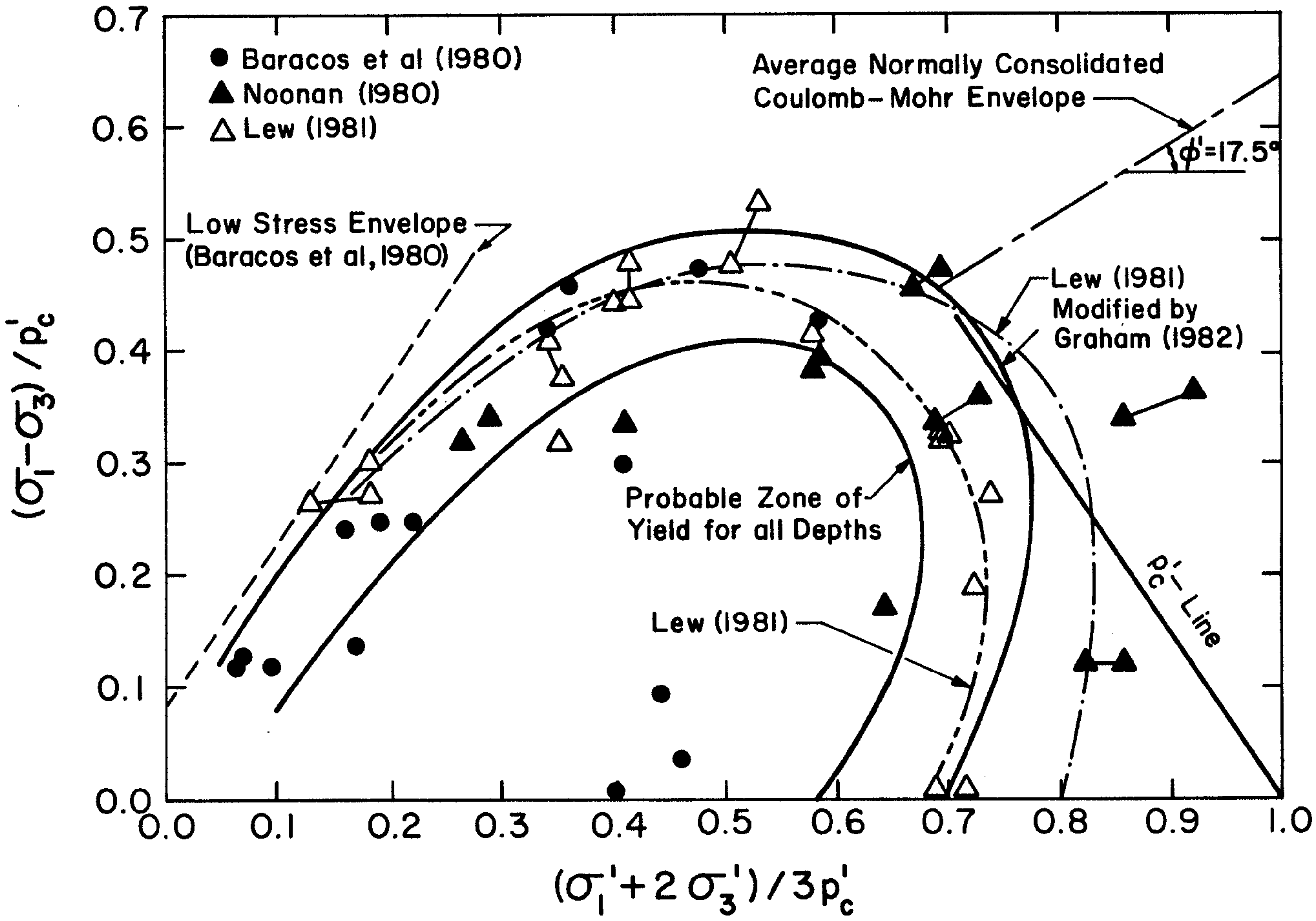


FIG. 1.2 SUMMARY OF ALL AVAILABLE YIELD ENVELOPES FOR WINNIPEG CLAY

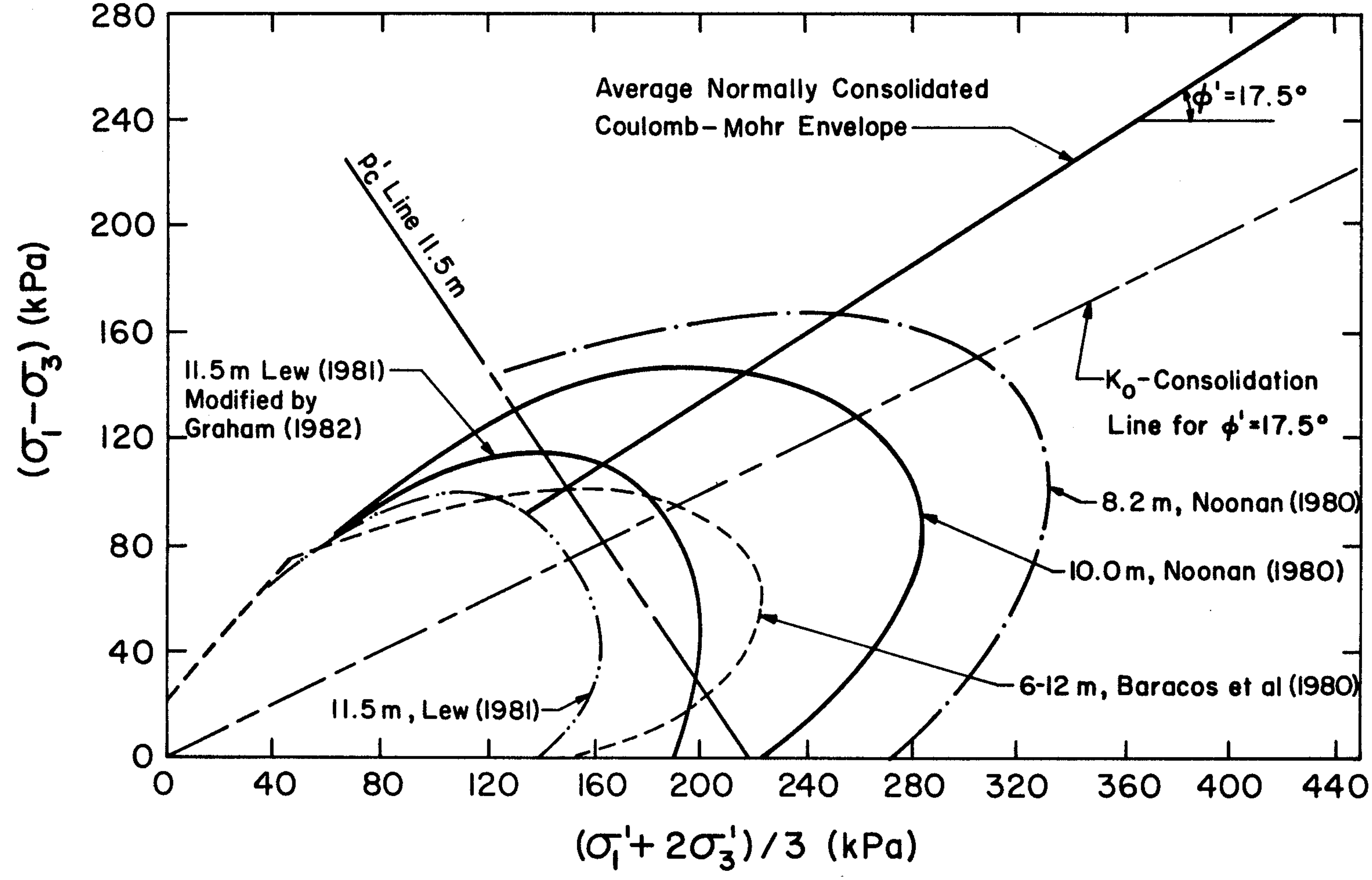


FIG. 1.3 NORMALIZED YIELD ENVELOPE FOR WINNIPEG CLAY

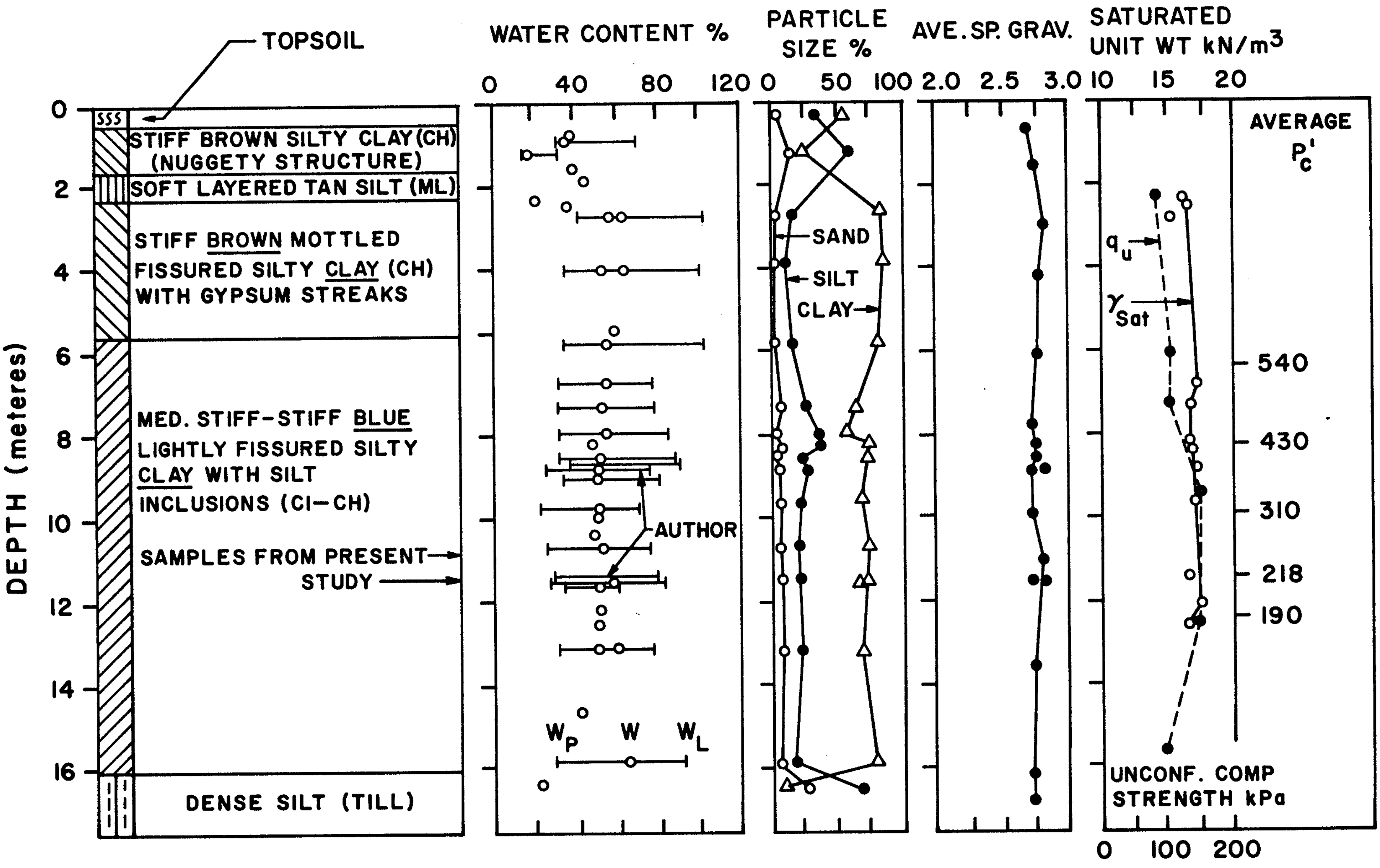


FIG. 1.4 AVERAGE BOREHOLE LOG INFORMATION, UNIVERSITY OF MANITOBA CAMPUS

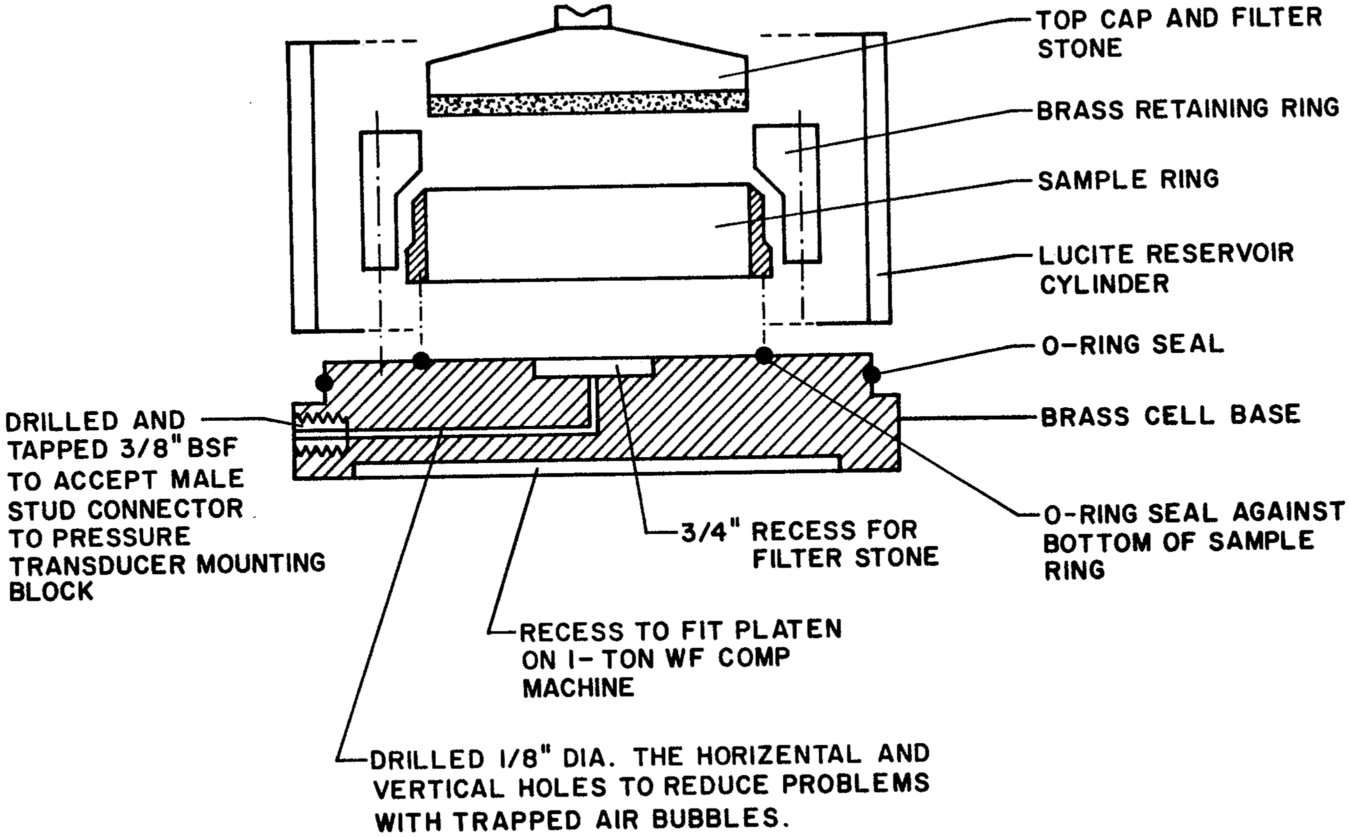


FIG. 2.1 SKETCH OF NEW BASE FOR OEDOMETER TO PERMIT POREWATER PRESSURE MEASUREMENT DURING CRS TESTS

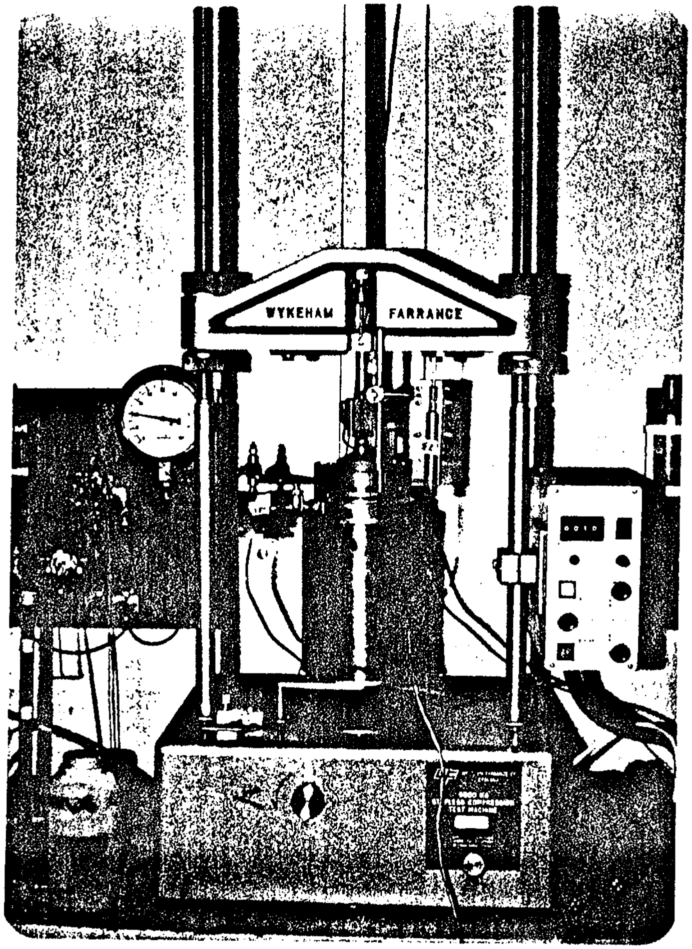


FIG. 2.2 CRS OEDOMETER SET-UP

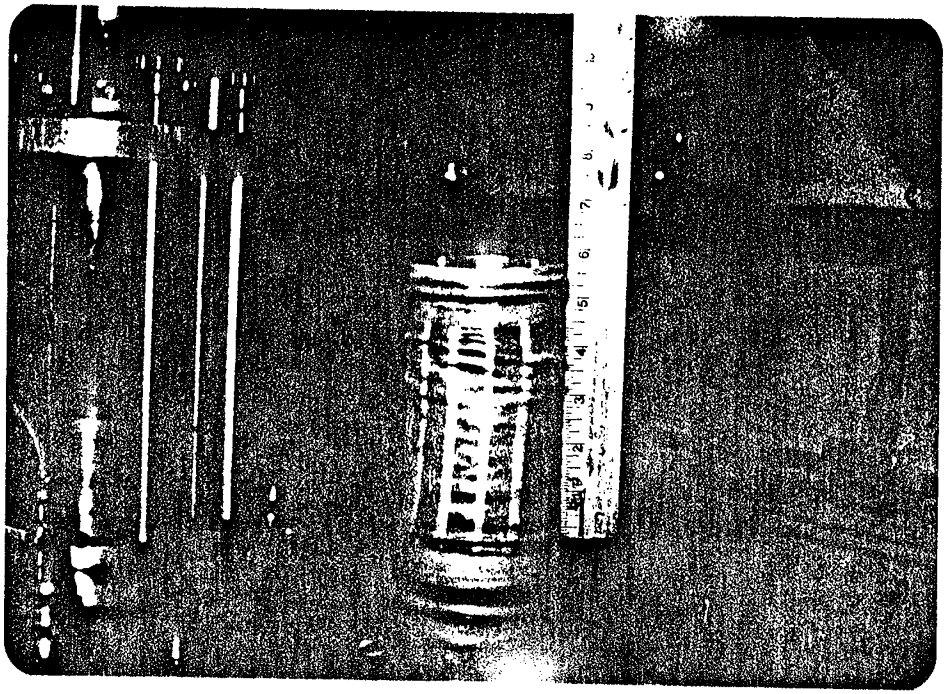


FIG. 2.3 'FREEZE-THAW' SAMPLE T421

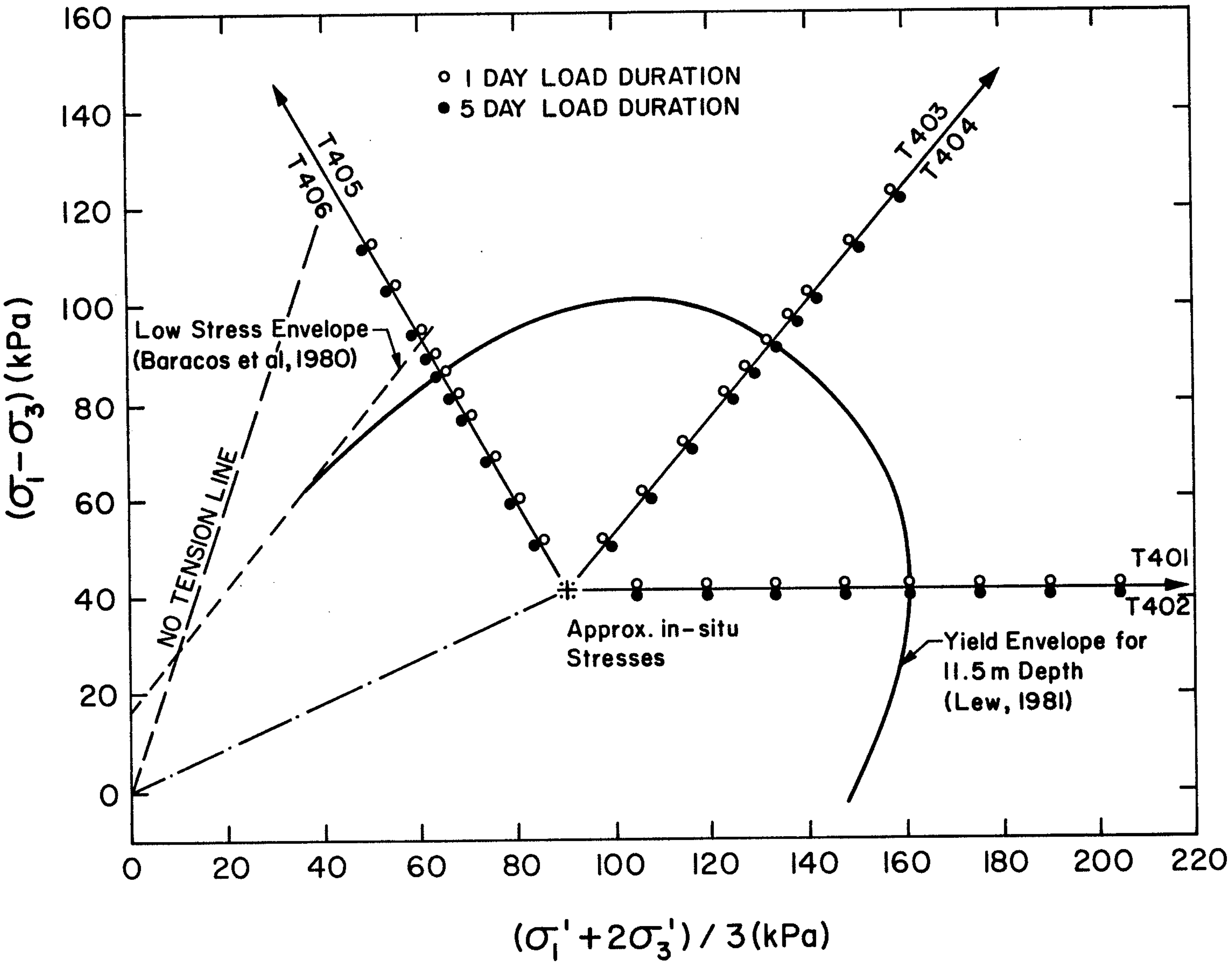


FIG. 3.1 PROPOSED STRESS PATHS FOR TESTS T401 TO T406

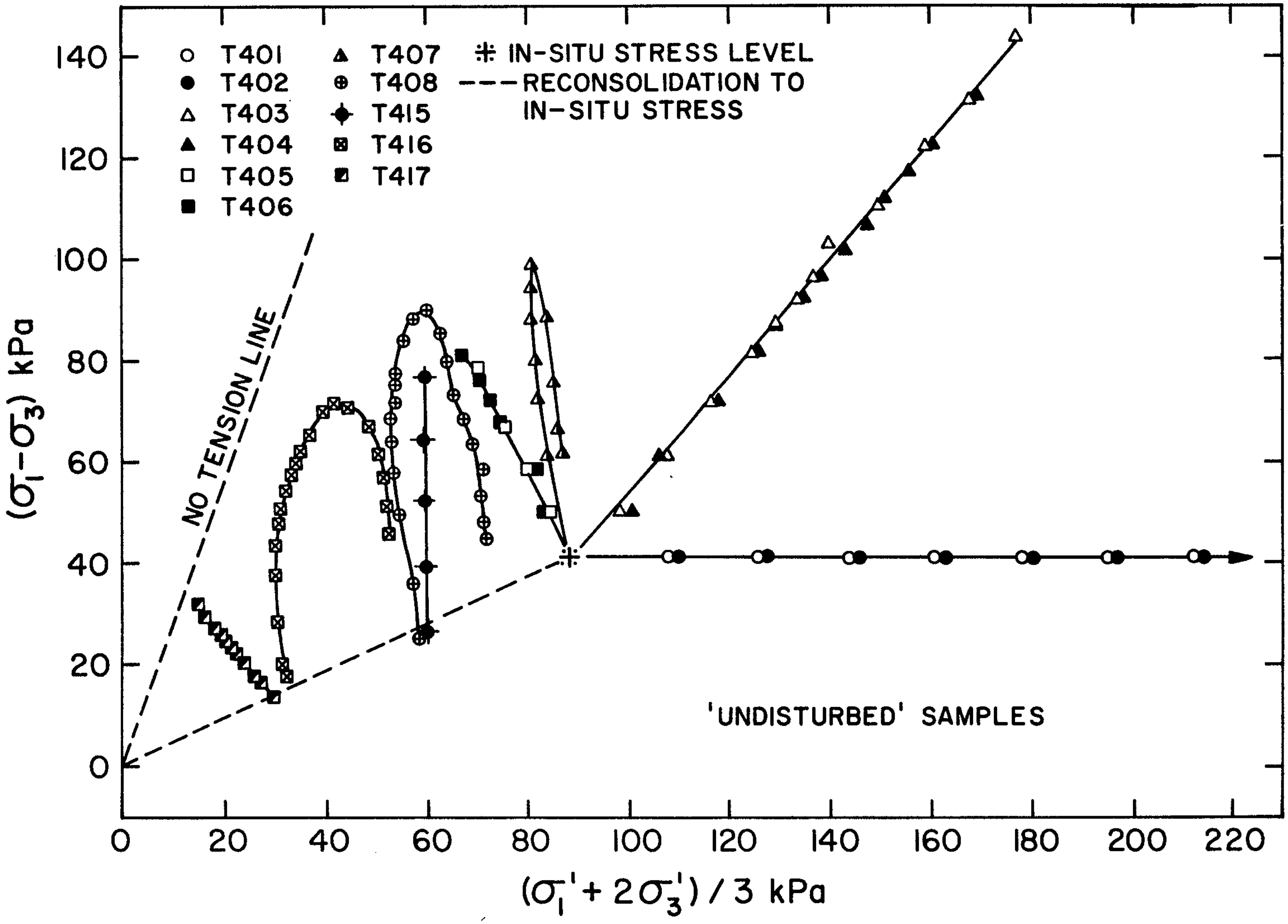


FIG. 3.2 STRESS PATHS FOLLOWED BY UNDISTURBED SAMPLES DURING TEST PROGRAM

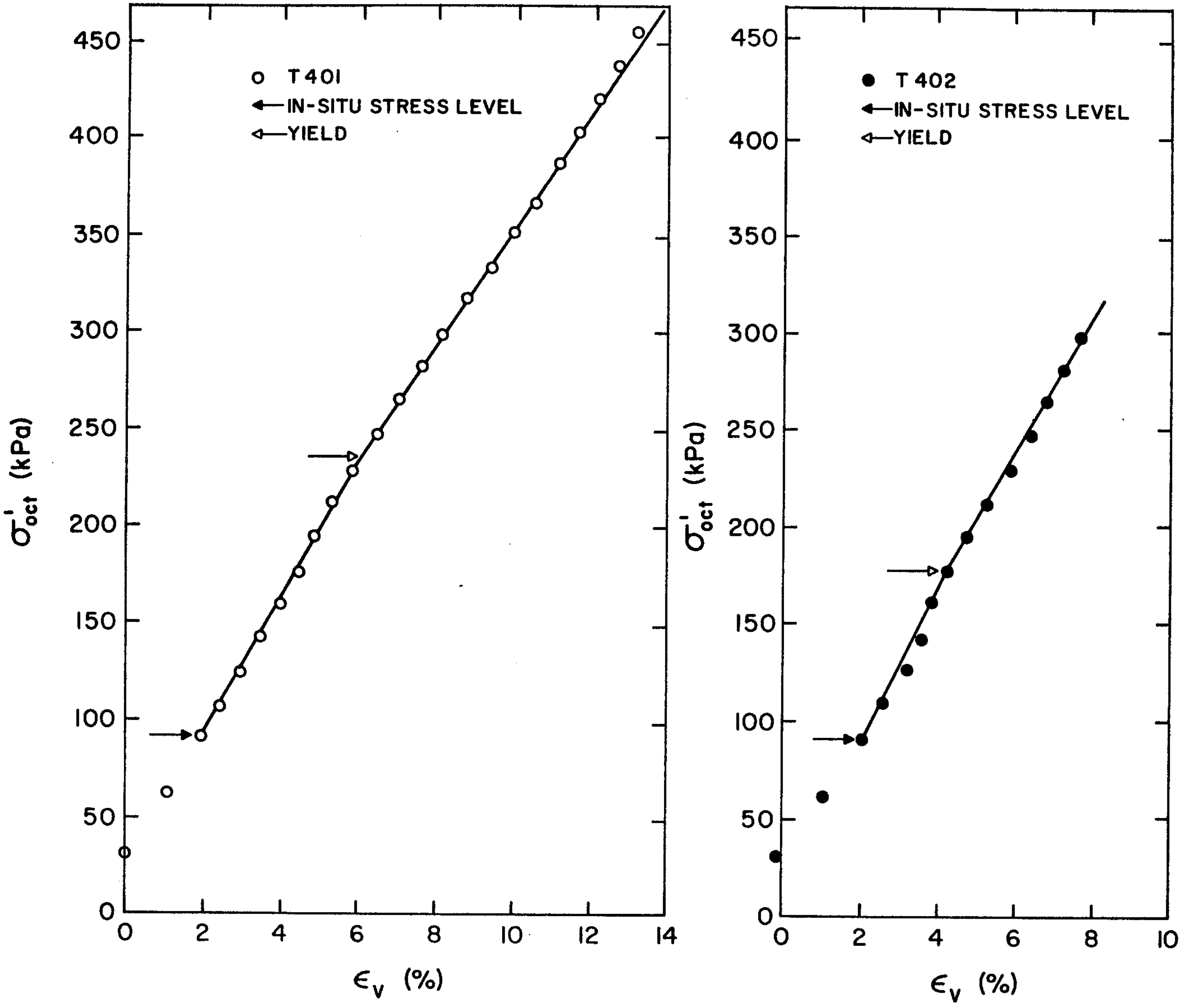


FIG. 3.3 YIELD DETERMINATION, σ'_{oct} vs ε_v; T401, T402

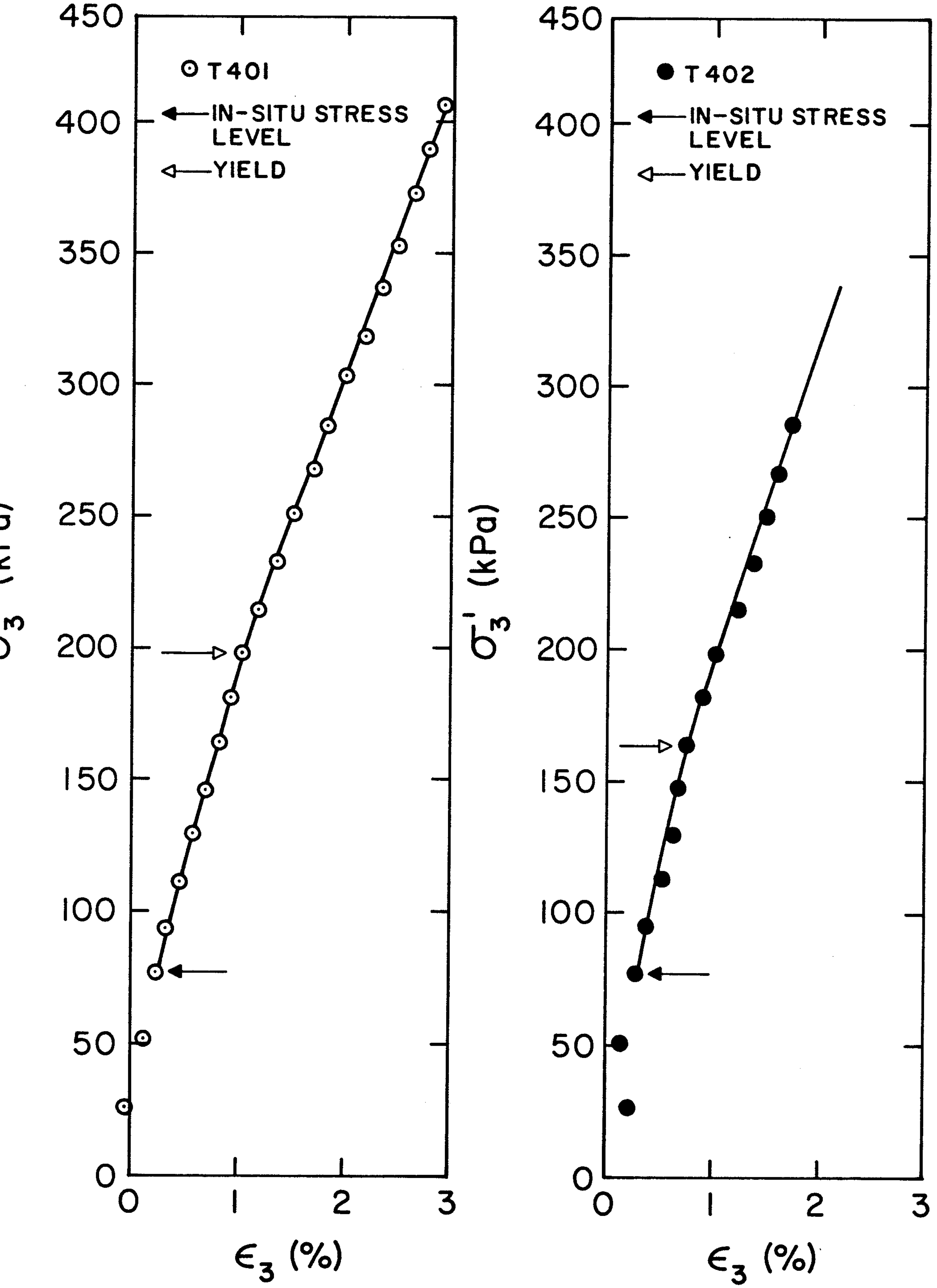


FIG. 3.4 YIELD DETERMINATION, σ_3' vs ε_3; T401, T402

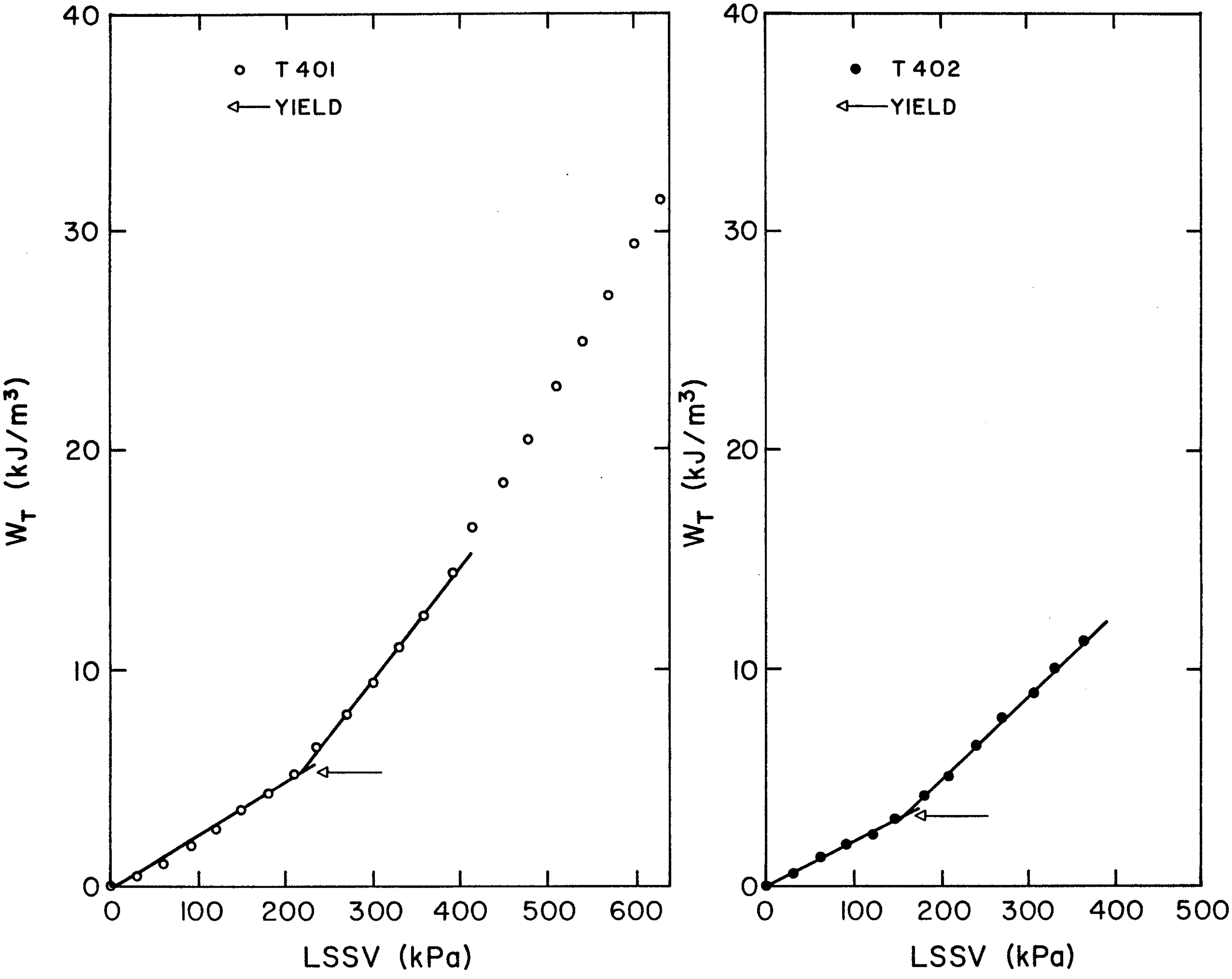


FIG. 3.5 YIELD DETERMINATION, W_T vs LSSV; T401, T402

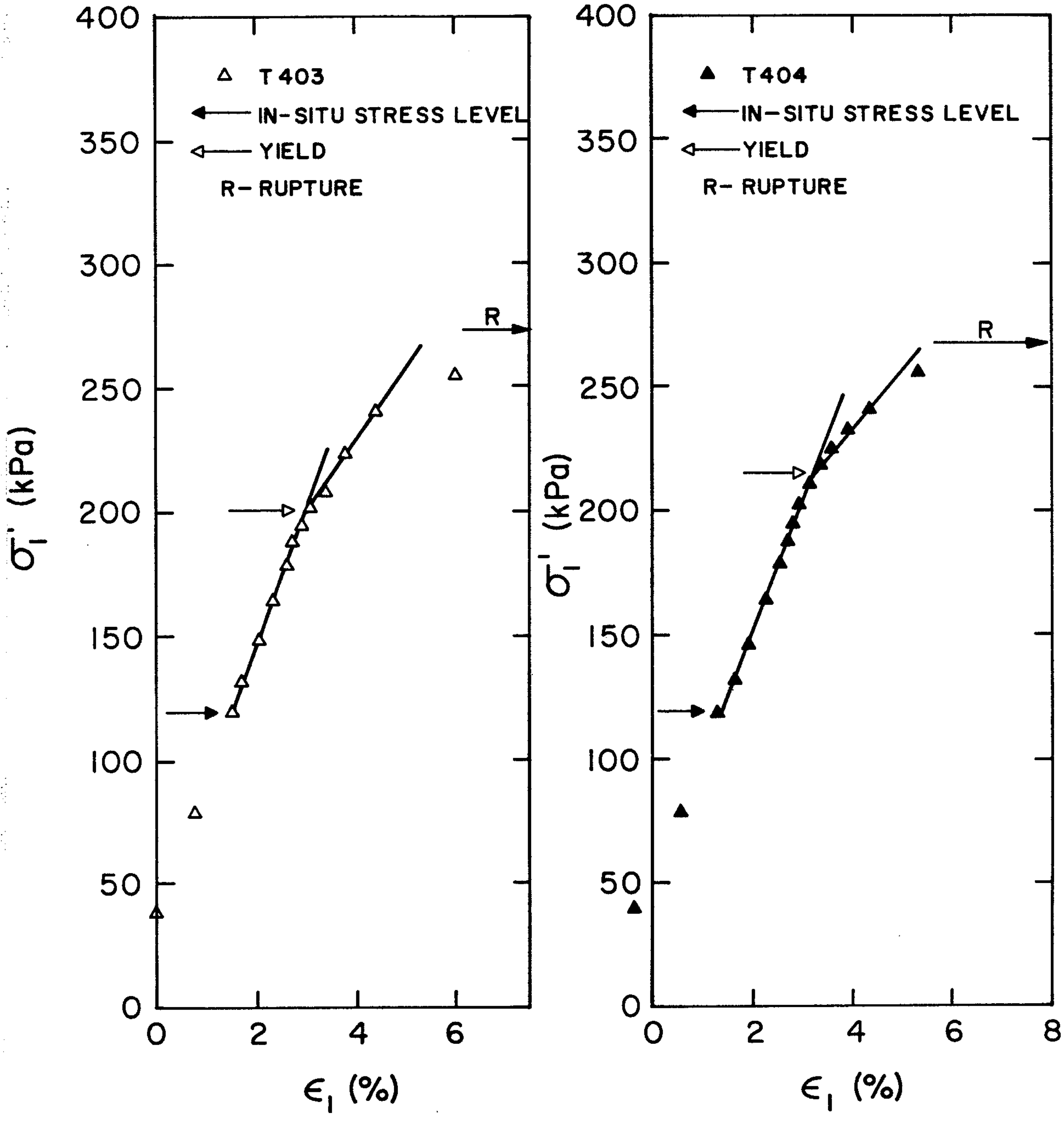


FIG. 3.6 YIELD DETERMINATION, σ_1' vs ε_1; T403, T404

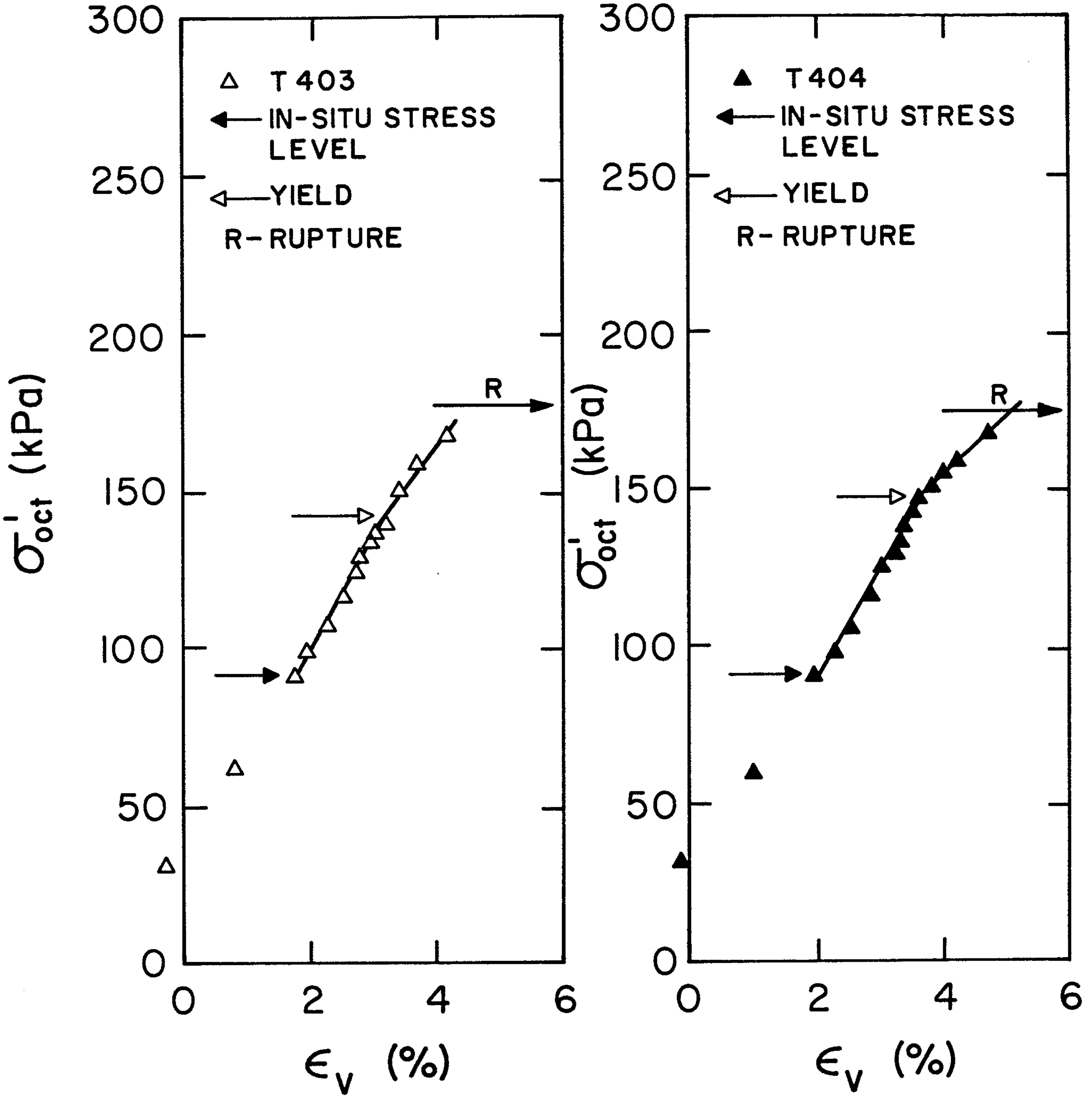


FIG. 3.7 YIELD DETERMINATION, σ'_{oct} vs ε_v; T403, T404

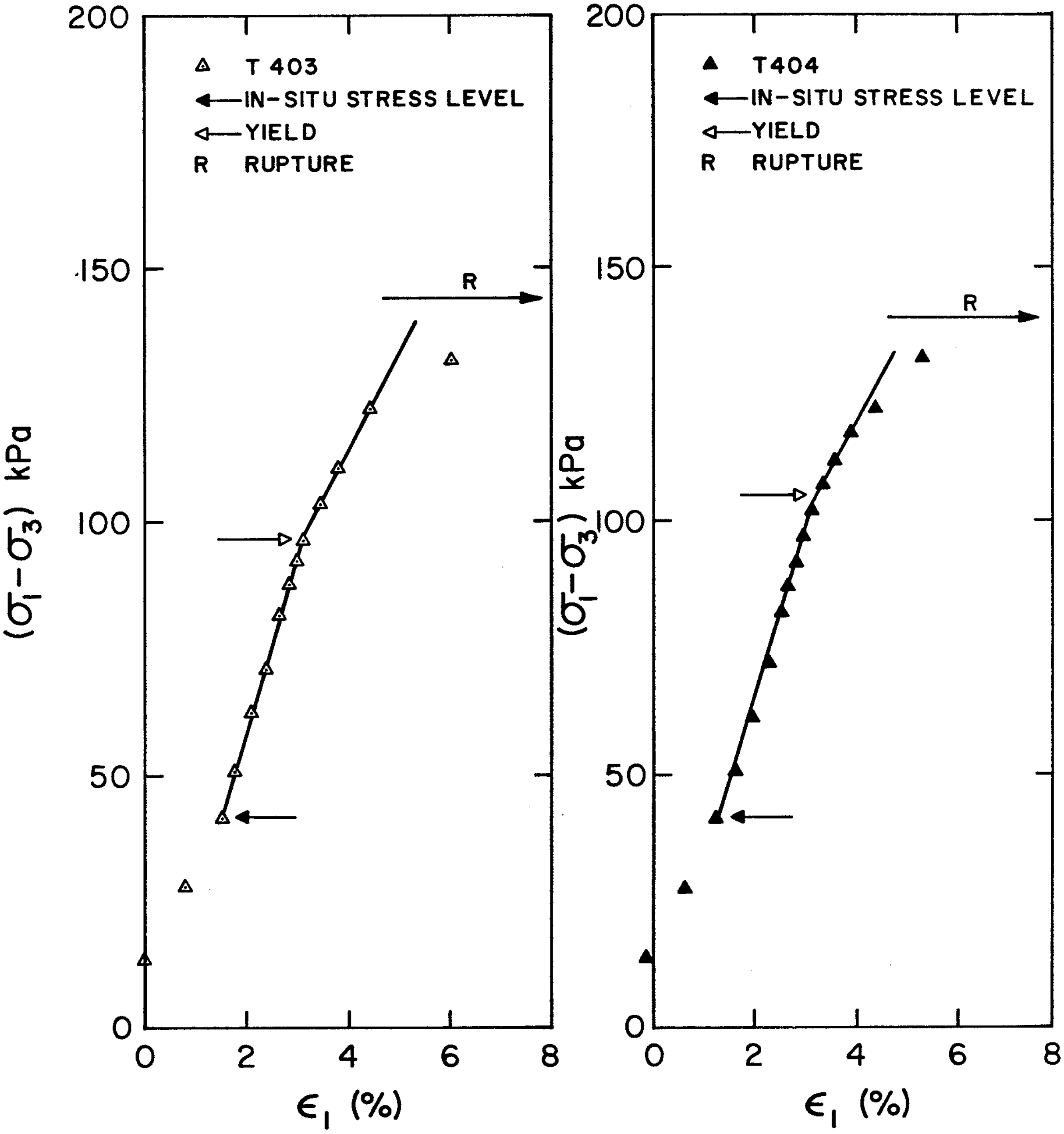


FIG. 3.8 YIELD DETERMINATION, $(\sigma_1-\sigma_3)$ vs ε_1; T403, T404

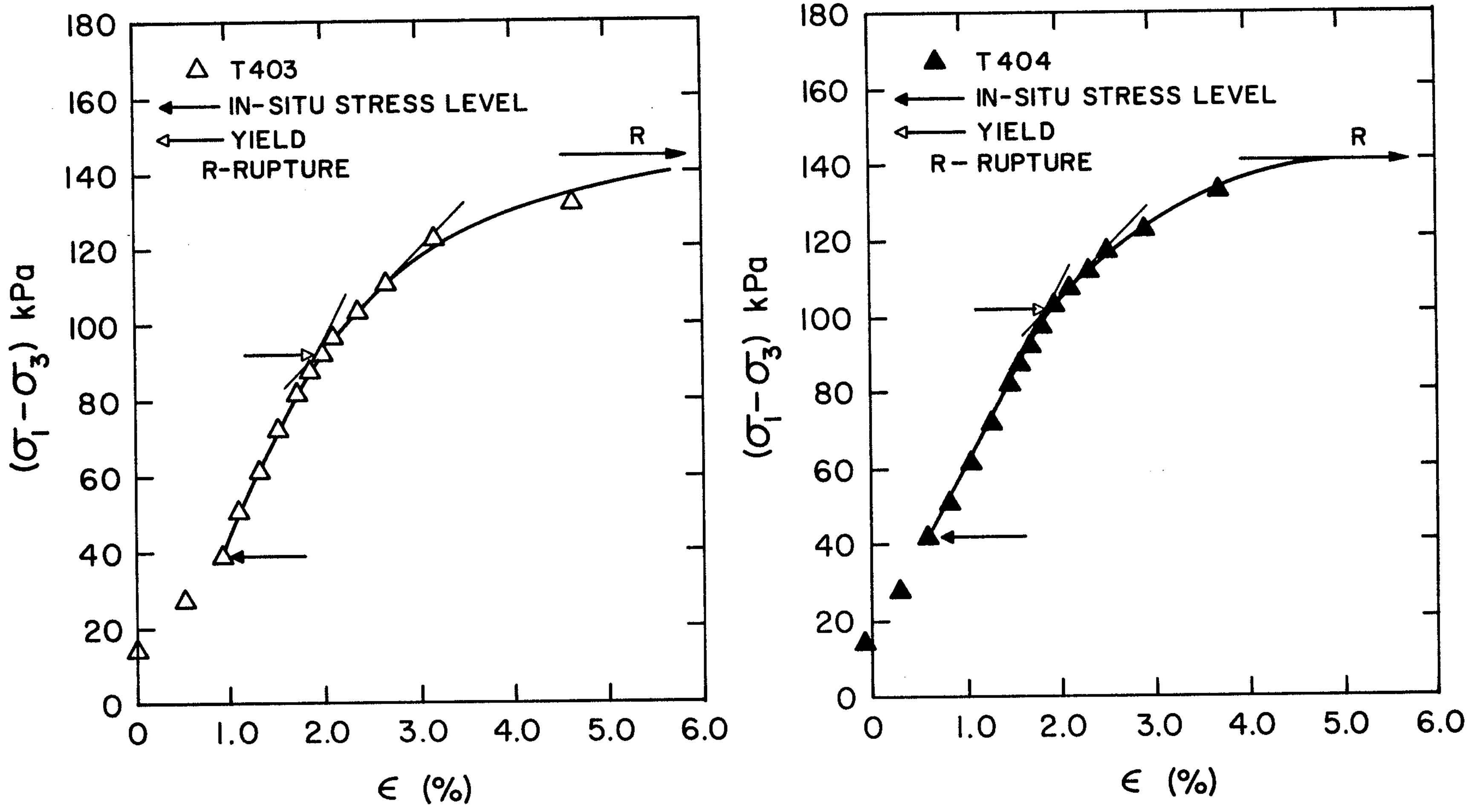


FIG. 3.9 YIELD DETERMINATION, $(\sigma_1-\sigma_3)$ vs ε; T403, T404

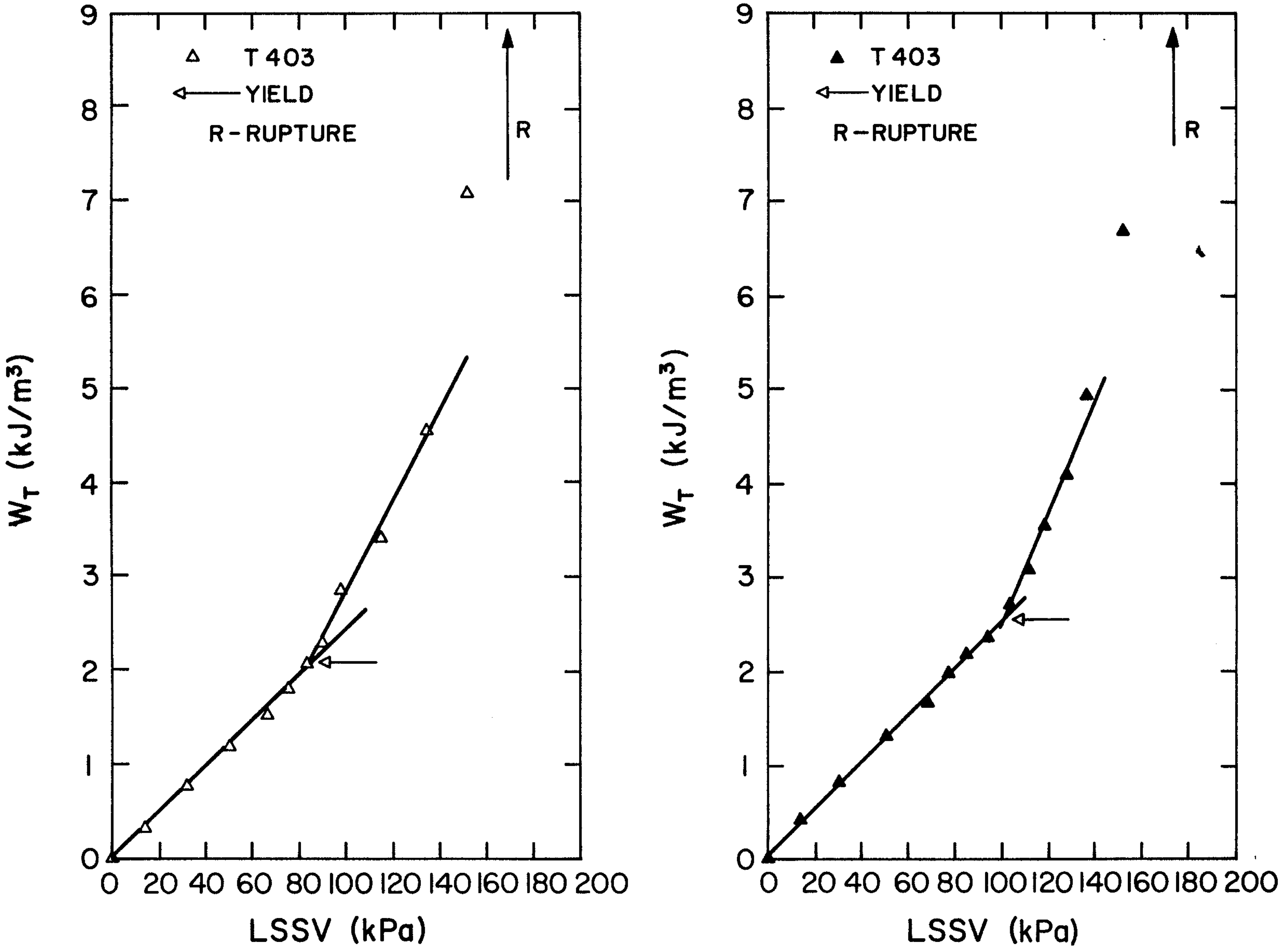


FIG. 3.10 YIELD DETERMINATION, W_T vs LSSV; T403, T404

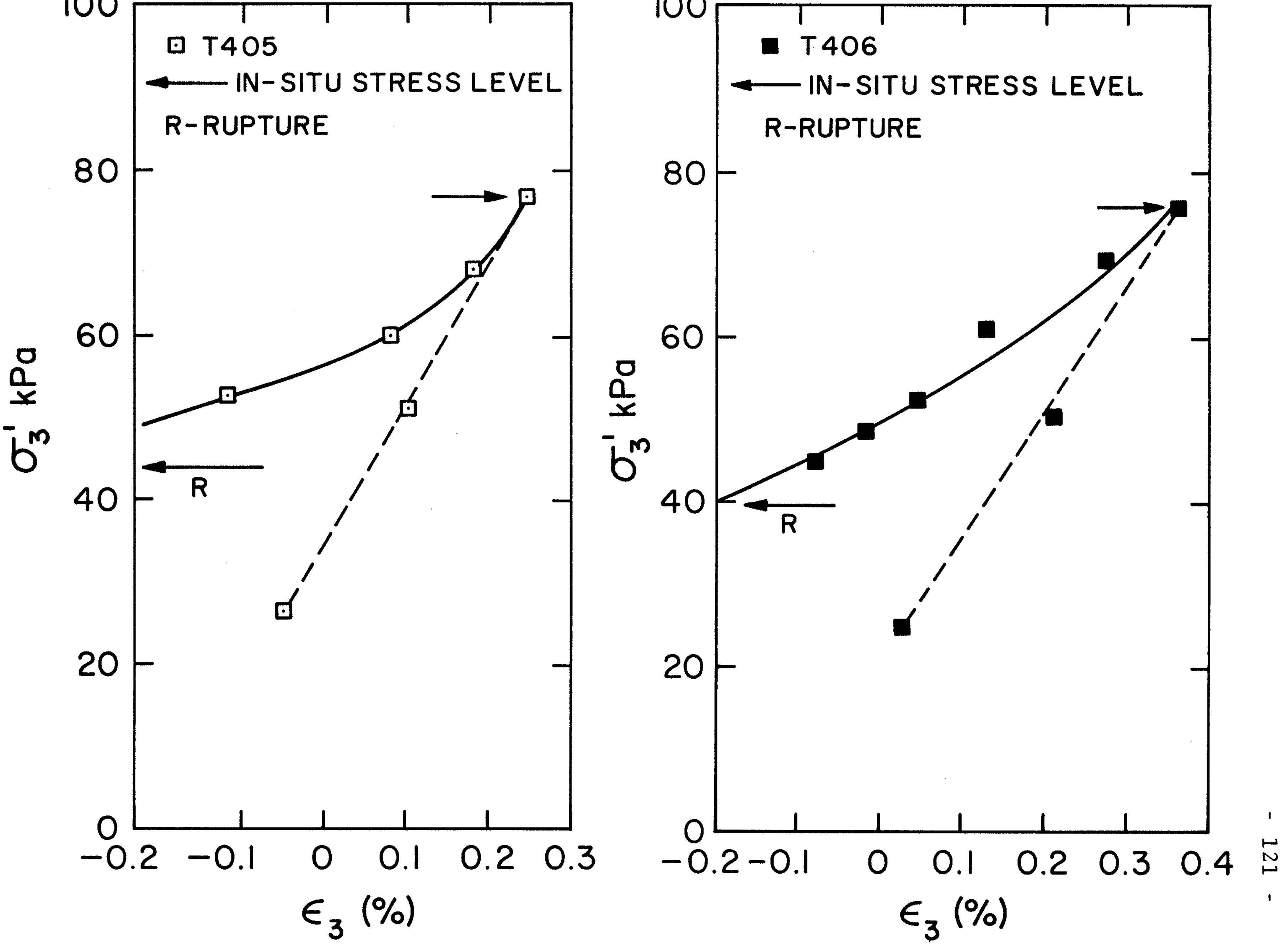


FIG. 3.11 YIELD DETERMINATION, σ_3' vs ε_3; T405, T406

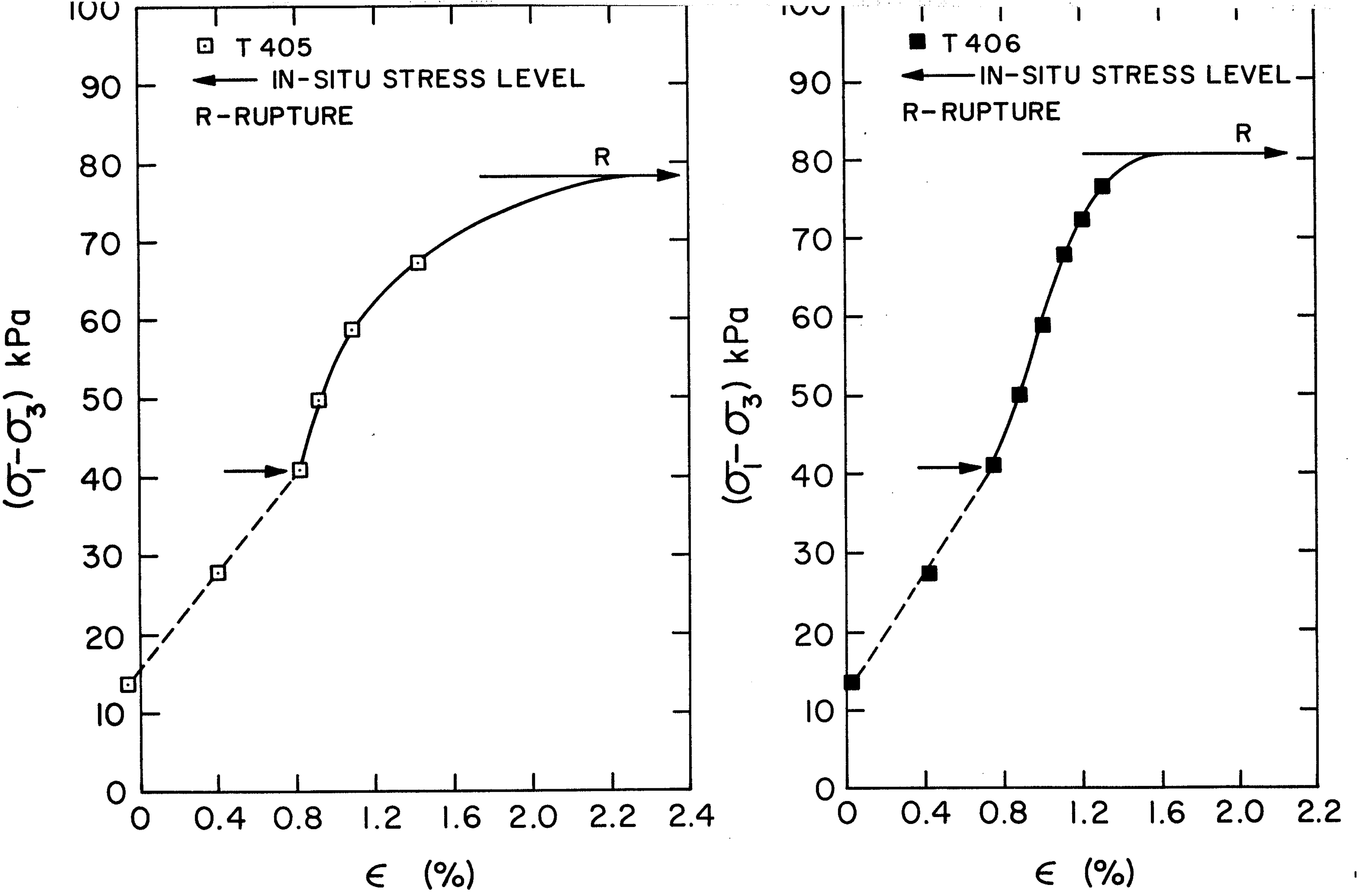


FIG. 3.12 YIELD DETERMINATION, $(\sigma_1-\sigma_3)$ vs ε; T405, T406

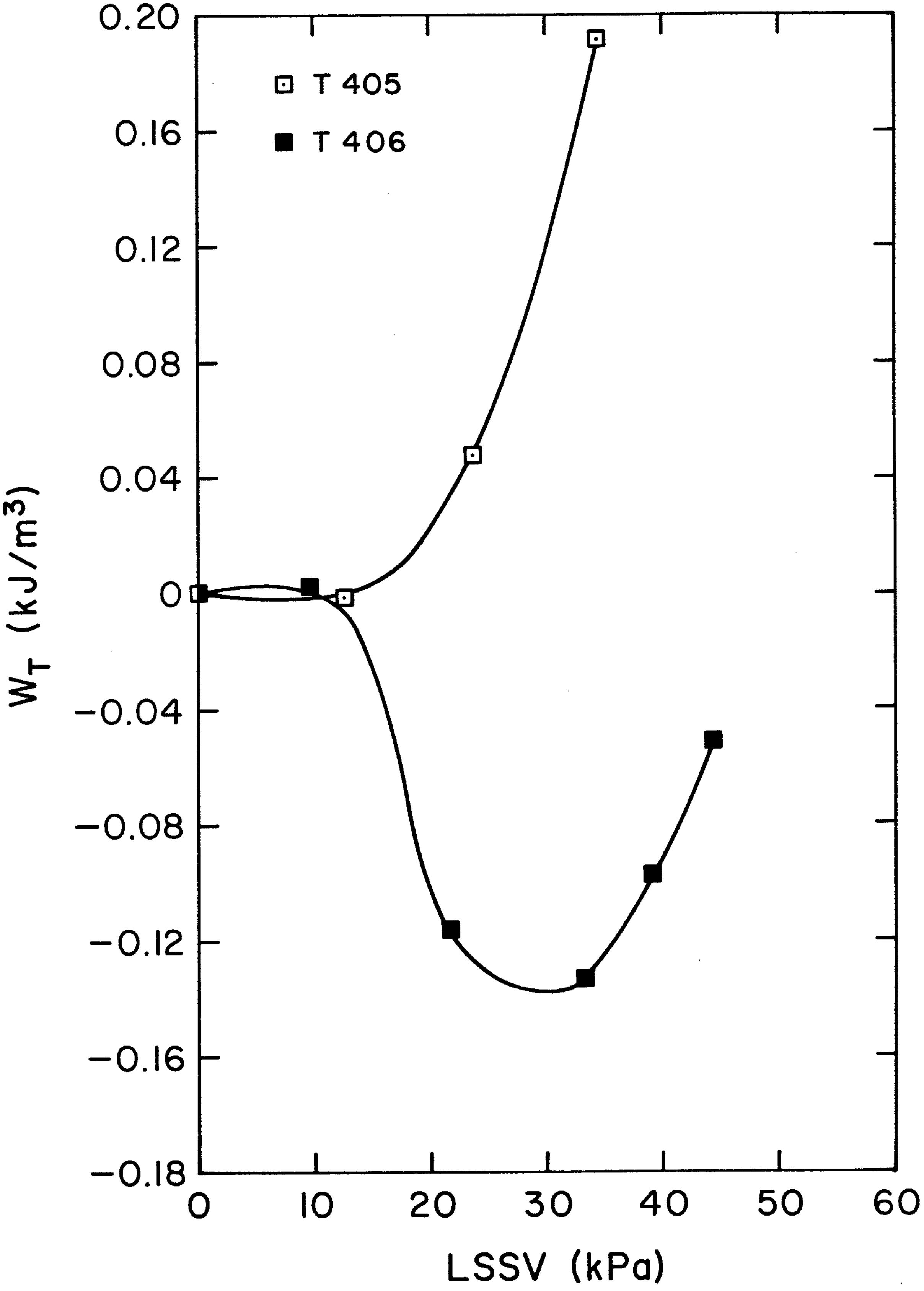


FIG. 3.13 YIELD DETERMINATION, W_T vs LSSV; T403, T404

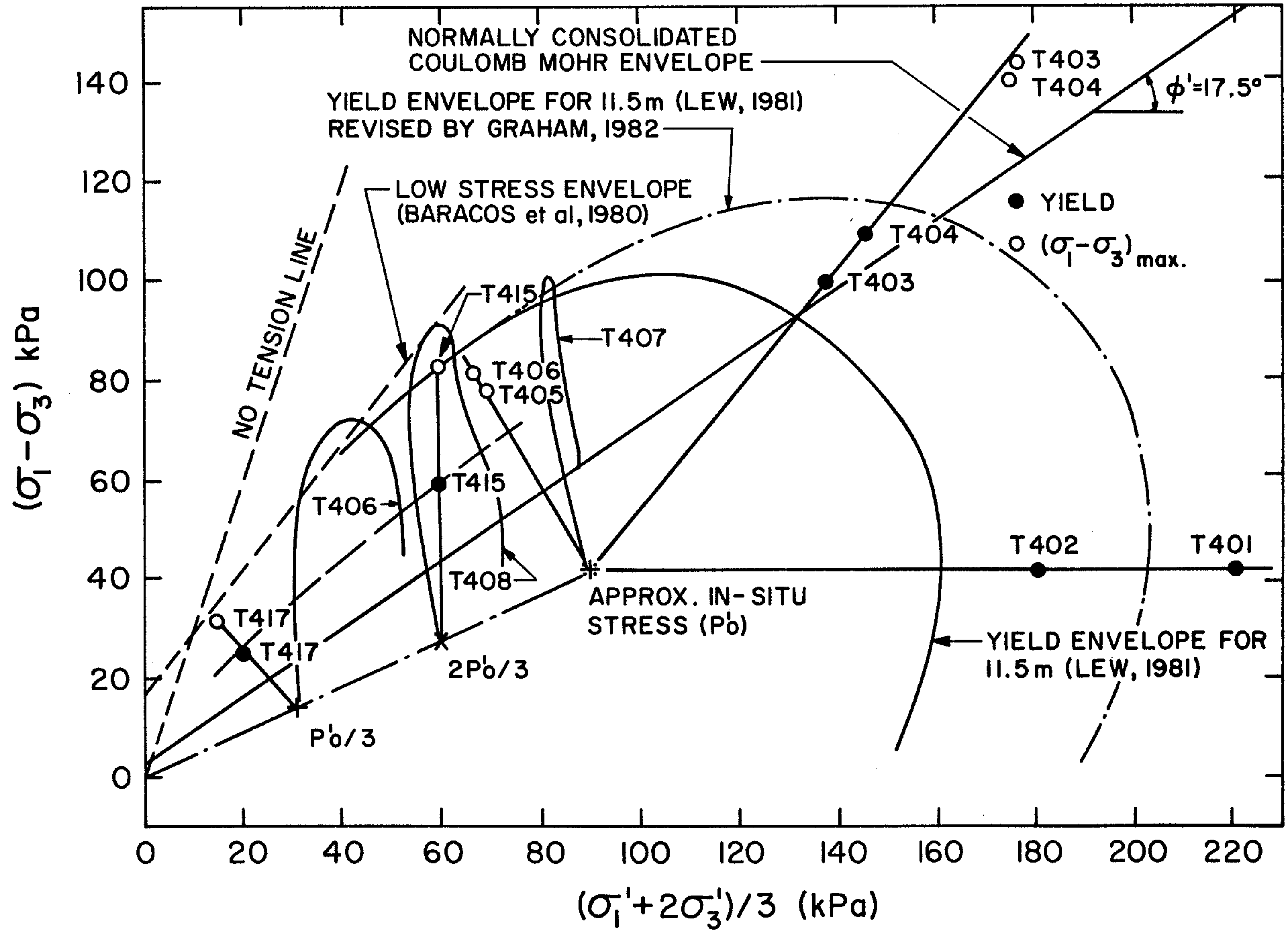


FIG. 3.14 YIELD AND MAXIMUM DEVIATOR STRESSES FOR UNDISTURBED SAMPLES

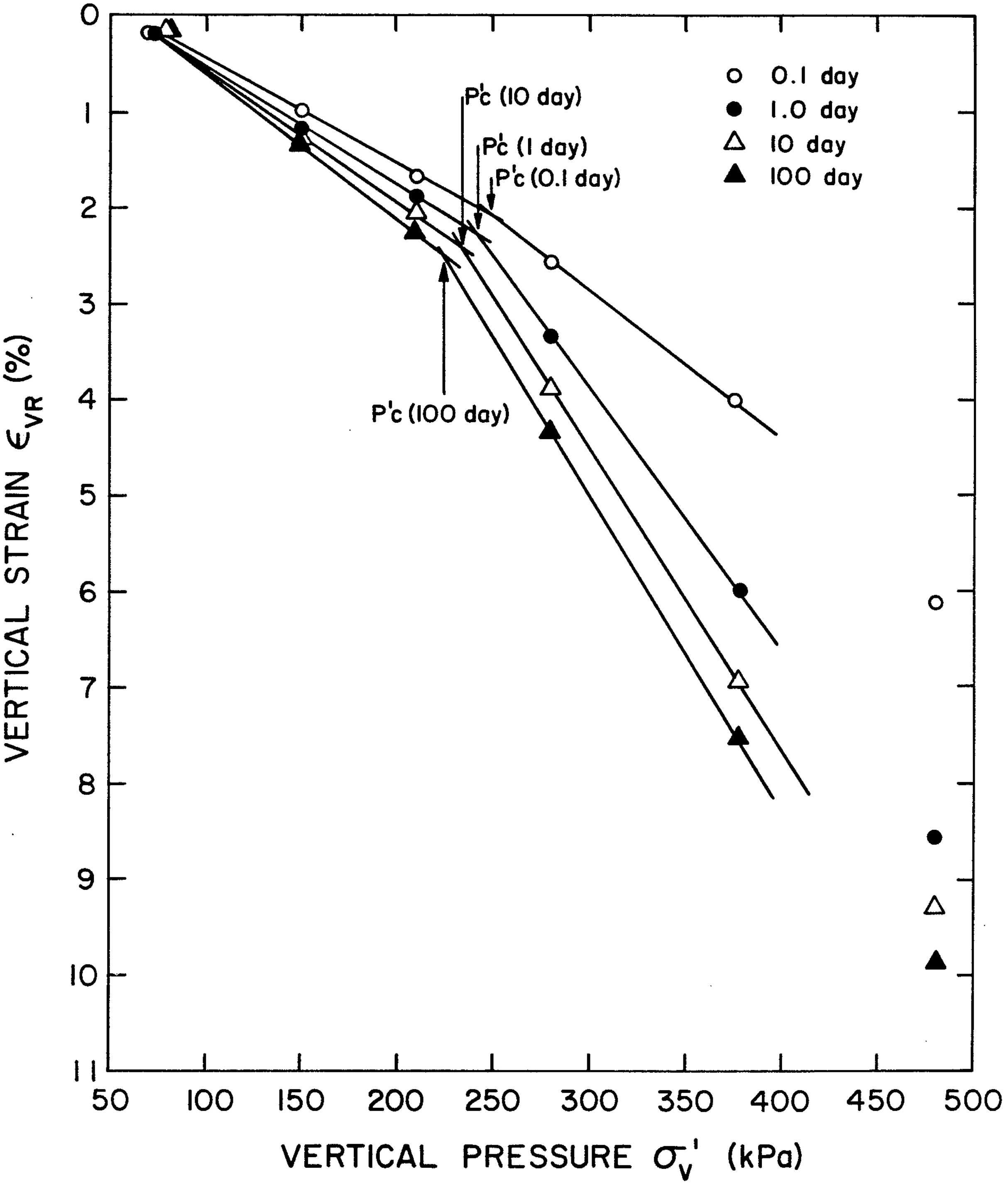


FIG. 3.15 NON-STANDARD OEDOMETER TESTS, ε_{VR} vs σ_v'

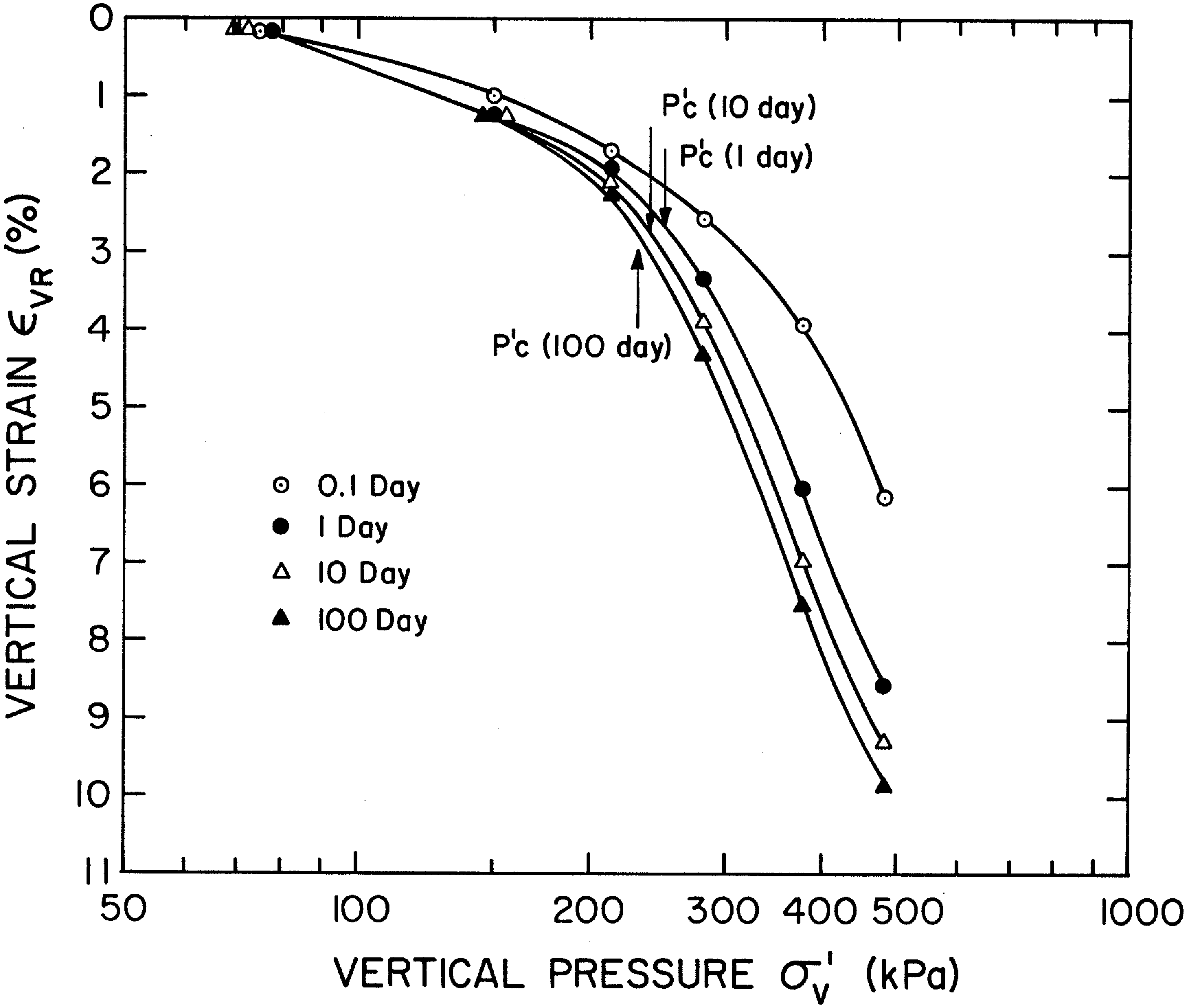


FIG. 3.16 NON-STANDARD OEDOMETER TESTS, ε_{VR} vs $\log\sigma_v'$

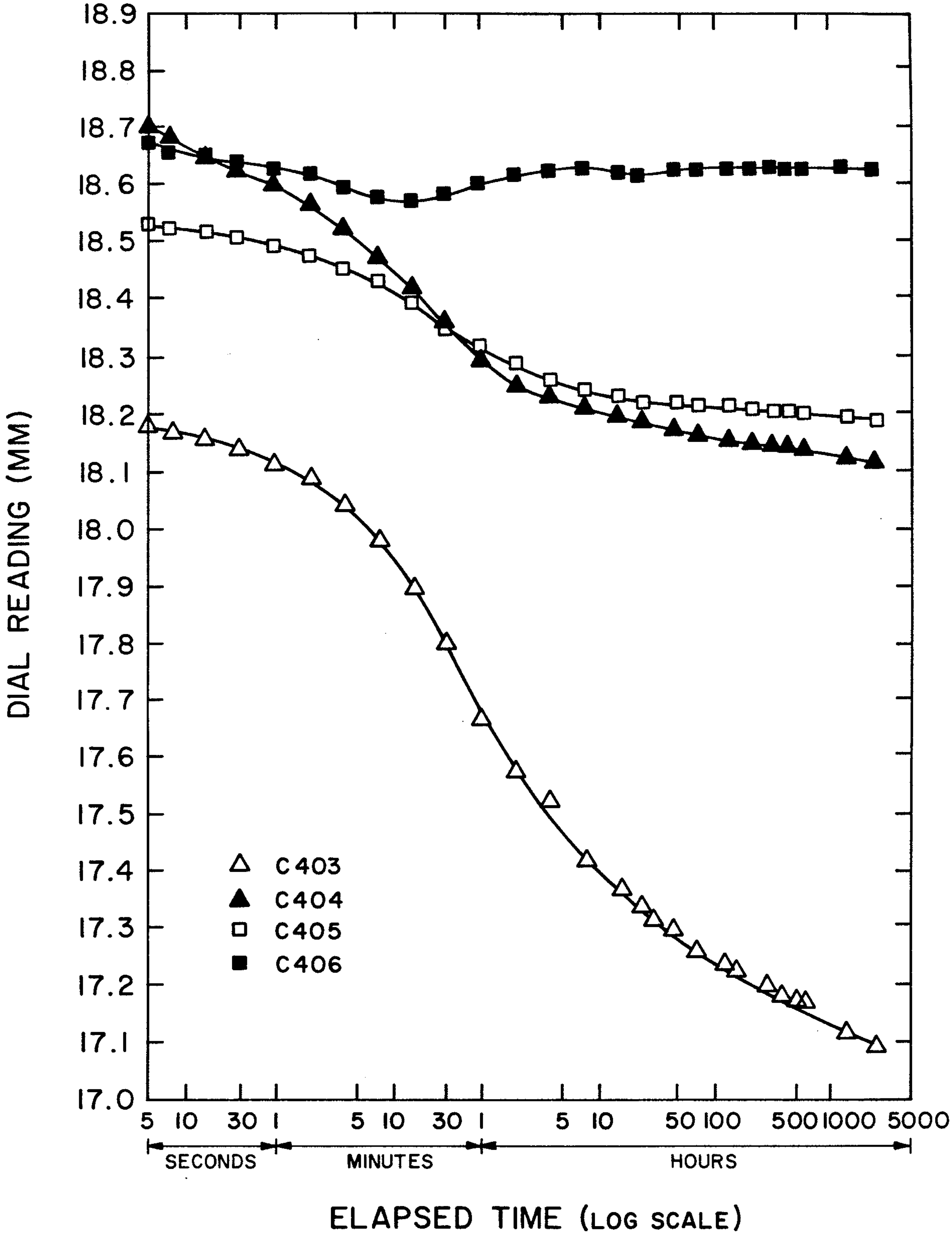


FIG. 3.17 CONSOLIDATION TIME CURVES; C403 TO C406

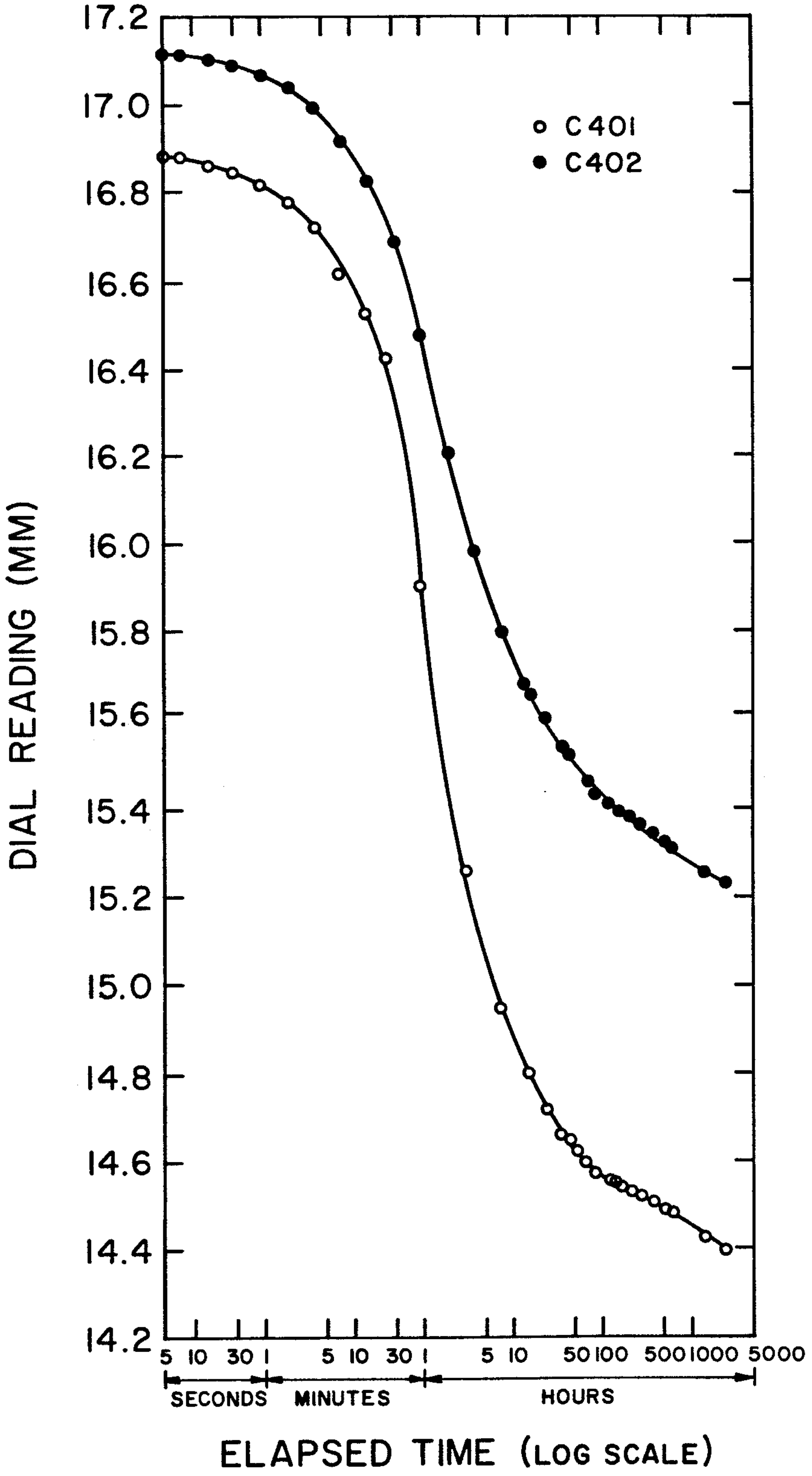


FIG. 3.18 CONSOLIDATION TIME CURVES; C401 TO C402

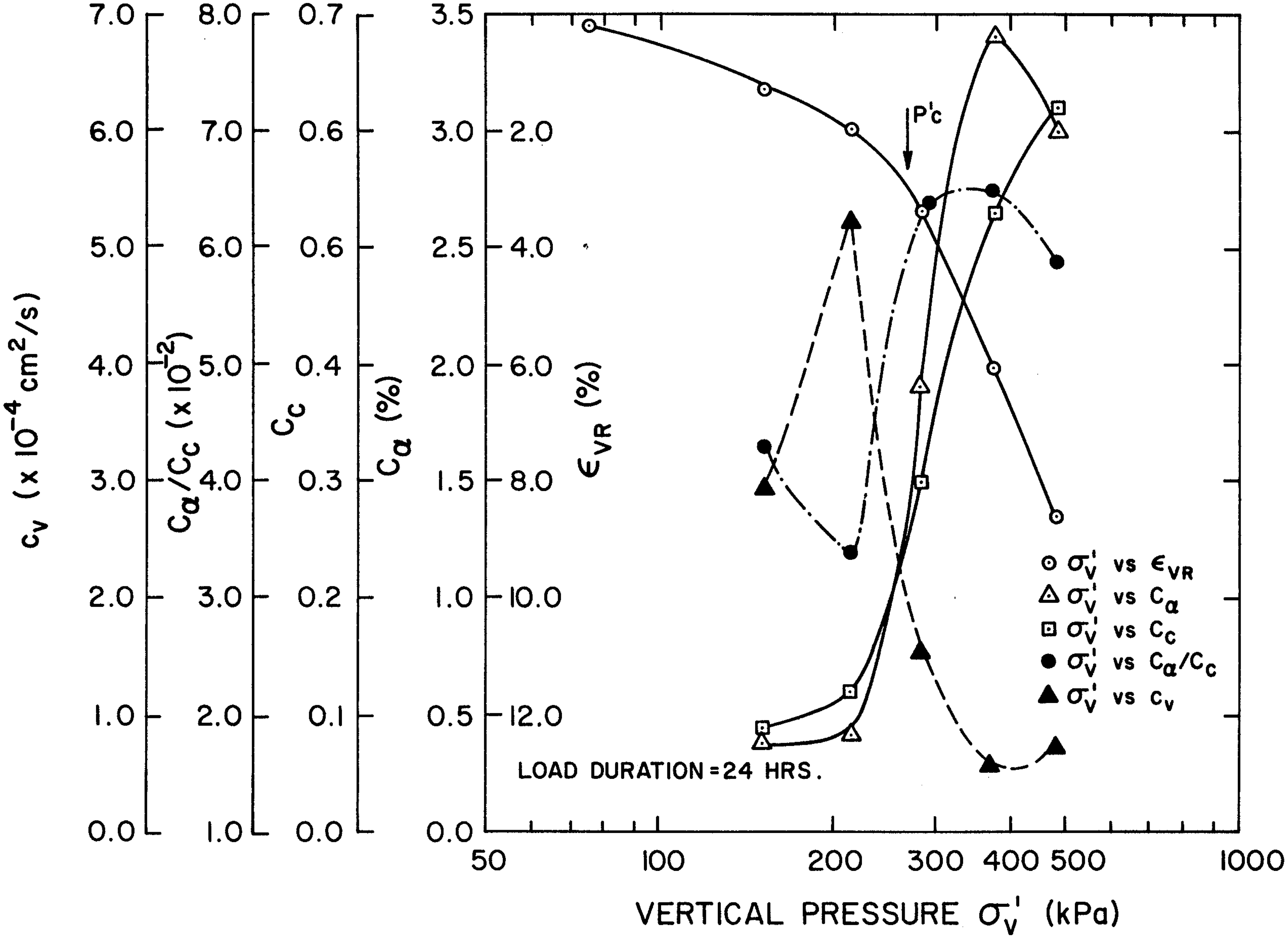


FIG. 3.19 GRAPH OF c_v, C_c, C_α, C_α/C_c, ϵ_{VR} vs $\log\sigma_v'$ FOR NON-STANDARD OEDOMETER TESTS AT 24 HOUR LOAD DURATION

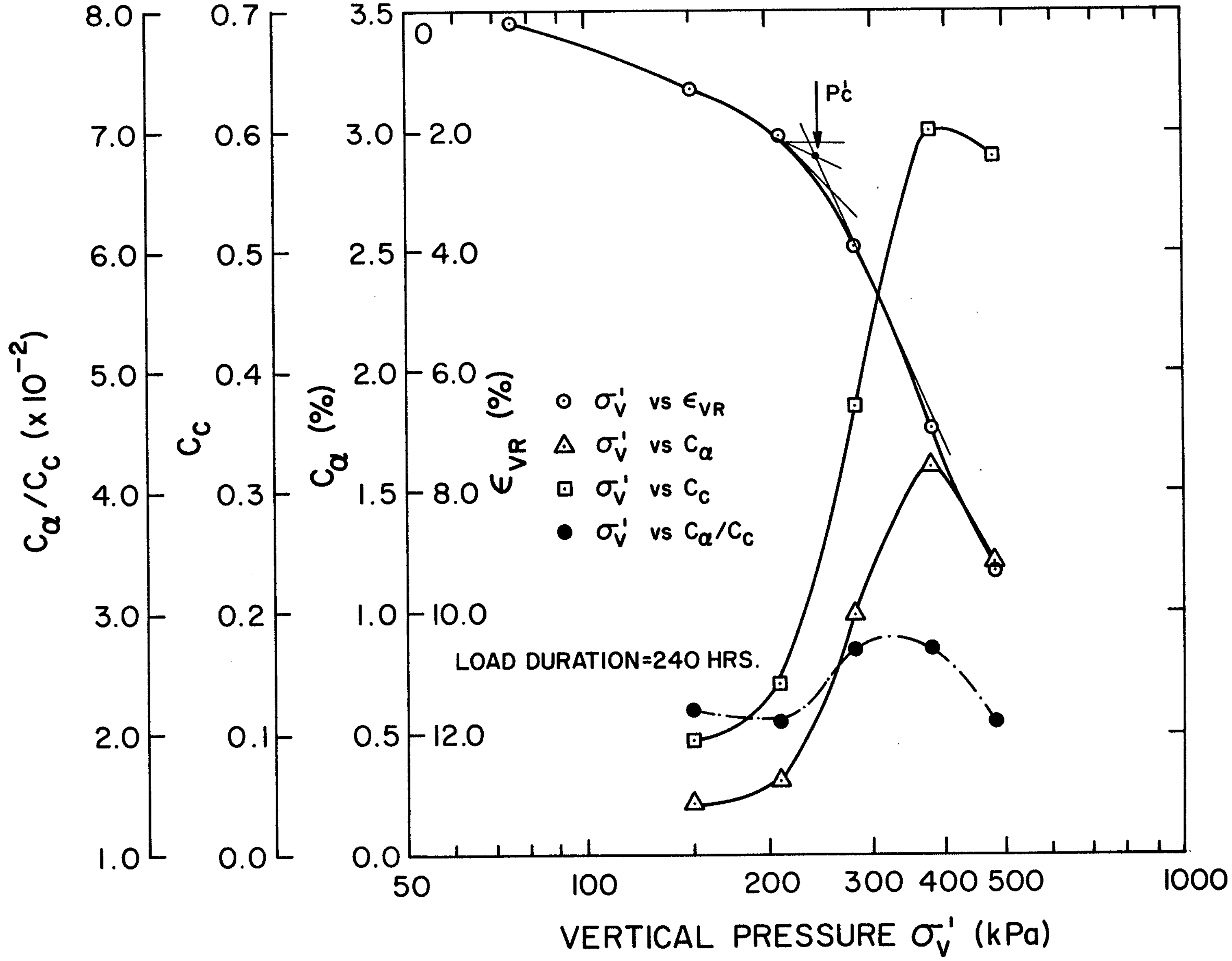


FIG. 3.20 GRAPH OF C_c, C_α, C_α/C_c, ϵ_{VR} vs $\log\sigma_V'$ FOR NON-STANDARD OEDOMETER TESTS AT 240 HOUR LOAD DURATION

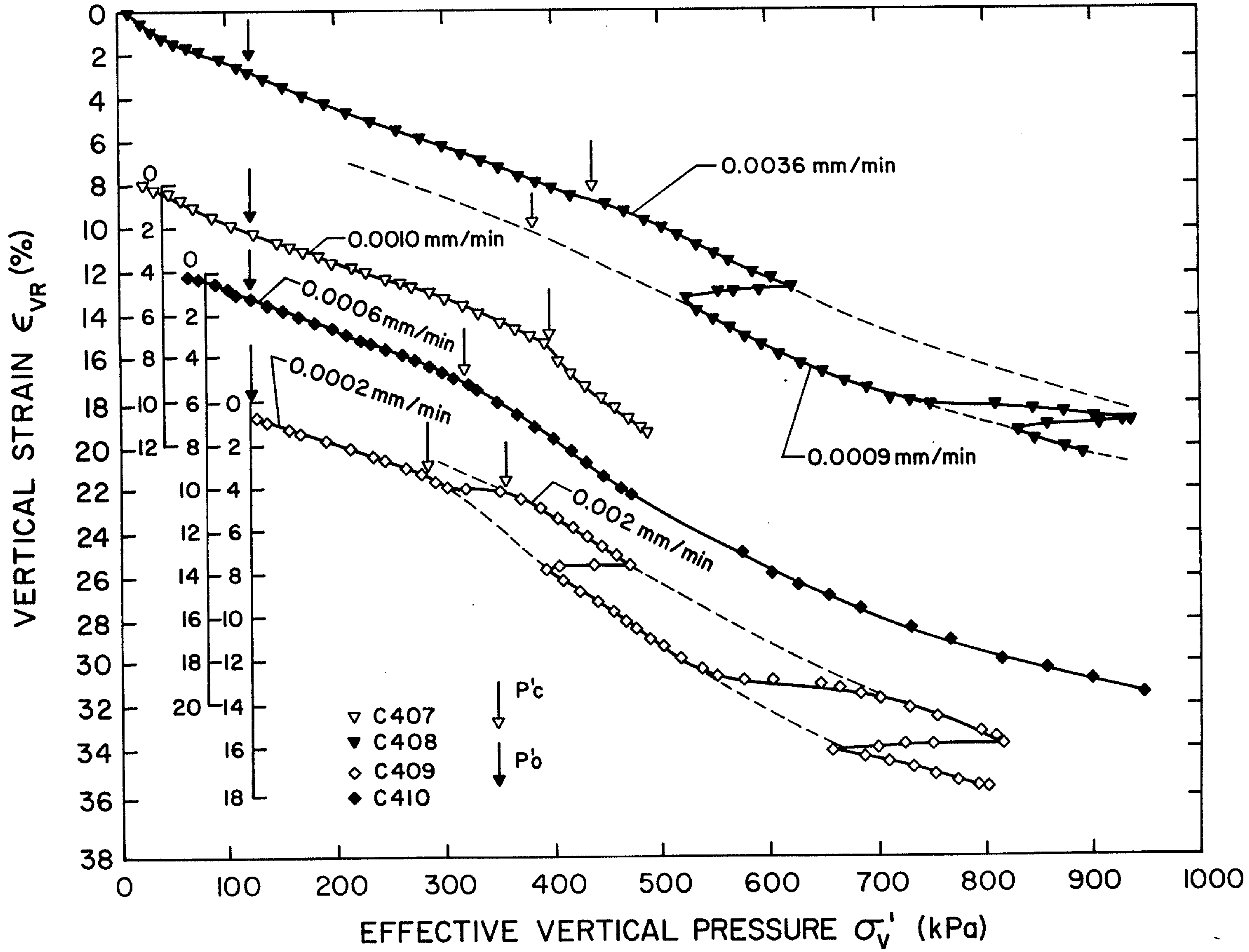


FIG. 3.21 STRAIN-RATE CONTROLLED OEDOMETER TESTS, ϵ_{VR} vs σ_v'

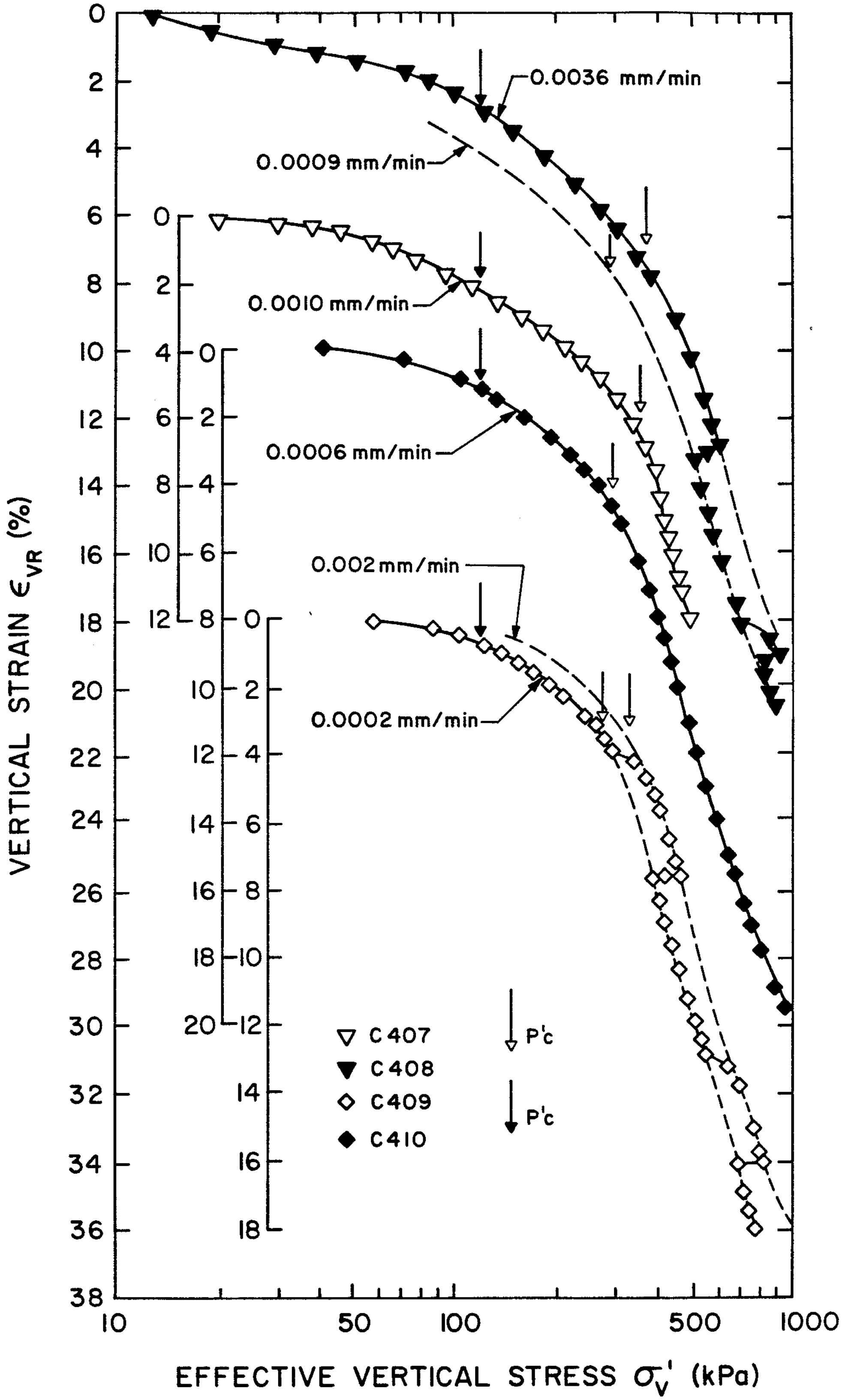


FIG. 3.22 STRAIN-RATE CONTROLLED OEDOMETER TESTS, ε_{VR} vs $\log\sigma_v'$

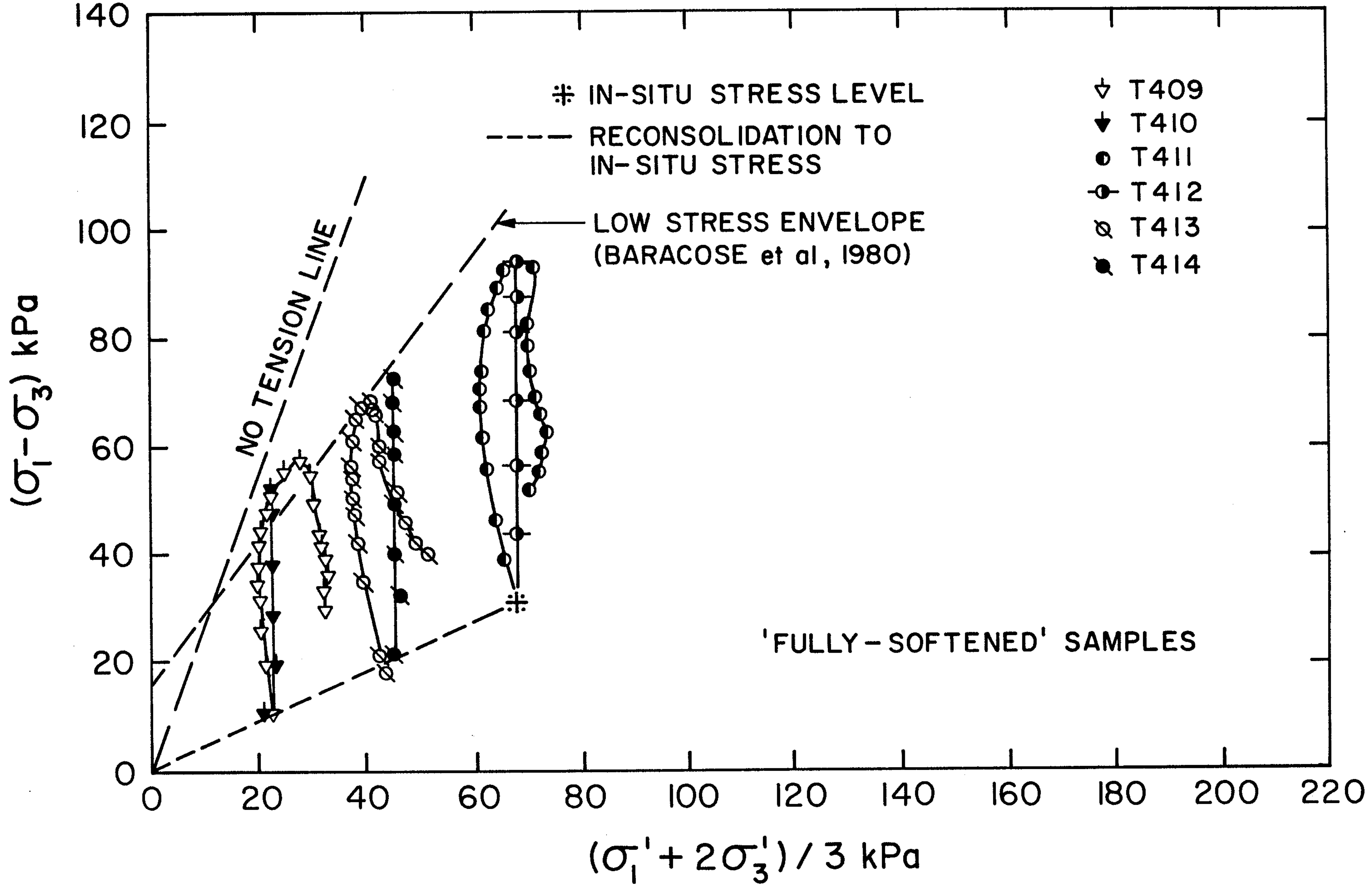


FIG. 4.1 STRESS APTHS FOLLOWED BY 'FULLY-SOFTENED' SAMPLES DURING TEST PROGRAM

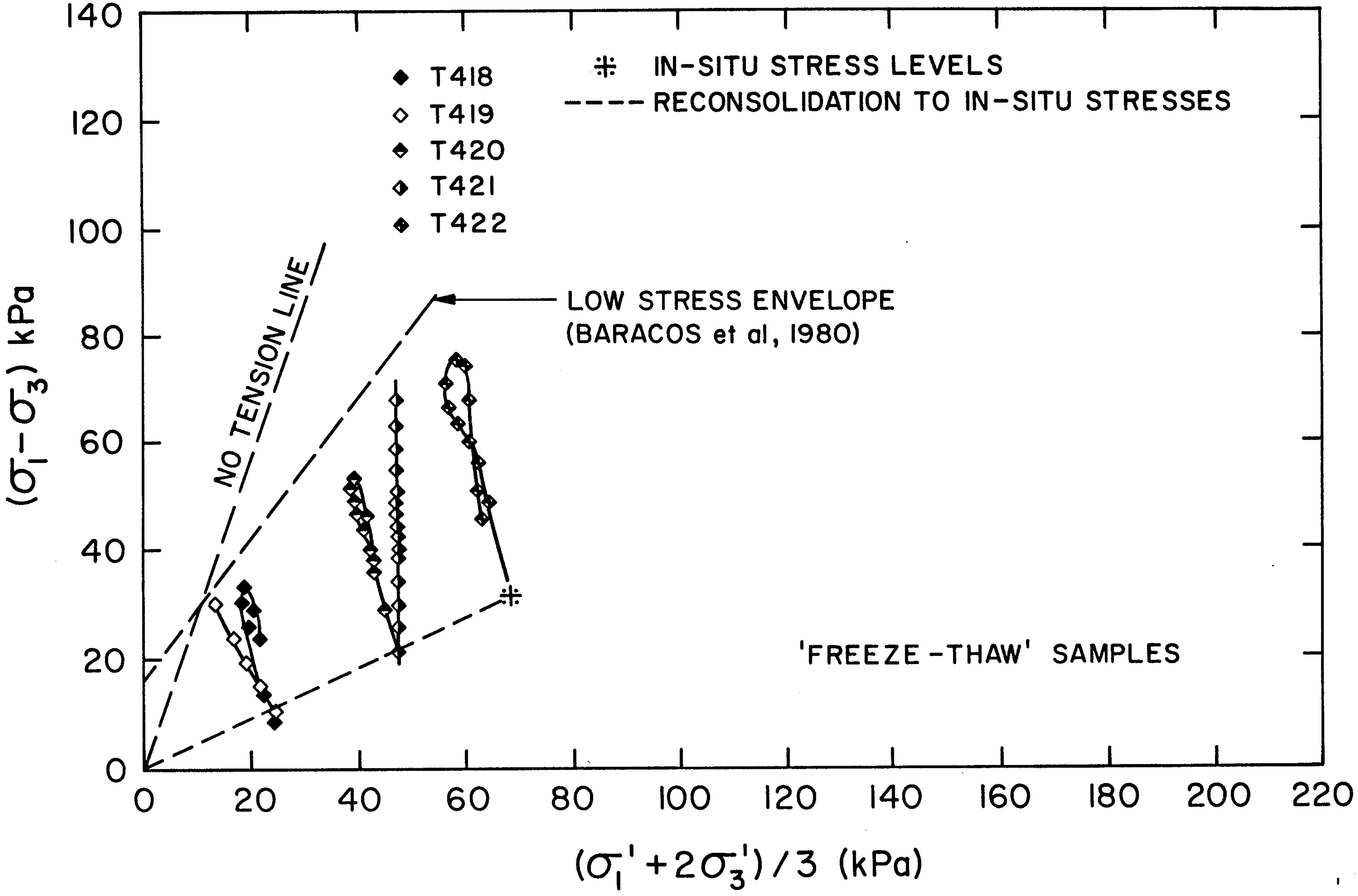


FIG. 4.2 STRESS PATHS FOLLOWED BY 'FREEZE-THAW' SAMPLES DURING TEST PROGRAM

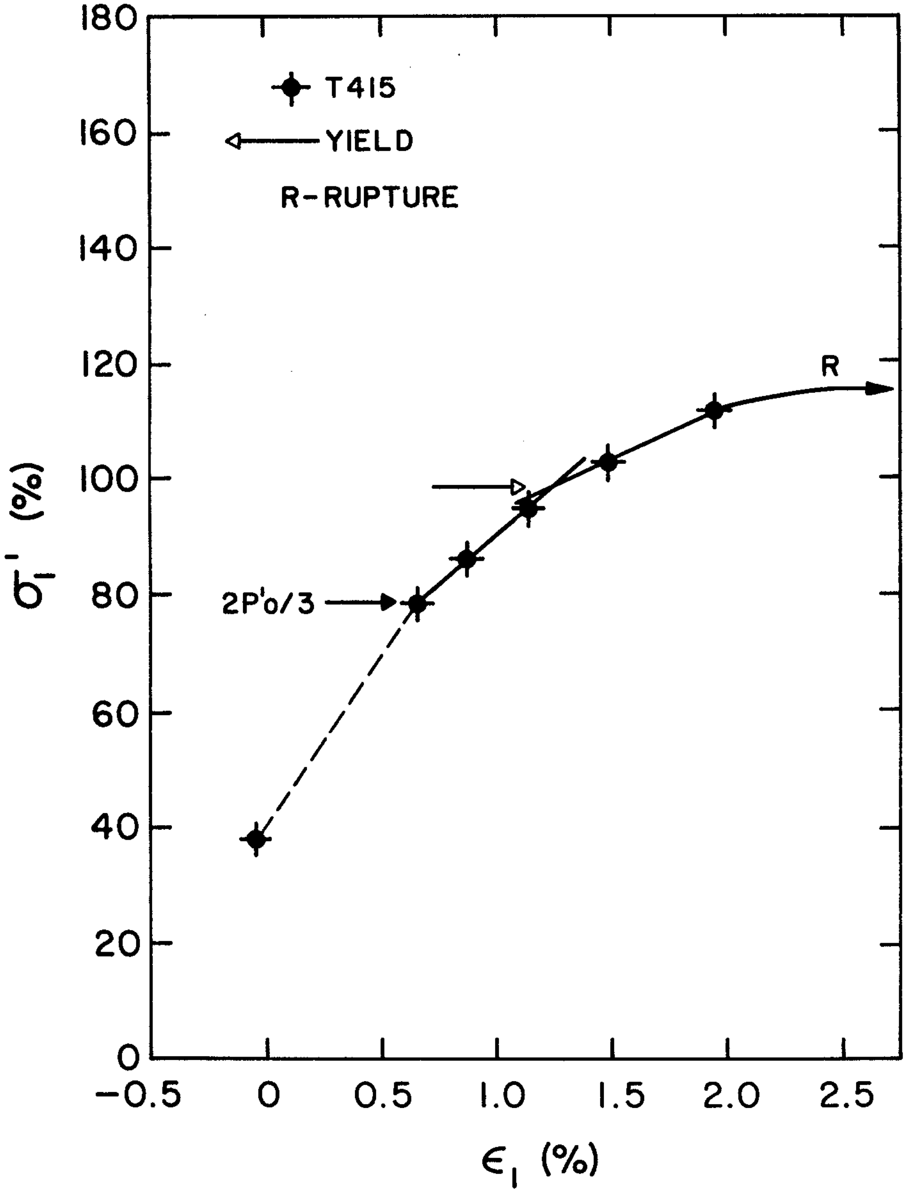


FIG. 4.3 YIELD DETERMINATION, σ_1' vs ε_1; T415

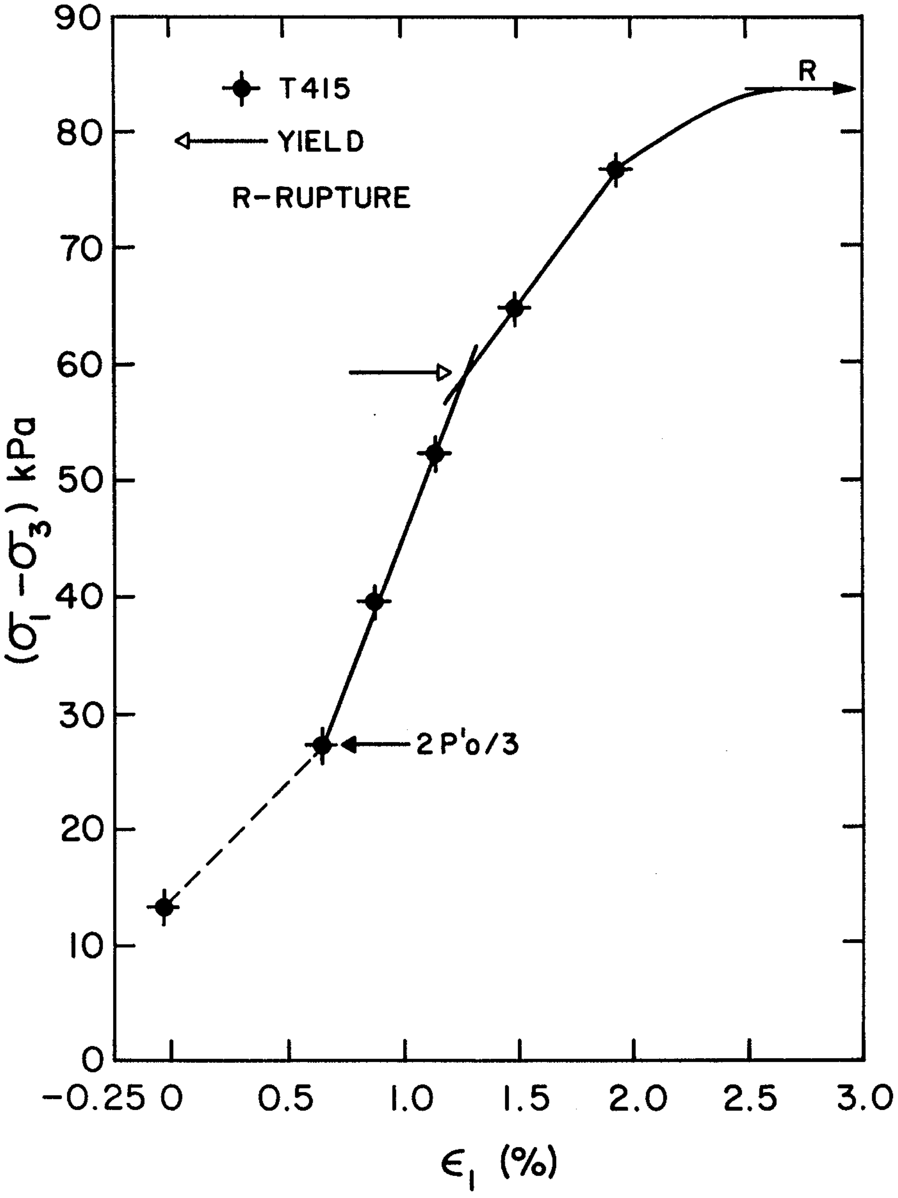


FIG. 4.4 YIELD DETERMINATION, $(\sigma_1 - \sigma_3)$ vs ε_1; T415

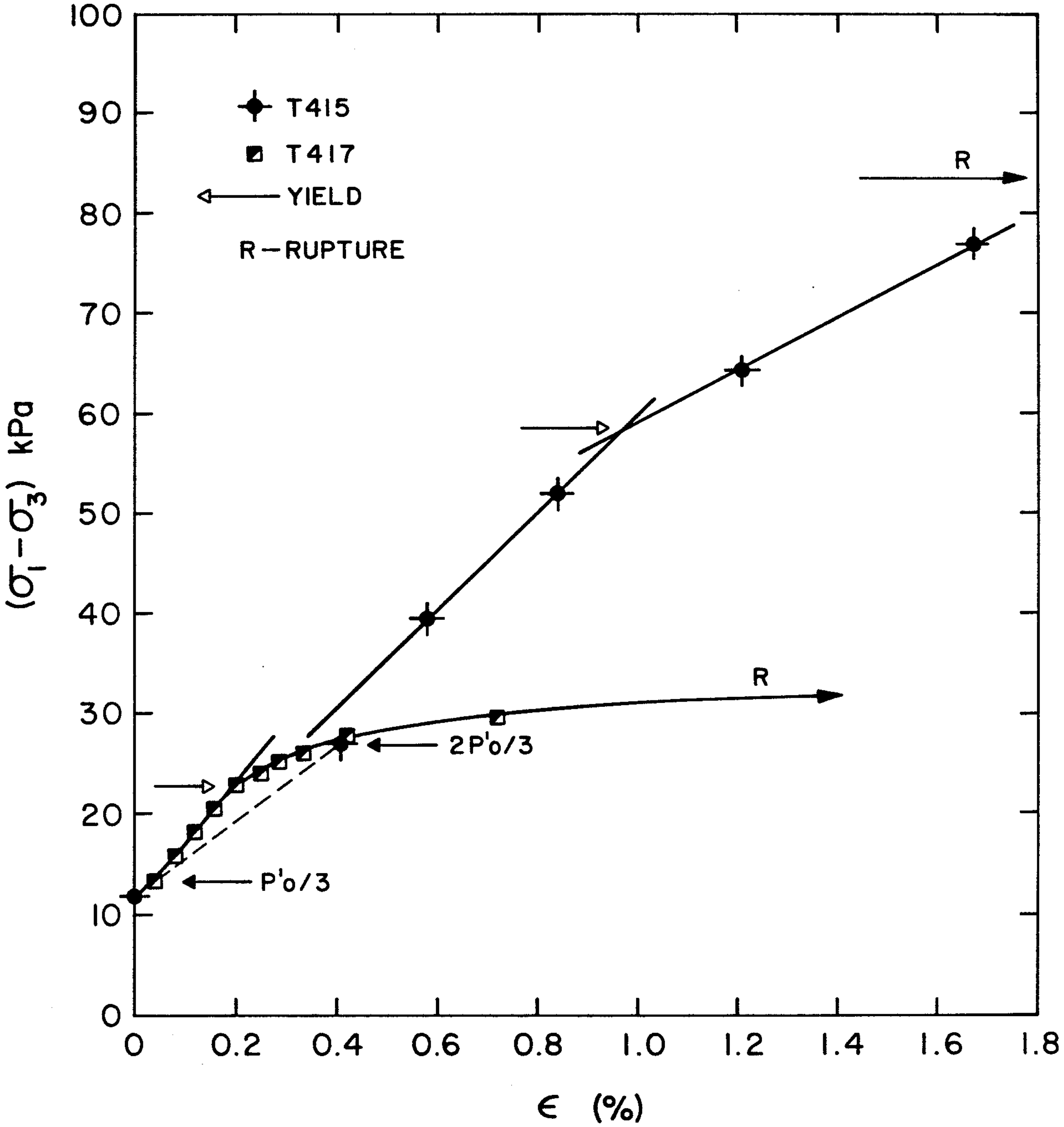


FIG. 4.5 YIELD DETERMINATION, $(\sigma_1-\sigma_3)$ vs ε; T415, T417

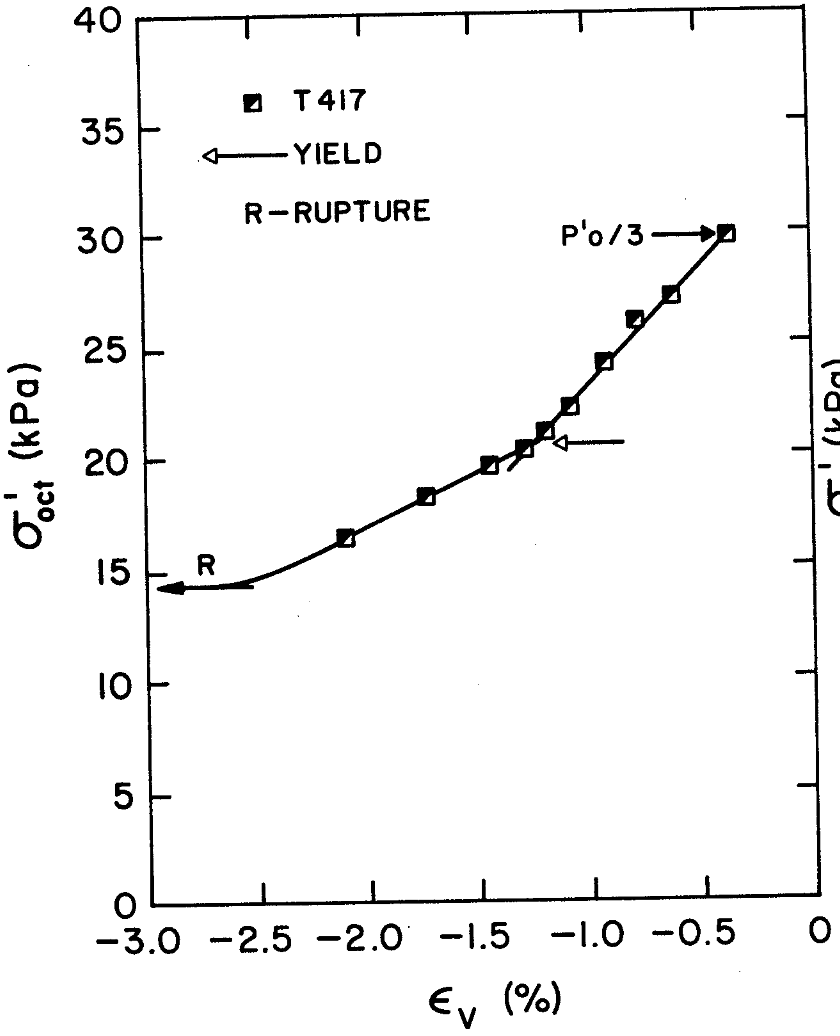


FIG. 4.6 YIELD DETERMINATION, σ'_{oct} vs ε_v; T417

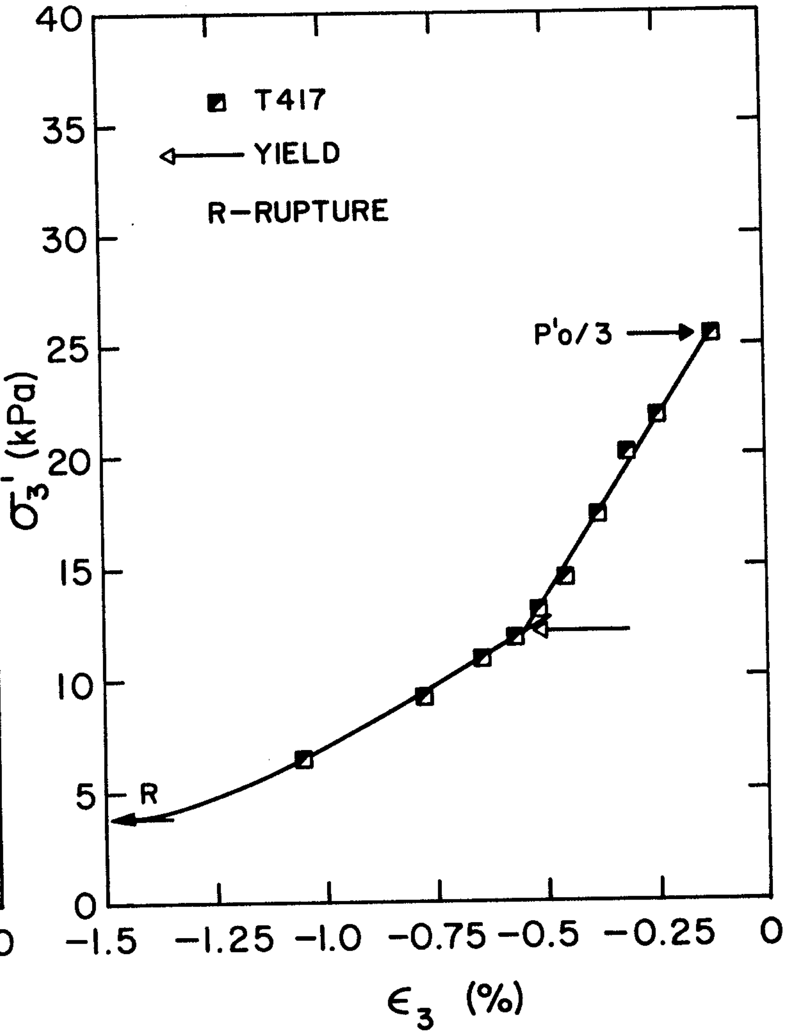


FIG. 4.7 YIELD DETERMINATION σ'_3 vs ε_3; T417

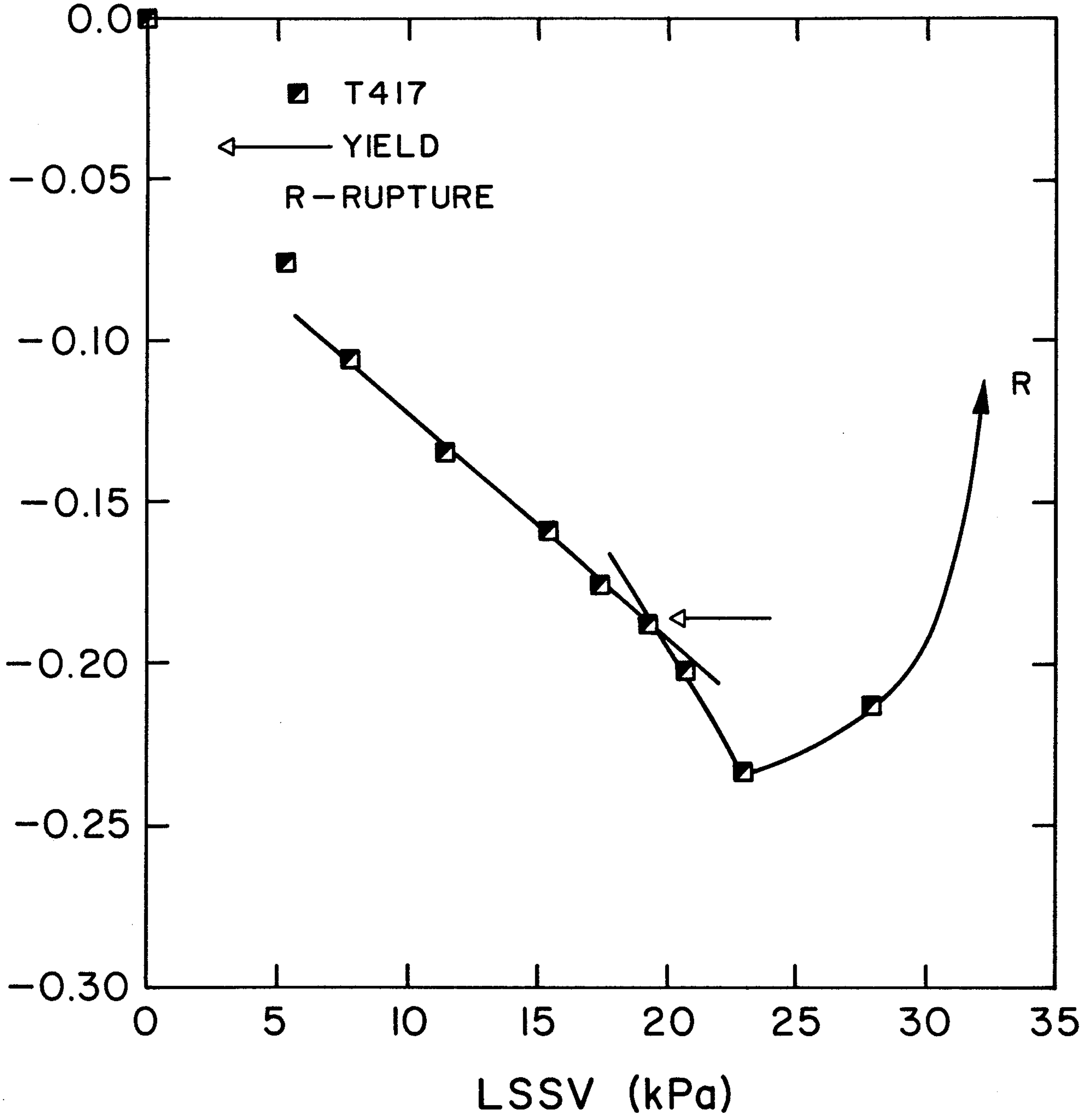


FIG. 4.8 YIELD DETERMINATION, W_T vs LSSV; T417

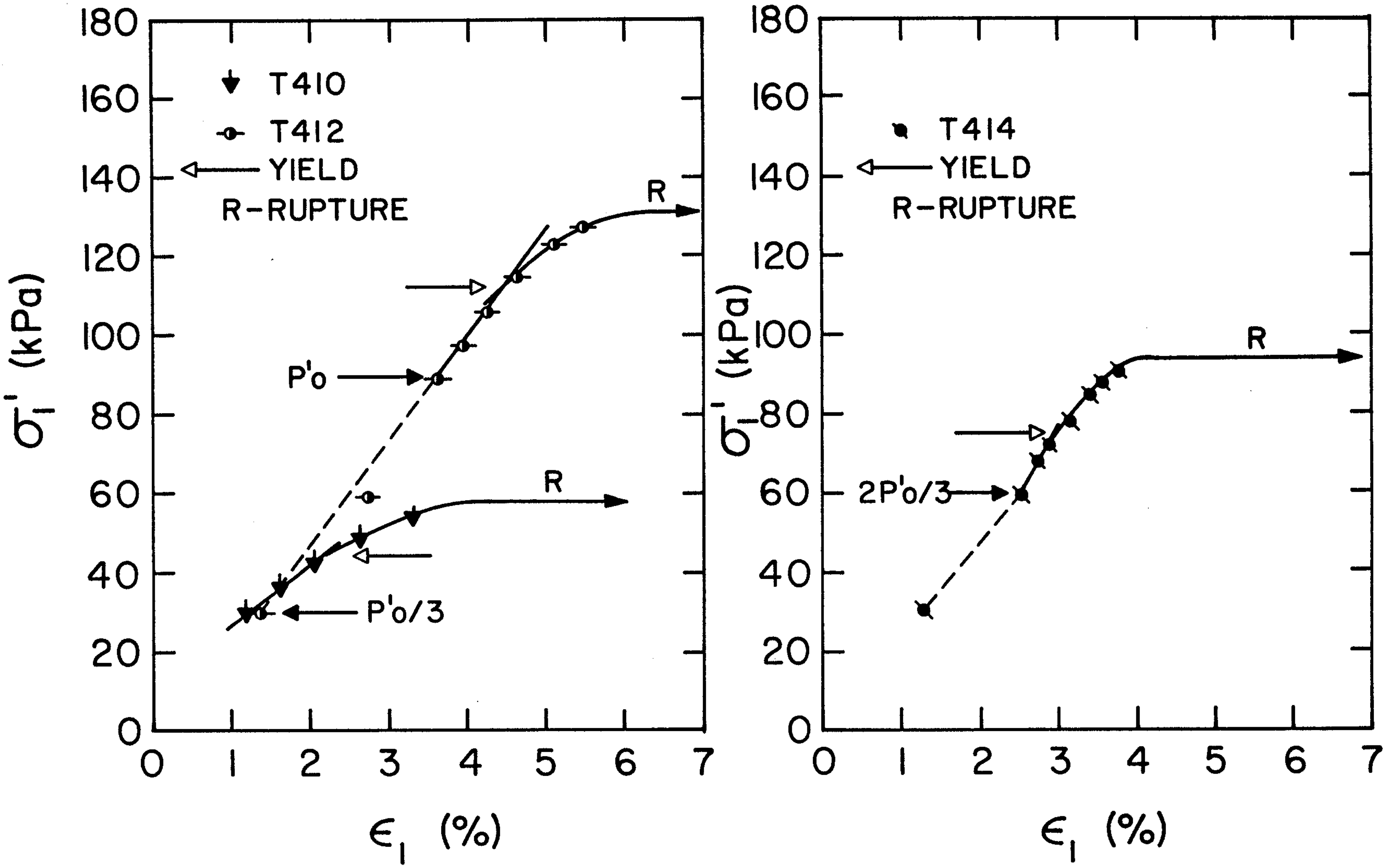


FIG. 4.9 YIELD DETERMINATION, σ_1' vs ϵ_1; T410, T412, T414

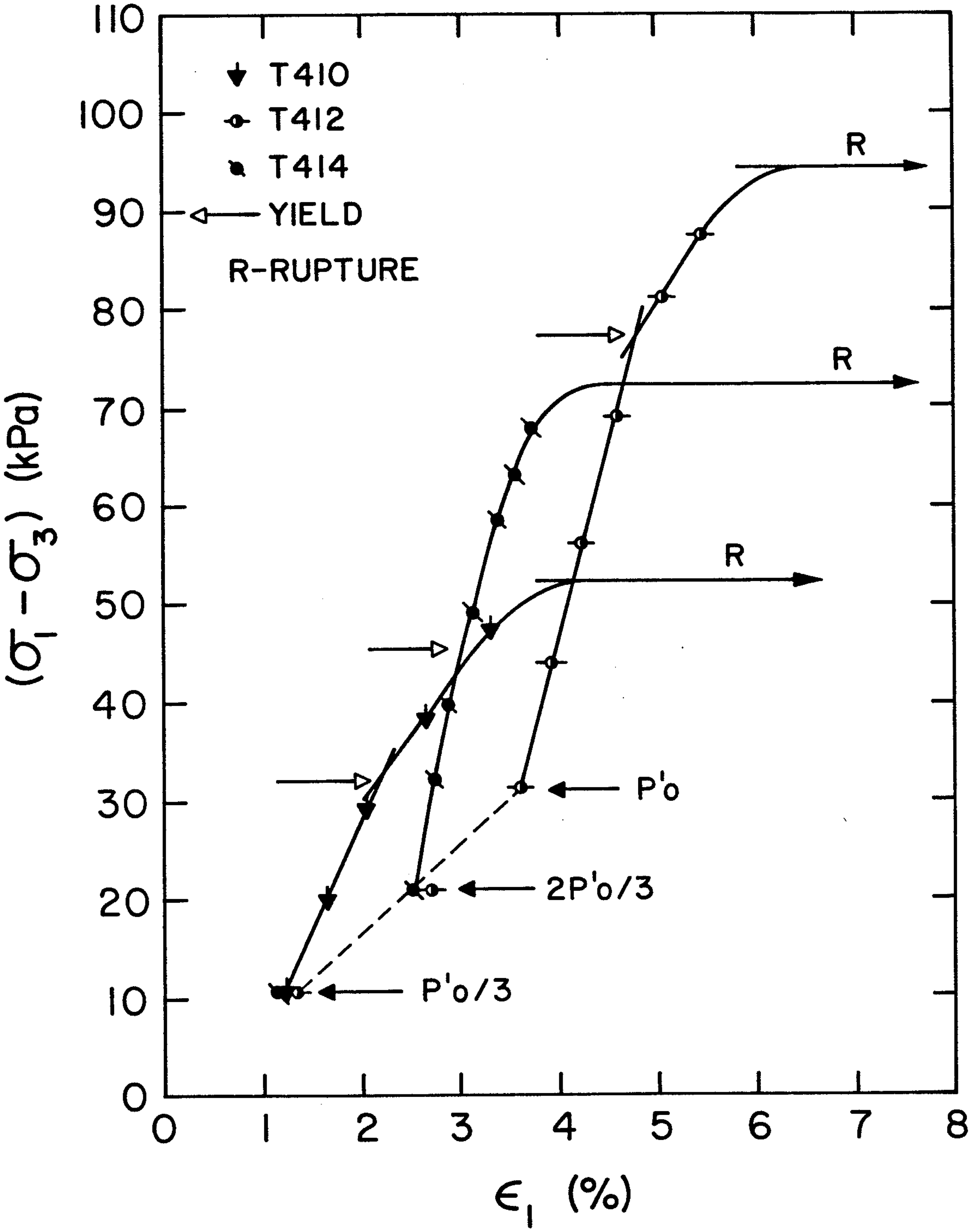


FIG. 4.10 YIELD DETERMINATION, $(\sigma_1 - \sigma_3)$ vs ε_1; T410, T412, T414

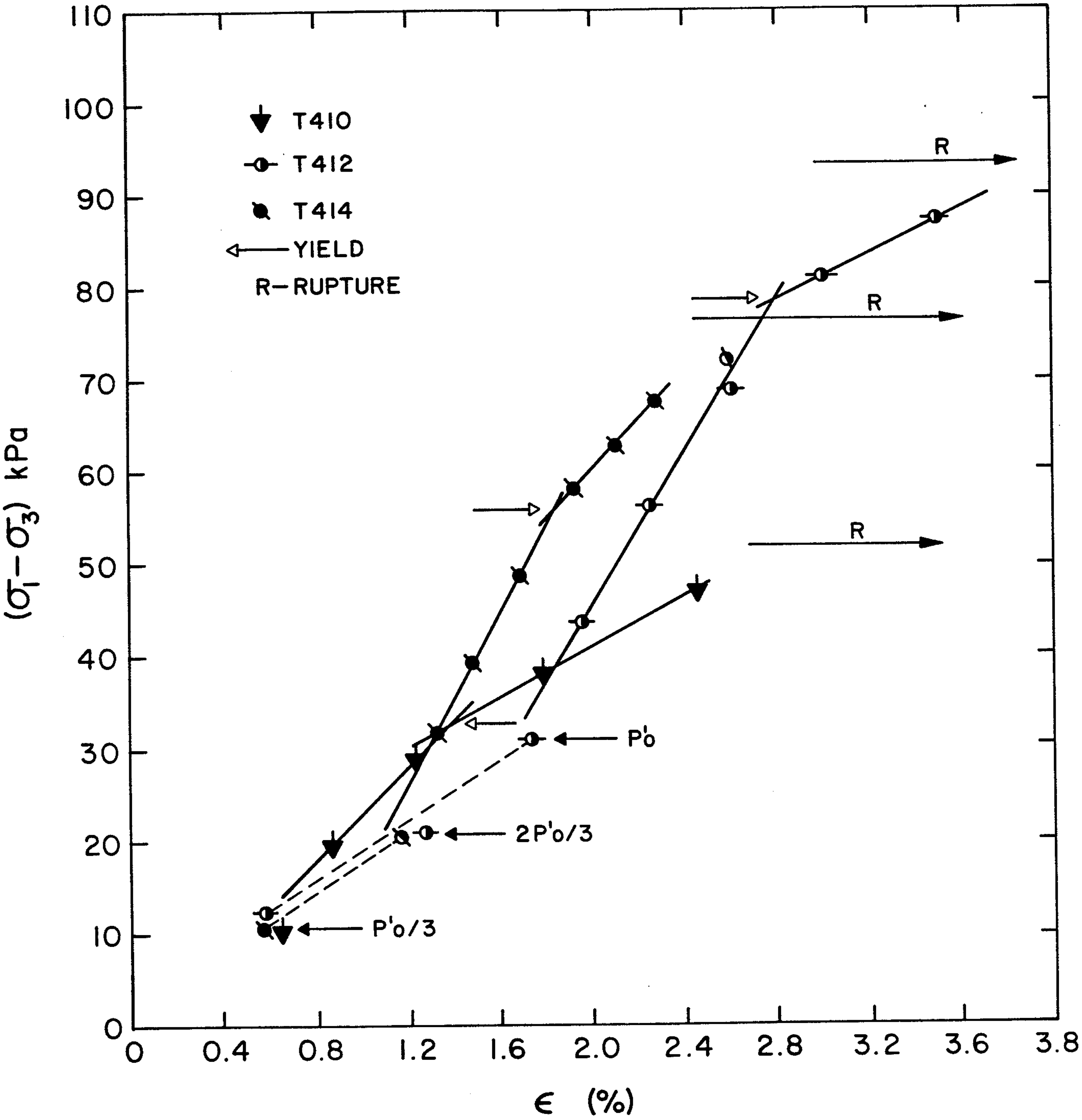


FIG. 4.11 YIELD DETERMINATION, $(\sigma_1-\sigma_3)$ vs ε; T410, T412, T414

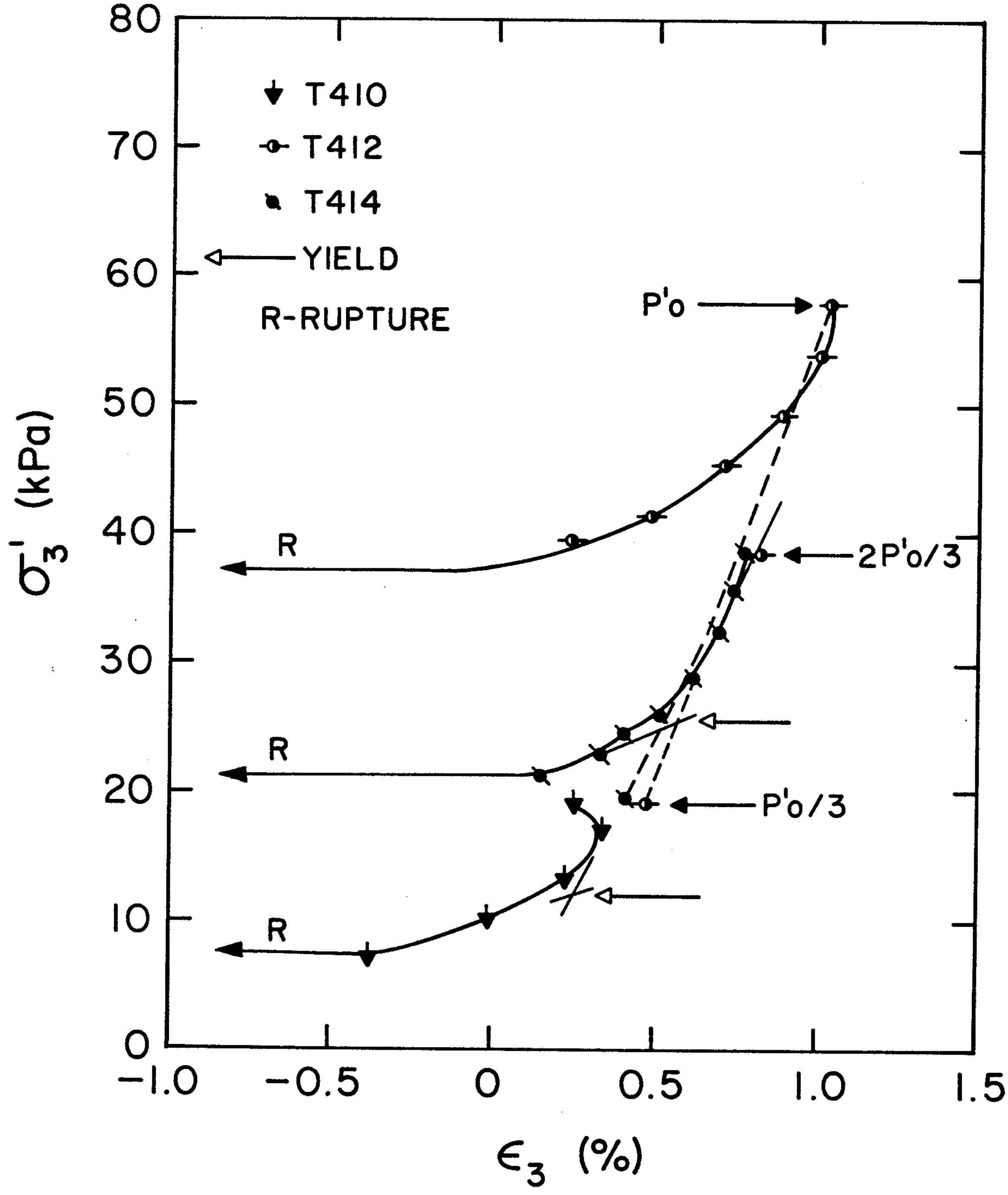


FIG. 4.12 YIELD DETERMINATION, σ_3' vs ε_3; T410, T412, T414

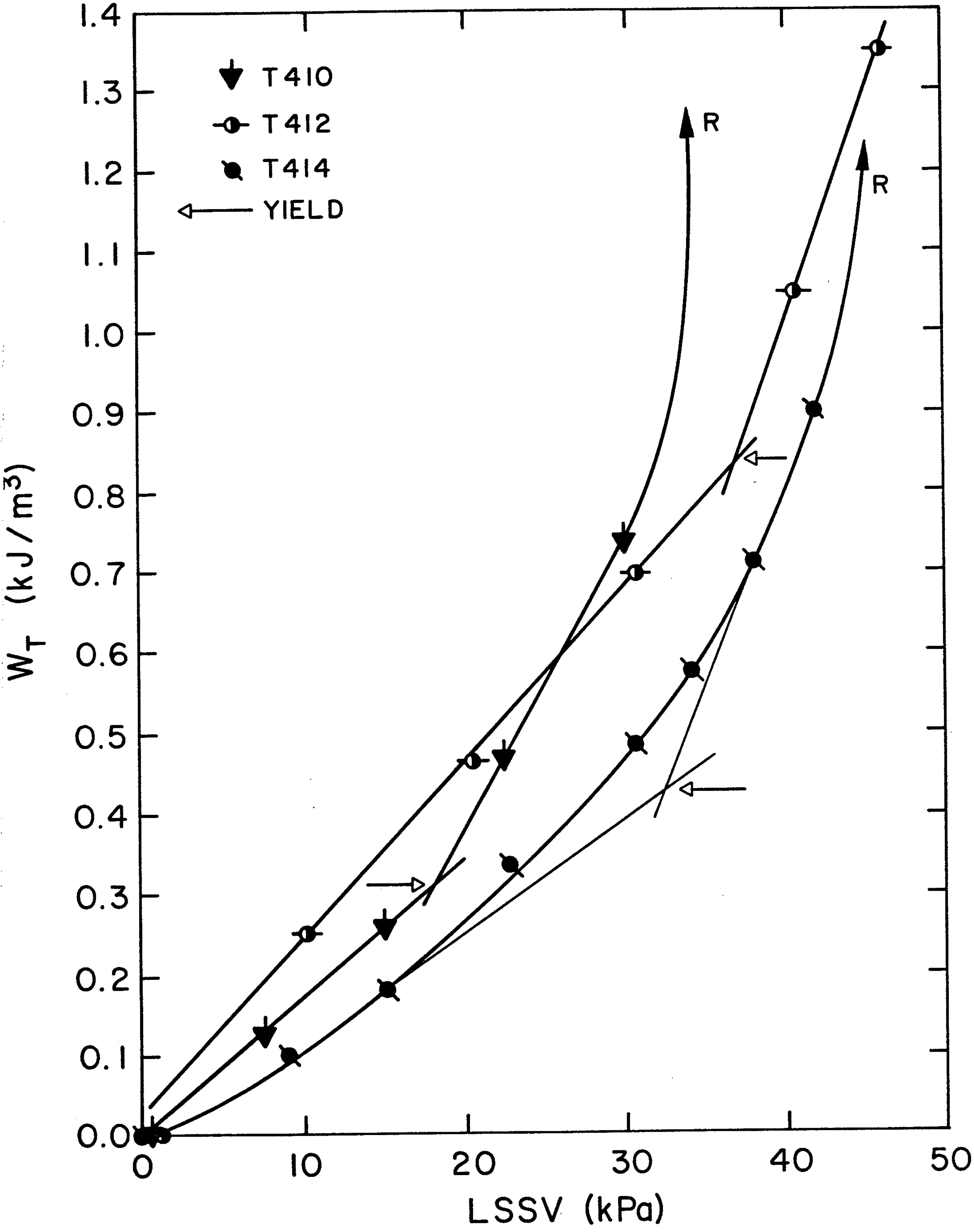


FIG. 4.13 YIELD DETERMINATION, W_T vs LSSV; T410, T412, T414

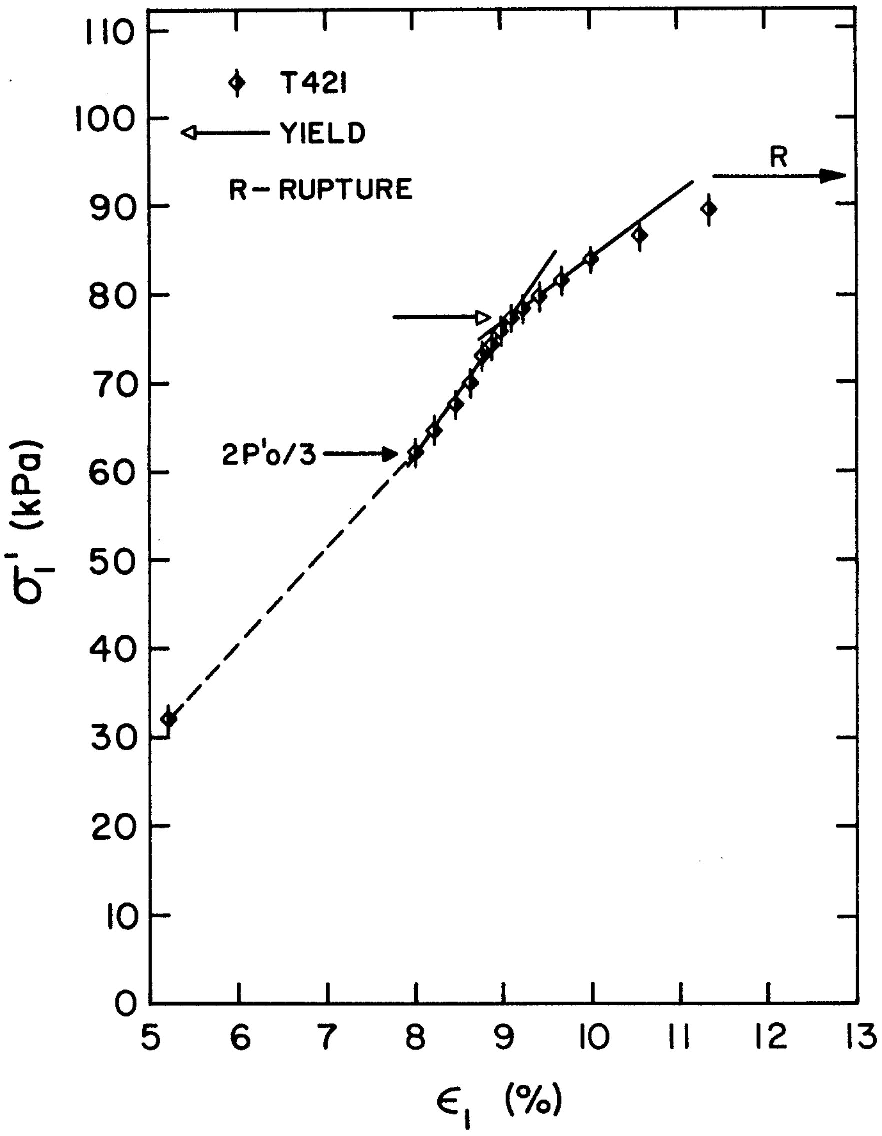


FIG. 4.14 YIELD DETERMINATION, σ_1' vs ϵ_1; T421

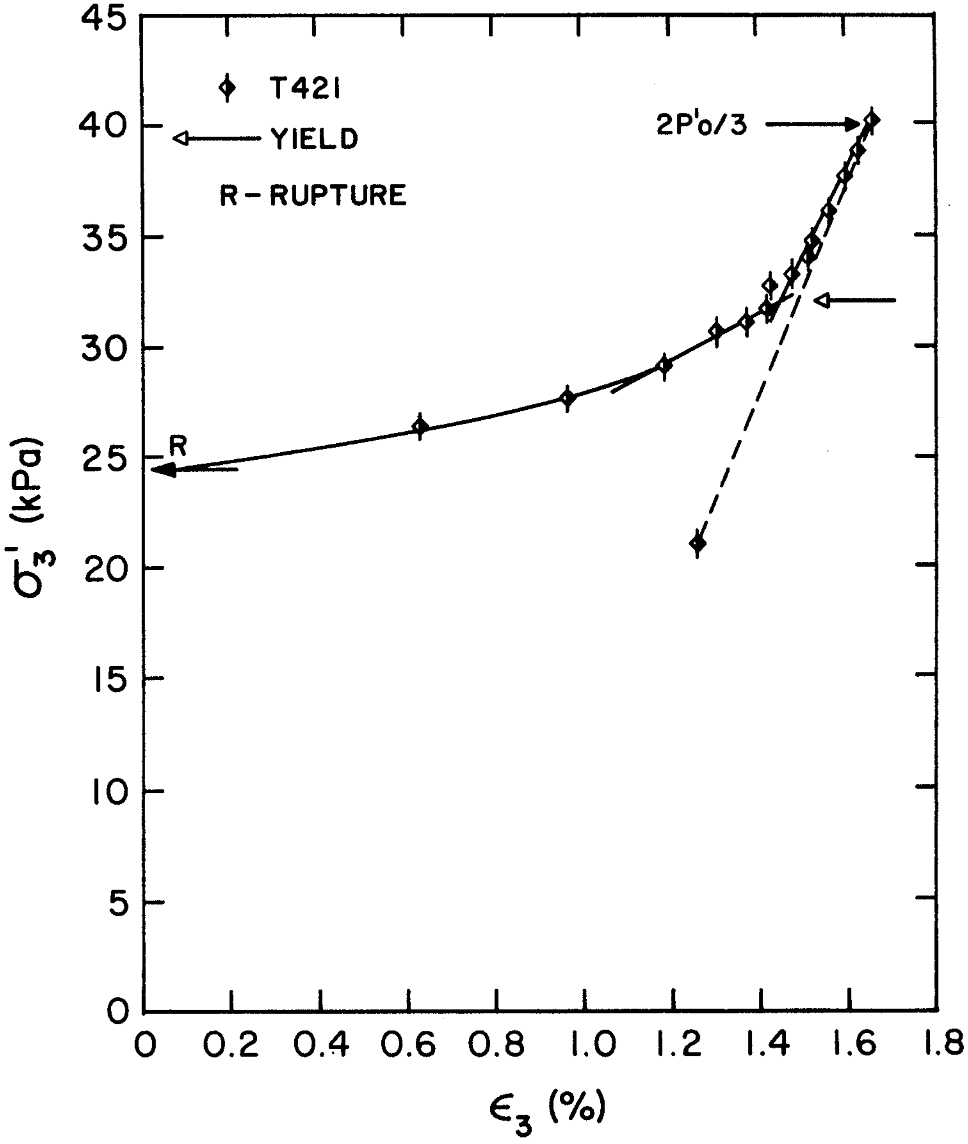


FIG. 4.15 YIELD DETERMINATION, σ_3' vs ϵ_3; T421

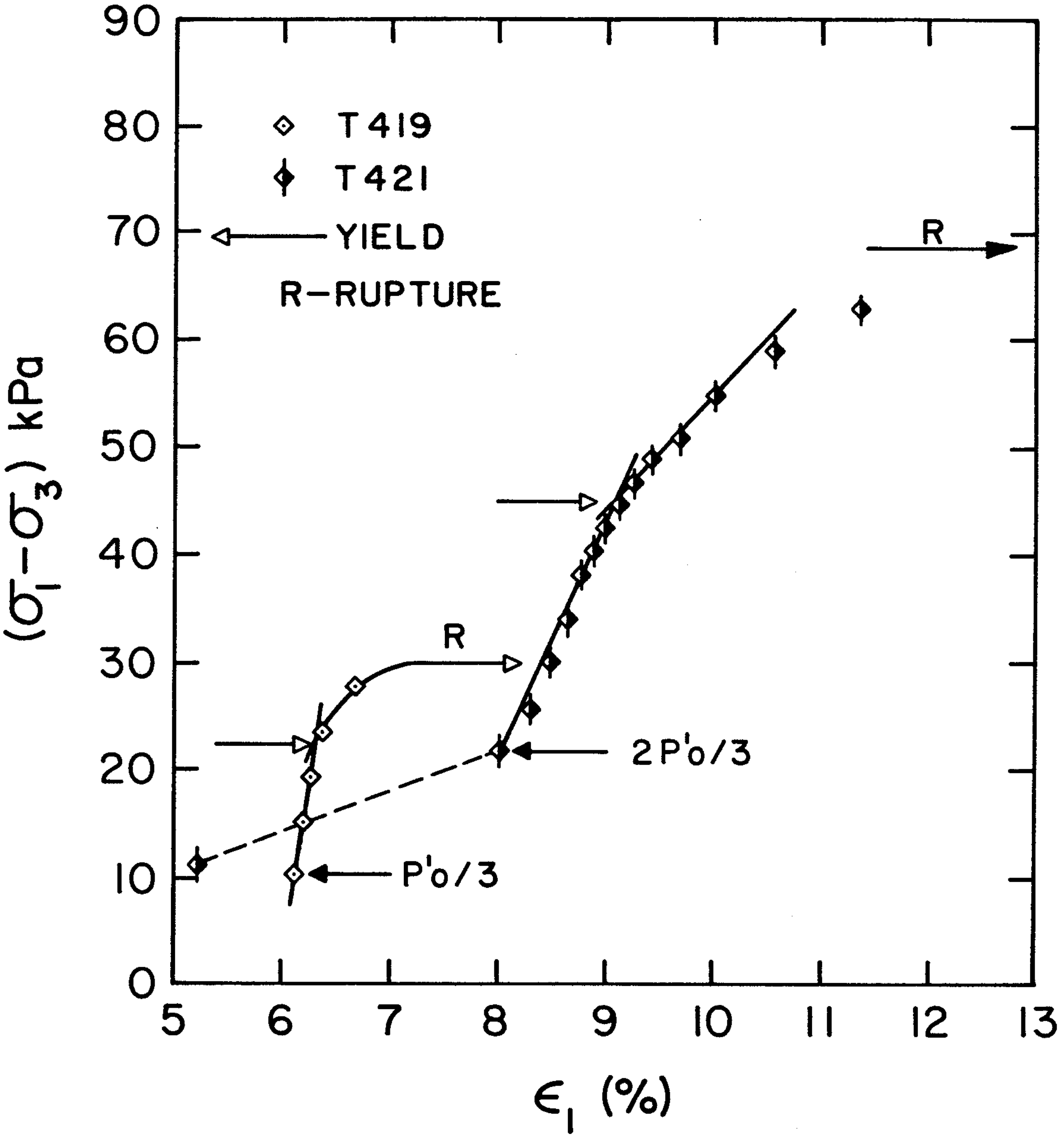


FIG. 4.16 YIELD DETERMINATION, $(\sigma_1-\sigma_3)$ vs ε_1; T419, T421

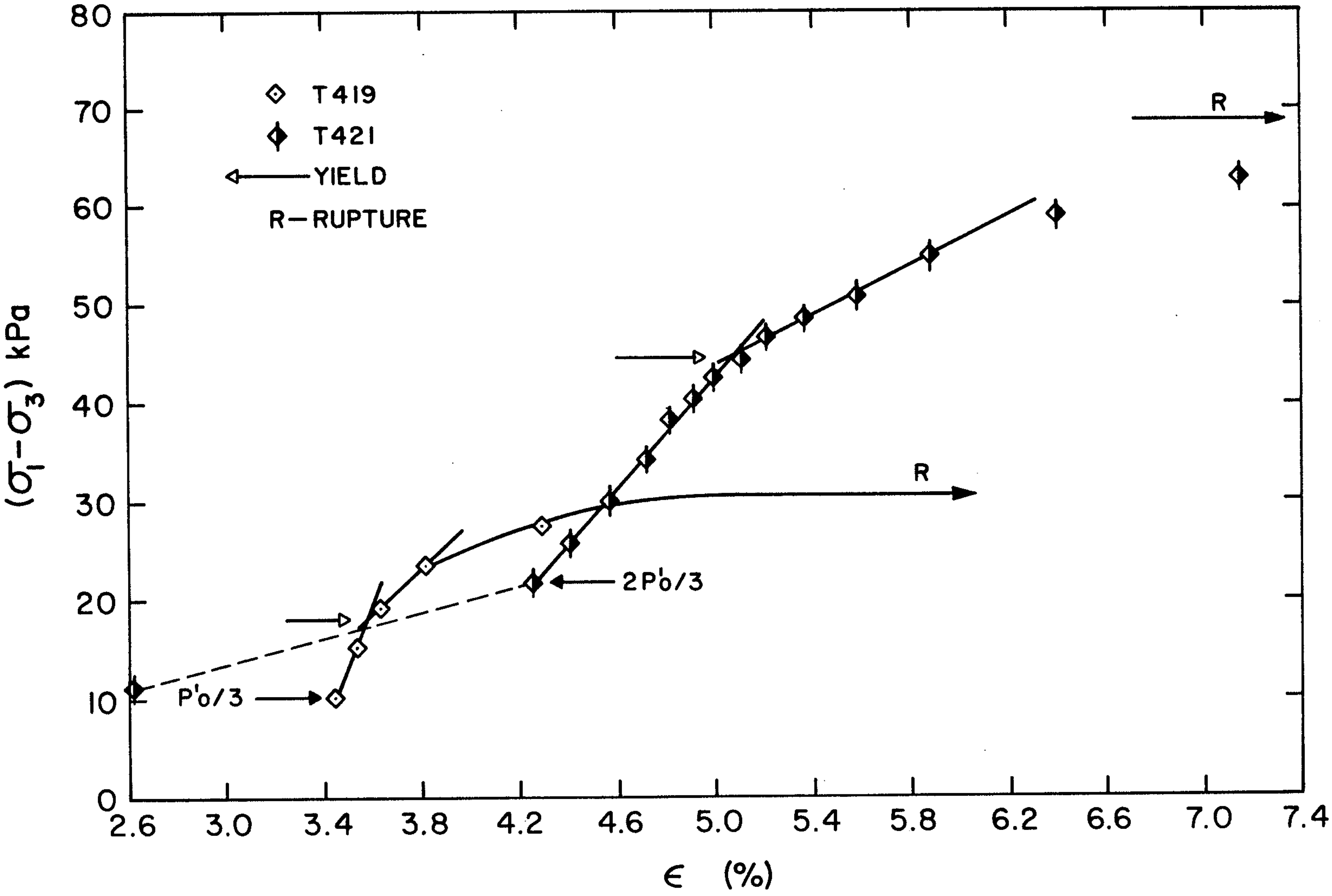


FIG. 4.17 YIELD DETERMINATION, $(\sigma_1-\sigma_3)$ vs ε; T419, T421

), 1982, FIG 4.18

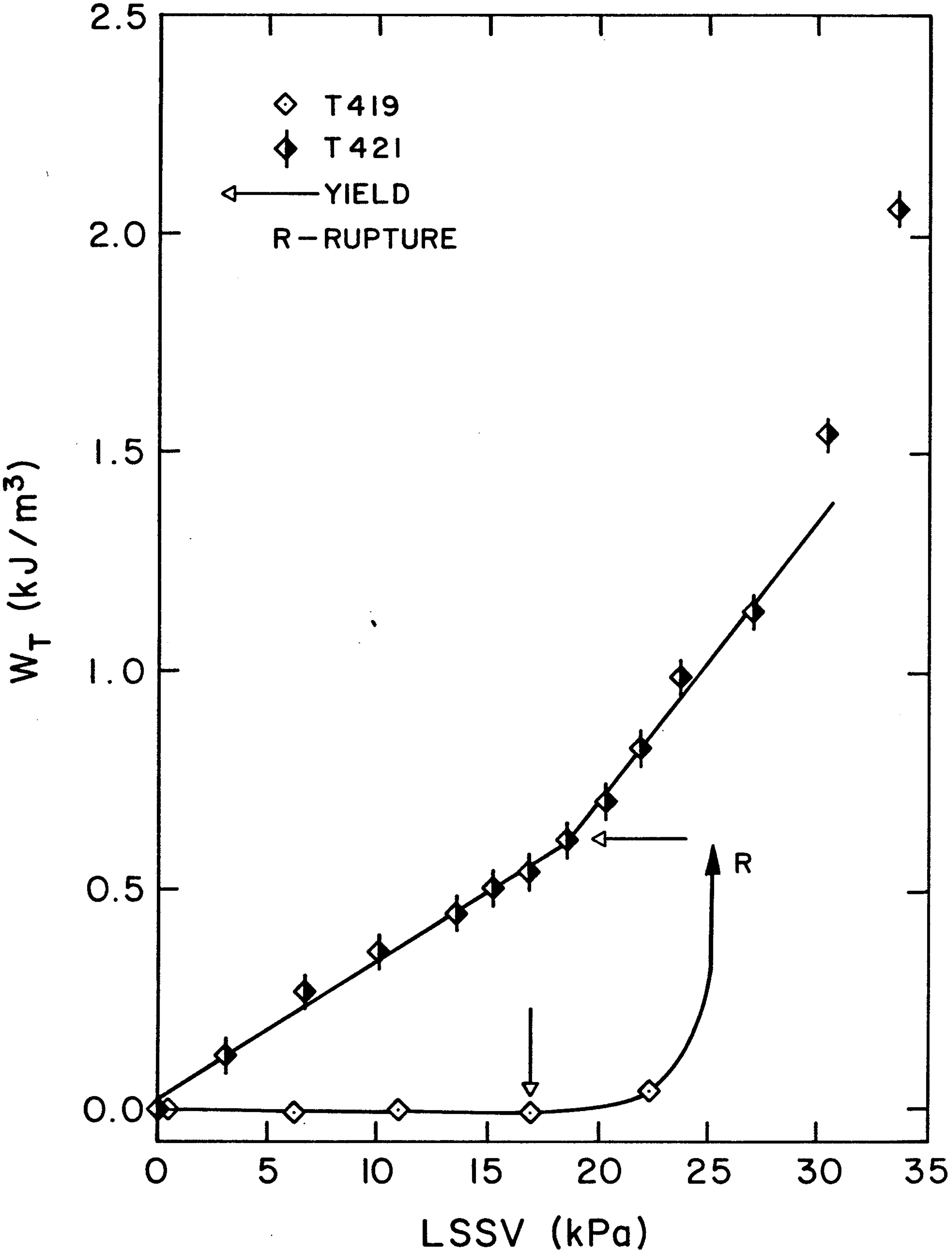


FIG. 4.18 YIELD DETERMINATION, W_T vs LSSV; T419, T421

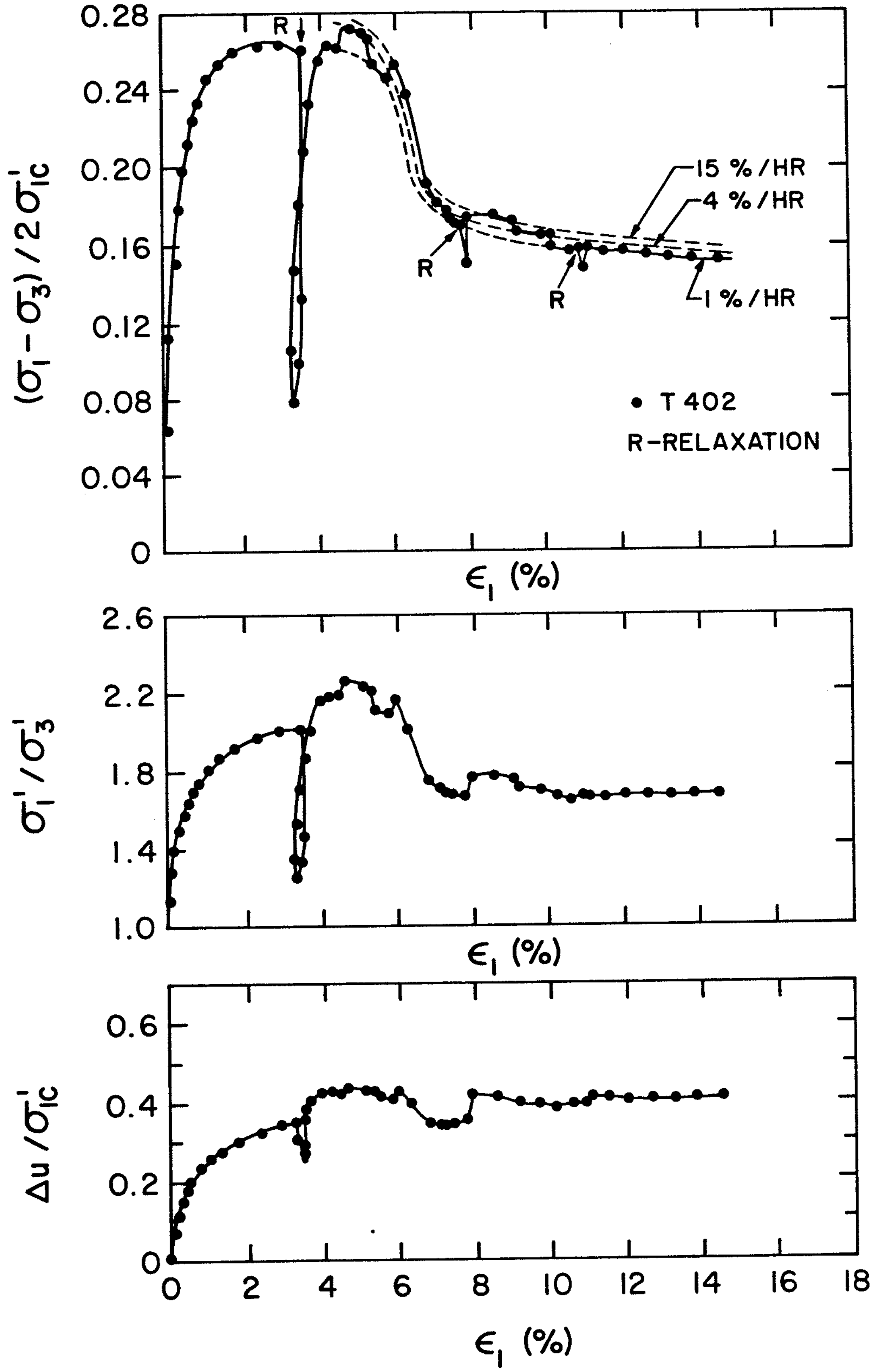


FIG. 4.19 UNDRAINED STRESS-STRAIN-POREWATER PRESSURE RESULTS, T402

20

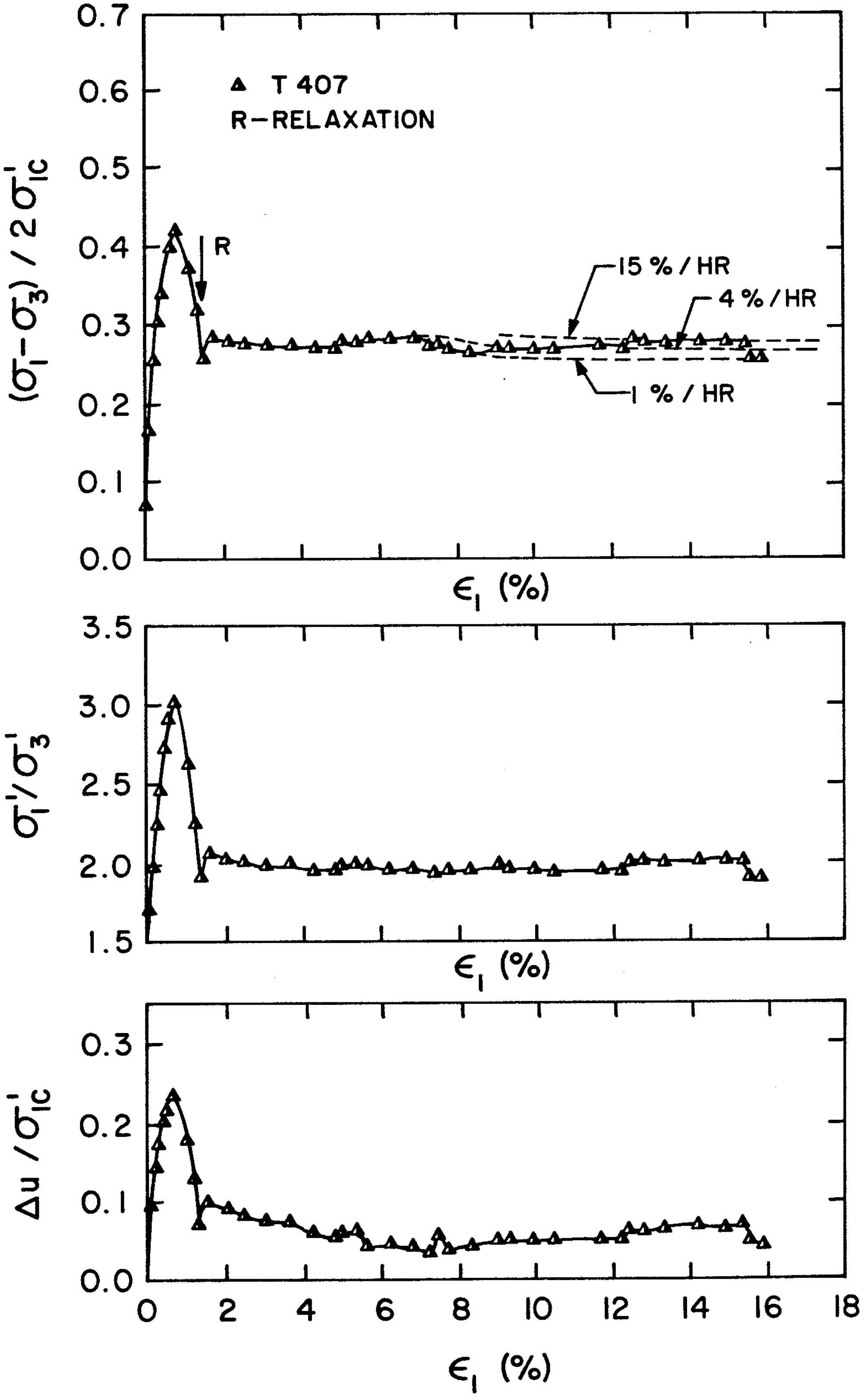


FIG. 4.20 UNDRAINED STRESS-STRAIN-POREWATER PRESSURE RESULTS, T407

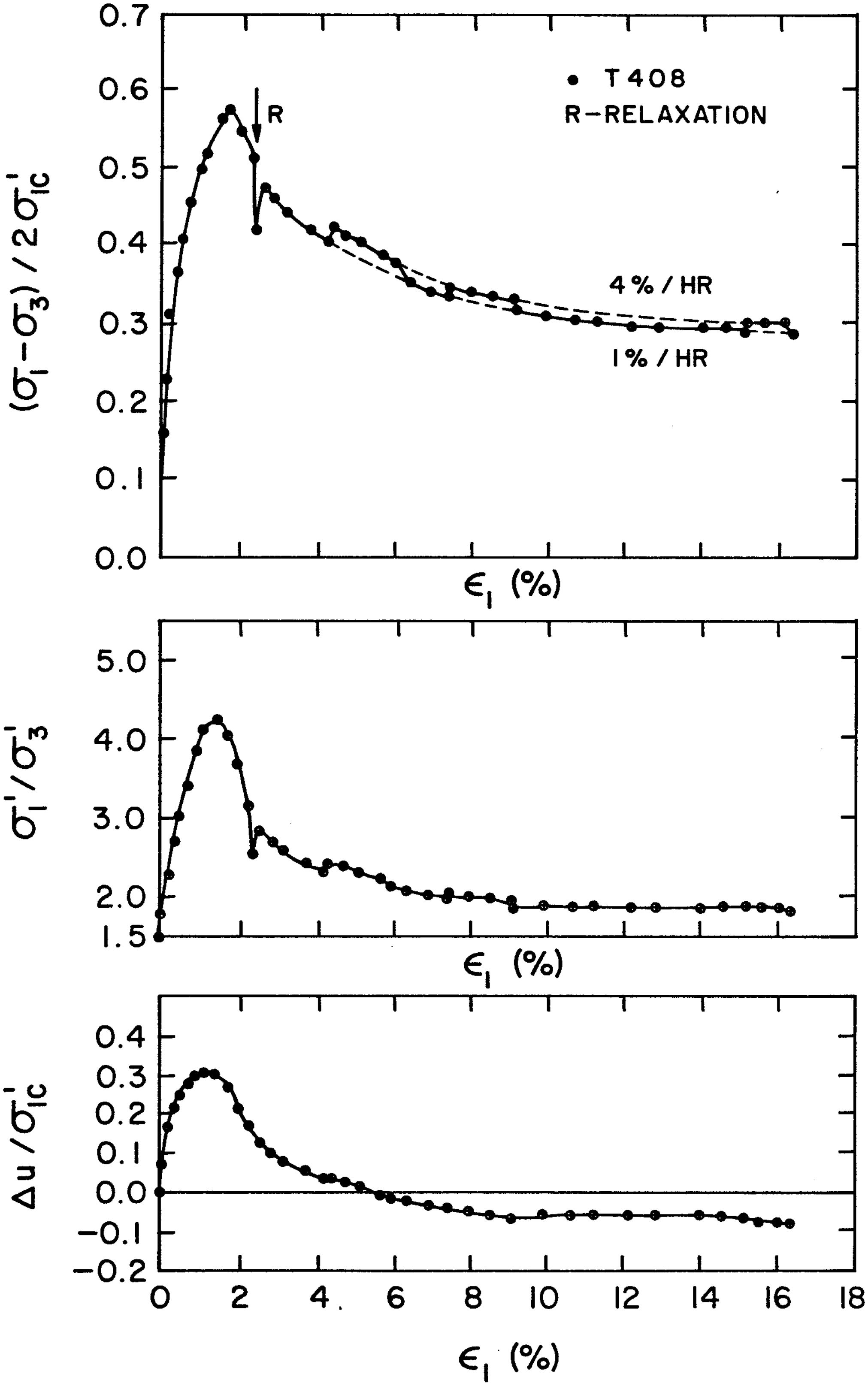


FIG. 4.21 UNDRAINED STRESS-STRAIN-POREWATER PRESSURE RESULTS, T408

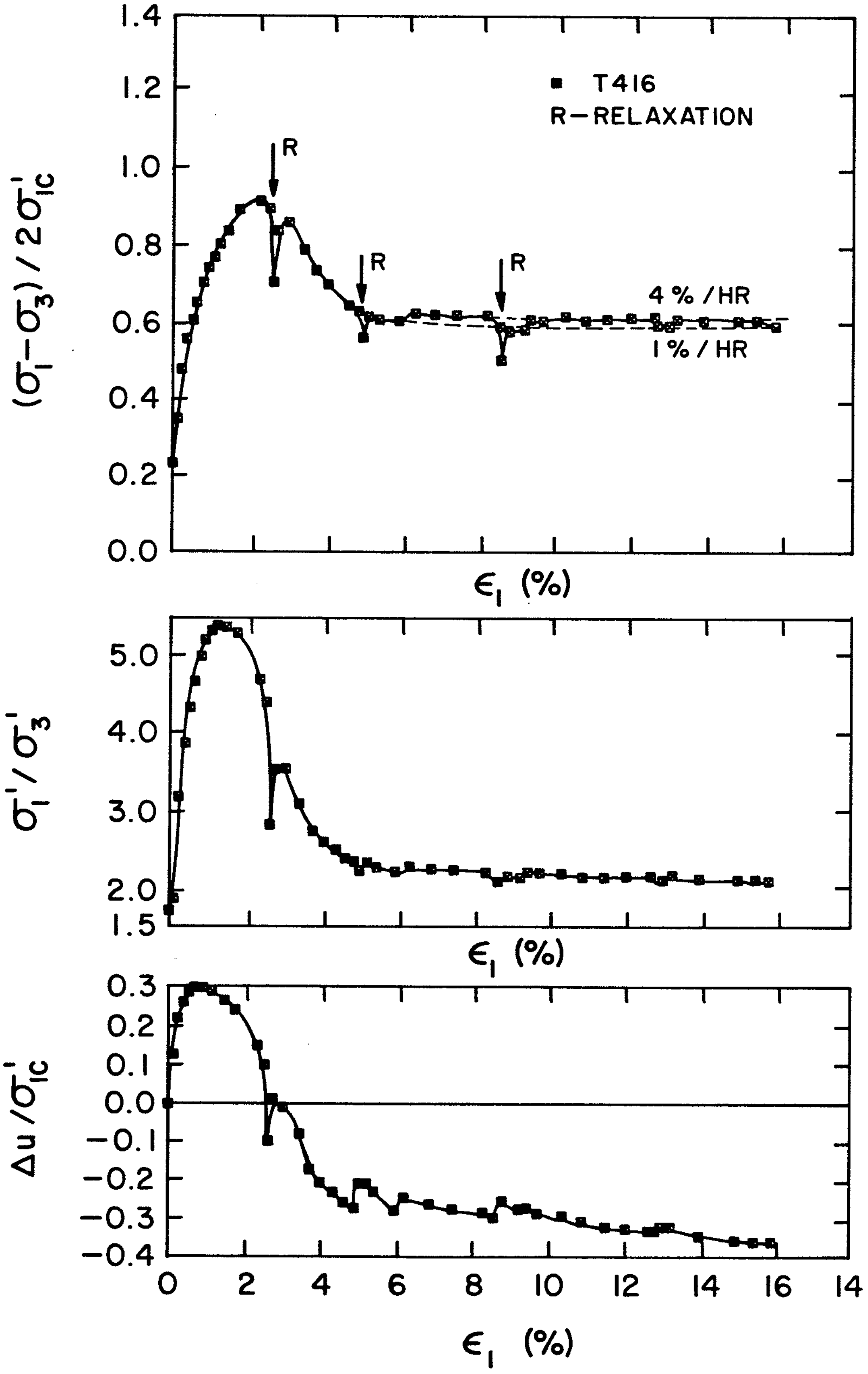


FIG. 4.22 UNDRAINED STRESS-STRAIN-POREWATER PRESSURE RESULTS, T416

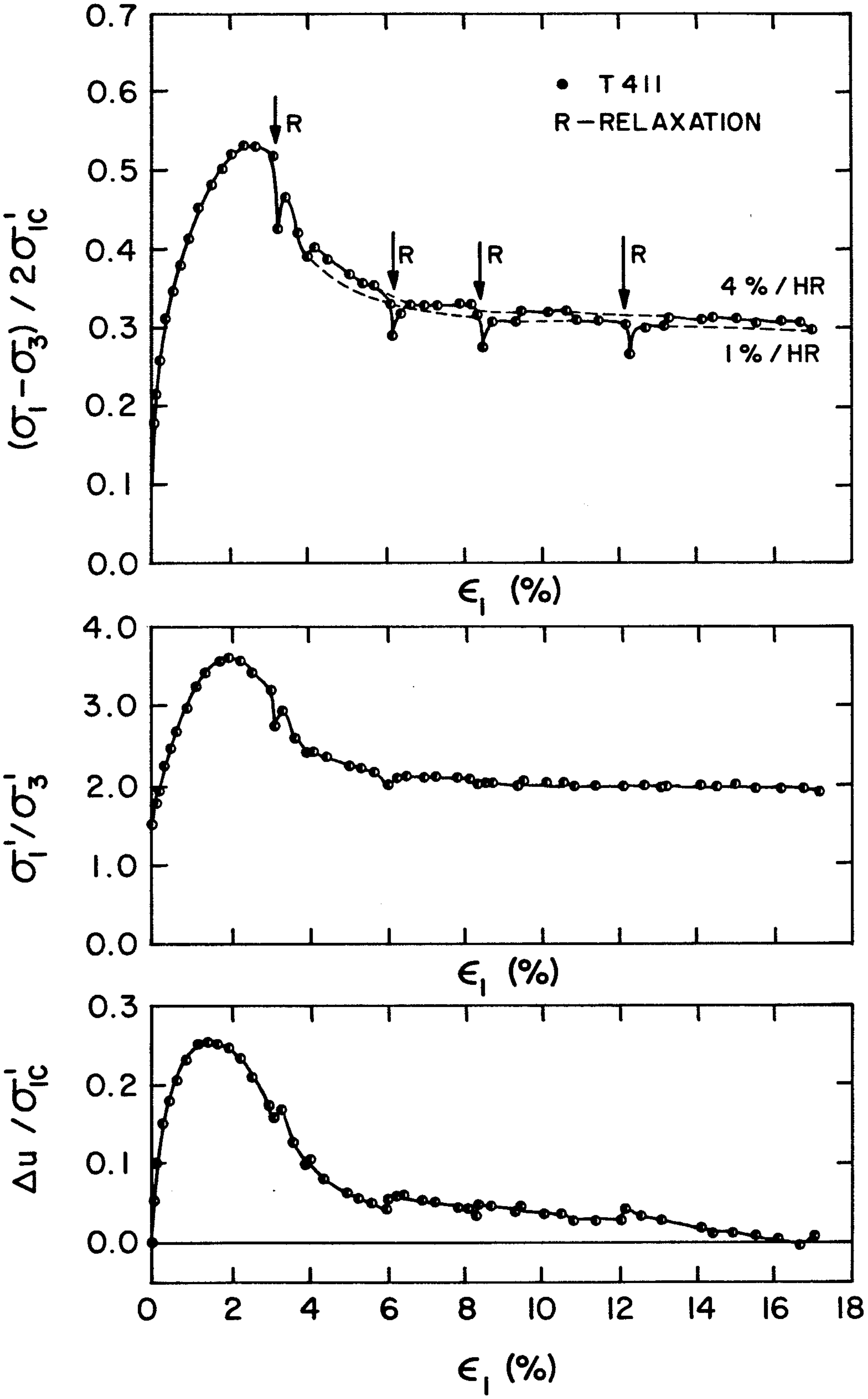


FIG. 4.23 UNDRAINED STRESS-STRAIN-POREWATER PRESSURE RESULTS, T411

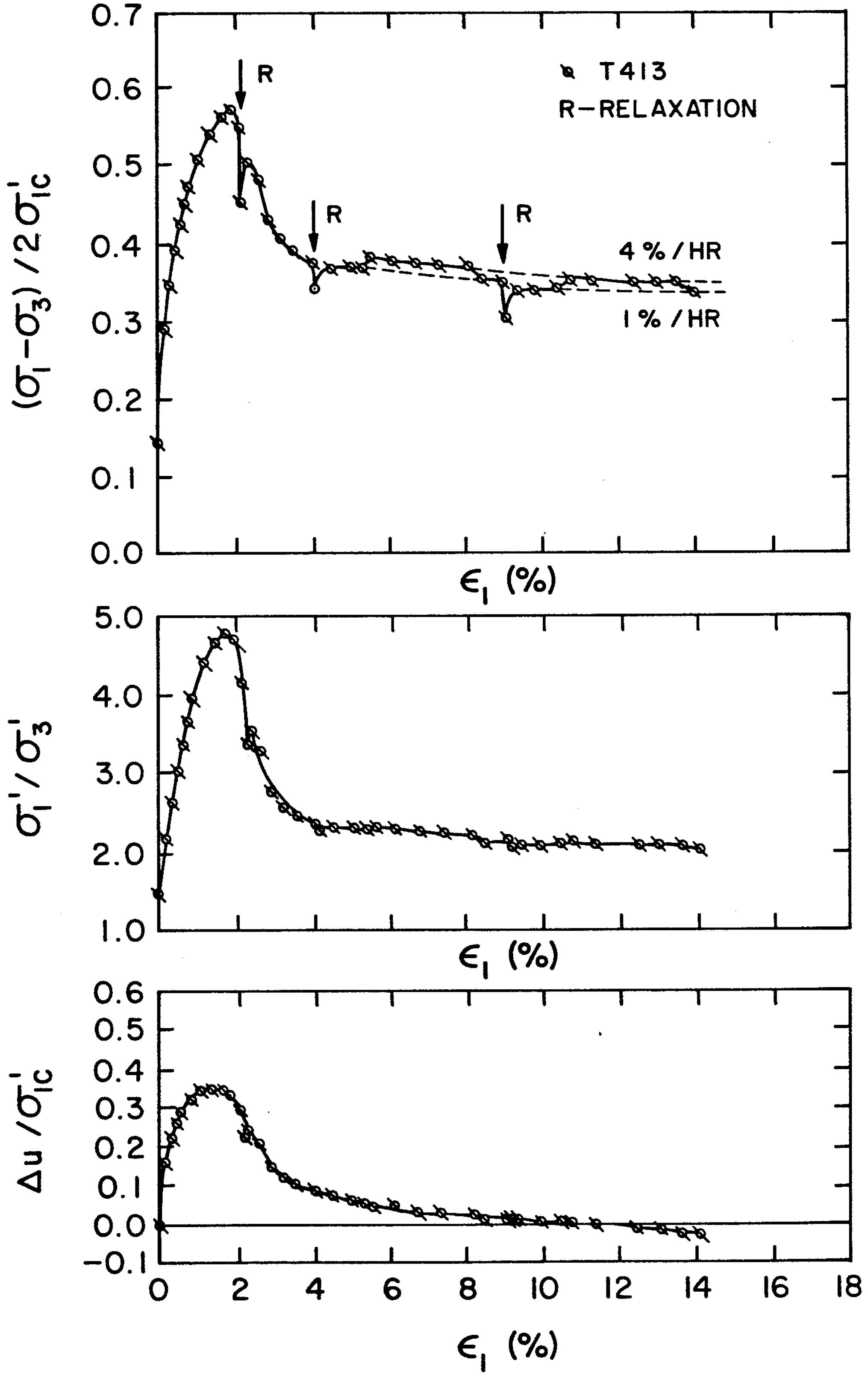


FIG. 4.24 UNDRAINED STRESS-STRAIN-POREWATER PRESSURE RESULTS, T413

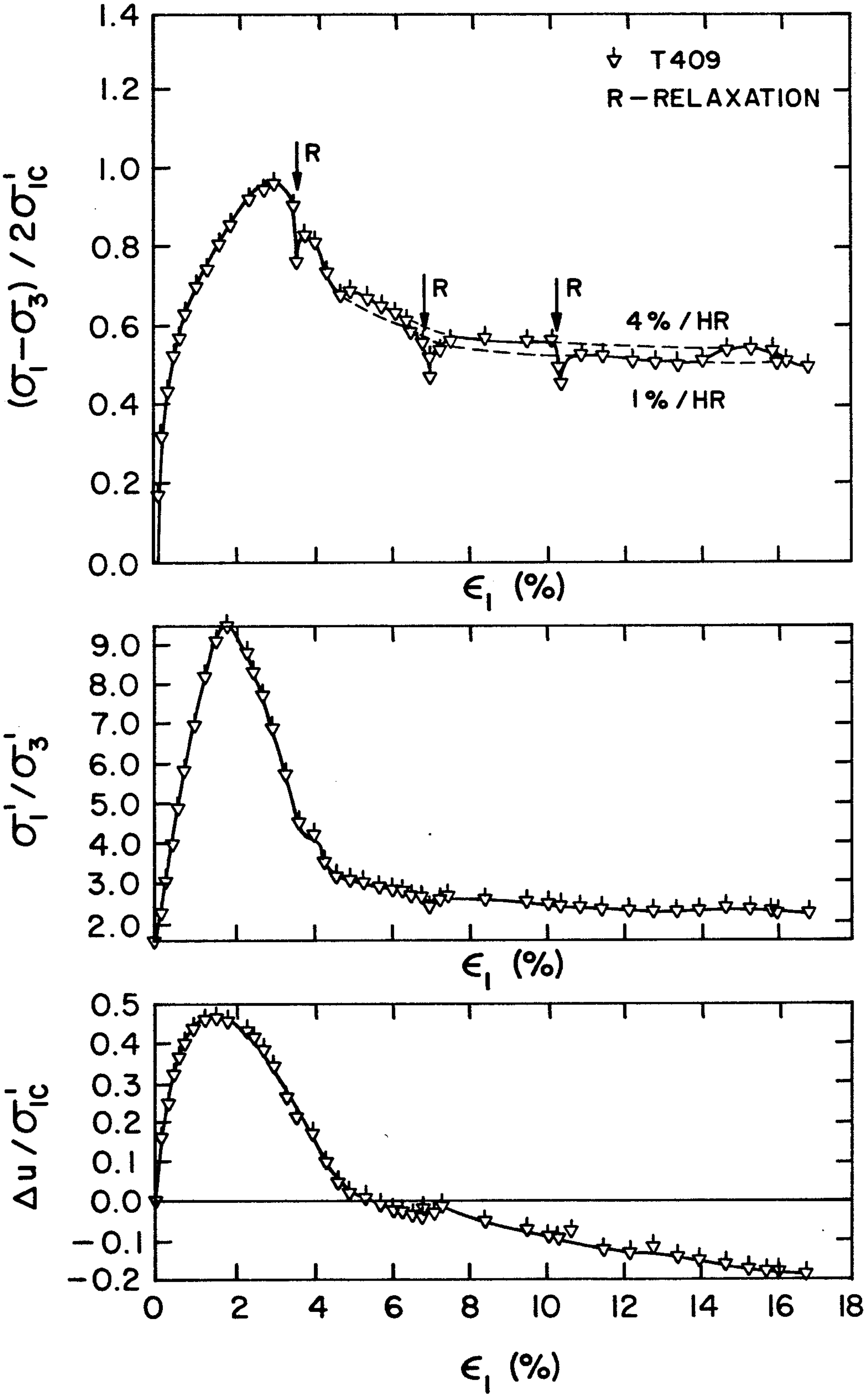


FIG. 4.25 UNDRAINED STRESS-STRAIN-POREWATER PRESSURE RESULTS, T409

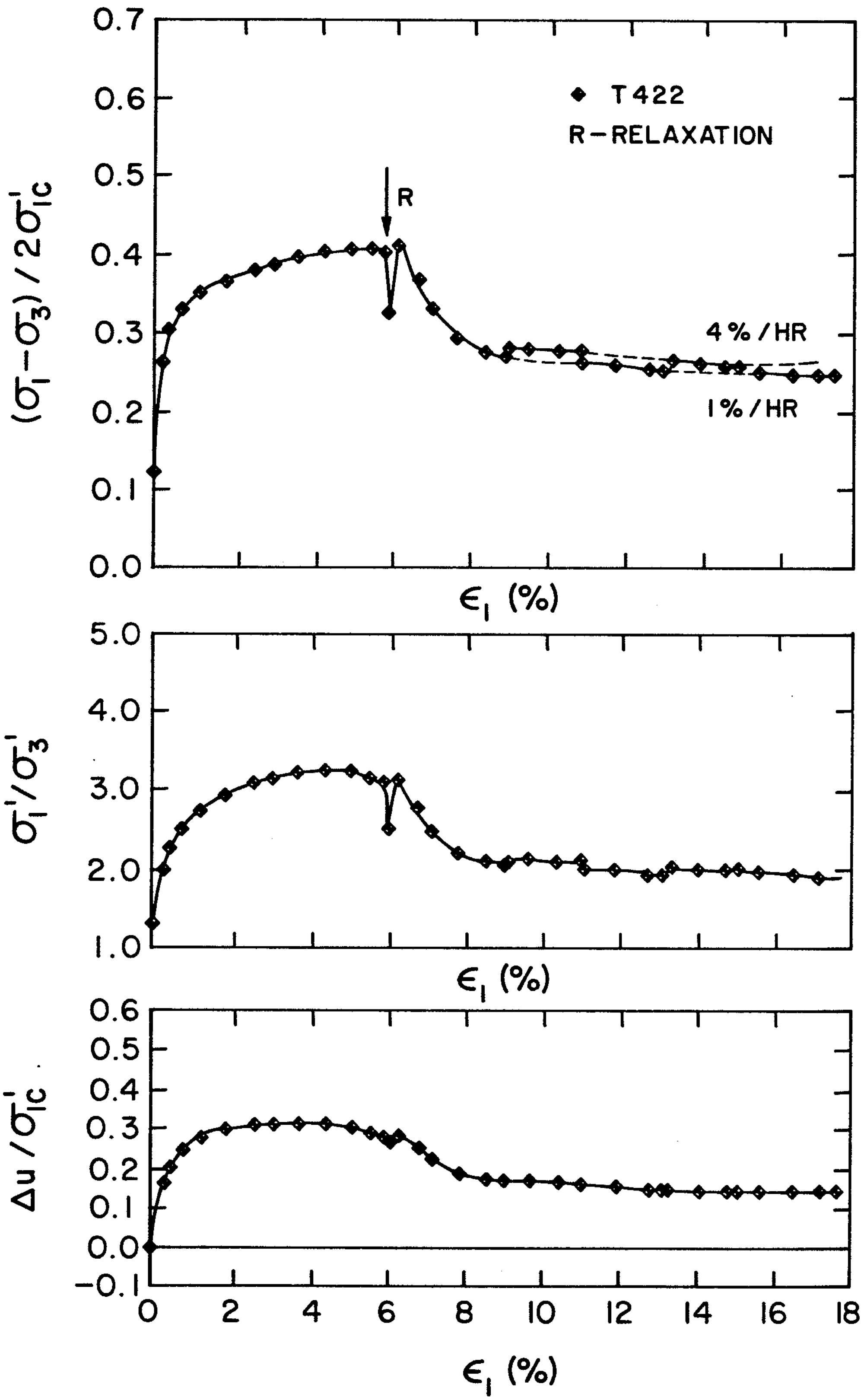


FIG. 4.26 UNDRAINED STRESS-STRAIN-POREWATER PRESSURE RESULTS, T422

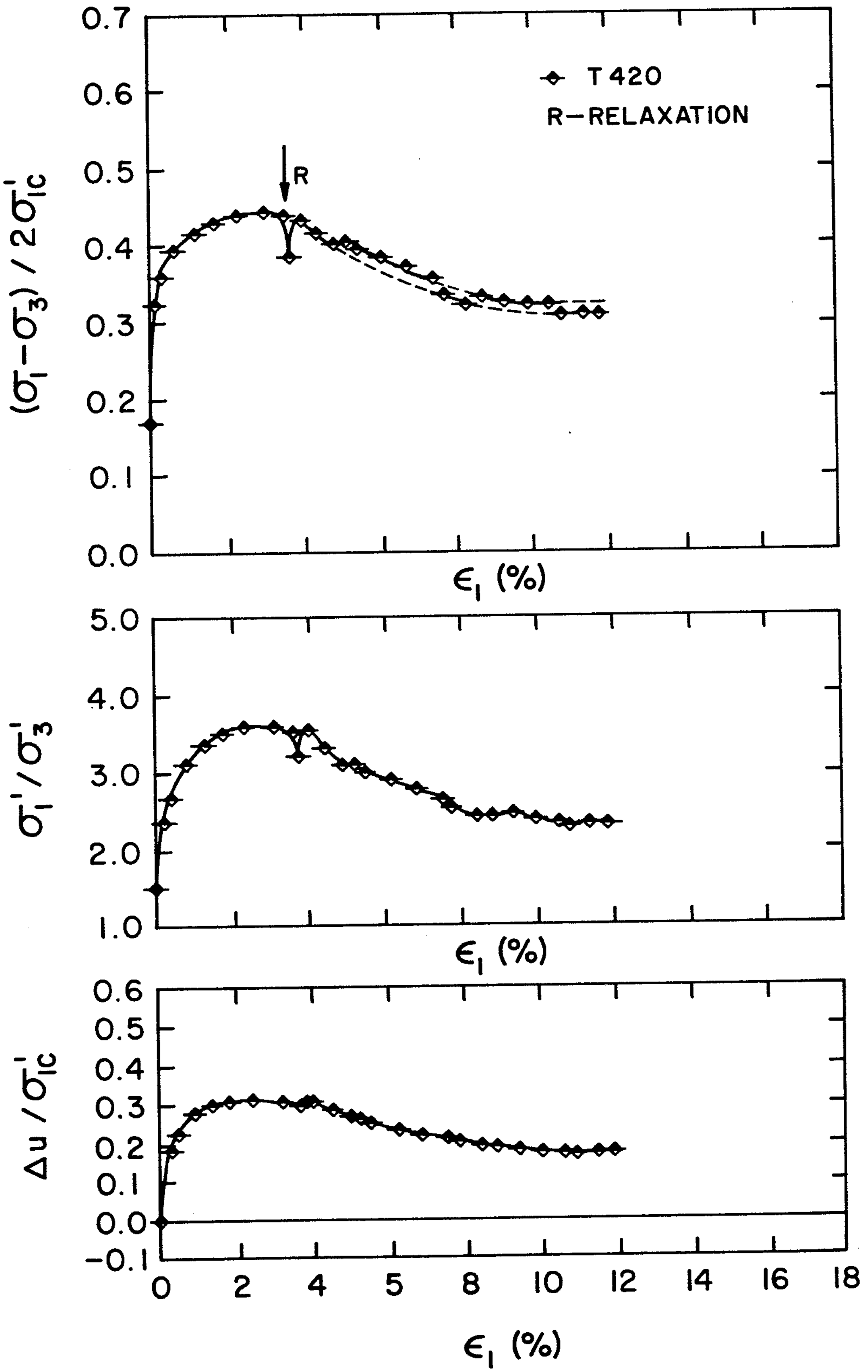


FIG. 4.27 UNDRAINED STRESS-STRAIN-POREWATER PRESSURE RESULTS, T420

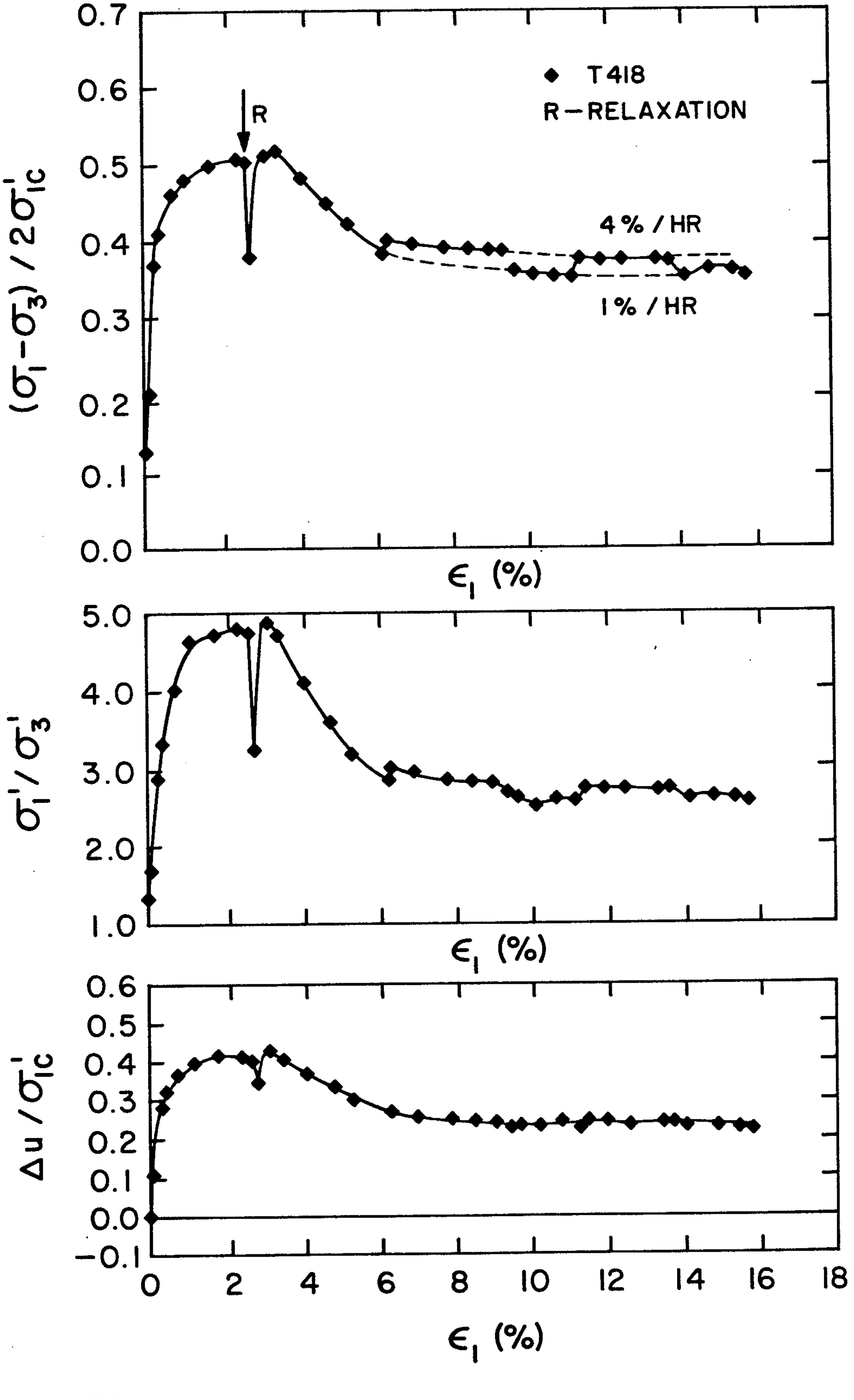


FIG. 4.28 UNDRAINED STRESS-STRAIN-POREWATER PRESSURE RESULTS, T418

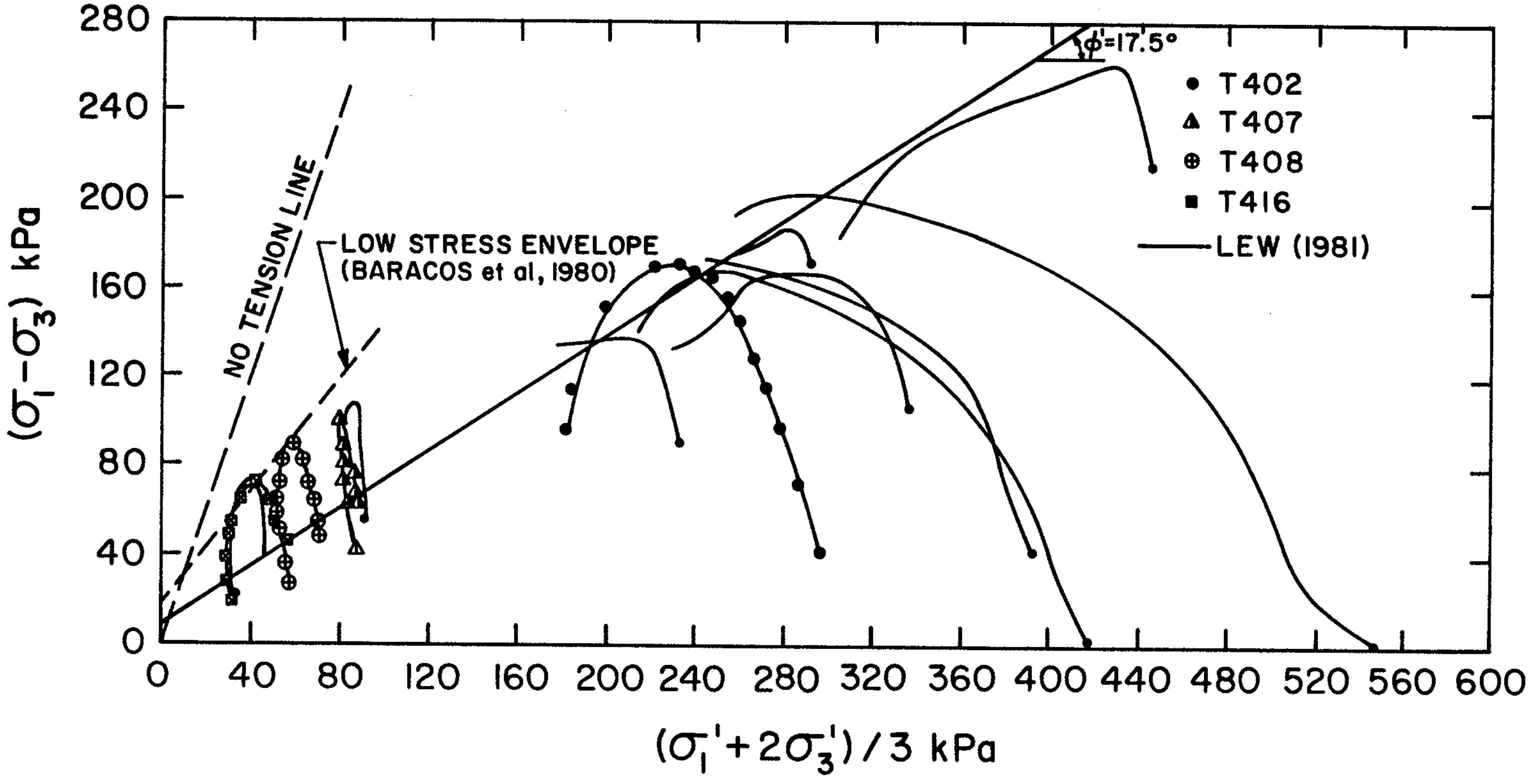


FIG. 4.29 EFFECTIVE STRESS PATHS FOR UNDISTURBED SAMPLES FROM UNDRAINED TESTS

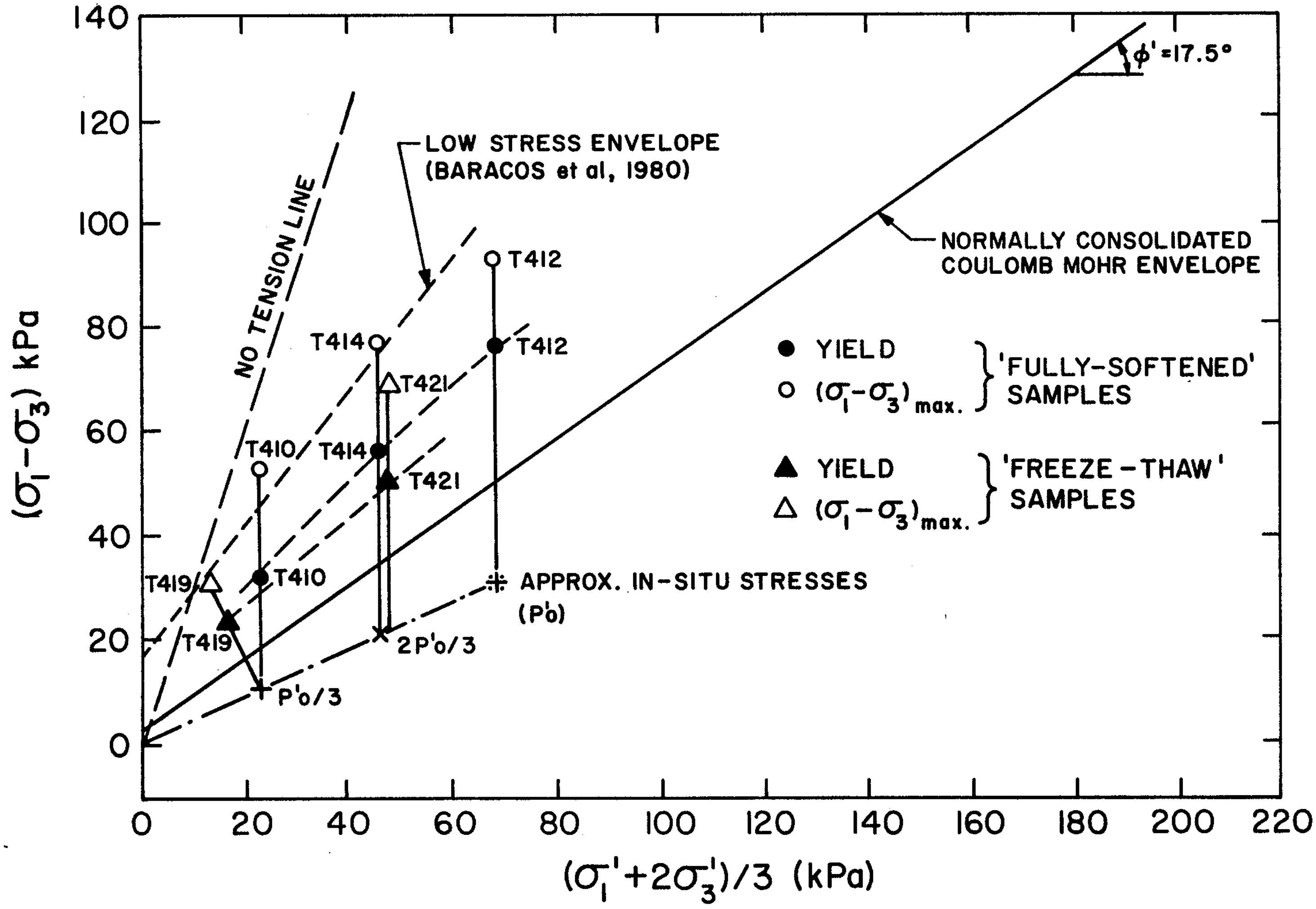


FIG. 4.30 YIELD AND MAXIMUM DEVIATOR STRESS FOR 'FULLY-SOFTENED' AND 'FREEZE-THAW' SAMPLES

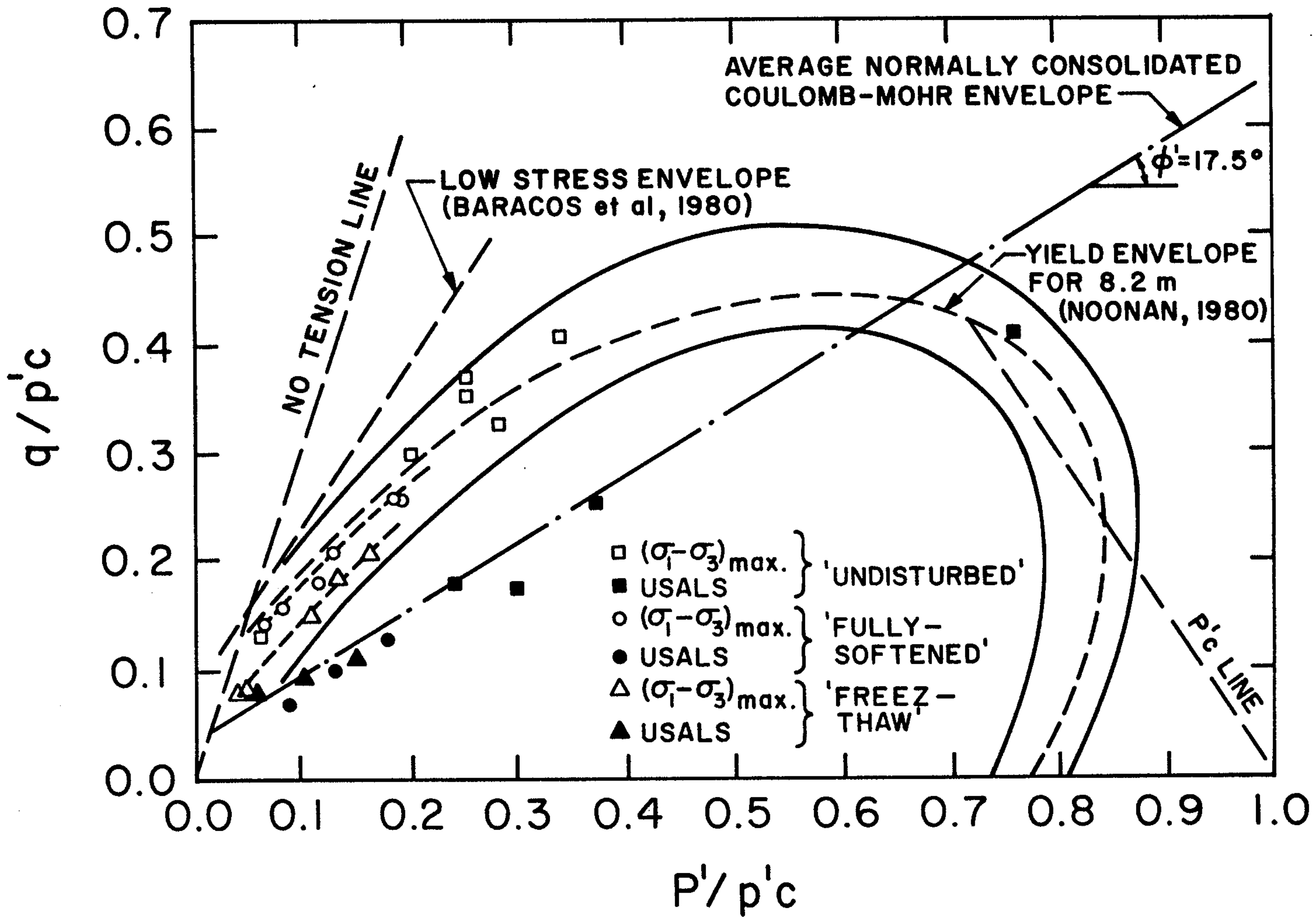


FIG. 4.31 NORMALIZED LOW STRESS TEST RESULTS

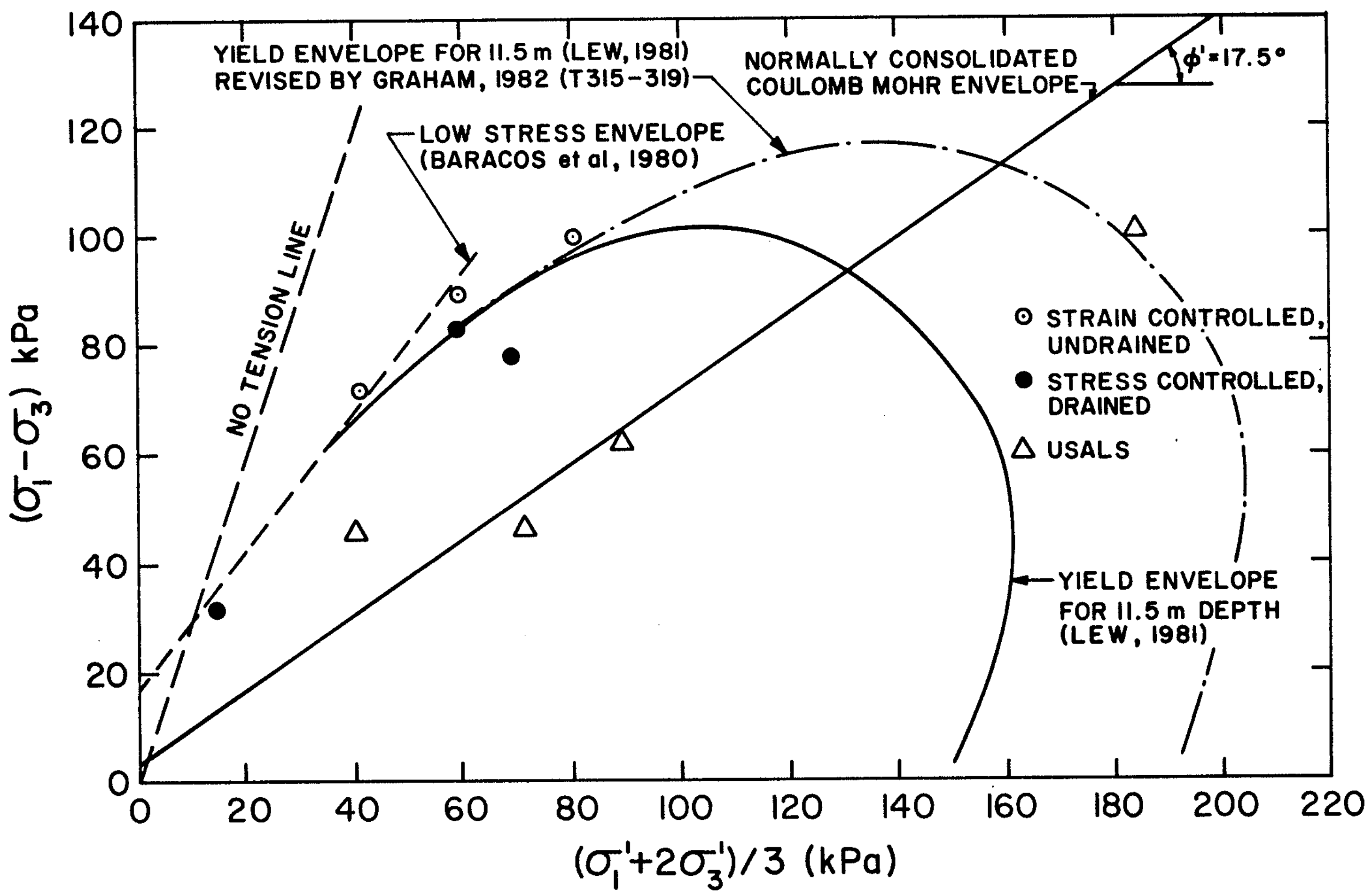


FIG. 4.32 LOW STRESS STRENGTHS AND USALS FOR UNDISTURBED SAMPLES

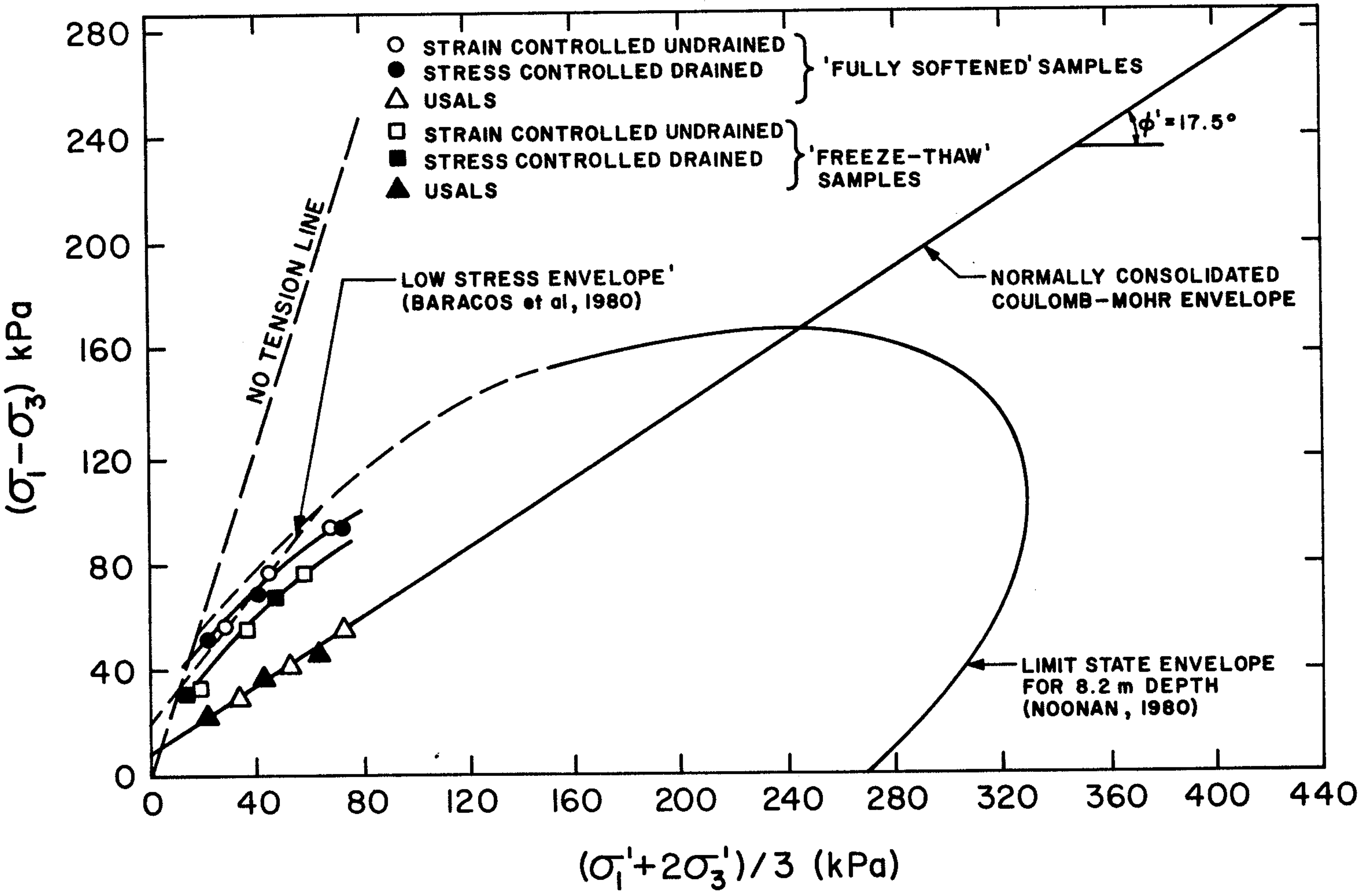


FIG. 4.33 LOW STRESS STRENGTHS AND USALS FOR 'FULLY-SOFTENED' AND 'FREEZE-THAW' SAMPLES

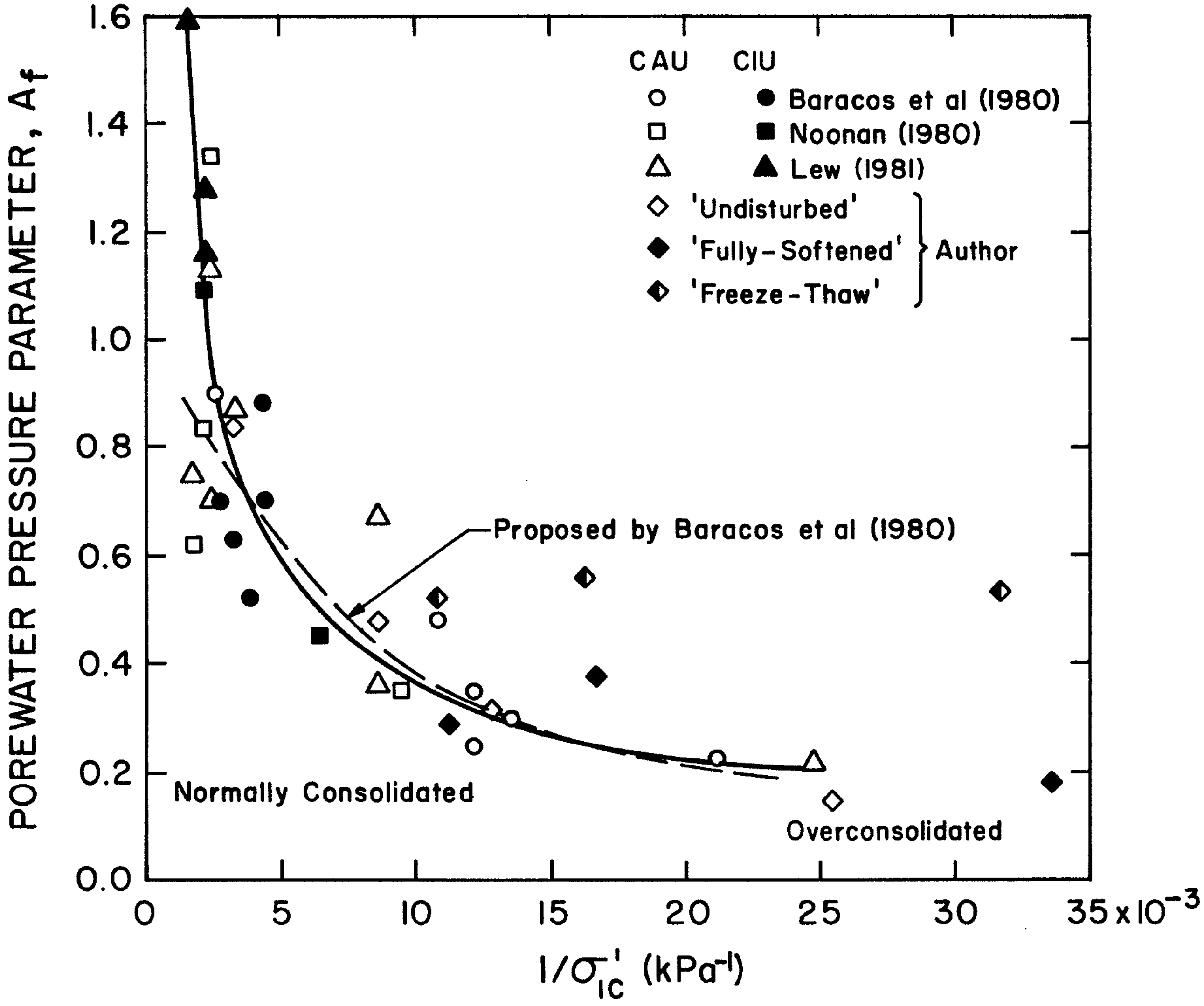


FIG. 4.34 GRAPH OF POREWATER PRESSURE PARAMETER A_f vs $1/\sigma'_{1c}$ FOR WINNIPEG CLAY

AU 1982 FIG 4.35

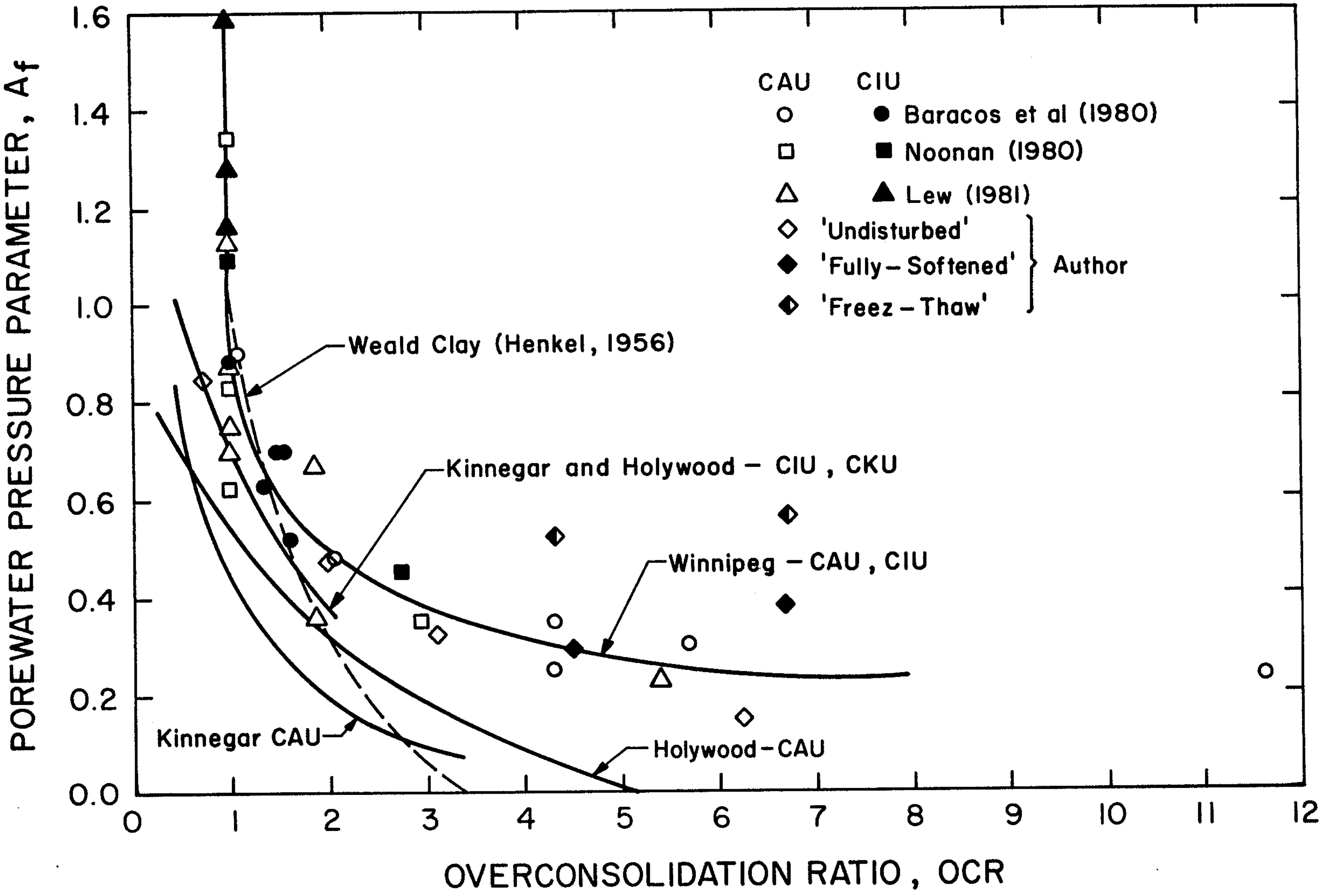


FIG. 4.35 SUMMARY GRAPH OF POREWATER PRESSURE PARAMETER A_f vs OVERCONSOLIDATION RATIO

?2 FIG 4.36

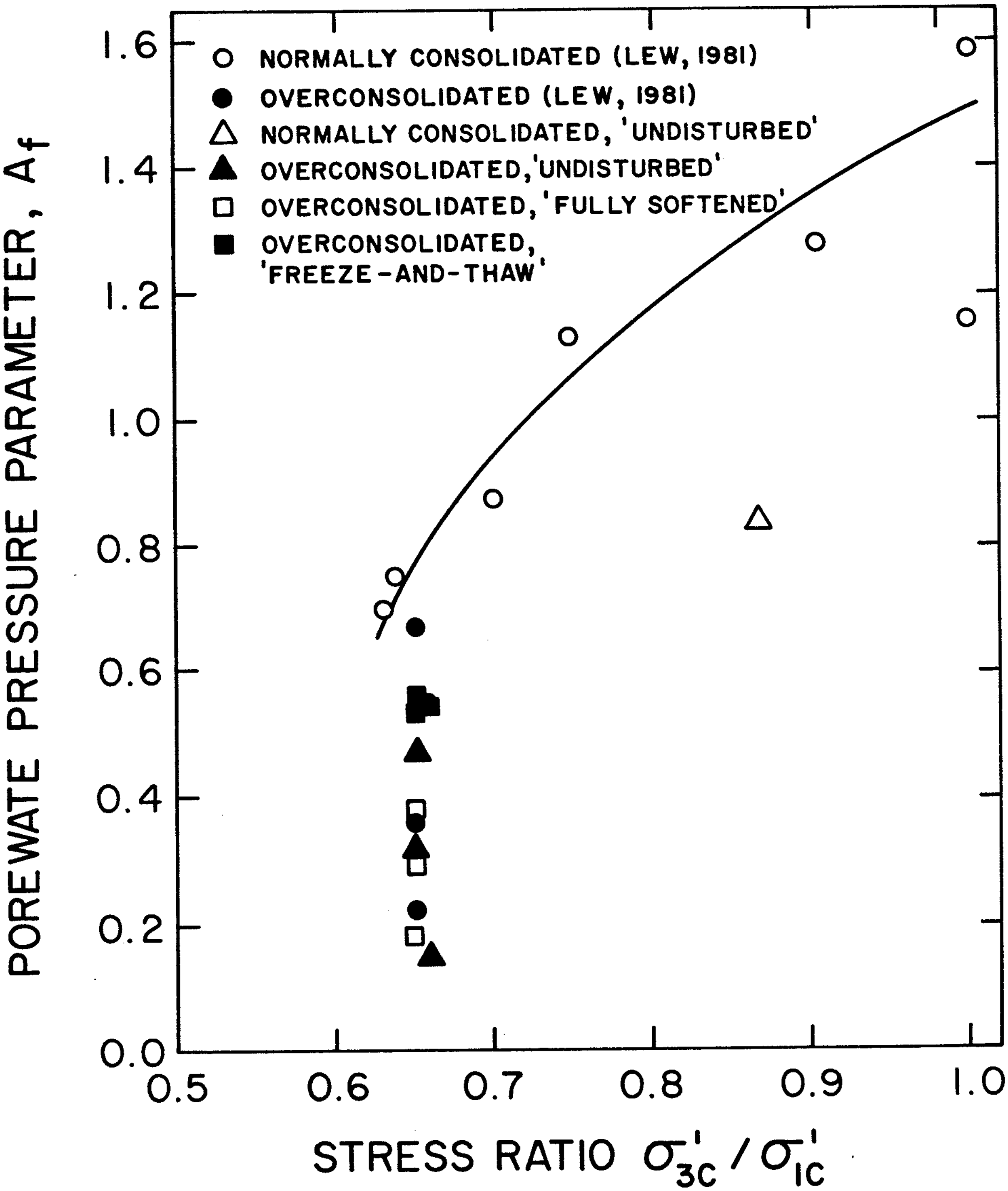


FIG. 4.36 DEPENDENCE OF POREWATER PRESSURE PARAMETER A_f ON STRESS LEVELS AND STRESS RATIO DURING CONSOLIDATION

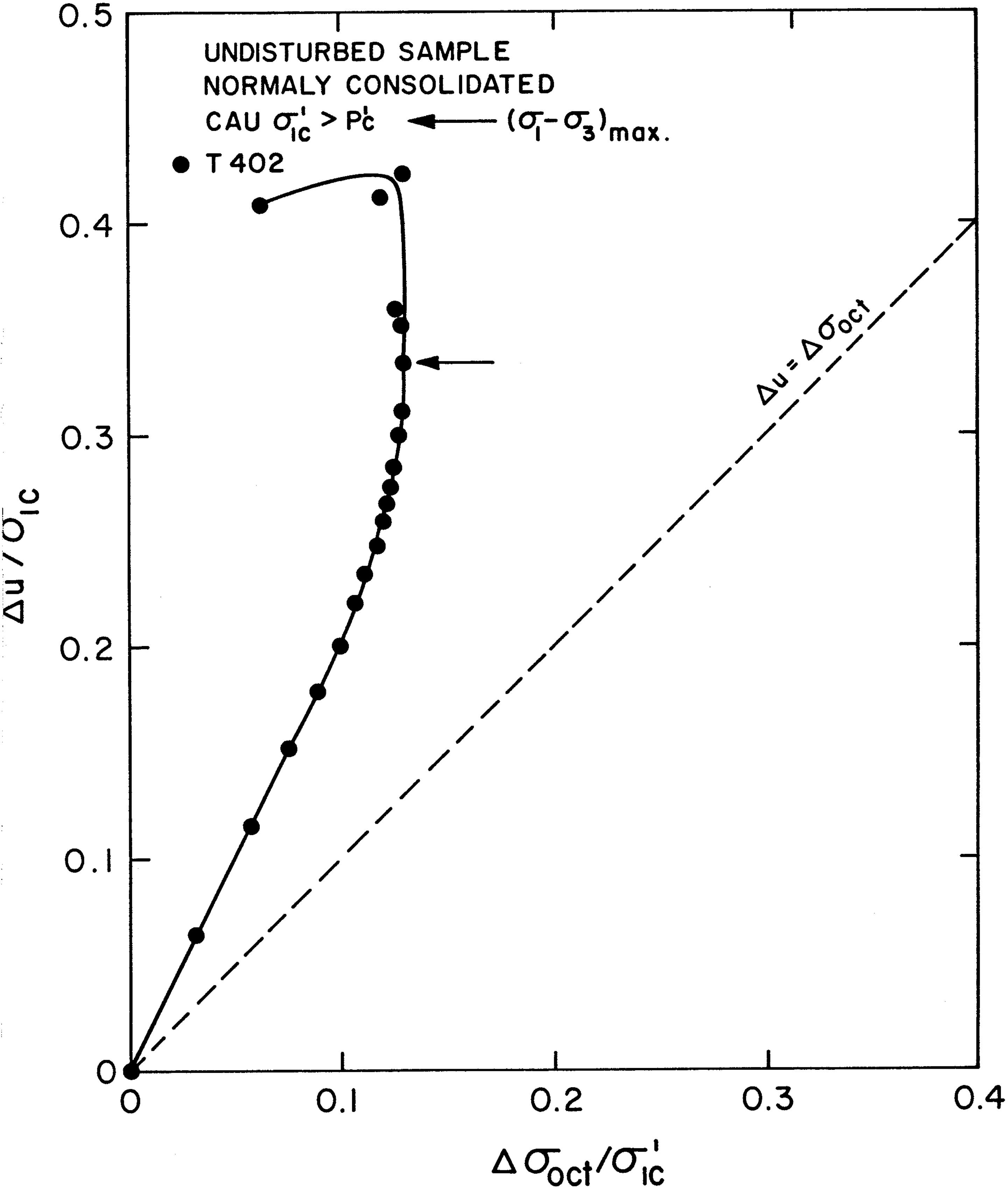


FIG. 4.37 POREWATER PRESSURE BEHAVIOUR, $\Delta u/\sigma'_{1c}$ vs $\Delta\sigma_{oct}/\sigma'_{1c}$; T402

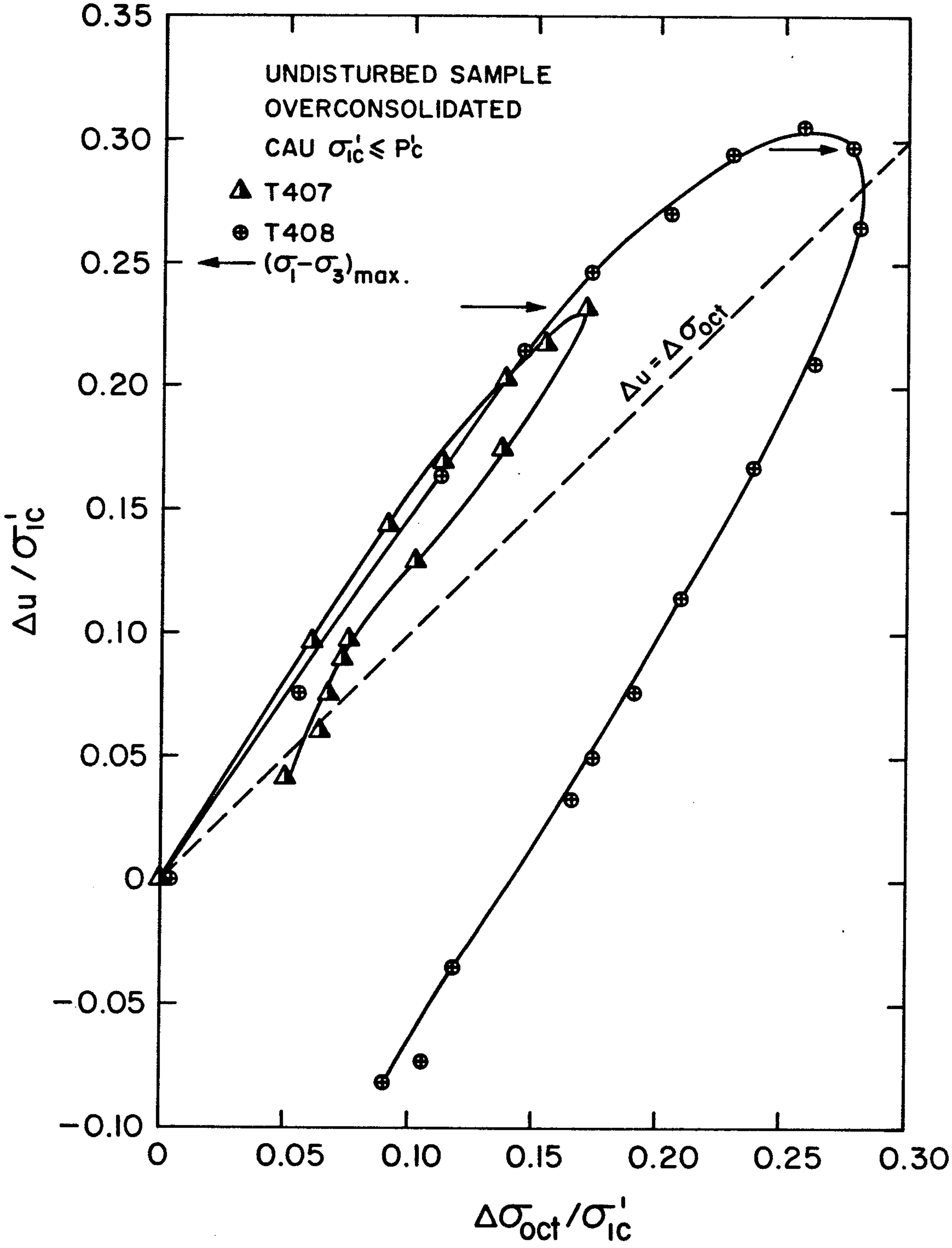


FIG. 4.38 POREWATER PRESSURE BEHAVIOUR, $\Delta u/\sigma'_{1c}$ vs $\Delta\sigma_{oct}/\sigma'_{1c}$; T407, T408

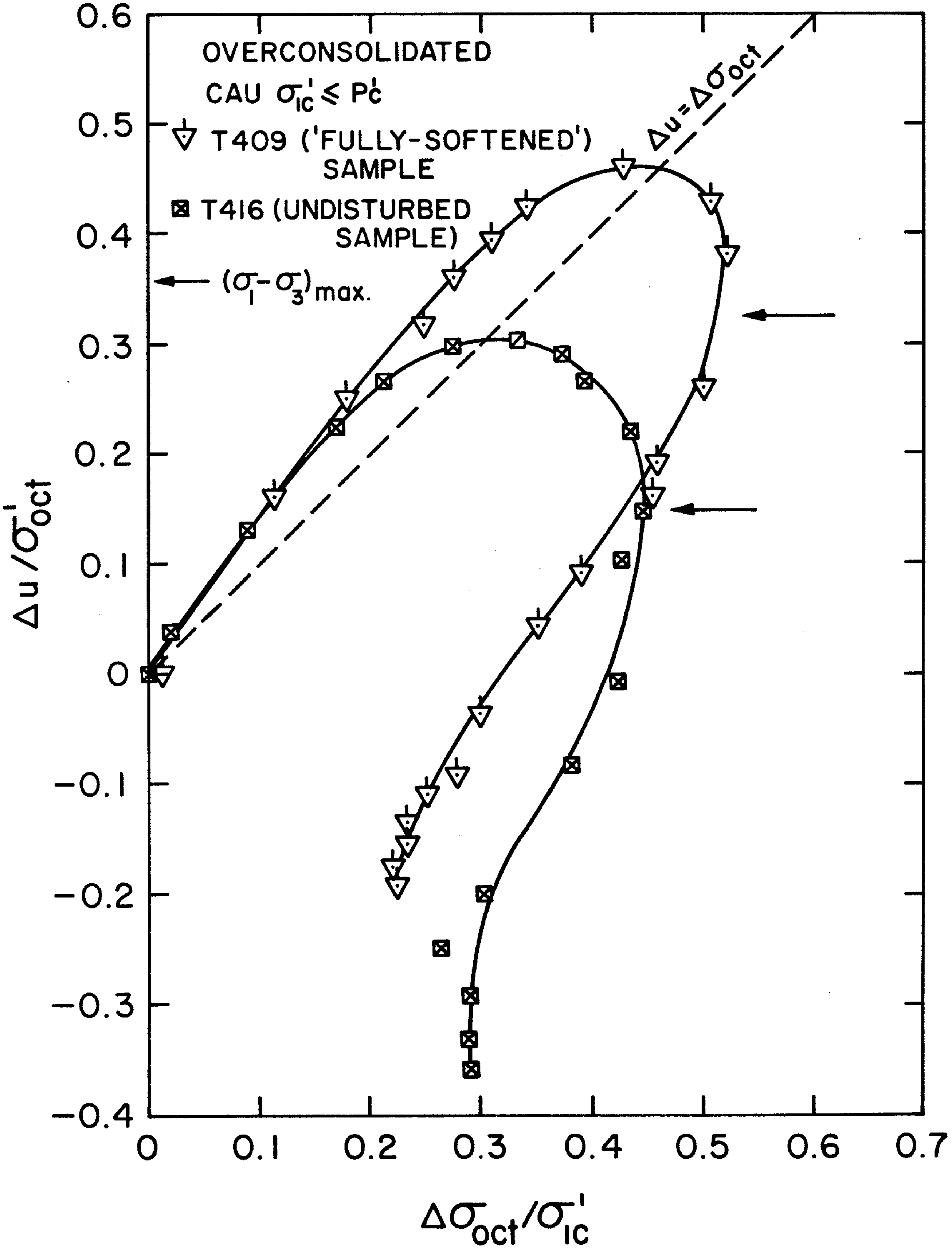


FIG. 4.39 POREWATER PRESSURE BEHAVIOUR, $\Delta u/\sigma'_{1c}$ vs $\Delta\sigma_{oct}/\sigma'_{1c}$; T409, T416

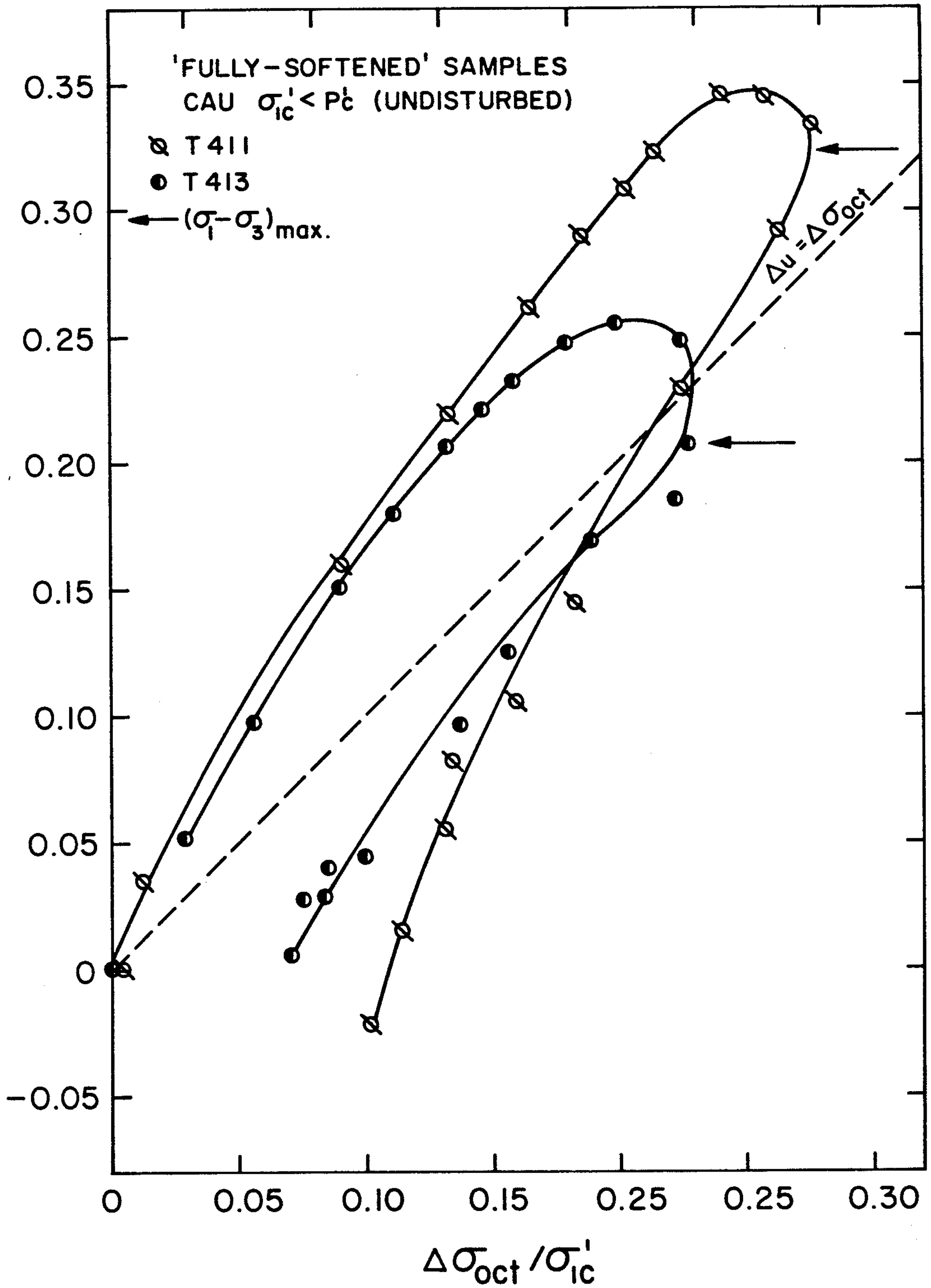


FIG. 4.40 POREWATER PRESSURE BEHAVIOUR, $\Delta u/\sigma'_{1c}$ vs $\Delta\sigma_{oct}/\sigma'_{1c}$; T411, T413

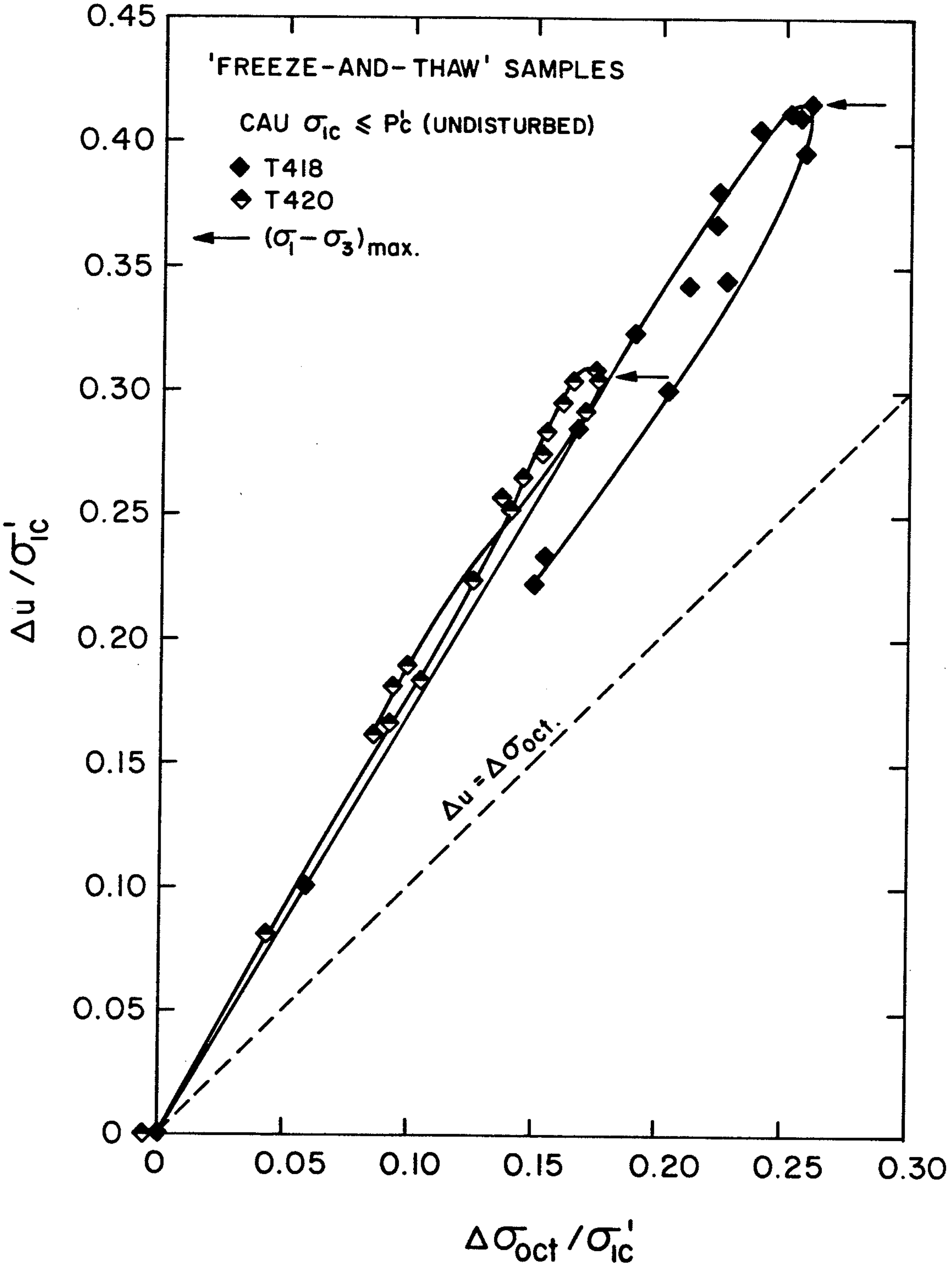


FIG. 4.41 POREWATER PRESSURE BEHAVIOUR, $\Delta u/\sigma'_{1c}$ vs $\Delta\sigma_{oct}/\sigma'_{1c}$; T418, T420

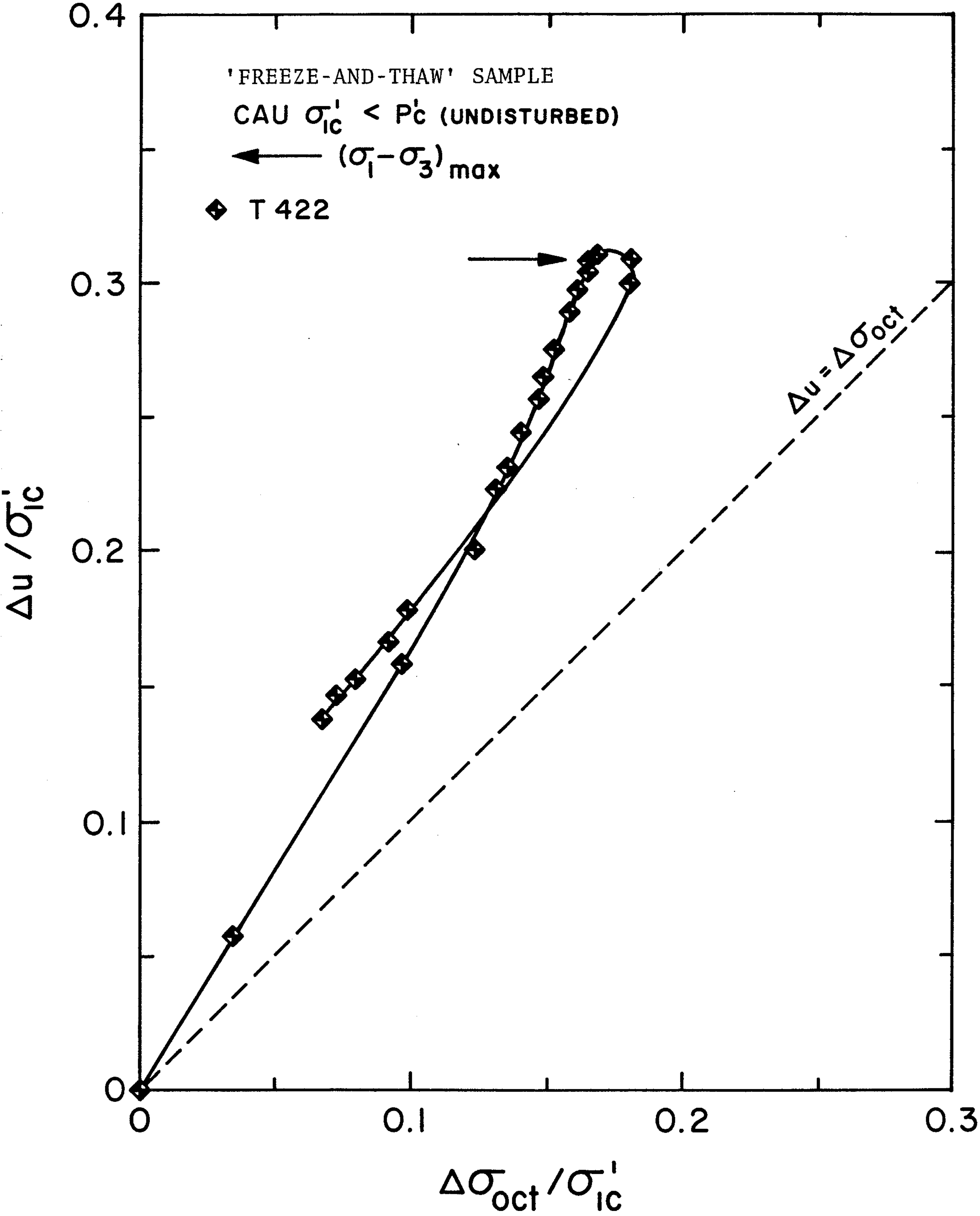


FIG. 4.42 POREWATER PRESSURE BEHAVIOUR, $\Delta u/\sigma'_{1c}$ vs $\Delta\sigma_{oct}/\sigma'_{1c}$; T422

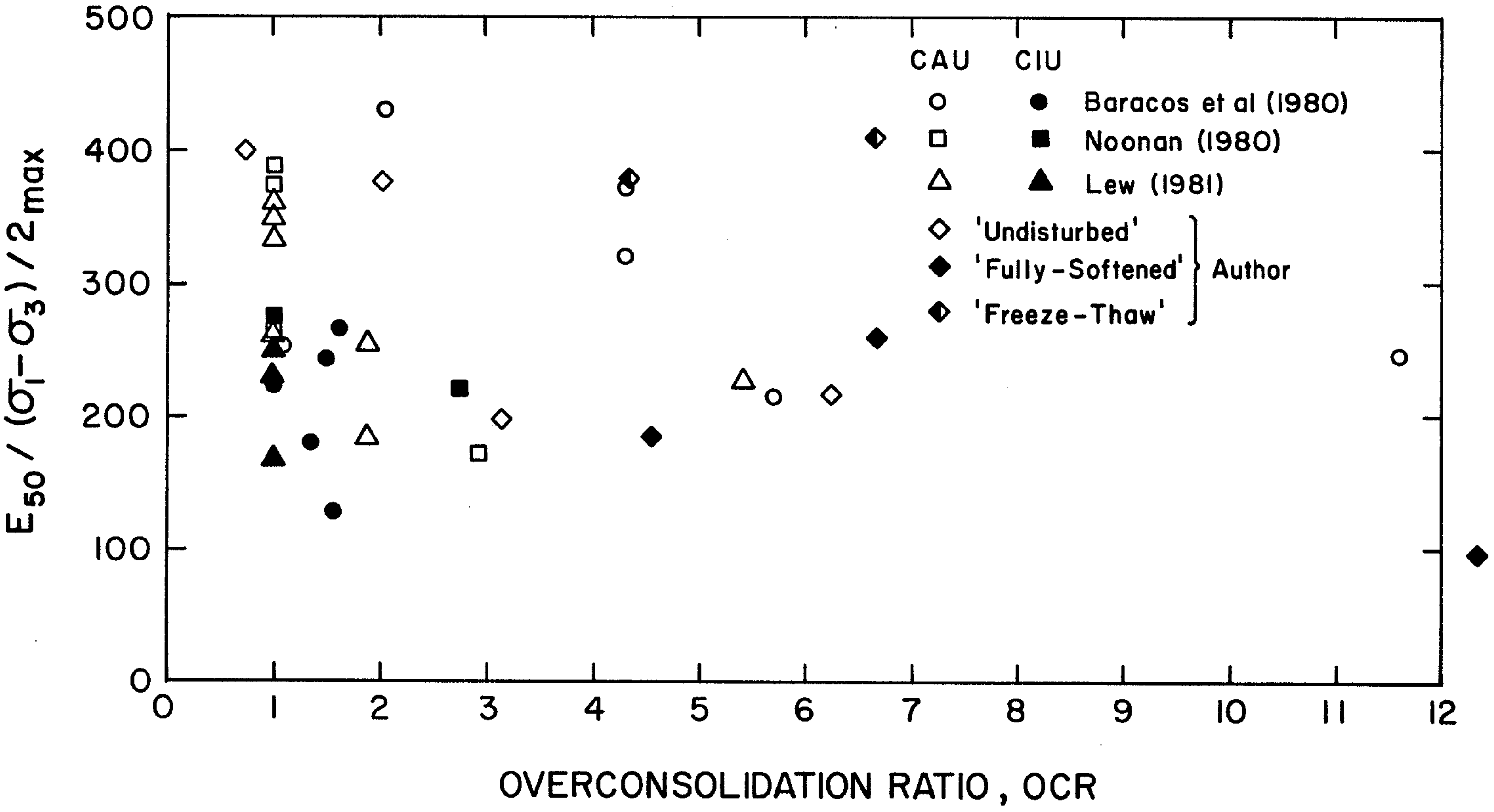


FIG. 4.43 RELATIVE STIFFNESS E_{50}/s_u vs OVERCONSOLIDATION RATIO

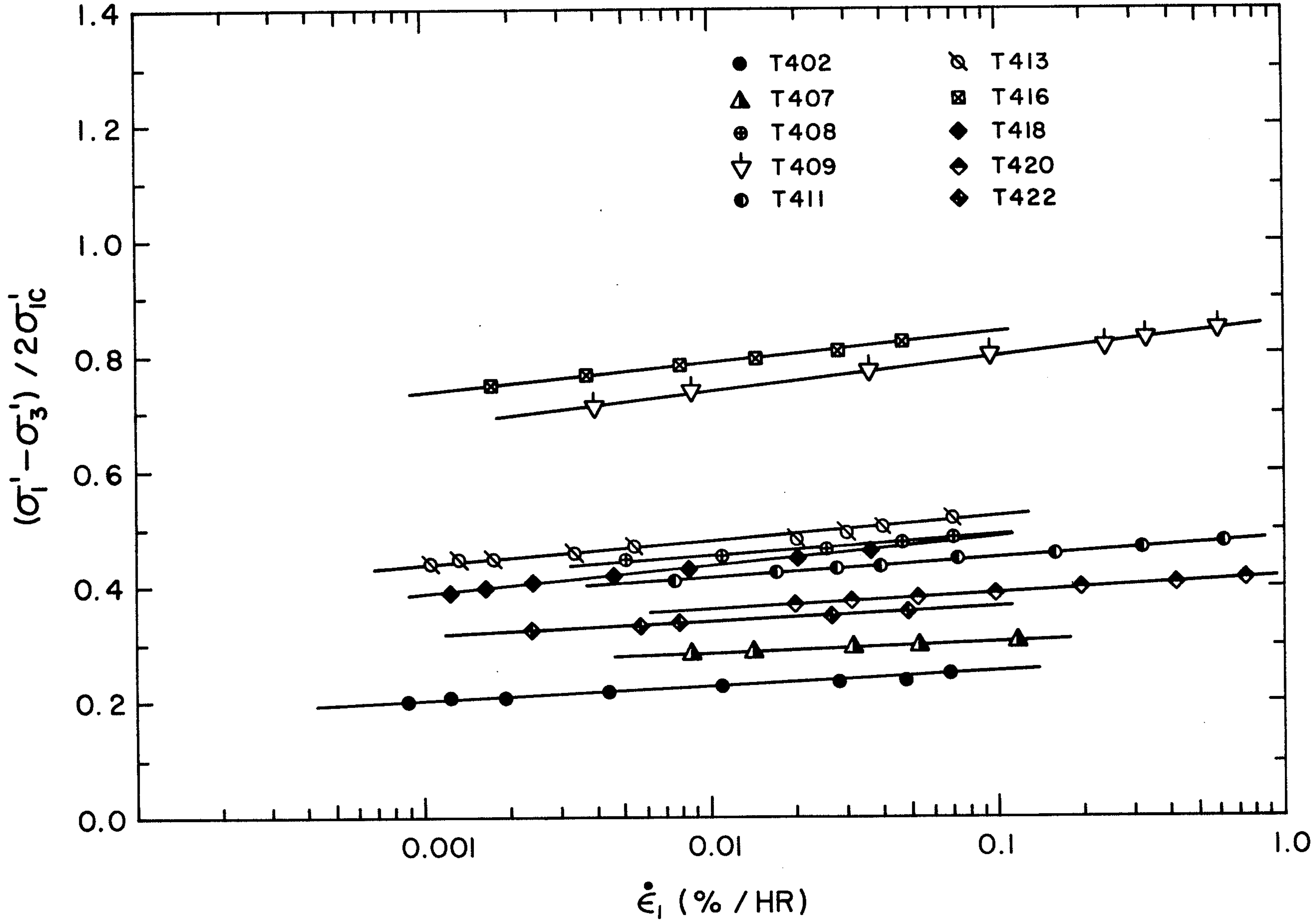


FIG. 4.44 STRAIN RATE EFFECTS FROM FIRST RELAXATION TESTS

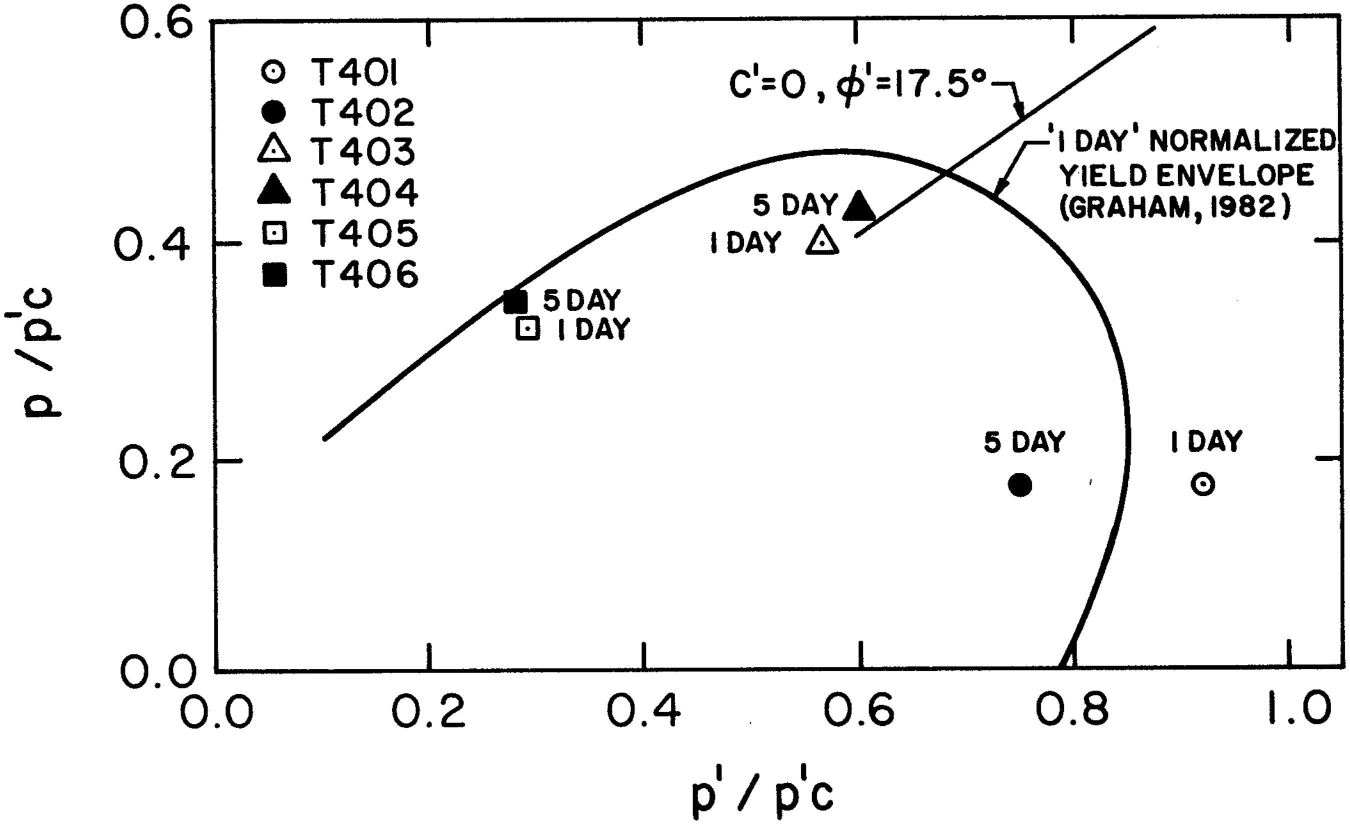
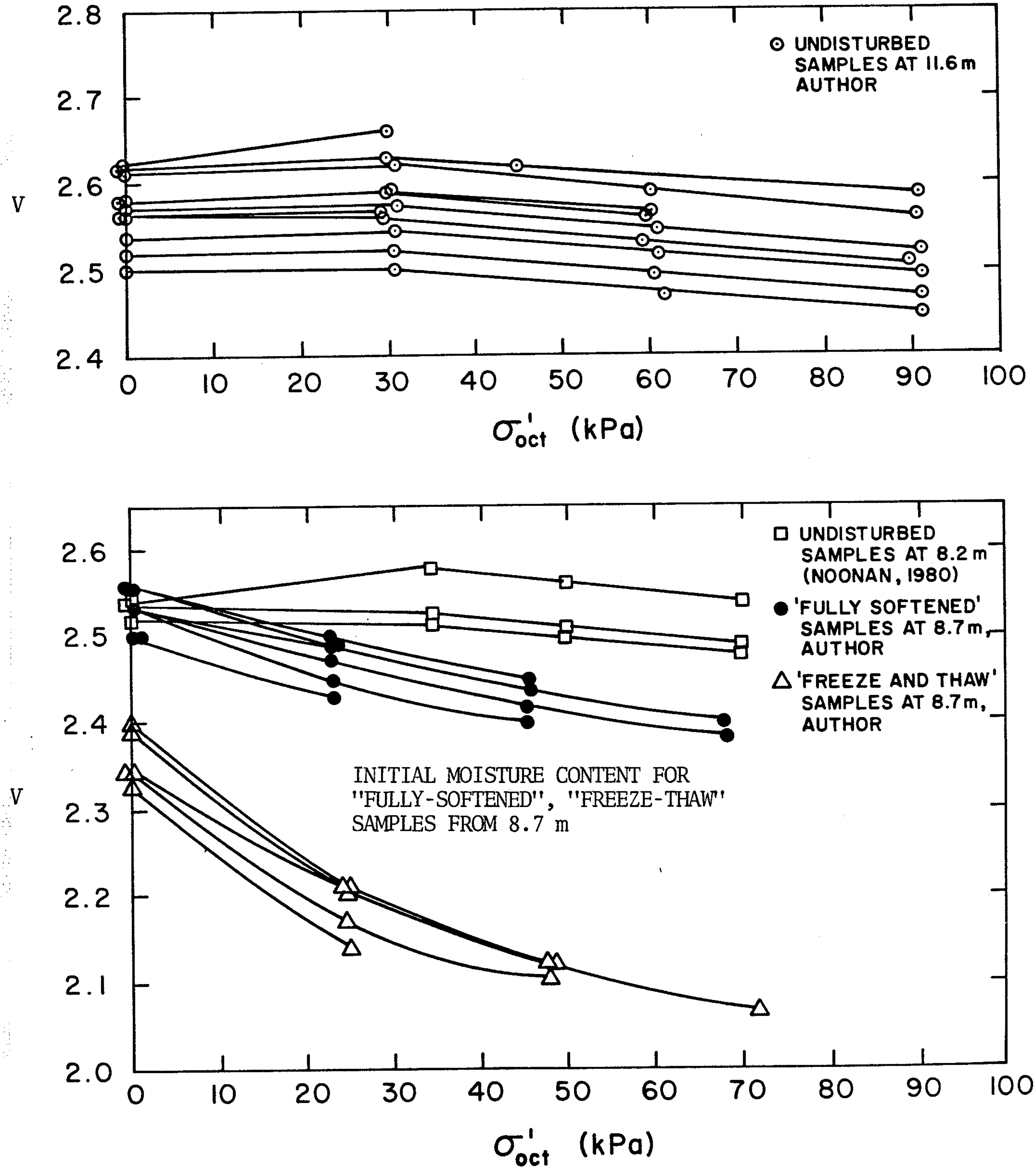


FIG. 5.1 NORMALIZED YIELD STRESSES FOR SAMPLES T401 TO T406



INITIAL MOISTURE CONTENT FOR "FULLY-SOFTENED", "FREEZE-THAW" SAMPLES FROM 8.7 m

FIG. 5.2 GRAPH OF SPECIFIC VOLUME V vs σ'_{oct}

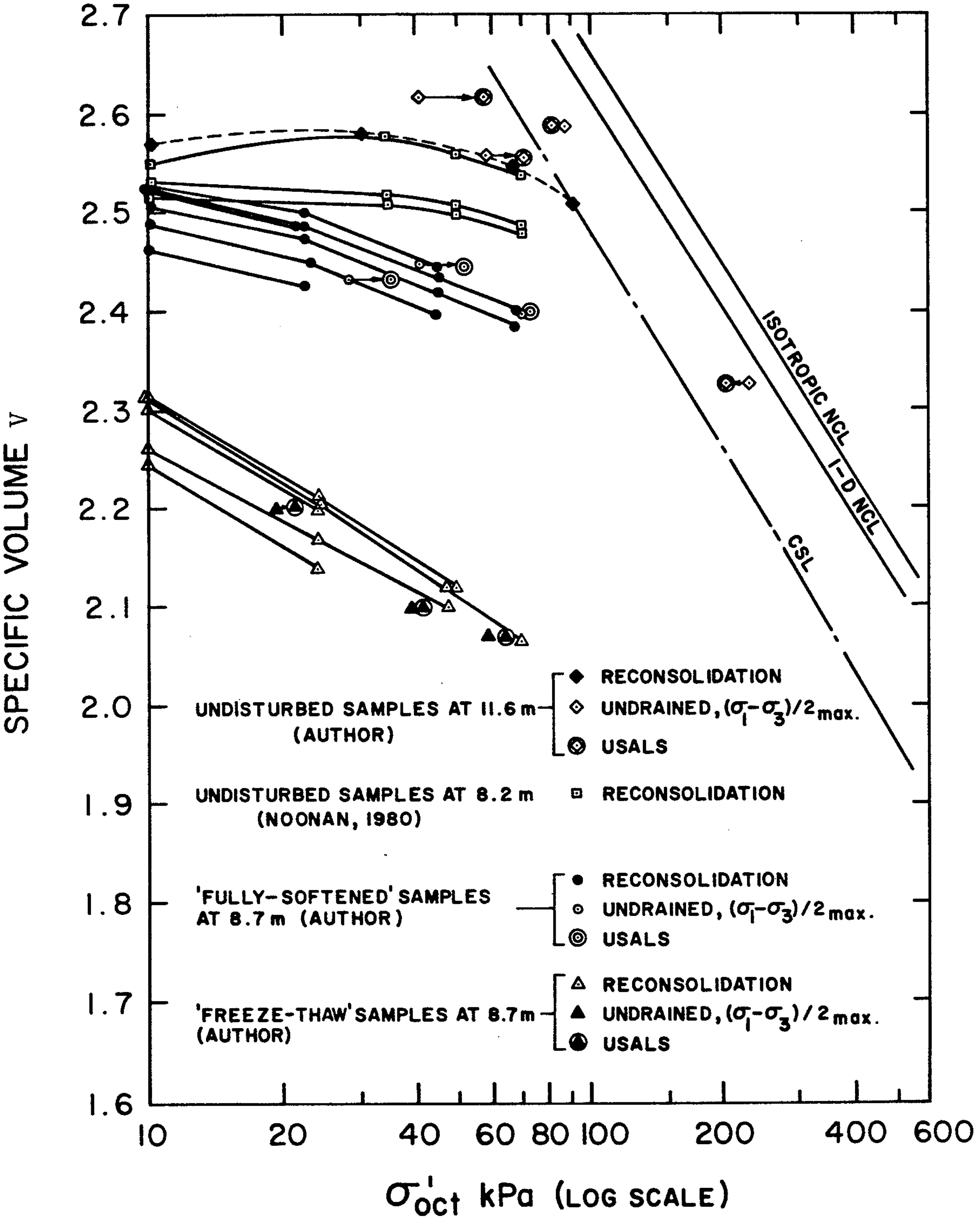


FIG. 5.3 GRAPH OF SPECIFIC VOLUME V vs logσ'_{oct}

~~5-3~~
5-4

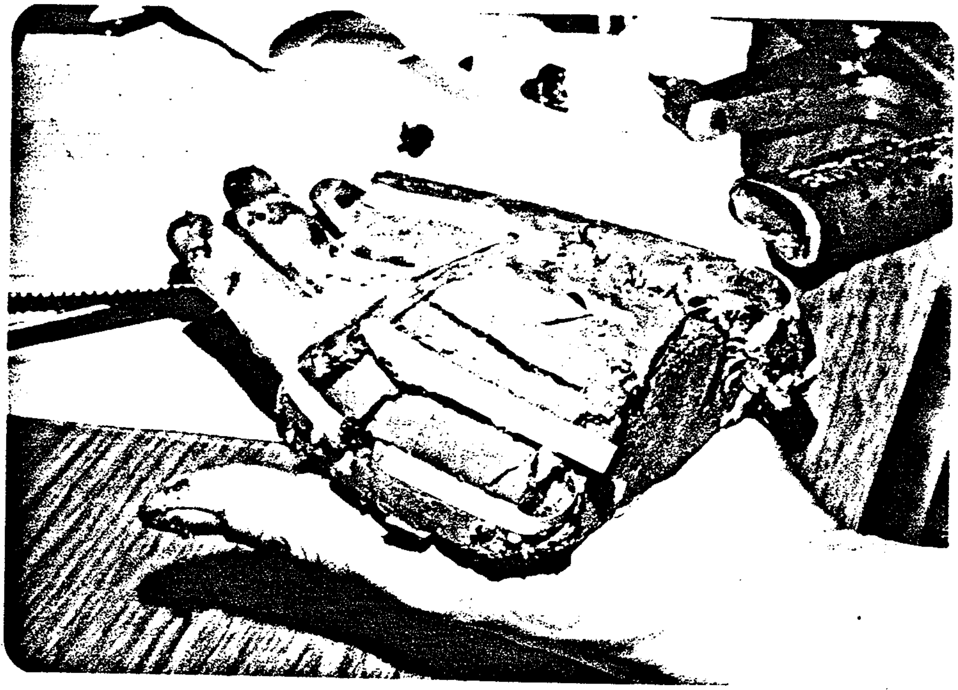


FIG. 5.4 TYPICAL CLAY STRUCTURE FOR 'FULLY-SOFTENED' SAMPLES AFTER FAILURE, T410

5-5
5-4

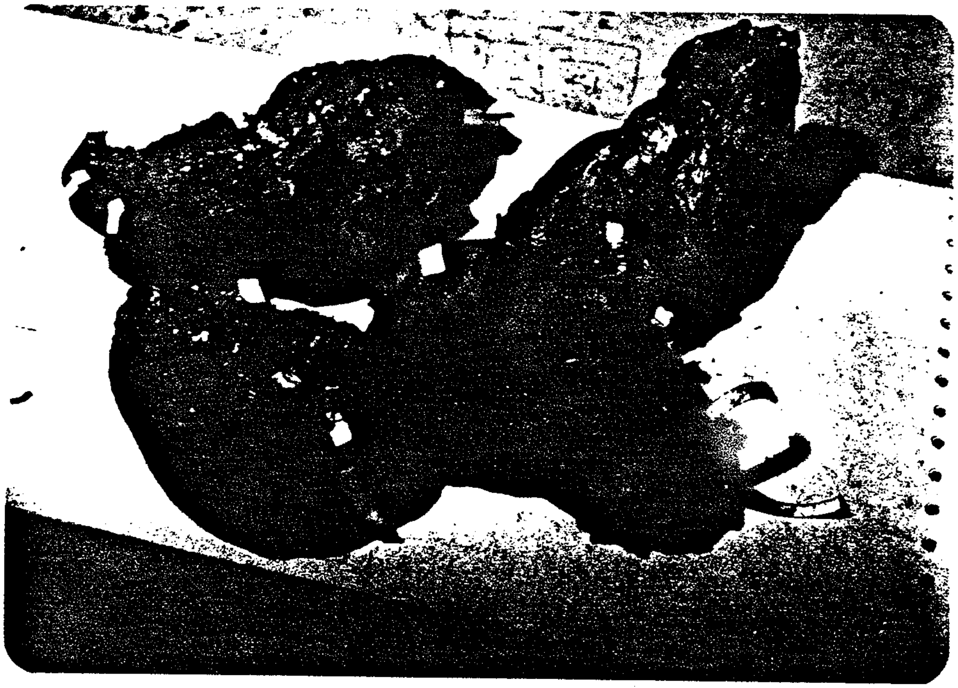


FIG. 5.5 TYPICAL CLAY STRUCTURE FOR 'FREEZE-THAW' SAMPLES AFTER FAILURE, T422

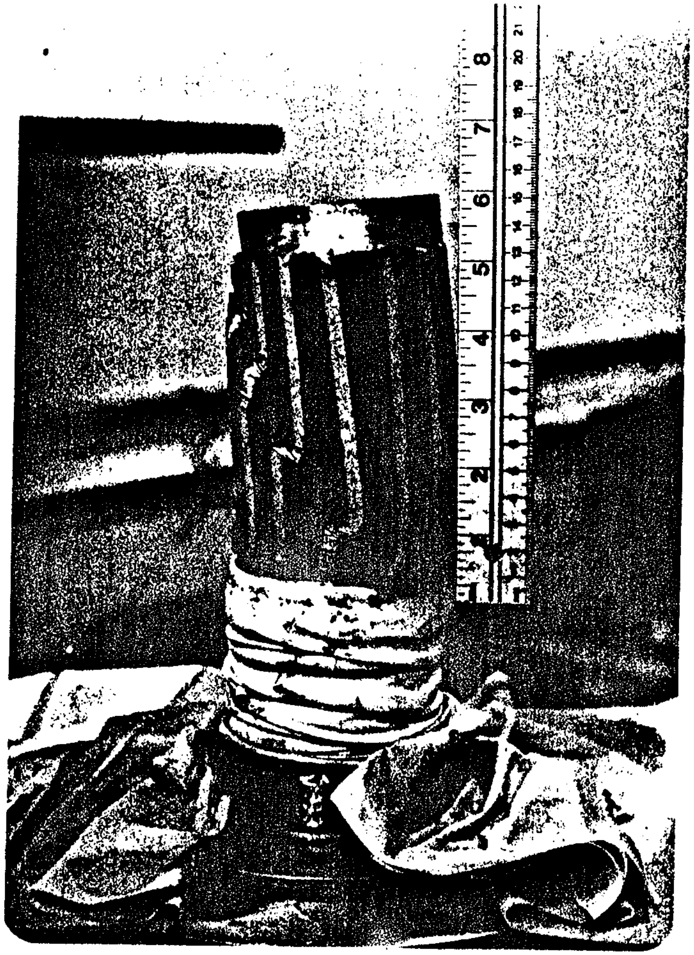


FIG. 5.6 TYPICAL FAILURE PLANE FOR 'FULLY-SOFTENED' SAMPLES, T409

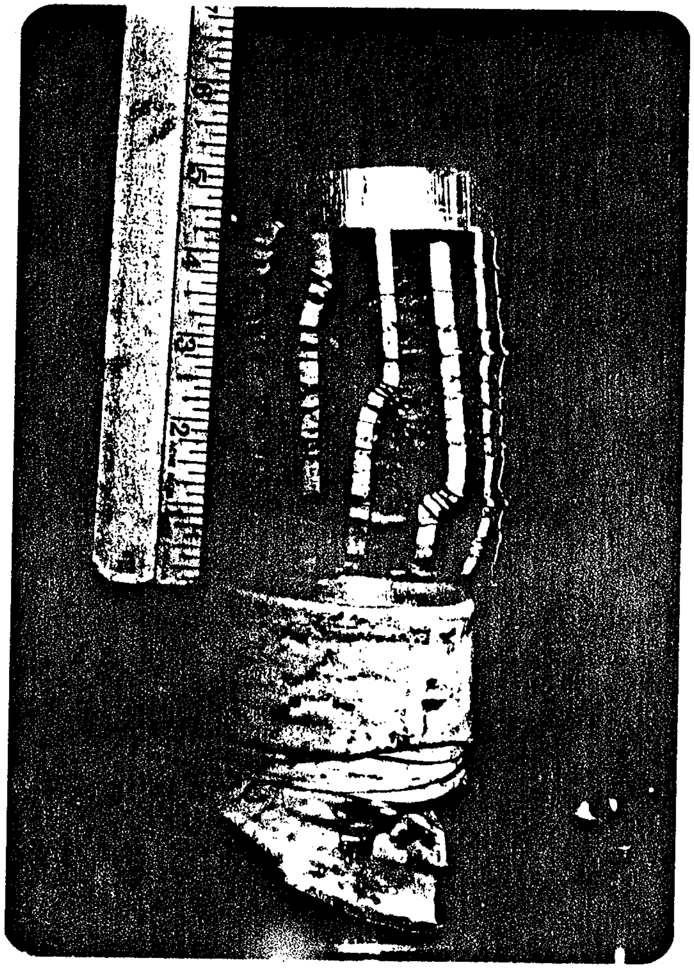


FIG. 5.7 TYPICAL FAILURE PLANE FOR 'FREEZE-THAW' SAMPLES, T421

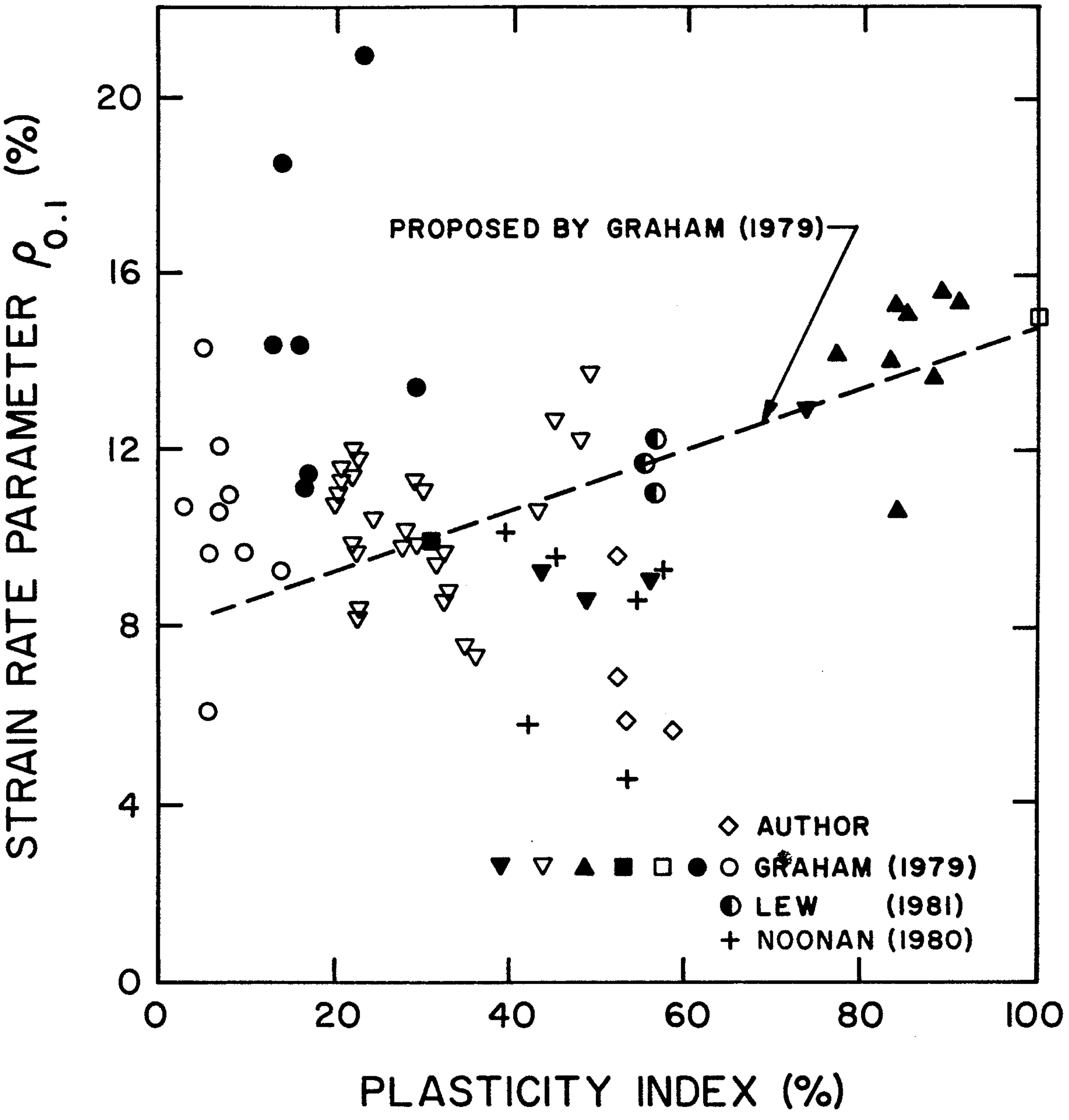


Fig. 5.8 The Relationship Between Strain Rate and Plasticity Index

APPENDIX I

TRIAXIAL TEST RESULTS

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = F 432       HOLE NO. =    6       DEPTH =  11.48 METRES TO  11.66 METRES

SAMPLE HEIGHT AFTER CONSOLIDATION =  13.006 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 564.330 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  43.390 SQUARE CENTIMETRES

CONSTANT LOAD                     =   14.06  N .
PROVING RING FACTOR               =  4.1560  N ./DIV
PISTON AREA                       =  5.0600 SQUARE CENTIMETRES

INITIAL DIAL READING              = 1416.40 DIVISIONS


SHEAR TEST RESULTS    START  19810730     END  19810803


CONSOLIDATED UNDRAINED TRIAXIAL TEST
::::::::::::::::::::::::::::::::::::::::


 PT  TIME       DISPL     RRING     PORE      PER       EFFECT    EFFECT    HALF      DEV       EFFECT    RATIO OF        A
                DIAL      DIAL      PRESS     CENT      SIGMA1    SIGMA3    DEV       STRESS    OCT       EFF SIGMA1
                RDG       RDG       KPA       STRAIN    KPA       KPA       STRESS    KPA       STRESS    EFF SIGMA3
                                                                          KPA                 KPA

  1  1115     1416.4     104.5     243.4     0.00      325.0     283.1      21.0      41.9     297.1      1.148     UUUUUUU
  2  1125     1409.0     137.5     264.4     0.06      335.5     262.0      36.8      73.5     286.5      1.281        0.67
  3  1135     1397.5     163.0     281.2     0.15      343.1     245.3      48.9      97.8     277.9      1.399        0.68
  4  1145     1384.1     182.4     293.2     0.25      349.6     233.3      58.1     116.3     272.1      1.498        0.67
  5  1155     1369.1     196.2     302.0     0.36      353.5     224.2      64.7     129.3     267.3      1.577        0.67
  6  1205     1353.7     206.2     308.9     0.48      355.9     217.2      69.4     138.7     263.4      1.639        0.68
  7  1215     1336.5     214.8     315.0     0.61      357.8     211.1      73.4     146.7     260.0      1.695        0.68
  8  1225     1319.3     221.0     319.9     0.75      358.4     206.0      76.2     152.4     256.8      1.740        0.69
  9  1235     1302.2     226.0     324.0     0.88      358.9     201.9      78.5     157.0     254.2      1.778        0.70
 10  1245     1284.0     230.0     327.9     1.02      358.6     198.0      80.3     160.6     251.5      1.811        0.71
 11  1255     1265.5     233.0     330.8     1.16      358.0     194.8      81.6     163.2     249.2      1.838        0.72
 12  1305     1247.8     235.8     333.7     1.30      357.5     191.9      82.8     165.6     247.1      1.863        0.73
 13  1315     1230.6     237.8     336.5     1.43      356.4     189.1      83.6     167.3     244.9      1.885        0.74
 14  1335     1192.2     241.0     341.5     1.72      353.8     184.0      84.9     169.8     240.6      1.923        0.77
 15  1355     1155.3     243.0     345.4     2.01      351.0     179.8      85.6     171.2     236.9      1.952        0.79
 16  1415     1117.8     244.2     349.2     2.30      347.8     175.9      85.9     171.9     233.2      1.977        0.81
 17  1435     1081.2     244.8     352.5     2.58      344.6     172.7      86.0     171.9     230.0      1.995        0.84
 18  1455     1041.9     245.0     355.4     2.88      341.2     169.6      85.8     171.6     226.8      2.012        0.86
 19  1515     1004.5     245.2     358.3     3.17      338.0     166.7      85.6     171.3     223.8      2.027        0.89
 20  1525      986.0     245.0     359.7     3.31      336.1     165.3      85.4     170.8     222.2      2.033        0.90
 21  1535      967.0     245.1     360.7     3.46      334.7     164.0      85.4     170.7     220.9      2.041        0.91
101  1537      963.9     241.4     RELAXATION TEST
102  1538      963.6     240.9     RELAXATION TEST
103  1540      963.0     239.1     RELAXATION TEST
104  1544      962.0     236.0     RELAXATION TEST
105  1551      961.2     232.6     RELAXATION TEST
106  1559      960.5     230.0     RELAXATION TEST
107  1625      959.9     224.4     RELAXATION TEST
108  1730      956.5     218.3     RELAXATION TEST
109  2120      953.2     208.7     RELAXATION TEST
110  2235      952.5     206.3     RELAXATION TEST
111     4      952.2     204.2     RELAXATION TEST
112   922      950.8     197.4     RELAXATION TEST
113  1128      950.9     196.1     RELAXATION TEST
114  1357      950.9     196.0     RELAXATION TEST
 22  1410      958.0     153.8     339.8     3.52      272.3     186.2      43.0      86.1     214.9      1.462        2.18
 23  1420      971.5     130.1     327.4     3.42      262.7     198.5      32.1      64.2     219.9      1.324        3.76
 24  1430      984.9     115.5     319.9     3.32      256.7     205.9      25.4      50.8     222.8      1.247        8.62
 25  1440      991.0     134.9     326.1     3.27      268.6     199.8      34.4      68.8     222.7      1.344        3.08
 26  1450      980.7     164.5     345.6     3.35      276.4     180.3      48.1      96.1     212.3      1.533        1.89
 27  1500      968.0     188.2     359.1     3.45      284.9     167.0      59.0     117.9     206.3      1.706        1.52
 28  1510      955.1     207.0     368.9     3.55      292.3     157.1      67.6     135.2     202.2      1.861        1.35
 29  1520      940.2     225.0     376.5     3.66      301.1     149.4      75.8     151.7     200.0      2.015        1.21
 30  1540      906.7     242.0     381.6     3.92      311.1     144.2      83.5     166.9     199.8      2.157        1.11
 31  1600      870.6     247.0     381.6     4.20      315.1     144.1      85.5     171.0     201.1      2.187        1.07
 32  1515      841.3     248.0     381.3     4.42      316.2     144.7      85.8     171.5     201.9      2.185        1.06
 33  1618      822.0     254.8     385.8     4.57      317.6     140.1      88.7     177.5     199.3      2.267        1.05
 34  1620      805.3     255.2     385.6     4.70      317.9     140.3      88.8     177.6     199.5      2.266        1.05
 35  1622      790.5     255.0     385.1     4.81      317.9     140.7      88.6     177.2     199.8      2.259        1.05
 36  1624      776.3     254.5     384.4     4.92      317.9     141.3      88.3     176.6     200.2      2.250        1.05
 37  1626      757.0     253.2     383.7     5.07      317.3     142.2      87.5     175.1     200.6      2.231        1.05
 38  1628      744.5     252.2     383.1     5.17      316.7     142.7      87.0     174.0     200.7      2.219        1.06
```

39	1530	729.3	251.2	382.5	5.28	316.3	143.4	86.4	172.9	201.0	2.206	1.06
40	1635	715.2	242.1	377.8	5.38	312.5	148.0	82.2	164.5	202.8	2.111	1.10
41	1640	705.6	241.0	378.1	5.46	311.1	147.8	81.7	163.3	202.2	2.105	1.11
42	1650	687.4	239.5	378.5	5.61	308.8	147.1	80.9	161.7	201.0	2.100	1.13
43	1700	568.0	238.0	378.8	5.75	307.0	146.9	80.1	160.1	200.3	2.090	1.15
44	1702	640.0	245.0	384.0	5.97	307.7	141.6	83.0	166.1	197.0	2.173	1.13
45	1703	592.0	234.0	371.5	6.26	309.8	154.1	77.8	155.7	206.0	2.010	1.13
46	1705	533.0	201.0	357.0	6.79	293.9	168.6	62.7	125.3	210.4	1.743	1.36
47	1706	517.0	196.0	355.1	6.92	291.4	170.7	60.3	120.7	210.9	1.707	1.42
48	1707	509.0	195.0	355.3	6.98	290.3	170.6	59.9	119.7	210.5	1.702	1.44
49	1708	500.0	194.2	355.7	7.05	288.8	169.9	59.5	118.9	209.5	1.700	1.46
50	1710	484.6	192.8	356.1	7.16	287.0	169.5	58.8	117.5	208.7	1.693	1.49
51	1713	461.5	191.2	356.5	7.34	285.0	169.1	57.9	115.9	207.7	1.685	1.53
52	1716	454.0	188.5	356.2	7.40	282.7	169.3	56.7	113.4	207.1	1.670	1.58
53	1730	427.3	186.4	359.3	7.60	277.7	166.4	55.7	111.3	203.5	1.669	1.67
54	1740	408.4	185.7	360.4	7.75	275.7	165.2	55.3	110.5	202.0	1.669	1.71
201	1742	406.8	184.0	RELAXATION TEST								
202	1743	406.7	183.9	RELAXATION TEST								
203	1745	406.7	183.7	RELAXATION TEST								
204	1749	406.5	183.2	RELAXATION TEST								
205	1756	405.4	182.8	RELAXATION TEST								
206	1811	406.0	182.2	RELAXATION TEST								
207	1831	405.5	181.6	RELAXATION TEST								
208	1941	404.8	180.0	RELAXATION TEST								
209	2150	403.8	178.2	RELAXATION TEST								
210	1025	402.9	174.9	RELAXATION TEST								
211	1304	401.8	173.8	RELAXATION TEST								
55	1936	389.0	189.0	378.9	7.90	260.9	147.7	56.6	113.2	185.4	1.766	1.90
56	1937	364.2	190.8	379.5	8.09	261.5	147.0	57.3	114.5	185.2	1.779	1.88
57	1938	344.1	191.0	378.7	8.24	262.3	147.8	57.2	114.5	186.0	1.775	1.86
58	1939	304.4	191.0	377.7	8.55	262.8	148.7	57.1	114.1	186.7	1.767	1.86
59	1940	268.9	190.0	376.5	8.82	262.9	150.0	56.5	112.9	187.6	1.753	1.88
60	1941	239.0	189.0	375.5	9.06	252.7	151.0	55.9	111.7	188.2	1.740	1.89
61	1943	218.0	185.7	373.4	9.21	261.9	153.2	54.3	108.7	189.4	1.709	1.95
62	1945	213.0	185.4	372.9	9.25	262.1	153.7	54.2	108.4	189.8	1.705	1.95
63	1947	195.5	186.0	372.2	9.46	262.9	154.3	54.3	108.6	190.5	1.704	1.93
64	1949	170.8	186.2	371.8	9.58	263.4	154.7	54.3	108.7	190.9	1.703	1.92
65	1951	157.0	185.2	371.3	9.68	262.9	155.2	53.8	107.7	191.1	1.694	1.95
66	1953	142.2	185.2	371.0	9.80	263.0	155.5	53.8	107.5	191.3	1.692	1.94
67	1955	127.0	184.8	370.6	9.91	262.9	155.8	53.5	107.1	191.5	1.687	1.95
68	1957	111.0	184.8	370.5	10.04	263.1	156.2	53.4	106.9	191.8	1.684	1.96
69	2000	107.2	181.8	369.2	10.07	261.6	157.3	52.1	104.3	192.1	1.663	2.02
70	2010	89.0	181.5	369.3	10.21	261.3	157.4	51.9	103.9	192.0	1.660	2.03
71	2020	70.4	181.5	369.3	10.35	260.7	157.0	51.9	103.7	191.6	1.661	2.04
72	2030	55.6	180.0	368.7	10.46	260.1	157.8	51.1	102.3	191.9	1.648	2.08
73	2050	36.0	180.2	370.6	10.61	258.5	156.2	51.1	102.3	190.3	1.655	2.11
74	2110	-0.9	181.8	370.8	10.90	259.2	155.9	51.7	103.3	190.3	1.663	2.08
301	2112	-3.2	179.8	RELAXATION TEST								
302	2113	-3.2	179.5	RELAXATION TEST								
303	2115	-3.3	179.0	RELAXATION TEST								
304	2119	-3.5	178.5	RELAXATION TEST								
305	2126	-3.5	177.8	RELAXATION TEST								
306	2141	-4.0	177.0	RELAXATION TEST								
307	2211	-4.3	176.0	RELAXATION TEST								
308	2311	-5.0	175.0	RELAXATION TEST								
309	33	-5.8	174.0	RELAXATION TEST								
310	1333	-6.5	170.8	RELAXATION TEST								
311	1257	-7.0	169.2	RELAXATION TEST								
75	1305	-15.6	174.4	376.9	11.01	246.9	150.0	48.4	96.9	182.3	1.646	2.43
76	1310	-24.5	176.8	377.5	11.08	248.1	149.3	49.4	98.8	182.2	1.662	2.36
77	1320	-42.0	179.2	377.5	11.21	250.0	149.3	50.4	100.7	182.9	1.675	2.28
78	1340	-79.0	181.2	376.9	11.50	252.2	150.1	51.0	102.1	184.1	1.680	2.22
79	1400	-115.9	182.0	376.1	11.79	253.3	150.9	51.2	102.4	185.0	1.679	2.19
80	1420	-153.8	182.0	375.5	12.07	253.2	151.1	51.1	102.1	185.1	1.676	2.19
81	1440	-191.4	182.0	375.3	12.36	253.2	151.4	50.9	101.8	185.3	1.672	2.20
82	1500	-229.7	181.9	375.1	12.66	252.8	151.4	50.7	101.4	185.2	1.670	2.22
83	1540	-304.9	181.8	375.3	13.23	251.8	151.2	50.3	100.6	184.7	1.666	2.25
84	1620	-381.2	181.5	376.0	13.82	250.1	150.4	49.9	99.7	183.6	1.663	2.30
85	1708	-471.3	182.0	376.8	14.51	249.1	149.8	49.7	99.3	182.9	1.663	2.33

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CONSOLIDATION AXIAL STRESS         =  326.80 KPA
PRECONSOLIDATION PRESSURE          =  118.40 KPA
NORMALIZING STRESS                 =  326.80 KPA

NORMALIZED SHEAR TEST RESULTS     START  19810730      END  19810803

 PT     PER       NRMLZD     NRMLZD     NRMLZD      NRMLZD
        CENT      HALF       DEV        OCT         CHANGE
        STRAIN    DEV        STRESS     STRESS      IN PWP
                  STRESS     KPA        KPA         KPA
                  KPA

  1     0.00      0.064      0.128      0.909       0.000
  2     0.06      0.112      0.225      0.877       0.064
  3     0.15      0.150      0.299      0.850       0.115
  4     0.25      0.178      0.356      0.832       0.152
  5     0.36      0.198      0.396      0.818       0.179
  6     0.48      0.212      0.424      0.806       0.200
  7     0.61      0.224      0.449      0.796       0.219
  8     0.75      0.233      0.466      0.786       0.234
  9     0.88      0.240      0.480      0.778       0.247
 10     1.02      0.246      0.491      0.770       0.259
 11     1.16      0.250      0.499      0.763       0.267
 12     1.30      0.253      0.507      0.756       0.276
 13     1.43      0.256      0.512      0.749       0.285
 14     1.72      0.260      0.520      0.736       0.300
 15     2.01      0.262      0.524      0.725       0.312
 16     2.30      0.263      0.526      0.714       0.324
 17     2.59      0.263      0.526      0.704       0.334
 18     2.88      0.263      0.525      0.694       0.343
 19     3.17      0.262      0.524      0.685       0.352
 20     3.31      0.261      0.523      0.680       0.355
 21     3.46      0.261      0.522      0.676       0.359
 22     3.52      0.132      0.263      0.658       0.295
 23     3.42      0.098      0.197      0.673       0.257
 24     3.32      0.078      0.155      0.682       0.234
 25     3.27      0.105      0.211      0.682       0.253
 26     3.35      0.147      0.294      0.650       0.313
 27     3.45      0.180      0.361      0.631       0.354
 28     3.55      0.207      0.414      0.619       0.384
 29     3.66      0.232      0.464      0.612       0.407
 30     3.92      0.255      0.511      0.611       0.423
 31     4.20      0.262      0.523      0.615       0.423
 32     4.42      0.262      0.525      0.618       0.422
 33     4.57      0.272      0.543      0.610       0.436
 34     4.70      0.272      0.543      0.610       0.435
 35     4.81      0.271      0.542      0.611       0.434
 36     4.92      0.270      0.540      0.612       0.431
 37     5.07      0.268      0.536      0.614       0.429
 38     5.17      0.266      0.532      0.614       0.427
 39     5.28      0.264      0.529      0.615       0.426
 40     5.39      0.252      0.503      0.621       0.411
 41     5.46      0.250      0.500      0.619       0.412
 42     5.61      0.247      0.495      0.615       0.413
 43     5.75      0.245      0.490      0.613       0.414
 44     5.97      0.254      0.508      0.603       0.430
 45     6.26      0.238      0.476      0.630       0.392
 46     6.79      0.192      0.384      0.644       0.349
 47     6.92      0.185      0.369      0.645       0.342
 48     6.99      0.183      0.366      0.644       0.342
 49     7.05      0.182      0.364      0.641       0.344
 50     7.16      0.180      0.360      0.639       0.345
 51     7.34      0.177      0.355      0.636       0.346
 52     7.40      0.174      0.347      0.634       0.345
 53     7.60      0.170      0.341      0.623       0.355
 54     7.75      0.169      0.338      0.618       0.358
 55     7.90      0.173      0.346      0.567       0.415
 56     8.09      0.175      0.350      0.567       0.415
 57     8.24      0.175      0.350      0.569       0.414
 58     8.55      0.175      0.349      0.571       0.411
 59     8.82      0.173      0.345      0.574       0.407
 60     9.06      0.171      0.342      0.576       0.404
 61     9.21      0.166      0.333      0.580       0.398
 62     9.25      0.166      0.332      0.581       0.395
 63     9.46      0.166      0.332      0.583       0.394
 64     9.58      0.166      0.333      0.584       0.393
 65     9.68      0.165      0.330      0.585       0.391
 66     9.80      0.165      0.329      0.586       0.390
 67     9.91      0.164      0.328      0.586       0.389
 68    10.04      0.164      0.327      0.587       0.389
 69    10.07      0.160      0.319      0.588       0.385
 70    10.21      0.159      0.318      0.588       0.385
 71    10.35      0.159      0.317      0.586       0.385
 72    10.46      0.157      0.313      0.587       0.383
 73    10.61      0.156      0.313      0.582       0.383
 74    10.90      0.158      0.316      0.582       0.390
 75    11.01      0.148      0.296      0.558       0.409
 76    11.08      0.151      0.302      0.558       0.410
 77    11.21      0.154      0.308      0.560       0.410
 78    11.50      0.156      0.312      0.563       0.409
 79    11.79      0.157      0.313      0.566       0.406
 80    12.07      0.156      0.313      0.567       0.404
 81    12.36      0.156      0.311      0.567       0.404
 82    12.66      0.155      0.310      0.567       0.403
 83    13.23      0.154      0.308      0.565       0.404
 84    13.82      0.153      0.305      0.562       0.405
 85    14.51      0.152      0.304      0.560       0.408
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UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 407 HOLE NO. = 6 DEPTH = 11.30 METRES TO 11.48 METRES

SAMPLE HEIGHT AFTER CONSOLIDATION = 12.887 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 577.640 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION = 44.825 SQUARE CENTIMETRES

CONSTANT LOAD = 13.93 N .
PROVING RING FACTOR = 4.1560 N ./DIV
PISTON AREA = 5.0600 SQUARE CENTIMETRES

INITIAL DIAL READING = 1866.00 DIVISIONS

SHEAR TEST RESULTS START 19810903 END 19810904

CONSOLIDATED UNDRAINED TRIAXIAL TEST
:::::::::::::::::::::::::::::::::::::

PT	TIME	DISPL DIAL RDG	PRING DIAL RDG	PORE PRESS KPA	PER CENT STRAIN	EFFECT SIGMA1 KPA	EFFECT SIGMA3 KPA	HALF DEV STRESS KPA	DEV STRESS KPA	EFFECT OCT STRESS KPA	RATIO OF EFF SIGMA1 EFF SIGMA3	A
1	955	1866.0	75.3	211.3	0.00	115.3	74.7	20.3	40.6	88.2	1.544	UUUUUUU
2	1005	1855.0	97.8	222.7	0.09	124.9	63.5	30.7	61.4	84.0	1.967	0.55
3	1015	1841.8	110.0	228.3	0.19	130.5	57.8	36.3	72.7	82.0	2.257	0.53
4	1025	1831.0	118.0	231.3	0.27	134.9	54.9	40.0	80.0	81.6	2.457	0.51
5	1035	1815.5	127.0	235.2	0.39	139.4	51.2	44.1	88.2	80.6	2.722	0.50
6	1045	1803.9	134.0	236.9	0.48	143.9	49.3	47.3	94.6	80.8	2.918	0.47
7	1055	1788.0	139.5	238.7	0.61	147.1	47.6	49.8	99.5	80.8	3.091	0.47
8	1115	1743.4	127.5	231.9	0.95	142.5	54.3	44.1	88.2	83.7	2.624	0.43
9	1130	1714.5	114.2	226.5	1.18	135.6	59.8	37.9	75.8	85.1	2.267	0.43
101	1132	1711.5	112.5	RELAXATION TEST								
102	1133	1711.2	111.8	RELAXATION TEST								
103	1135	1710.8	110.4	RELAXATION TEST								
104	1139	1710.4	109.2	RELAXATION TEST								
105	1146	1710.1	108.3	RELAXATION TEST								
106	1201	1709.2	106.0	RELAXATION TEST								
107	1231	1708.2	105.5	RELAXATION TEST								
108	1331	1706.5	104.0	RELAXATION TEST								
109	1531	1697.9	102.4	RELAXATION TEST								
110	1721	1696.0	101.5	RELAXATION TEST								
111	957	1694.6	98.8	RELAXATION TEST								
10	1010	1680.8	104.6	223.2	1.44	129.9	63.1	33.4	66.8	85.4	2.059	0.45
11	1020	1659.8	105.0	222.9	1.60	130.3	63.2	33.5	67.1	85.6	2.061	0.44
12	1040	1624.5	104.2	222.0	1.87	130.3	64.1	33.1	66.2	86.2	2.032	0.42
13	1050	1604.8	103.9	221.9	2.03	130.1	64.3	32.9	65.8	86.2	2.023	0.42
14	1100	1586.2	104.2	222.0	2.17	130.3	64.4	33.0	65.9	86.4	2.024	0.42
15	1120	1550.0	104.0	221.0	2.45	130.9	65.3	32.8	65.6	87.2	2.004	0.39
16	1140	1507.8	103.4	220.4	2.78	130.4	65.6	32.4	64.8	87.2	1.988	0.38
17	1200	1472.3	103.5	220.3	3.06	130.4	65.6	32.4	64.8	87.2	1.987	0.37
18	1220	1433.9	103.5	219.6	3.35	130.8	66.2	32.3	64.6	87.7	1.975	0.35
19	1240	1395.8	104.2	220.4	3.64	130.2	65.2	32.5	65.0	86.9	1.997	0.37
20	1300	1357.9	103.8	218.8	3.94	131.3	66.8	32.2	64.5	88.3	1.965	0.31
21	1320	1320.0	104.0	218.4	4.24	131.6	67.2	32.2	64.4	88.7	1.959	0.30
22	1340	1281.8	104.6	218.1	4.53	132.4	67.6	32.4	64.8	89.2	1.958	0.28
23	1400	1241.5	104.5	217.9	4.85	132.1	67.6	32.2	64.5	89.1	1.954	0.28
24	1403	1229.8	106.9	218.1	4.94	134.1	67.6	33.3	66.5	89.8	1.984	0.26
25	1405	1212.2	106.5	218.1	5.07	133.6	67.5	33.0	66.1	89.5	1.979	0.27
26	1410	1173.5	106.8	218.7	5.37	132.9	66.7	33.1	66.2	88.8	1.992	0.29
27	1415	1138.5	108.2	216.5	5.65	136.3	69.1	33.6	67.2	91.5	1.972	0.20
28	1420	1100.0	107.5	216.3	5.94	135.7	69.4	33.2	66.3	91.5	1.956	0.19
29	1425	1064.5	108.5	216.7	6.22	135.9	68.9	33.5	67.0	91.2	1.973	0.20
30	1430	1026.3	109.3	215.1	6.52	137.8	70.3	33.8	67.5	92.8	1.960	0.14
31	1435	987.8	109.0	216.4	6.81	136.3	69.3	33.5	67.0	91.6	1.967	0.19
32	1440	952.3	109.0	215.2	7.09	137.0	70.2	33.4	66.8	92.5	1.952	0.15
33	1442	944.8	107.5	216.1	7.15	134.9	69.4	32.8	65.5	91.2	1.944	0.19
34	1450	928.0	107.2	214.9	7.28	135.7	70.5	32.6	65.2	92.2	1.924	0.15
35	1500	903.5	107.0	218.1	7.42	132.3	67.4	32.4	64.9	89.0	1.963	0.28
36	1520	872.8	106.0	216.4	7.71	132.8	69.0	31.9	63.8	90.3	1.925	0.22
37	1600	795.3	105.2	216.5	8.31	131.4	68.6	31.4	62.8	89.5	1.915	0.23
38	1620	757.2	104.8	217.0	8.60	130.3	68.1	31.1	62.2	88.8	1.914	0.26
39	1630	735.8	104.8	216.7	8.77	130.5	68.4	31.1	62.1	89.1	1.908	0.25
40	1635	706.7	107.2	217.3	9.00	131.7	67.7	32.0	64.0	89.0	1.945	0.26
41	1640	667.9	107.2	217.5	9.30	131.6	67.8	31.9	63.8	89.1	1.940	0.27
42	1650	590.8	108.2	217.2	9.90	132.1	67.9	32.1	64.2	89.3	1.945	0.25
43	1700	520.5	108.0	217.4	10.44	131.4	67.8	31.8	63.6	89.0	1.938	0.27
44	1720	362.2	110.4	217.3	11.67	132.6	67.9	32.4	64.7	89.5	1.953	0.25
45	1730	292.5	110.0	217.2	12.21	131.7	67.7	32.0	64.0	89.0	1.946	0.25
46	1732	272.5	113.8	218.8	12.37	133.3	66.3	33.5	67.0	88.6	2.010	0.28
47	1734	220.5	113.9	218.6	12.77	133.3	66.6	33.4	66.7	88.8	2.002	0.28
48	1736	151.6	113.2	219.1	13.30	131.8	66.0	32.9	65.8	87.9	1.997	0.31
49	1738	96.0	113.2	219.6	13.74	131.0	65.5	32.7	65.5	87.3	1.999	0.33
50	1740	39.8	115.0	219.4	14.17	132.2	65.6	33.3	66.6	87.8	2.015	0.31
51	1743	-58.5	114.8	219.2	14.93	131.5	65.7	32.9	65.8	87.6	2.002	0.31
52	1745	-114.9	115.7	219.7	15.37	131.5	65.3	33.1	66.2	87.4	2.014	0.33
53	1747	-128.5	110.5	217.3	15.48	129.6	67.6	31.0	62.0	88.3	1.918	0.28
54	1750	-134.0	110.5	217.0	15.52	130.1	68.1	31.0	62.0	88.8	1.910	0.27
55	1800	-153.3	109.8	216.3	15.67	130.0	68.7	30.7	61.3	89.1	1.893	0.24
56	1810	-172.6	110.0	216.4	15.82	130.2	68.8	30.7	61.4	89.3	1.892	0.25
57	1816	-183.0	110.5	216.4	15.90	130.3	68.6	30.9	61.7	89.2	1.900	0.24

SAMPLE NO. = T 407   HOLE NO. = 6   DEPTH = 11.30 METRES TO 11.48 METRES

CONSOLIDATION AXIAL STRESS = 117.80 KPA
PRECONSOLIDATION PRESSURE = 210.00 KPA
NORMALIZING STRESS = 117.80 KPA

NORMALIZED SHEAR TEST RESULTS   START 19810903   END 19810904

PT	PER CENT STRAIN	NRMLZD HALF DEV STRESS KPA	NRMLZD DEV STRESS KPA	NRMLZD OCT STRESS KPA	NRMLZD CHANGE IN PWP KPA
1	0.00	0.172	0.345	0.749	0.000
2	0.09	0.261	0.521	0.713	0.097
3	0.19	0.308	0.617	0.696	0.144
4	0.27	0.340	0.679	0.692	0.170
5	0.39	0.374	0.749	0.684	0.203
6	0.48	0.401	0.803	0.686	0.217
7	0.61	0.422	0.845	0.686	0.233
8	0.95	0.374	0.748	0.710	0.175
9	1.18	0.322	0.643	0.722	0.129
10	1.44	0.284	0.567	0.725	0.101
11	1.60	0.285	0.569	0.726	0.098
12	1.87	0.281	0.562	0.731	0.091
13	2.03	0.279	0.558	0.732	0.090
14	2.17	0.280	0.560	0.733	0.091
15	2.45	0.278	0.557	0.740	0.082
16	2.78	0.275	0.550	0.740	0.077
17	3.06	0.275	0.550	0.740	0.075
18	3.35	0.274	0.548	0.745	0.070
19	3.64	0.276	0.552	0.737	0.077
20	3.94	0.274	0.547	0.749	0.064
21	4.24	0.274	0.547	0.753	0.060
22	4.53	0.275	0.550	0.757	0.058
23	4.85	0.274	0.547	0.756	0.055
24	4.94	0.282	0.565	0.762	0.059
25	5.07	0.280	0.561	0.760	0.059
26	5.37	0.281	0.562	0.753	0.063
27	5.65	0.285	0.570	0.777	0.044
28	5.94	0.282	0.563	0.777	0.042
29	6.22	0.284	0.569	0.775	0.045
30	6.52	0.287	0.573	0.788	0.032
31	6.81	0.284	0.569	0.778	0.043
32	7.09	0.284	0.567	0.785	0.033
33	7.15	0.278	0.556	0.774	0.041
34	7.28	0.277	0.553	0.783	0.031
35	7.42	0.275	0.551	0.756	0.058
36	7.71	0.271	0.542	0.766	0.043
37	8.31	0.266	0.533	0.760	0.044
38	8.60	0.264	0.528	0.754	0.048
39	8.77	0.264	0.527	0.756	0.045
40	9.00	0.272	0.543	0.756	0.051
41	9.30	0.271	0.541	0.756	0.053
42	9.90	0.272	0.545	0.758	0.050
43	10.44	0.270	0.540	0.756	0.052
44	11.67	0.275	0.549	0.760	0.051
45	12.21	0.272	0.544	0.756	0.050
46	12.37	0.284	0.569	0.752	0.064
47	12.77	0.283	0.567	0.754	0.062
48	13.30	0.279	0.558	0.746	0.065
49	13.74	0.278	0.556	0.741	0.070
50	14.17	0.283	0.565	0.745	0.069
51	14.93	0.279	0.559	0.744	0.067
52	15.37	0.281	0.562	0.742	0.071
53	15.48	0.263	0.527	0.749	0.051
54	15.52	0.263	0.526	0.754	0.048
55	15.67	0.260	0.521	0.757	0.042
56	15.82	0.260	0.521	0.758	0.043
57	15.90	0.262	0.524	0.757	0.043

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SOIL MECHANICS LABORATORY

SAMPLE NO. = T 408       HOLE NO. =    6       DEPTH =  11.30 METRES TO  11.48 METRES

SAMPLE HEIGHT AFTER CONSOLIDATION =  12.991 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 583.540 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  44.919 SQUARE CENTIMETRES

CONSTANT LOAD                     =   13.93  N .
PROVING RING FACTOR               =  4.1560  N ./DIV
PISTON AREA                       =  5.0600 SQUARE CENTIMETRES

INITIAL DIAL READING              = 1930.80 DIVISIONS


SHEAR TEST RESULTS    START  19810913     END  19810914


CONSOLIDATED UNDRAINED TRIAXIAL TEST
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 PT  TIME      DISPL    RING    PORE    PER     EFFECT   EFFECT   HALF     DEV     EFFECT   RATIO OF      A
               DIAL     DIAL    PRESS   CENT    SIGMA1   SIGMA3   DEV      STRESS  OCT      EFF SIGMA1
               RDG      RDG     KPA     STRAIN  KPA      KPA      STRESS   KPA     STRESS   EFF SIGMA3
                                                                  KPA              KPA

   1  1025    1930.8    59.0   240.8   0.00     75.0     50.1     12.5     24.9     58.4     1.497    UUUUUUU
   2  1030    1925.4    70.8   246.6   0.04     80.7     45.0     17.9     35.7     56.9     1.794       0.54
   3  1040    1910.4    85.2   253.6   0.16     87.0     38.0     24.5     49.0     54.3     2.290       0.53
   4  1050    1894.4    94.5   257.6   0.28     91.3     33.8     28.8     57.5     53.0     2.703       0.51
   5  1100    1873.8   101.0   260.1   0.40     94.9     31.4     31.7     63.5     52.6     3.021       0.50
   6  1110    1860.5   106.3   261.6   0.54     98.1     29.9     34.1     68.2     52.6     3.282       0.48
   7  1120    1847.5   108.9   261.9   0.64    100.3     29.7     35.3     70.6     53.2     3.376       0.46
   8  1130    1832.8   113.5   263.3   0.75    102.9     28.2     37.4     74.7     53.1     3.649       0.45
   9  1140    1816.0   116.5   263.8   0.88    104.9     27.5     38.7     77.4     53.3     3.814       0.44
  10  1200    1787.4   123.8   264.7   1.10    110.6     26.7     41.9     83.9     54.7     4.142       0.41
  11  1220    1750.0   129.2   264.0   1.39    115.9     27.3     44.3     88.6     56.8     4.244       0.36
  12  1240    1713.0   130.7   261.5   1.68    119.4     29.7     44.8     89.7     59.6     4.020       0.32
  13  1300    1675.0   126.4   257.2   1.97    119.5     34.0     42.8     85.5     62.5     3.516       0.27
  14  1315    1643.0   120.2   253.9   2.22    117.0     37.3     39.9     79.7     63.9     3.137       0.24
 101  1317    1641.0   118.9   RELAXATION TEST
 102  1318    1640.9   117.8   RELAXATION TEST
 103  1320    1640.5   115.8   RELAXATION TEST
 104  1324    1640.1   114.8   RELAXATION TEST
 105  1331    1639.7   113.4   RELAXATION TEST
 106  1346    1638.8   111.2   RELAXATION TEST
 107  1416    1638.0   109.5   RELAXATION TEST
 108  1455    1637.1   107.9   RELAXATION TEST
 109  2328    1631.8   105.8   RELAXATION TEST
 110  1019    1628.0   104.8   RELAXATION TEST
  15  1030    1618.9   112.8   251.1   2.40    113.0     40.1     36.4     72.9     64.4     2.817       0.21
  16  1040    1595.0   114.3   250.3   2.58    114.9     40.8     37.0     74.1     65.5     2.816       0.19
  17  1050    1582.3   112.8   249.8   2.68    114.1     41.5     36.3     72.6     65.7     2.751       0.19
  18  1100    1562.0   111.5   248.5   2.84    114.1     42.7     35.7     71.4     66.5     2.672       0.17
  19  1120    1523.8   108.9   246.9   3.13    113.2     44.4     34.4     68.8     67.3     2.550       0.14
  20  1140    1481.9   106.8   245.4   3.46    112.4     45.7     33.4     66.7     67.9     2.460       0.11
  21  1200    1451.8   105.5   244.7   3.69    111.7     46.3     32.7     65.4     68.1     2.413       0.10
  22  1220    1404.0   104.5   243.7   4.06    111.4     47.1     32.2     64.3     68.5     2.365       0.07
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23	1230	1393.5	103.6	243.4	4.21	111.0	47.6	31.7	63.4	68.7	2.332	0.07
24	1232	1370.8	106.5	243.7	4.31	113.3	47.4	32.9	65.9	69.4	2.390	0.07
25	1235	1353.5	106.5	243.3	4.44	113.5	47.7	32.9	65.8	69.6	2.379	0.06
26	1240	1314.6	105.3	242.8	4.74	112.6	48.0	32.3	64.6	69.5	2.345	0.05
27	1245	1267.5	104.2	242.0	5.11	112.3	49.0	31.7	63.3	70.1	2.292	0.03
28	1250	1224.5	102.0	240.8	5.44	111.4	50.2	30.6	61.2	70.6	2.219	0.00
29	1255	1194.3	101.6	240.0	5.67	110.8	50.0	30.4	60.8	70.3	2.216	-0.02
30	1300	1155.8	99.5	239.3	5.97	110.3	51.6	29.3	58.7	71.2	2.137	-0.04
31	1320	1108.1	95.6	238.9	6.33	107.1	52.0	27.5	55.1	70.4	2.059	-0.06
32	1340	1068.5	95.2	238.7	6.60	105.9	51.3	27.3	54.6	69.5	2.065	-0.07
33	1400	1030.8	93.8	238.1	6.93	105.8	52.6	26.6	53.2	70.3	2.011	-0.10
34	1420	991.5	93.8	237.8	7.23	105.7	52.7	26.5	53.0	70.4	2.006	-0.11
35	1430	974.5	93.0	238.0	7.36	105.0	52.8	26.1	52.2	70.2	1.989	-0.10
36	1432	957.0	95.0	238.0	7.42	106.7	52.8	27.0	53.9	70.8	2.021	-0.10
37	1435	938.5	94.8	237.5	7.64	106.8	53.2	26.8	53.6	71.1	2.008	-0.11
38	1440	899.6	94.7	237.2	7.94	106.8	53.4	26.7	53.4	71.2	2.000	-0.13
39	1445	871.3	94.4	236.7	8.16	106.9	53.9	26.5	53.0	71.6	1.983	-0.15
40	1450	829.4	94.0	236.0	8.49	107.2	54.7	26.2	52.5	72.2	1.959	-0.17
41	1455	786.0	93.2	235.6	8.81	106.8	55.2	25.8	51.6	72.4	1.935	-0.19
42	1500	754.3	93.2	235.3	9.06	107.0	55.5	25.7	51.5	72.7	1.927	-0.21
43	1502	749.1	91.2	235.1	9.10	105.4	55.7	24.9	49.7	72.3	1.893	-0.23
44	1557	643.2	90.2	236.1	9.91	103.2	54.7	24.2	48.5	70.9	1.886	-0.20
45	1630	580.0	90.2	235.9	10.40	103.0	54.8	24.1	48.2	70.9	1.880	-0.21
46	1650	542.5	89.8	235.9	10.69	102.7	55.0	23.9	47.7	70.9	1.867	-0.22
47	1710	503.2	89.8	236.1	10.99	102.4	54.9	23.8	47.5	70.7	1.866	-0.21
48	1818	475.0	89.2	236.0	11.21	101.7	54.8	23.5	46.9	70.4	1.857	-0.22
49	1830	353.2	89.1	236.0	12.14	101.3	54.9	23.2	46.4	70.4	1.844	-0.22
50	1859	299.0	89.1	236.1	12.57	101.2	55.1	23.1	46.1	70.5	1.837	-0.22
51	1920	261.5	89.1	235.9	12.85	101.3	55.4	23.0	45.9	70.7	1.829	-0.23
52	1940	219.6	89.8	235.9	13.17	101.7	55.4	23.2	46.3	70.8	1.836	-0.23
53	2002	174.0	89.5	236.1	13.52	101.1	55.2	23.0	45.9	70.5	1.832	-0.22
54	2020	145.8	89.5	235.6	13.74	101.1	55.3	22.9	45.8	70.6	1.829	-0.25
55	2040	107.8	89.5	235.7	14.03	101.1	55.4	22.8	45.7	70.6	1.824	-0.25
56	2100	71.9	89.7	235.7	14.31	101.2	55.5	22.8	45.7	70.7	1.823	-0.25
57	2120	33.2	90.0	235.7	14.61	101.3	55.6	22.9	45.7	70.8	1.823	-0.25
58	2140	-5.5	89.9	235.7	14.91	101.3	55.8	22.7	45.5	71.0	1.815	-0.25
59	2153	-30.2	89.8	235.6	15.10	101.2	55.9	22.6	45.3	71.0	1.810	-0.26
60	2155	-38.3	91.8	235.4	15.16	102.8	55.9	23.4	46.9	71.5	1.838	-0.25
61	2200	-92.0	92.2	234.5	15.57	103.7	56.8	23.5	46.9	72.4	1.826	-0.29
62	2205	-119.9	92.2	234.5	15.79	103.7	56.9	23.4	46.8	72.5	1.823	-0.29
63	2212	-169.0	92.8	234.1	16.16	104.4	57.3	23.5	47.1	73.0	1.821	-0.30
64	2215	-175.5	90.5	234.4	16.21	102.3	57.1	22.6	45.2	72.2	1.792	-0.31
65	2225	-192.2	90.0	234.5	16.34	101.6	56.8	22.4	44.8	71.7	1.789	-0.32

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SAMPLE NO. = T 408       HOLE NO. =   6       DEPTH =  11.30 METRES TO  11.48 METRES

CONSOLIDATION AXIAL STRESS         =   78.00 KPA
PRECONSOLIDATION PRESSURE          =  210.00 KPA
NORMALIZING STRESS                 =   78.00 KPA


NORMALIZED SHEAR TEST RESULTS     START  19810913      END  19810914


 PT      PER         NRMLZD      NRMLZD    NRMLZD      NRMLZD
         CENT        HALF        DEV       OCT         CHANGE
         STRAIN      DEV         STRESS    STRESS      IN PWP
                     STRESS      KPA       KPA         KPA
                     KPA

  1      0.00        0.160       0.319     0.749       0.000
  2      0.04        0.229       0.458     0.730       0.074
  3      0.16        0.314       0.628     0.697       0.164
  4      0.28        0.369       0.738     0.679       0.215
  5      0.40        0.407       0.814     0.674       0.247
  6      0.54        0.437       0.875     0.675       0.267
  7      0.64        0.452       0.905     0.682       0.271
  8      0.75        0.479       0.958     0.681       0.283
  9      0.88        0.496       0.992     0.683       0.295
 10      1.10        0.538       1.075     0.701       0.306
 11      1.39        0.568       1.136     0.729       0.297
 12      1.68        0.575       1.150     0.764       0.265
 13      1.97        0.548       1.097     0.801       0.210
 14      2.22        0.511       1.022     0.819       0.168
 15      2.40        0.467       0.934     0.826       0.132
 16      2.58        0.475       0.950     0.840       0.122
 17      2.68        0.466       0.931     0.843       0.115
 18      2.84        0.458       0.915     0.852       0.093
 19      3.13        0.441       0.882     0.863       0.077
 20      3.46        0.428       0.856     0.871       0.059
 21      3.69        0.419       0.839     0.873       0.050
 22      4.06        0.412       0.824     0.879       0.037
 23      4.21        0.406       0.813     0.881       0.033
 24      4.31        0.422       0.845     0.889       0.037
 25      4.44        0.422       0.844     0.892       0.032
 26      4.74        0.414       0.828     0.891       0.026
 27      5.11        0.406       0.812     0.899       0.015
 28      5.44        0.392       0.784     0.905       0.000
 29      5.67        0.390       0.779     0.901      -0.010
 30      5.97        0.376       0.752     0.912      -0.013
 31      6.33        0.353       0.706     0.902      -0.024
 32      6.64        0.350       0.700     0.891      -0.027
 33      6.93        0.341       0.682     0.902      -0.035
 34      7.23        0.340       0.680     0.902      -0.033
 35      7.36        0.335       0.670     0.900      -0.036
 36      7.42        0.346       0.691     0.907      -0.036
 37      7.64        0.344       0.688     0.911      -0.042
 38      7.94        0.342       0.684     0.913      -0.046
 39      8.16        0.340       0.679     0.918      -0.053
 40      8.49        0.336       0.673     0.925      -0.062
 41      8.81        0.331       0.661     0.928      -0.067
 42      9.06        0.330       0.660     0.931      -0.071
 43      9.10        0.319       0.638     0.927      -0.073
 44      9.91        0.311       0.621     0.908      -0.060
 45     10.40        0.309       0.618     0.909      -0.063

 46     10.69        0.306       0.612     0.909      -0.063
 47     10.99        0.305       0.609     0.907      -0.060
 48     11.21        0.301       0.602     0.903      -0.062
 49     12.14        0.297       0.594     0.902      -0.062
 50     12.57        0.296       0.591     0.903      -0.060
 51     12.85        0.295       0.589     0.907      -0.063
 52     13.17        0.297       0.594     0.908      -0.063
 53     13.52        0.294       0.589     0.904      -0.060
 54     13.74        0.294       0.588     0.905      -0.067
 55     14.03        0.293       0.585     0.905      -0.065
 56     14.31        0.293       0.585     0.907      -0.065
 57     14.61        0.293       0.586     0.908      -0.065
 58     14.91        0.292       0.583     0.910      -0.065
 59     15.10        0.290       0.581     0.910      -0.067
 60     15.16        0.300       0.601     0.917      -0.069
 61     15.57        0.301       0.602     0.929      -0.081
 62     15.79        0.300       0.600     0.930      -0.081
 63     16.16        0.302       0.603     0.936      -0.086
 64     16.21        0.290       0.580     0.925      -0.082
 65     16.34        0.287       0.574     0.920      -0.081
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UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 409       HOLE NO. =    6       DEPTH =   8.56 METRES TO   8.74 METRES

SAMPLE HEIGHT AFTER CONSOLIDATION =  13.130 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 611.590 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  46.580 SQUARE CENTIMETRES

CONSTANT LOAD                     =   14.23  N .
PROVING RING FACTOR               =  4.1560  N ./DIV
PISTON AREA                       =  5.0600 SQUARE CENTIMETRES

INITIAL DIAL READING              = 1916.20 DIVISIONS


SHEAR TEST RESULTS    START  19810930     END  19811002


CONSOLIDATED UNDRAINED TRIAXIAL TEST
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 PT  TIME      DISPL    PRING   PORE    PER     EFFECT   EFFECT   HALF    DEV     EFFECT   RATIO OF      A
               DIAL     DIAL    PRESS   CENT    SIGMA1   SIGMA3   DEV     STRESS  OCT      EFF SIGMA1
               RDG      RDG     KPA     STRAIN  KPA      KPA      STRESS  KPA     STRESS   EFF SIGMA3
                                                                  KPA             KPA

  1  1240     1916.2    35.7   209.8   0.00     29.5     19.5      5.0    10.0     22.8     1.513   UUUUUUU
  2  1255     1903.5    46.0   214.5   0.10     34.2     15.1      9.6    19.1     21.5     2.267      0.51
  3  1305     1887.3    53.3   217.2   0.22     37.8     12.2     12.8    25.6     20.7     3.101      0.47
  4  1315     1871.2    59.5   219.2   0.34     41.5     10.4     15.5    31.1     20.8     3.990      0.45
  5  1325     1853.8    62.6   220.7   0.48     42.6      8.8     16.9    33.8     20.1     4.843      0.46
  6  1335     1833.0    66.7   221.5   0.63     45.2      7.8     18.7    37.4     20.3     5.797      0.43
  7  1345     1817.0    69.5   222.4   0.76     46.9      7.1     19.9    39.8     20.4     6.610      0.42
  8  1355     1799.8    71.2   222.3   0.89     48.3      7.0     20.6    41.3     20.8     6.900      0.40
  9  1415     1762.6    74.3   223.4   1.17     50.0      6.1     21.9    43.9     20.7     8.196      0.40
 10  1435     1725.2    78.8   223.5   1.45     53.6      5.9     23.9    47.7     21.8     9.091      0.36
 11  1455     1688.8    81.9   223.3   1.73     56.2      5.9     25.2    50.3     22.7     9.533      0.33
 12  1530     1622.0    87.0   222.5   2.24     61.5      7.0     27.2    54.5     25.2     8.785      0.29
 13  1540     1604.8    87.2   222.0   2.37     62.0      7.4     27.3    54.6     25.6     8.380      0.27
 14  1600     1567.2    89.0   221.1   2.66     64.4      8.4     28.0    56.0     27.1     7.667      0.25
 15  1620     1529.6    90.2   219.8   2.94     66.6      9.7     28.4    56.9     28.7     6.864      0.21
 16  1640     1491.4    88.0   217.5   3.24     66.5     11.7     27.4    54.8     30.0     5.687      0.17
 17  1650     1472.3    86.8   216.9   3.38     66.2     12.5     26.9    53.7     30.4     5.296      0.16
101  1651     1471.0    86.7   RELAXATION TEST
102  1652     1470.8    84.5   RELAXATION TEST
103  1653     1470.7    84.0   RELAXATION TEST
104  1655     1470.5    83.2   RELAXATION TEST
105  1659     1470.2    82.0   RELAXATION TEST
106  1706     1469.9    81.0   RELAXATION TEST
107  1710     1469.6    80.5   RELAXATION TEST
108  1801     1468.3    78.2   RELAXATION TEST
109  1933     1467.1    76.2   RELAXATION TEST
110  2211     1466.2    75.0   RELAXATION TEST
111   809     1466.0    73.2   RELAXATION TEST
 18   813     1462.1    76.8   216.0   3.46     58.7     13.7     22.5    45.0     28.7     4.286      0.18
 19   820     1450.2    80.3   216.1   3.55     61.8     13.8     24.0    48.0     29.8     4.475      0.17
 20   830     1431.5    81.6   215.5   3.69     63.4     14.4     24.5    49.0     30.7     4.403      0.15
 21   840     1431.0    81.4   214.8   3.70     63.8     15.0     24.4    48.8     31.3     4.256      0.13
 22   850     1394.2    80.9   214.6   3.98     63.7     15.4     24.1    48.3     31.5     4.133      0.13
 23   900     1374.3    78.0   213.6   4.13     62.0     16.3     22.9    45.7     31.5     3.804      0.11
 24   910     1355.0    75.2   212.5   4.27     60.6     17.3     21.6    43.3     31.7     3.500      0.08
 25   920     1333.2    72.5   211.8   4.44     59.0     18.1     20.4    40.9     31.7     3.258      0.06
 26   930     1316.2    71.4   211.1   4.57     58.6     18.7     19.9    39.9     32.0     3.133      0.04
 27   931     1311.2    72.2   211.2   4.61     59.2     18.6     20.3    40.6     32.1     3.180      0.05
 28   935     1263.2    72.5   210.3   4.93     60.2     19.5     20.3    40.7     33.1     3.086      0.02
 29   940     1223.0    71.2   210.0   5.28     59.5     20.1     19.7    39.4     33.2     2.960      0.01
 30   945     1198.2    70.2   209.7   5.47     58.9     20.4     19.2    38.5     33.2     2.886     -0.00
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31	950	1170.5	70.5	209.7	5.68	58.9	20.3	19.3	38.6	33.2	2.904	-0.00
32	955	1121.0	69.0	209.0	6.06	58.1	20.8	18.6	37.3	33.2	2.791	-0.03
33	1000	1099.5	68.2	208.9	6.30	57.4	20.9	18.2	36.5	33.1	2.746	-0.03
34	1001	1095.5	67.5	208.6	6.33	57.1	21.2	17.9	35.9	33.2	2.693	-0.05
35	1010	1070.4	66.0	208.7	6.44	55.9	21.3	17.3	34.6	32.8	2.623	-0.04
36	1030	1031.8	64.2	208.6	6.74	54.3	21.3	16.5	33.0	32.3	2.548	-0.05
37	1035	1022.2	64.0	208.6	6.81	54.3	21.5	16.4	32.8	32.4	2.524	-0.05
201	1036	1021.0	63.0	RELAXATION TEST								
202	1037	1021.1	62.9	RELAXATION TEST								
203	1039	1021.0	62.4	RELAXATION TEST								
204	1043	1020.8	62.0	RELAXATION TEST								
205	1050	1020.7	62.3	RELAXATION TEST								
206	1105	1020.3	62.0	RELAXATION TEST								
207	1135	1020.0	60.8	RELAXATION TEST								
208	1235	1019.2	60.2	RELAXATION TEST								
209	1500	1018.5	59.4	RELAXATION TEST								
210	1535	1018.4	59.3	RELAXATION TEST								
38	1539	1015.3	61.2	209.2	6.86	51.2	20.8	15.2	30.4	30.9	2.463	-0.03
39	1540	1011.2	61.1	208.8	6.89	51.4	21.1	15.2	30.3	31.2	2.438	-0.05
40	1550	993.2	61.9	208.8	7.03	51.9	21.0	15.4	30.9	31.3	2.471	-0.05
41	1600	975.6	63.0	208.9	7.16	52.6	20.7	15.9	31.9	31.3	2.539	-0.04
42	1602	958.5	63.9	209.4	7.29	53.0	20.5	16.3	32.5	31.3	2.587	-0.02
43	1605	937.5	64.8	209.1	7.45	54.1	20.9	16.6	33.2	32.0	2.589	-0.03
44	1620	814.8	65.3	208.2	8.39	54.9	21.6	16.7	33.3	32.7	2.542	-0.07
45	1630	784.4	65.2	208.3	8.62	54.8	21.7	16.6	33.1	32.7	2.526	-0.06
46	1640	671.2	65.1	207.5	9.48	55.2	22.5	16.4	32.7	33.4	2.454	-0.10
47	1650	593.9	66.0	207.0	10.07	56.1	22.8	16.6	33.3	33.9	2.458	-0.12
48	1655	580.2	63.8	207.2	10.18	54.2	22.8	15.7	31.4	33.3	2.379	-0.12
49	1700	572.3	63.8	207.5	10.24	53.9	22.5	15.7	31.4	33.0	2.396	-0.11
301	1703	569.6	62.4	RELAXATION TEST								
302	1704	569.7	62.8	RELAXATION TEST								
303	1706	569.8	61.8	RELAXATION TEST								
304	1713	569.5	62.2	RELAXATION TEST								
305	1717	569.4	61.8	RELAXATION TEST								
306	1732	569.2	61.5	RELAXATION TEST								
307	1755	569.0	61.4	RELAXATION TEST								
308	1923	568.3	60.9	RELAXATION TEST								
309	2218	567.7	60.0	RELAXATION TEST								
310	757	567.7	59.6	RELAXATION TEST								
50	801	565.4	60.6	207.0	10.29	51.6	22.7	14.4	28.9	32.3	2.271	-0.15
51	805	558.7	61.8	207.5	10.34	52.0	22.2	14.9	29.8	32.1	2.343	-0.12
52	810	548.8	62.4	207.5	10.41	52.5	22.2	15.1	30.3	32.3	2.363	-0.11
53	820	528.9	62.9	207.4	10.57	53.2	22.6	15.3	30.6	32.8	2.353	-0.12
54	840	492.9	63.5	206.5	10.84	54.3	23.3	15.5	31.0	33.6	2.330	-0.16
55	900	455.2	62.9	206.3	11.13	53.6	23.2	15.2	30.4	33.3	2.312	-0.17
56	920	419.2	63.8	206.1	11.40	54.5	23.5	15.5	31.0	33.8	2.321	-0.18
57	943	374.6	63.4	206.2	11.74	54.0	23.4	15.3	30.6	33.6	2.308	-0.17
58	1010	322.6	62.8	205.8	12.14	53.8	23.8	15.0	30.0	33.8	2.261	-0.20
59	1030	285.6	62.8	206.1	12.42	53.6	23.7	14.9	29.9	33.7	2.261	-0.19
60	1050	246.5	63.2	206.2	12.72	53.7	23.6	15.0	30.1	33.6	2.275	-0.18
61	1116	197.8	63.0	205.8	13.09	53.8	24.0	14.9	29.8	33.9	2.242	-0.20
62	1140	163.2	63.1	205.5	13.35	54.0	24.2	14.9	29.8	34.1	2.232	-0.22
63	1200	117.9	64.0	205.5	13.70	54.4	24.0	15.2	30.4	34.1	2.267	-0.21
64	1215	96.8	63.9	205.2	13.93	54.5	24.3	15.1	30.2	34.4	2.241	-0.23
65	1220	69.7	64.8	204.9	14.06	55.4	24.5	15.4	30.9	34.8	2.261	-0.23
66	1230	-3.9	66.2	204.8	14.62	56.5	24.7	15.9	31.8	35.3	2.285	-0.23
67	1240	-94.6	66.8	204.5	15.24	57.0	25.0	16.0	32.0	35.7	2.279	-0.24
68	1250	-158.7	66.3	204.2	15.80	56.5	25.1	15.7	31.4	35.6	2.251	-0.26
69	1253	-169.9	64.8	204.4	15.89	55.2	25.0	15.1	30.2	35.1	2.210	-0.27
70	1300	-184.6	64.9	204.4	16.00	55.5	25.2	15.1	30.3	35.3	2.201	-0.27
71	1310	-204.7	65.1	204.4	16.15	55.5	25.1	15.2	30.4	35.2	2.209	-0.27
72	1320	-222.7	64.5	204.6	16.29	54.5	24.6	14.9	29.9	34.6	2.215	-0.26
73	1340	-238.5	64.2	204.8	16.41	54.1	24.5	14.8	29.6	34.4	2.209	-0.25
74	1400	-276.3	64.8	204.1	16.70	55.2	25.2	15.0	30.0	35.2	2.189	-0.29

SAMPLE NO. = T 409   HOLE NO. = 6   DEPTH = 8.56 METRES TO 8.74 METRES

CONSOLIDATION AXIAL STRESS = 29.70 KPA
PRECONSOLIDATION PRESSURE = 270.00 KPA
NORMALIZING STRESS = 29.70 KPA

NORMALIZED SHEAR TEST RESULTS   START 19810930   END 19811002

PT	PER CENT STRAIN	NRMLZD HALF DEV STRESS KPA	NRMLZD DEV STRESS KPA	NRMLZD OCT STRESS KPA	NRMLZD CHANGE IN PWP KPA
1	0.00	0.168	0.337	0.769	0.000
2	0.10	0.322	0.644	0.723	0.158
3	0.22	0.432	0.863	0.698	0.249
4	0.34	0.523	1.047	0.699	0.316
5	0.48	0.569	1.139	0.676	0.367
6	0.63	0.630	1.260	0.683	0.394
7	0.76	0.671	1.341	0.686	0.424
8	0.89	0.695	1.391	0.699	0.421
9	1.17	0.739	1.478	0.698	0.458
10	1.45	0.804	1.607	0.734	0.461
11	1.73	0.848	1.695	0.764	0.455
12	2.24	0.917	1.835	0.847	0.428
13	2.37	0.919	1.839	0.862	0.411
14	2.66	0.943	1.886	0.911	0.380
15	2.94	0.958	1.915	0.965	0.337
16	3.24	0.923	1.846	1.009	0.259
17	3.38	0.904	1.808	1.024	0.239
18	3.46	0.758	1.516	0.956	0.209
19	3.55	0.807	1.615	1.003	0.212
20	3.69	0.825	1.650	1.035	0.192
21	3.70	0.822	1.645	1.053	0.163
22	3.98	0.812	1.625	1.060	0.162
23	4.13	0.769	1.539	1.062	0.128
24	4.27	0.728	1.456	1.068	0.091
25	4.44	0.688	1.376	1.068	0.067
26	4.57	0.671	1.343	1.077	0.044
27	4.61	0.683	1.365	1.081	0.047
28	4.93	0.685	1.369	1.113	0.017
29	5.28	0.663	1.326	1.119	0.007
30	5.47	0.648	1.295	1.119	-0.003
31	5.68	0.651	1.301	1.117	-0.003
32	6.06	0.627	1.254	1.118	-0.027
33	6.30	0.614	1.229	1.113	-0.030
34	6.33	0.604	1.208	1.117	-0.040
35	6.44	0.582	1.164	1.105	-0.037
36	6.74	0.555	1.110	1.087	-0.040
37	6.81	0.552	1.103	1.092	-0.040
38	6.86	0.512	1.025	1.042	-0.020
39	6.89	0.511	1.022	1.051	-0.034
40	7.03	0.520	1.040	1.054	-0.034
41	7.16	0.536	1.073	1.055	-0.030
42	7.29	0.548	1.095	1.055	-0.013
43	7.45	0.559	1.118	1.076	-0.024
44	8.39	0.561	1.121	1.101	-0.054
45	8.62	0.558	1.115	1.102	-0.051
46	9.48	0.551	1.102	1.125	-0.077
47	10.07	0.560	1.120	1.141	-0.094
48	10.18	0.529	1.058	1.120	-0.088
49	10.24	0.529	1.058	1.110	-0.077
50	10.29	0.486	0.972	1.098	-0.094
51	10.34	0.502	1.004	1.082	-0.077
52	10.41	0.509	1.019	1.087	-0.077
53	10.57	0.515	1.030	1.104	-0.081
54	10.84	0.522	1.043	1.132	-0.111
55	11.13	0.512	1.025	1.123	-0.118
56	11.40	0.523	1.045	1.140	-0.125
57	11.74	0.515	1.031	1.131	-0.121
58	12.14	0.505	1.010	1.138	-0.135
59	12.42	0.503	1.006	1.133	-0.125
60	12.72	0.507	1.013	1.132	-0.121
61	13.09	0.502	1.004	1.143	-0.135
62	13.35	0.502	1.004	1.149	-0.145
63	13.70	0.512	1.024	1.149	-0.145
64	13.93	0.508	1.016	1.157	-0.155
65	14.06	0.520	1.040	1.172	-0.165
66	14.62	0.535	1.069	1.188	-0.169
67	15.24	0.538	1.077	1.201	-0.179
68	15.80	0.529	1.057	1.198	-0.189
69	15.89	0.509	1.018	1.181	-0.182
70	16.00	0.509	1.019	1.188	-0.182
71	16.15	0.511	1.022	1.186	-0.182
72	16.29	0.503	1.006	1.164	-0.175
73	16.41	0.499	0.997	1.157	-0.163
74	16.70	0.504	1.009	1.185	-0.192

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UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 411      HOLE NO. =   6      DEPTH =   9.56 METRES TO   8.74 METRES

SAMPLE HEIGHT AFTER CONSOLIDATION =  12.895 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 586.490 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  45.482 SQUARE CENTIMETRES

CONSTANT LOAD                     =   13.83  N .
PROVING RING FACTOR               =  4.1560  N ./DIV
PISTON AREA                       =  5.0600 SQUARE CENTIMETRES

INITIAL DIAL READING              = 1866.20 DIVISIONS


SHEAR TEST RESULTS    START  19811012     END  19811014


CONSOLIDATED UNDRAINED TRIAXIAL TEST
::::::::::::::::::::::::::::::::::::


 PT  TIME       DISPL    RING     PORE     PER      EFFECT   EFFECT   HALF     DEV      EFFECT    RATIO OF      A
                DIAL     DIAL     PRESS    CENT     SIGMA1   SIGMA3   DEV      STRESS   OCT       EFF SIGMA1
                RDG      RDG      KPA      STRAIN   KPA      KPA      STRESS   KPA      STRESS    EFF SIGMA3
                                                                      KPA               KPA

  1   840      1866.2     63.7    210.1    0.00      89.2     57.8     15.7     31.4     68.3      1.544     UUUUUUU
  2   845      1861.5     71.4    214.7    0.04      91.8     53.4     19.2     38.4     66.2      1.720        0.66
  3   850      1854.3     79.7    218.8    0.09      95.2     49.2     23.0     46.0     64.5      1.935        0.60
  4   900      1837.8     90.2    223.5    0.22      99.9     44.4     27.8     55.5     62.9      2.251        0.56
  5   910      1823.0     96.4    226.1    0.34     102.9     41.8     30.6     61.1     62.2      2.462        0.54
  6   923      1797.9    103.0    228.5    0.53     106.4     39.4     33.5     67.0     61.7      2.700        0.52
  7   932      1782.3    107.0    229.7    0.65     108.7     39.1     35.3     70.6     61.6      2.852        0.50
  8   940      1769.1    110.4    230.7    0.75     110.8     37.2     36.8     73.6     61.7      2.977        0.49
  9  1000      1732.1    117.8    232.0    1.04     115.7     35.6     40.0     80.1     62.3      3.249        0.45
 10  1020      1697.2    123.8    232.7    1.31     120.1     34.8     42.6     85.3     63.2      3.450        0.42
 11  1040      1658.1    128.2    232.5    1.61     123.9     34.9     44.5     89.0     64.6      3.549        0.39
 12  1100      1623.8    132.2    232.1    1.88     127.7     35.4     46.2     92.3     66.2      3.608        0.36
 13  1120      1585.2    134.0    230.9    2.18     130.2     36.6     46.8     93.6     67.8      3.558        0.33
 14  1140      1546.5    134.8    228.5    2.48     132.8     38.7     47.0     94.1     70.1      3.431        0.29
 15  1204      1502.3    133.7    226.1    2.82     133.8     41.0     46.4     92.8     71.9      3.263        0.26
 16  1211      1487.8    132.8    225.7    2.93     133.5     41.6     45.9     91.9     72.2      3.208        0.26
101  1216      1480.7    130.7    RELAXATION TEST
102  1217      1480.2    129.5    RELAXATION TEST
103  1219      1479.9    128.2    RELAXATION TEST
104  1223      1479.4    126.3    RELAXATION TEST
105  1230      1478.9    124.2    RELAXATION TEST
106  1245      1477.9    121.8    RELAXATION TEST
107  1315      1477.0    120.0    RELAXATION TEST
108  1441      1475.0    116.0    RELAXATION TEST
109  1519      1474.7    115.3    RELAXATION TEST
110  1702      1474.0    115.7    RELAXATION TEST
111  2147      1473.2    112.0    RELAXATION TEST
112   923      1472.8    110.0    RELAXATION TEST
 17   927      1470.0    114.5    224.5    3.07     118.6     43.1     37.8     75.5     68.3      2.752        0.33
 18   930      1465.8    119.5    225.1    3.11     122.4     42.5     40.0     79.9     69.1      2.880        0.31
 19   940      1447.6    122.8    225.0    3.25     125.2     42.5     41.4     82.7     70.1      2.946        0.29
 20   950      1428.5    119.3    223.6    3.39     123.6     44.1     39.7     79.5     70.6      2.802        0.28
 21  1000      1407.7    113.2    221.2    3.56     120.4     46.4     37.0     74.0     71.1      2.594        0.26
 22  1015      1378.1    109.0    219.4    3.79     118.4     48.3     35.1     70.1     71.7      2.451        0.24
 23  1020      1367.2    107.7    218.7    3.87     117.8     48.9     34.5     68.9     71.9      2.409        0.23
 24  1023      1357.8    109.2    219.3    3.94     118.4     48.2     35.1     70.2     71.6      2.456        0.24
 25  1025      1339.3    109.6    218.6    4.09     119.3     48.9     35.2     70.4     72.4      2.440        0.22
 26  1030      1303.9    107.4    217.3    4.36     118.4     50.1     34.2     68.3     72.9      2.364        0.20
 27  1035      1261.3    105.0    216.5    4.69     116.9     50.9     33.0     66.0     72.9      2.296        0.19
 28  1040      1225.7    104.1    215.7    4.97     116.9     51.9     32.5     65.0     73.6      2.252        0.17
 29  1045      1186.6    102.1    215.1    5.27     115.5     52.4     31.5     63.1     73.4      2.204        0.16
 30  1050      1144.2    101.8    214.4    5.60     115.7     53.1     31.3     62.6     74.0      2.179        0.14
 31  1100      1123.9     98.6    214.0    5.76     113.2     53.5     29.9     59.7     73.4      2.116        0.14
 32  1105      1114.8     97.5    214.1    5.83     112.2     53.5     29.4     58.7     73.1      2.098        0.15
 33  1115      1096.6     97.2    214.0    5.97     111.8     53.4     29.2     58.4     72.9      2.094        0.14
201  1116      1095.2     96.5    RELAXATION TEST
202  1117      1094.8     95.5    RELAXATION TEST
203  1119      1094.8     94.8    RELAXATION TEST
204  1123      1094.5     94.5    RELAXATION TEST
205  1130      1094.5     94.2    RELAXATION TEST
206  1145      1094.2     93.2    RELAXATION TEST
207  1336      1092.9     91.6    RELAXATION TEST
208  1430      1092.5     91.4    RELAXATION TEST
209  1533      1092.3     91.2    RELAXATION TEST
```

34	1537	1091.1	92.2	215.2	6.01	106.4	52.3	27.0	54.1	70.3	2.034	0.23
35	1540	1086.5	93.7	215.3	6.05	107.5	52.2	27.7	55.3	70.6	2.060	0.22
36	1550	1067.4	95.4	215.2	6.19	109.0	52.3	28.4	56.7	71.2	2.084	0.20
37	1600	1048.7	95.1	215.0	6.34	108.8	52.4	28.2	56.4	71.2	2.076	0.20
38	1502	1037.9	97.0	215.4	6.42	109.9	52.0	29.0	57.9	71.3	2.114	0.20
39	1605	1013.7	97.7	215.4	6.61	110.5	52.1	29.2	58.4	71.6	2.121	0.20
40	1510	981.8	97.7	214.6	6.86	111.1	52.8	29.1	58.3	72.2	2.104	0.17
41	1615	936.0	98.0	214.6	7.21	111.1	52.8	29.2	58.3	72.2	2.104	0.17
42	1620	900.9	99.0	214.6	7.49	112.0	53.0	29.5	59.0	72.7	2.112	0.16
43	1625	859.2	99.0	214.0	7.82	112.2	53.4	29.4	58.8	73.0	2.101	0.14
44	1630	823.4	99.0	213.8	8.09	112.3	53.7	29.3	58.6	73.2	2.091	0.14
45	1632	818.7	97.0	213.2	8.12	111.1	54.2	28.4	56.9	73.2	2.050	0.12
46	1635	814.3	95.7	213.3	8.16	109.9	54.1	27.9	55.8	72.7	2.031	0.13
47	1642	799.9	95.7	213.3	8.28	109.9	54.2	27.9	55.7	72.8	2.028	0.13
301	1644	797.2	95.3	RELAXATION TEST								
302	1645	797.1	94.2	RELAXATION TEST								
303	1647	796.8	93.5	RELAXATION TEST								
304	1651	796.8	93.1	RELAXATION TEST								
305	1658	796.8	93.0	RELAXATION TEST								
306	1710	796.5	91.8	RELAXATION TEST								
307	1738	796.3	91.8	RELAXATION TEST								
308	1925	195.7	91.2	RELAXATION TEST								
309	2010	795.3	90.2	RELAXATION TEST								
310	953	794.5	88.5	RELAXATION TEST								
48	956	792.4	90.8	214.4	8.33	104.8	53.2	25.8	51.6	70.4	1.969	0.21
49	1020	750.5	94.9	214.3	8.65	108.1	53.3	27.4	54.8	71.6	2.028	0.18
50	1040	713.2	95.0	214.0	8.94	108.3	53.6	27.4	54.7	71.8	2.021	0.17
51	1103	669.5	95.1	213.7	9.28	108.6	54.0	27.3	54.6	72.2	2.011	0.16
52	1105	653.5	97.3	214.2	9.40	109.7	53.4	28.2	56.3	72.2	2.055	0.16
53	1115	573.0	98.2	213.2	10.03	111.0	54.3	28.3	56.7	73.2	2.044	0.12
54	1120	541.0	99.5	213.3	10.28	112.0	54.4	28.8	57.6	73.6	2.059	0.12
55	1125	505.1	99.3	212.8	10.55	112.1	54.9	28.6	57.2	74.0	2.043	0.10
56	1126	501.8	96.5	212.9	10.58	109.7	54.8	27.5	54.9	73.1	2.002	0.12
57	1130	494.4	96.5	212.7	10.64	109.8	54.9	27.5	54.9	73.2	2.000	0.11
58	1140	475.0	97.2	212.4	10.79	110.5	55.1	27.7	55.4	73.6	2.005	0.10
59	1200	437.5	97.0	212.5	11.08	110.1	55.0	27.5	55.1	73.4	2.001	0.10
60	1220	399.4	96.8	212.5	11.37	109.7	55.0	27.4	54.7	73.2	1.995	0.10
61	1240	361.5	96.8	212.4	11.67	109.6	55.1	27.3	54.5	73.3	1.990	0.10
62	1307	310.9	96.0	212.7	12.06	108.4	54.8	26.8	53.6	72.7	1.979	0.12
401	1309	309.4	94.8	RELAXATION TEST								
402	1310	309.2	94.5	RELAXATION TEST								
403	1312	309.0	94.3	RELAXATION TEST								
404	1316	308.9	93.9	RELAXATION TEST								
405	1323	309.7	93.7	RELAXATION TEST								
406	1337	308.5	93.0	RELAXATION TEST								
407	1415	307.8	92.2	RELAXATION TEST								
408	1500	307.4	92.1	RELAXATION TEST								
409	1948	306.2	90.2	RELAXATION TEST								
63	1952	303.5	92.0	213.7	12.12	104.2	53.8	25.2	50.4	70.6	1.937	0.19
64	2000	289.4	94.2	213.7	12.23	105.7	53.6	26.1	52.1	71.0	1.972	0.17
65	2023	247.7	95.9	213.3	12.55	107.4	54.1	26.6	53.3	71.9	1.985	0.15
66	2058	181.8	96.7	212.6	13.06	108.2	54.6	26.8	53.6	72.5	1.982	0.11
67	2100	170.8	98.2	212.5	13.15	109.5	54.8	27.4	54.7	73.0	1.999	0.10
68	2115	55.0	99.4	211.6	14.05	110.9	55.8	27.6	55.1	74.2	1.988	0.06
69	2120	12.7	100.2	211.2	14.37	111.6	56.1	27.8	55.5	74.6	1.990	0.05
70	2130	-57.1	100.5	211.1	14.92	111.6	56.2	27.7	55.4	74.7	1.986	0.04
71	2140	-131.1	99.3	211.2	15.49	110.2	56.1	27.1	54.1	74.1	1.965	0.05
71	2150	-212.6	100.8	210.1	16.12	112.0	57.1	27.4	54.9	75.4	1.961	0.00
72	2200	-282.6	100.8	209.6	16.66	111.9	57.4	27.3	54.5	75.6	1.950	-0.02
73	2202	-293.4	99.0	210.1	16.75	110.0	56.9	26.6	53.1	74.6	1.933	0.00
74	2210	-309.7	99.0	210.2	16.87	110.0	57.0	26.5	53.0	74.7	1.930	0.00
75	2220	-328.8	98.5	210.6	17.02	109.1	56.5	26.3	52.6	74.0	1.930	0.02
76	2230	-347.2	98.5	210.6	17.16	108.9	56.4	26.2	52.5	73.9	1.930	0.02

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SAMPLE NO. = T 411       HOLE NO. =    6       DEPTH =   8.56 METRES TO   8.74 METRES

CONSOLIDATION AXIAL STRESS           =    88.90 KPA
PRECONSOLIDATION PRESSURE            =   210.00 KPA
NORMALIZING STRESS                   =    88.80 KPA

NORMALIZED SHEAR TEST RESULTS     START  19811012      END  19811014

 PT     PER        NRMLZD      NRMLZD     NRMLZD      NRMLZD
        CENT       HALF        DEV        OCT         CHANGE
        STRAIN     DEV         STRESS     STRESS      IN PWP
                   STRESS      KPA        KPA         KPA
                   KPA

  1     0.00       0.177       0.354      0.769       0.000
  2     0.04       0.216       0.433      0.746       0.052
  3     0.09       0.259       0.518      0.727       0.098
  4     0.22       0.313       0.625      0.708       0.151
  5     0.34       0.344       0.688      0.700       0.180
  6     0.53       0.377       0.754      0.695       0.207
  7     0.65       0.397       0.795      0.694       0.221
  8     0.75       0.414       0.828      0.695       0.232
  9     1.04       0.451       0.902      0.701       0.247
 10     1.31       0.480       0.960      0.712       0.255
 11     1.61       0.501       1.002      0.727       0.252
 12     1.88       0.520       1.040      0.745       0.249
 13     2.18       0.527       1.054      0.764       0.234
 14     2.48       0.530       1.060      0.789       0.207
 15     2.82       0.523       1.045      0.810       0.180
 16     2.93       0.517       1.035      0.813       0.176
 17     3.07       0.425       0.850      0.769       0.162
 18     3.11       0.450       0.900      0.779       0.169
 19     3.25       0.466       0.931      0.783       0.168
 20     3.39       0.448       0.895      0.795       0.152
 21     3.56       0.417       0.833      0.800       0.125
 22     3.79       0.395       0.789      0.807       0.105
 23     3.87       0.388       0.776      0.809       0.097
 24     3.94       0.395       0.790      0.806       0.104
 25     4.09       0.397       0.793      0.815       0.096
 26     4.36       0.385       0.769      0.821       0.081
 27     4.69       0.372       0.743      0.821       0.072
 28     4.97       0.366       0.732      0.828       0.063
 29     5.27       0.355       0.710      0.827       0.056
 30     5.60       0.352       0.705      0.833       0.048
 31     5.76       0.336       0.673      0.827       0.044
 32     5.83       0.331       0.661      0.823       0.045
 33     5.97       0.329       0.658      0.821       0.044
 34     6.01       0.304       0.609      0.792       0.057
 35     6.05       0.312       0.623      0.796       0.059
 36     6.19       0.319       0.639      0.802       0.057
 37     6.34       0.317       0.635      0.802       0.055
 38     6.42       0.326       0.653      0.803       0.060
 39     6.61       0.329       0.658      0.806       0.060
 40     6.86       0.328       0.656      0.813       0.051
 41     7.21       0.328       0.657      0.813       0.051
 42     7.49       0.332       0.664      0.818       0.051
 43     7.82       0.331       0.662      0.822       0.044
 44     8.09       0.330       0.660      0.825       0.042
 45     8.12       0.320       0.641      0.824       0.035
 46     8.16       0.314       0.628      0.819       0.036
 47     8.28       0.314       0.627      0.819       0.036
 48     8.33       0.290       0.581      0.793       0.048
 49     8.65       0.309       0.617      0.806       0.047
 50     8.94       0.308       0.616      0.809       0.044
 51     9.28       0.307       0.615      0.813       0.041
 52     9.40       0.317       0.634      0.813       0.046
 53    10.03       0.319       0.638      0.824       0.035
 54    10.28       0.324       0.648      0.829       0.036
 55    10.55       0.322       0.645      0.833       0.030
 56    10.58       0.309       0.619      0.823       0.032
 57    10.64       0.309       0.618      0.824       0.029
 58    10.79       0.312       0.624      0.828       0.026
 59    11.08       0.310       0.620      0.826       0.027
 60    11.37       0.308       0.616      0.825       0.027
 61    11.67       0.307       0.614      0.825       0.026
 62    12.06       0.302       0.604      0.818       0.029
 63    12.12       0.284       0.568      0.795       0.041
 64    12.23       0.293       0.587      0.799       0.041
 65    12.55       0.300       0.600      0.809       0.036
 66    13.06       0.302       0.604      0.816       0.028
 67    13.15       0.309       0.617      0.823       0.027
 68    14.05       0.310       0.621      0.835       0.017
 69    14.37       0.313       0.625      0.840       0.012
 70    14.92       0.312       0.624      0.841       0.011
 71    15.49       0.305       0.609      0.835       0.012
 71    16.12       0.309       0.618      0.849       0.000
 72    16.66       0.307       0.614      0.851      -0.005
 73    16.75       0.299       0.598      0.840       0.000
 74    16.87       0.299       0.597      0.841       0.001
 75    17.02       0.296       0.592      0.834       0.006
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UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 413       HOLE NO. =    6       DEPTH =   8.56 METRES TO   8.74 METRES

SAMPLE HEIGHT AFTER CONSOLIDATION =  13.104 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 595.780 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  45.466 SQUARE CENTIMETRES

CONSTANT LOAD                     =   14.13  N .
PROVING RING FACTOR               =  4.1560  N ./DIV
PISTON AREA                       =  5.0600 SQUARE CENTIMETRES

INITIAL DIAL READING              = 1996.20 DIVISIONS


SHEAR TEST RESULTS    START  19811102     END  19811103


CONSOLIDATED UNDRAINED TRIAXIAL TEST
::::::::::::::::::::::::::::::::::::


 PT  TIME       DISPL    RING     PORE     PER      EFFECT   EFFECT    HALF      DEV      EFFECT    RATIO OF      A
                DIAL     DIAL     PRESS    CENT     SIGMA1   SIGMA3    DEV       STRESS   OCT       EFF SIGMA1
                RDG      RDG      KPA      STRAIN   KPA      KPA       STRESS    KPA      STRESS    EFF SIGMA3
                                                                       KPA                KPA

   1   825     1996.2    49.9    240.3    0.00      56.0     38.3       8.9      17.7     44.2       1.463    UUUUUUU
   2   830     1994.9    52.8    242.4    0.01      56.5     36.1      10.2      20.4     42.9       1.564       0.79
   3   840     1979.2    68.2    249.8    0.13      63.0     28.6      17.2      34.4     40.1       2.204       0.57
   4   850     1962.0    75.8    253.4    0.26      66.6     25.3      20.6      41.3     39.1       2.631       0.56
   5   900     1943.9    81.9    255.8    0.40      69.7     22.9      23.4      46.8     38.5       3.042       0.53
   6   910     1928.5    86.0    257.5    0.52      71.6     21.2      25.2      50.4     38.0       3.379       0.53
   7   920     1911.0    89.5    258.6    0.66      73.6     20.1      26.8      53.5     37.9       3.664       0.51
   8   930     1892.5    92.4    259.5    0.79      75.1     19.0      28.1      56.1     37.7       3.954       0.50
   9   950     1855.8    97.5    260.8    1.07      78.4     17.8      30.3      60.6     38.0       4.403       0.48
  10  1010     1819.5   101.8    261.0    1.35      81.7     17.4      32.1      64.3     38.8       4.695       0.44
  11  1030     1782.5   105.0    260.8    1.63      84.6     17.6      33.5      67.0     39.9       4.806       0.42
  12  1040     1761.8   106.0    260.1    1.79      85.0     18.2      33.9      67.8     40.8       4.725       0.40
  13  1050     1744.2   106.2    259.5    1.92      86.8     18.9      33.9      67.9     41.5       4.591       0.38
  14  1100.    1725.2   103.5    257.7    2.07      86.1     20.7      32.7      65.4     42.5       4.157       0.37
 101  1101     1725.2   102.8    RELAXATION TEST
 102  1102     1729.4   101.5    RELAXATION TEST
 103  1104     1724.7   100.0    RELAXATION TEST
 104  1108     1724.1    98.2    RELAXATION TEST
 105  1115     1723.9    96.8    RELAXATION TEST
 106  1130     1723.1    95.0    RELAXATION TEST
 107  1200     1722.3    93.3    RELAXATION TEST
 108  1300     1721.5    91.8    RELAXATION TEST
 109  1428     1720.9    90.6    RELAXATION TEST
 110  1600     1720.5    89.8    RELAXATION TEST
 111  1700     1720.4    89.4    RELAXATION TEST
 112  1925     1720.1    88.8    RELAXATION TEST
  15  1930     1715.0    94.0    254.0    2.15      80.8     23.9      28.4      56.9     42.9       3.379       0.35
  16  1940     1697.9    97.3    254.6    2.28      83.1     23.4      29.9      59.7     43.3       3.552       0.34
  17  1950     1677.5    97.0    253.9    2.43      83.5     24.1      29.7      59.4     43.9       3.463       0.33
  18  2000     1659.5    95.0    252.8    2.57      82.7     25.2      28.7      57.5     44.4       3.281       0.31
  19  2020     1620.5    87.9    248.9    2.87      80.4     29.4      25.5      51.0     46.4       2.734       0.26
  20  2040     1581.9    85.0    247.6    3.16      79.0     30.8      24.1      48.2     46.9       2.566       0.24
  21  2103     1536.8    83.5    246.6    3.51      78.6     31.8      23.4      46.8     47.4       2.470       0.22
  22  2120     1504.6    82.0    246.1    3.75      77.8     32.5      22.6      45.3     47.6       2.394       0.21
  23  2140     1467.8    81.4    245.8    4.03      77.4     32.8      22.3      44.6     47.7       2.361       0.20
 201  2141     1466.7    81.2    RELAXATION TEST
 202  2142     1466.1    80.6    RELAXATION TEST
 203  2144     1466.1    79.6    RELAXATION TEST
 204  2148     1465.8    79.0    RELAXATION TEST
 205  2157     1465.5    78.5    RELAXATION TEST
 206  2210     1465.2    78.0    RELAXATION TEST
 207  2240     1464.8    77.6    RELAXATION TEST
 208  2310     1464.3    77.5    RELAXATION TEST
 209  2334     1464.1    77.2    RELAXATION TEST
 210   801     1463.7    75.7    RELAXATION TEST
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 24   805   1459.5    78.3   245.4   4.10    74.4    32.4    21.0    42.0    46.4    2.295    0.21
 25   810   1450.3    79.7   245.5   4.17    75.6    32.4    21.6    43.2    46.8    2.332    0.20
 26   820   1431.5    80.5   245.2   4.31    76.5    32.7    21.9    43.8    47.3    2.339    0.19
 27   830   1412.3    80.7   244.8   4.46    77.0    33.1    21.9    43.9    47.7    2.326    0.17
 28   850   1375.7    81.0   244.4   4.74    77.5    33.5    22.0    44.0    48.2    2.314    0.16
 29   910   1337.5    81.2   244.1   5.03    77.8    33.7    22.0    44.1    48.4    2.308    0.14
 30   930   1297.8    81.2   243.6   5.33    78.1    34.1    22.0    44.0    48.8    2.289    0.13
 31   933   1287.5    82.4   243.6   5.41    79.1    34.2    22.5    44.9    49.2    2.314    0.12
 32   935   1270.1    82.9   243.3   5.54    79.7    34.4    22.7    45.3    49.5    2.317    0.11
 33   940   1234.9    82.7   243.4   5.81    79.4    34.4    22.5    45.0    49.4    2.308    0.11
 34   945   1196.7    82.6   243.2   6.10    79.4    34.6    22.4    44.8    49.5    2.294    0.11
 35   950   1157.7    82.4   242.8   6.40    79.5    35.0    22.2    44.5    49.8    2.271    0.09
 36   955   1119.4    82.4   242.4   6.69    79.6    35.3    22.2    44.3    50.1    2.256    0.08
 37  1000   1069.9    82.5   242.5   7.07    79.5    35.3    22.1    44.2    50.0    2.253    0.08
 38  1005   1041.6    82.4   242.4   7.28    79.4    35.3    22.0    44.1    50.0    2.248    0.08
 39  1010   1006.8    82.5   241.6   7.55    80.0    36.0    22.0    44.0    50.7    2.223    0.05
 40  1015    967.7    82.5   241.9   7.85    79.6    35.7    21.9    43.9    50.3    2.229    0.06
 41  1020    932.6    82.5   241.7   8.12    79.5    35.7    21.9    43.8    50.3    2.226    0.05
 42  1025    897.6    82.4   241.5   8.38    79.6    36.1    21.8    43.5    50.6    2.206    0.05
 43  1027    890.3    81.0   241.4   8.44    78.6    36.3    21.2    42.3    50.4    2.166    0.04
 44  1030    883.9    80.5   241.4   8.49    78.0    36.1    21.0    41.9    50.1    2.161    0.05
 45  1040    864.3    80.4   241.2   8.60    78.0    36.2    20.9    41.8    50.1    2.154    0.04
 46  1050    846.5    80.4   241.4   8.77    77.8    36.1    20.9    41.7    50.0    2.155    0.05
 47  1110    810.0    80.2   241.4   9.05    77.5    36.1    20.7    41.4    49.9    2.147    0.05
301  1111    809.2    78.9   RELAXATION TEST
302  1112    809.1    78.6   RELAXATION TEST
303  1114    808.9    78.0   RELAXATION TEST
304  1118    808.8    77.5   RELAXATION TEST
305  1128    808.7    77.2   RELAXATION TEST
306  1200    808.0    76.4   RELAXATION TEST
307  1242    807.6    75.8   RELAXATION TEST
308  1315    807.0    75.7   RELAXATION TEST
309  1345    806.8    75.4   RELAXATION TEST
310  1504    806.7    75.0   RELAXATION TEST
311  1917    806.6    74.0   RELAXATION TEST
 48  1920    804.0    77.0   242.3   9.10    74.3    35.6    19.3    38.7    48.5    2.087    0.10
 49  1930    785.0    78.5   241.7   9.24    76.0    36.1    19.9    39.9    49.4    2.105    0.06
 50  1940    766.9    78.9   241.5   9.38    76.5    36.3    20.1    40.2    49.7    2.106    0.05
 51  1950    748.8    79.0   241.4   9.52    76.8    36.6    20.1    40.2    50.0    2.097    0.05
 52  2010    709.0    79.2   240.7   9.82    77.0    36.8    20.1    40.2    50.2    2.093    0.02
 53  2020    690.0    79.5   241.1   9.97    76.8    36.4    20.2    40.4    49.9    2.110    0.04
 54  2030    670.1    79.8   240.8  10.12    77.3    36.7    20.3    40.6    50.2    2.106    0.02
 55  2053    628.0    80.0   240.8  10.44    77.2    36.6    20.3    40.6    50.1    2.110    0.02
 56  2108    600.8    79.8   240.7  10.65    77.1    36.7    20.2    40.4    50.2    2.100    0.02
 57  2110    589.8    81.9   240.7  10.73    78.8    36.8    21.0    42.0    50.8    2.142    0.02
 58  2115    551.2    81.3   240.5  11.03    78.4    37.0    20.7    41.4    50.8    2.119    0.01
 59  2120    512.8    81.5   240.5  11.32    78.5    37.1    20.7    41.4    50.9    2.117    0.01
 60  2130    435.6    81.8   240.2  11.91    78.7    37.3    20.7    41.4    51.1    2.110   -0.00
 61  2140    365.5    82.2   239.9  12.44    79.2    37.8    20.7    41.4    51.6    2.097   -0.02
 62  2150    288.5    82.5   239.5  13.03    79.7    38.3    20.7    41.4    52.1    2.081   -0.03
 63  2200    211.8    82.6   239.1  13.62    80.0    38.8    20.6    41.2    52.5    2.062   -0.05
 64  2203    204.2    81.5   239.0  13.68    79.2    38.9    20.1    40.3    52.3    2.036   -0.06
 65  2210    190.8    81.0   239.0  13.78    78.7    38.8    19.9    39.9    52.1    2.027   -0.06
 66  2220    169.9    81.0   238.9  13.94    78.7    38.9    19.9    39.8    52.2    2.023   -0.06
 67  2230    154.0    80.9   239.1  14.06    78.5    38.9    19.8    39.6    52.1    2.019   -0.05
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SAMPLE NO. = T 413       HOLE NO. =    6       DEPTH =    8.56 METRES TO    8.74 METRES

CONSOLIDATION AXIAL STRESS          =    59.50 KPA
PRECONSOLIDATION PRESSURE           =   210.00 KPA
NORMALIZING STRESS                  =    59.50 KPA


NORMALIZED SHEAR TEST RESULTS     START  19811102      END  19811103

 PT      PER          NRMLZD       NRMLZD      NRMLZD      NRMLZD
         CENT         HALF         DEV         OCT         CHANGE
         STRAIN       DEV          STRESS      STRESS      IN PWP
                      STRESS       KPA         KPA         KPA
                      KPA

  1      0.00         0.149        0.298       0.743       0.000
  2      0.01         0.171        0.342       0.721       0.035
  3      0.13         0.289        0.578       0.674       0.160
  4      0.26         0.347        0.694       0.656       0.220
  5      0.40         0.393        0.786       0.647       0.261
  6      0.52         0.424        0.848       0.639       0.289
  7      0.66         0.450        0.900       0.638       0.309
  8      0.79         0.472        0.943       0.634       0.323
  9      1.07         0.509        1.018       0.638       0.345
 10      1.35         0.540        1.081       0.653       0.348
 11      1.63         0.563        1.126       0.671       0.345
 12      1.79         0.570        1.139       0.686       0.333
 13      1.92         0.570        1.141       0.698       0.323
 14      2.07         0.549        1.098       0.714       0.292
 15      2.15         0.478        0.956       0.720       0.230
 16      2.28         0.502        1.004       0.728       0.240
 17      2.43         0.499        0.998       0.738       0.229
 18      2.57         0.483        0.966       0.746       0.210
 19      2.87         0.428        0.857       0.780       0.145
 20      3.16         0.405        0.811       0.786       0.123
 21      3.51         0.393        0.786       0.796       0.106
 22      3.75         0.381        0.761       0.800       0.097
 23      4.03         0.375        0.750       0.801       0.092
 24      4.10         0.353        0.705       0.780       0.086
 25      4.17         0.363        0.725       0.786       0.087
 26      4.31         0.368        0.736       0.795       0.082
 27      4.46         0.369        0.738       0.802       0.075
 28      4.74         0.370        0.740       0.810       0.069
 29      5.03         0.370        0.741       0.813       0.064
 30      5.33         0.369        0.739       0.819       0.055
 31      5.41         0.378        0.755       0.827       0.055
 32      5.54         0.381        0.762       0.832       0.050
 33      5.91         0.378        0.756       0.830       0.052
 34      6.10         0.376        0.753       0.832       0.049
 35      6.40         0.374        0.747       0.837       0.042
 36      6.69         0.373        0.745       0.842       0.035
 37      7.07         0.372        0.743       0.841       0.037
 38      7.29         0.370        0.741       0.840       0.035
 39      7.55         0.370        0.740       0.852       0.022
 40      7.85         0.369        0.738       0.846       0.027
 41      8.12         0.368        0.736       0.845       0.024
 42      8.38         0.366        0.732       0.851       0.020
 43      8.44         0.356        0.712       0.847       0.018
 44      8.49         0.352        0.705       0.842       0.018
 45      8.64         0.351        0.702       0.842       0.015
 46      8.77         0.350        0.701       0.840       0.013
 47      9.05         0.348        0.696       0.839       0.018
 48      9.10         0.325        0.650       0.815       0.034
 49      9.24         0.335        0.670       0.830       0.024
 50      9.39         0.337        0.675       0.835       0.020
 51      9.52         0.337        0.675       0.840       0.018
 52      9.82         0.338        0.676       0.844       0.007
 53      9.97         0.340        0.679       0.838       0.013
 54     10.12         0.341        0.682       0.844       0.009
 55     10.44         0.341        0.683       0.843       0.008
 56     10.65         0.339        0.678       0.843       0.007
 57     10.73         0.353        0.706       0.854       0.007
 58     11.03         0.348        0.696       0.954       0.003
 59     11.32         0.348        0.696       0.856       0.003
 60     11.91         0.348        0.696       0.859      -0.002
 61     12.44         0.348        0.697       0.868      -0.007
 62     13.03         0.348        0.696       0.876      -0.013
 63     13.62         0.346        0.692       0.883      -0.020
 64     13.68         0.339        0.677       0.880      -0.022
 65     13.78         0.335        0.670       0.875      -0.022
 66     13.94         0.334        0.669       0.877      -0.024
 67     14.06         0.333        0.666       0.876      -0.020
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UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY


SAMPLE NO. = T 416      HOLE NO. =    6      DEPTH =  11.30 METRES TO  11.48 METRES

SAMPLE HEIGHT AFTER CONSOLIDATION =  13.050 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 590.720 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  45.266 SQUARE CENTIMETRES

CONSTANT LOAD                     =   13.93  N .
PROVING RING FACTOR               =  0.1560  N ./DIV
PISTON AREA                       =  5.0600 SQUARE CENTIMETRES

INITIAL DIAL READING              = 2051.00 DIVISIONS


SHEAR TEST RESULTS    START  19811106     END  19811108


CONSOLIDATED UNDRAINED TRIAXIAL TEST
::::::::::::::::::::::::::::::::::::


 PT  TIME      DISPL    RRING   PORE    PER     EFFECT    EFFECT    HALF     DEV      EFFECT    RATIO OF      A
               DIAL     DIAL    PRESS   CENT    SIGMA1    SIGMA3    DEV      STRESS   OCT       EFF SIGMA1
               RDG      RDG     KPA     STRAIN  KPA       KPA       STRESS   KPA      STRESS    EFF SIGMA3
                                                                    KPA               KPA

  1  1312     2051.0     45.5   209.5   0.00     44.3      25.8      9.3     18.5      32.0       1.719     UUUUUUU
  2  1315     2049.8     48.0   211.0   0.01     45.1      24.3     10.4     20.8      31.2       1.858        0.65
  3  1320     2042.9     56.5   214.6   0.06     49.4      20.8     14.3     28.6      30.3       2.376        0.51
  4  1330     2026.3     67.0   218.3   0.19     55.3      17.1     19.1     38.2      29.8       3.234        0.45
  5  1340     2009.1     72.9   219.9   0.32     59.0      15.4     21.8     43.6      29.9       3.829        0.42
  6  1350     1992.8     78.0   220.8   0.46     62.7      14.5     24.1     48.2      30.6       4.322        0.38
  7  1400     1974.8     81.2   221.2   0.58     65.0      14.0     25.5     51.0      31.0       4.646        0.36
  8  1410     1955.2     85.2   221.4   0.73     68.3      13.7     27.3     54.6      31.9       4.987        0.33
  9  1420     1935.8     89.1   221.4   0.88     71.9      13.9     29.0     58.1      33.2       5.209        0.30
 10  1430     1919.3     91.5   221.2   1.01     74.1      13.9     30.1     60.2      34.0       5.330        0.28
 11  1440     1900.6     94.5   221.0   1.15     77.0      14.2     31.4     62.8      35.1       5.424        0.26
 12  1450     1882.0     96.0   220.6   1.30     78.5      14.4     32.1     64.1      35.8       5.452        0.24
 13  1500     1866.0     98.0   220.0   1.42     80.8      15.0     32.9     65.8      36.9       5.389        0.22
 14  1520     1828.4    103.0   219.0   1.71     86.1      15.9     35.1     70.2      39.3       5.413        0.18
 15  1530     1809.4    104.0   218.1   1.85     87.8      16.8     35.5     71.0      40.5       5.224        0.16
 16  1540     1791.4    105.0   217.5   1.99     89.1      17.3     35.9     71.8      41.2       5.149        0.15
 17  1600     1753.7    105.3   215.3   2.28     91.5      19.7     35.9     71.8      43.6       4.645        0.11
 18  1610     1734.0    104.5   214.1   2.43     91.7      20.7     35.5     71.0      44.4       4.430        0.09
 19  1615     1724.5    104.0   213.5   2.50     91.7      21.2     35.3     70.5      44.7       4.326        0.08
101  1617     1723.6    101.8   RELAXATION TEST
102  1618     1723.4    101.5   RELAXATION TEST
103  1620     1723.0    100.4   RELAXATION TEST
104  1624     1722.6     98.2   RELAXATION TEST
105  1631     1722.2     97.0   RELAXATION TEST
106  1646     1721.7     95.8   RELAXATION TEST
107  1716     1720.5     95.0   RELAXATION TEST
108  1758     1720.2     93.6   RELAXATION TEST
109  2030     1718.4     91.2   RELAXATION TEST
110  2342     1717.8     90.0   RELAXATION TEST
111   847     1716.8     86.0   RELAXATION TEST
 20   850     1716.2     87.2   205.7   2.57     85.5      30.2     27.7     55.3      48.6       2.832       -0.10
 21   900     1700.9     99.0   210.0   2.68     91.7      25.9     32.9     65.8      47.8       3.540        0.01
 22   910     1683.0    101.5   210.0   2.82     93.7      25.8     34.0     67.9      48.4       3.633        0.01
 23   920     1662.9    101.2   209.2   2.97     94.1      26.5     33.8     67.6      49.0       3.550       -0.01
 24   930     1646.9     99.3   208.5   3.10     93.5      27.3     33.1     66.2      49.4       3.426       -0.02
 25   949     1608.2     95.2   206.3   3.39     91.4      29.5     31.0     61.9      50.1       3.100       -0.07
 26  1010     1567.9     90.1   202.9   3.70     89.8      32.5     28.6     57.3      51.6       2.763       -0.17
 27  1030     1528.3     87.0   201.6   4.01     88.1      33.7     27.2     54.4      51.8       2.614       -0.22
 28  1050     1490.1     84.5   200.6   4.30     86.5      34.5     26.0     52.0      51.8       2.508       -0.27
 29  1112     1451.0     82.8   199.7   4.60     85.8      35.4     25.2     50.4      52.2       2.423       -0.31
 30  1130     1414.3     81.8   199.0   4.88     85.3      35.9     24.7     49.4      52.4       2.376       -0.34
201  1132     1412.2     81.0   RELAXATION TEST
202  1133     1411.8     80.8   RELAXATION TEST
203  1135     1411.7     79.9   RELAXATION TEST
204  1139     1411.7     79.5   RELAXATION TEST
205  1146     1411.5     79.3   RELAXATION TEST
206  1155     1411.2     79.0   RELAXATION TEST
207  1230     1410.8     78.0   RELAXATION TEST
208  1435     1409.9     76.0   RELAXATION TEST
209  1900     1409.0     75.3   RELAXATION TEST
210   914     1408.0     72.3   RELAXATION TEST
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31	920	1399.7	79.0	200.8	4.99	83.7	37.1	23.3	46.6	52.6	2.255	-0.31
32	930	1383.6	80.5	201.1	5.11	84.5	36.7	23.9	47.8	52.6	2.303	-0.29
33	939	1366.8	80.2	200.8	5.24	84.5	37.0	23.8	47.5	52.8	2.284	-0.30
34	950	1345.2	80.1	200.5	5.41	84.5	37.2	23.7	47.3	53.0	2.273	-0.31
35	1000	1324.6	80.3	200.1	5.57	85.0	37.6	23.7	47.4	53.4	2.262	-0.33
36	1025	1281.6	80.3	198.6	5.90	86.2	38.9	23.6	47.3	54.7	2.216	-0.38
37	1035	1259.5	80.0	199.4	6.07	84.9	37.9	23.5	47.0	53.6	2.239	-0.36
38	1038	1247.3	81.5	199.9	6.16	85.7	37.5	24.1	48.2	53.6	2.285	-0.32
39	1040	1231.0	82.0	199.7	6.29	86.2	37.6	24.3	48.6	53.8	2.292	-0.33
40	1045	1194.6	82.0	199.3	6.64	86.6	38.2	24.2	48.4	54.3	2.266	-0.34
41	1050	1156.3	82.0	199.2	6.86	86.6	38.3	24.1	48.3	54.4	2.260	-0.35
42	1055	1114.8	82.0	199.2	7.17	86.3	38.2	24.1	48.1	54.2	2.259	-0.35
43	1100	1076.0	82.1	198.7	7.47	86.8	38.8	24.0	48.0	54.8	2.238	-0.37
44	1105	1037.5	83.0	198.9	7.77	87.2	38.6	24.3	48.6	54.8	2.260	-0.35
45	1110	1005.4	82.0	198.7	8.01	86.5	38.8	23.8	47.7	54.7	2.228	-0.37
46	1115	967.0	82.2	198.4	8.31	86.9	39.2	23.8	47.7	55.1	2.216	-0.38
47	1117	961.2	80.6	198.0	8.35	85.9	39.6	23.1	46.3	55.0	2.169	-0.41
48	1120	955.0	80.5	198.2	8.40	85.7	39.5	23.1	46.2	54.9	2.169	-0.41
49	1125	945.4	80.5	198.0	8.47	85.7	39.5	23.1	46.2	54.9	2.169	-0.42
50	1130	936.8	80.0	198.1	8.54	85.3	39.6	22.8	45.7	54.8	2.154	-0.42
51	1135	927.1	80.0	198.3	8.61	85.1	39.4	22.8	45.7	54.6	2.159	-0.41
301	1136	926.2	79.3	RELAXATION TEST								
302	1137	926.3	79.0	RELAXATION TEST								
303	1139	926.1	78.5	RELAXATION TEST								
304	1143	926.0	78.0	RELAXATION TEST								
305	1150	925.7	77.4	RELAXATION TEST								
306	1205	925.2	77.0	RELAXATION TEST								
307	1220	924.9	76.8	RELAXATION TEST								
308	1230	924.8	76.9	RELAXATION TEST								
309	1358	924.2	76.7	RELAXATION TEST								
310	1536	923.3	76.4	RELAXATION TEST								
311	1717	923.0	76.2	RELAXATION TEST								
312	1949	923.0	74.8	RELAXATION TEST								
52	1952	921.0	77.0	199.5	8.66	81.1	38.0	21.6	43.1	52.4	2.135	-0.41
53	1955	913.6	78.0	199.6	8.72	81.8	37.9	22.0	43.9	52.5	2.160	-0.39
54	2000	905.8	78.5	199.6	8.78	82.3	38.0	22.2	44.3	52.8	2.166	-0.38
55	2010	897.8	79.0	199.3	8.91	83.0	38.3	22.3	44.7	53.2	2.167	-0.39
56	2020	857.5	79.5	198.9	9.07	83.7	38.7	22.5	45.0	53.7	2.163	-0.40
57	2030	849.5	79.8	198.9	9.21	83.9	38.7	22.6	45.2	53.8	2.168	-0.40
58	2033	829.4	81.5	199.1	9.36	85.0	38.5	23.3	46.5	54.0	2.209	-0.37
59	2035	815.4	82.0	198.8	9.47	85.7	38.8	23.4	46.9	54.4	2.209	-0.38
60	2040	777.3	82.0	198.3	9.76	86.0	39.3	23.4	46.7	54.9	2.190	-0.40
61	2050	702.4	83.0	197.9	10.33	87.1	39.8	23.6	47.3	55.6	2.188	-0.40
62	2100	629.4	82.5	197.4	10.89	86.9	40.4	23.3	46.5	55.9	2.152	-0.43
63	2110	552.5	83.0	196.9	11.48	87.5	40.8	23.3	46.7	56.4	2.144	-0.45
64	2120	475.6	84.3	196.7	12.07	88.4	41.0	23.7	47.4	56.8	2.156	-0.44
65	2130	402.1	84.0	196.5	12.64	88.0	41.1	23.4	46.9	56.7	2.140	-0.46
66	2133	391.2	82.7	196.2	12.72	87.3	41.5	22.9	45.8	56.8	2.103	-0.49
67	2135	388.2	82.5	196.1	12.74	87.1	41.5	22.8	45.6	56.7	2.099	-0.50
68	2140	378.9	82.5	196.4	12.81	86.8	41.2	22.8	45.6	56.4	2.106	-0.48
69	2145	368.2	82.5	196.5	12.90	86.7	41.2	22.8	45.5	56.4	2.105	-0.48
70	2150	353.6	82.7	196.8	12.96	86.5	40.9	22.8	45.6	56.1	2.116	-0.47
71	2200	340.9	82.9	196.4	13.10	87.0	41.3	22.9	45.7	56.5	2.107	-0.48
72	2203	324.9	84.0	196.8	13.23	87.3	40.8	23.3	46.5	56.3	2.141	-0.45
73	2205	307.3	84.3	196.5	13.36	87.8	41.1	23.4	46.7	56.7	2.137	-0.46
74	2210	277.2	84.5	196.2	13.59	88.3	41.6	23.4	46.7	57.2	2.123	-0.47
75	2215	230.0	85.0	196.0	13.95	88.6	41.7	23.5	46.9	57.3	2.126	-0.48
76	2220	195.0	85.0	195.9	14.22	88.7	41.9	23.4	46.8	57.5	2.116	-0.48
77	2230	114.5	85.2	195.1	14.84	89.2	42.6	23.3	46.6	58.1	2.094	-0.51
78	2240	44.5	85.5	195.3	15.38	88.9	42.4	23.3	46.5	57.9	2.098	-0.51
79	2245	33.2	85.0	195.0	15.46	88.9	42.8	23.1	46.1	58.2	2.077	-0.53
80	2250	23.3	84.4	195.2	15.54	88.1	42.5	22.8	45.6	57.7	2.073	-0.53
81	2300	4.4	84.5	195.2	15.68	88.0	42.4	22.8	45.6	57.6	2.076	-0.53
82	2310	-13.9	84.7	195.4	15.82	88.0	42.3	22.8	45.7	57.5	2.080	-0.52

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SAMPLE NO. = T 416      HOLE NO. =   6      DEPTH =  11.30 METRES TO  11.48 METRES

CONSOLIDATION AXIAL STRESS          =    39.40 KPA
PRECONSOLIDATION PRESSURE           =   210.00 KPA
NORMALIZING STRESS                  =    39.40 KPA


NORMALIZED SHEAR TEST RESULTS    START  19811106     END  19811108


 PT    PER       NRMLZD     NRMLZD    NRMLZD     NRMLZD
       CENT      HALF       DEV       OCT        CHANGE
       STRAIN    DEV        STRESS    STRESS     IN PWP
                 STRESS     KPA       KPA        KPA
                 KPA

  1    0.00      0.235      0.471     0.812      0.000
  2    0.01      0.265      0.529     0.793      0.038
  3    0.06      0.363      0.726     0.770      0.129
  4    0.19      0.485      0.970     0.757      0.223
  5    0.32      0.553      1.106     0.759      0.264
  6    0.46      0.611      1.222     0.776      0.287
  7    0.58      0.648      1.295     0.787      0.297
  8    0.73      0.693      1.386     0.810      0.302
  9    0.88      0.737      1.474     0.842      0.302
 10    1.01      0.764      1.528     0.862      0.297
 11    1.15      0.797      1.594     0.892      0.292
 12    1.30      0.814      1.627     0.908      0.282
 13    1.42      0.836      1.671     0.938      0.266
 14    1.71      0.890      1.781     0.997      0.241
 15    1.85      0.901      1.801     1.027      0.218
 16    1.99      0.911      1.822     1.046      0.203
 17    2.28      0.911      1.823     1.108      0.147
 18    2.43      0.901      1.802     1.126      0.117
 19    2.50      0.895      1.790     1.135      0.102
 20    2.57      0.702      1.404     1.234     -0.095
 21    2.68      0.835      1.670     1.214      0.013
 22    2.82      0.862      1.724     1.230      0.013
 23    2.97      0.858      1.715     1.244     -0.008
 24    3.10      0.841      1.681     1.253     -0.025
 25    3.39      0.786      1.572     1.273     -0.081
 26    3.70      0.727      1.454     1.310     -0.168
 27    4.01      0.690      1.380     1.315     -0.201
 28    4.30      0.660      1.321     1.316     -0.226
 29    4.60      0.639      1.279     1.325     -0.249
 30    4.88      0.627      1.254     1.329     -0.266
 31    4.99      0.591      1.182     1.336     -0.221
 32    5.11      0.607      1.214     1.336     -0.213
 33    5.24      0.603      1.206     1.341     -0.221
 34    5.41      0.601      1.202     1.345     -0.228
 35    5.57      0.602      1.204     1.356     -0.239
 36    5.90      0.600      1.200     1.387     -0.277
 37    6.07      0.596      1.192     1.359     -0.256
 38    6.16      0.612      1.223     1.360     -0.244
 39    6.29      0.616      1.233     1.365     -0.249
 40    6.64      0.614      1.228     1.379     -0.259
 41    6.86      0.612      1.225     1.380     -0.261
 42    7.17      0.611      1.221     1.377     -0.261
 43    7.47      0.610      1.219     1.391     -0.274
 44    7.77      0.617      1.234     1.391     -0.269
 45    8.01      0.605      1.210     1.388     -0.274
 46    8.31      0.605      1.210     1.398     -0.282
 47    8.35      0.588      1.175     1.397     -0.292
 48    8.40      0.586      1.172     1.393     -0.287
 49    8.47      0.586      1.172     1.393     -0.292
 50    8.54      0.580      1.160     1.392     -0.289
 51    8.61      0.579      1.159     1.386     -0.284
 52    8.65      0.547      1.095     1.329     -0.254
 53    8.72      0.558      1.115     1.334     -0.251
 54    8.78      0.563      1.125     1.339     -0.251
 55    8.91      0.567      1.134     1.350     -0.259
 56    9.07      0.571      1.143     1.363     -0.269
 57    9.21      0.574      1.147     1.365     -0.269
 58    9.36      0.591      1.181     1.371     -0.264
 59    9.47      0.595      1.190     1.382     -0.272
 60    9.76      0.593      1.186     1.393     -0.284
 61   10.33      0.600      1.200     1.410     -0.294
 62   10.89      0.591      1.181     1.419     -0.307
 63   11.48      0.592      1.184     1.430     -0.320
 64   12.07      0.601      1.203     1.442     -0.325
 65   12.64      0.595      1.189     1.440     -0.330
 66   12.72      0.581      1.162     1.440     -0.338
 67   12.74      0.579      1.157     1.439     -0.340
 68   12.81      0.578      1.157     1.431     -0.332
 69   12.90      0.578      1.155     1.431     -0.330
 70   12.96      0.579      1.158     1.424     -0.322
 71   13.10      0.580      1.161     1.435     -0.332
 72   13.23      0.591      1.181     1.429     -0.322
 73   13.36      0.593      1.186     1.438     -0.330
 74   13.59      0.593      1.186     1.451     -0.338
 75   13.95      0.596      1.191     1.455     -0.343
 76   14.22      0.594      1.187     1.459     -0.345
 77   14.84      0.591      1.183     1.476     -0.365
 78   15.38      0.591      1.181     1.470     -0.360
 79   15.46      0.585      1.170     1.476     -0.363
 80   15.54      0.579      1.158     1.465     -0.363
 81   15.68      0.579      1.158     1.462     -0.363
 82   15.82      0.580      1.159     1.460     -0.358
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SAMPLE NO. = T 418      HOLE NO. =   6      DEPTH =   8.56 METRES TO   8.74 METRES

SAMPLE HEIGHT AFTER CONSOLIDATION =  12.260 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 561.540 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  45.803 SQUARE CENTIMETRES

CONSTANT LOAD                     =   14.32  N .
PROVING RING FACTOR               =  4.1560  N ./DIV
PISTON AREA                       =  5.0600 SOUARE CENTIMETRES

INITIAL DIAL READING              = 1447.50 DIVISIONS


SHEAR TEST RESULTS    START  19811211     END  19811212


CONSOLIDATED UNDRAINED TRIAXIAL TEST
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 PT  TIME       DISPL    PRING    PORE     PER      EFFECT   EFFECT   HALF     DEV      EFFECT   RATIO OF     A
                DIAL     DIAL     PRESS    CENT     SIGMA1   SIGMA3   DEV      STRESS   OCT      EFF SIGMA1
                RDG      RDG      KPA      STRAIN   KPA      KPA      STRESS   KPA      STRESS   EFF SIGMA3
                                                                      KPA               KPA

  1   945     1447.5    37.0    238.8    0.00      29.4     21.4      4.0      8.0     24.1     1.372    UUUUUUU
  2   950     1442.8    42.5    242.0    0.04      31.3     19.4      6.5     12.9     22.7     1.702       0.64
  3  1000     1423.2    54.2    247.8    0.20      36.0     12.5     11.8     23.5     20.3     2.880       0.58
  4  1009     1411.1    56.9    249.0    0.30      37.1     11.2     13.0     25.9     19.8     3.315       0.57
  5  1020     1391.0    59.5    249.6    0.46      38.7     10.5     14.1     28.2     19.9     3.690       0.53
  6  1030     1371.8    60.7    250.4    0.62      39.0      9.7     14.6     29.3     19.5     4.019       0.54
  7  1040     1351.0    61.8    250.8    0.79      39.3      9.0     15.1     30.3     19.1     4.362       0.54
  8  1050     1335.5    62.0    251.6    0.91      39.0      8.7     15.2     30.3     18.8     4.488       0.57
  9  1100     1314.6    62.2    251.5    1.08      38.8      8.3     15.3     30.5     18.5     4.678       0.56
 10  1120     1278.2    63.0    251.7    1.38      39.5      8.4     15.6     31.1     18.8     4.705       0.56
 11  1140     1241.2    63.5    251.8    1.68      39.9      8.5     15.7     31.4     19.0     4.700       0.55
 12  1200     1202.0    63.8    251.8    2.00      40.1      8.5     15.8     31.6     19.0     4.719       0.55
 13  1220     1162.5    64.5    251.9    2.32      40.5      8.4     16.1     32.1     19.1     4.825       0.54
 14  1230     1145.6    64.2    251.6    2.46      40.3      8.4     15.9     31.9     19.0     4.792       0.54
 15  1240     1129.2    64.3    251.8    2.60      40.4      8.5     15.9     31.9     19.1     4.748       0.54
101  1243     1123.4    63.8    RELAXATION TEST
102  1244     1123.2    63.2    RELAXATION TEST
103  1246     1123.0    62.2    RELAXATION TEST
104  1250     1123.0    61.8    RELAXATION TEST
105  1257     1122.8    61.0    RELAXATION TEST
106  1312     1122.2    60.0    RELAXATION TEST
107  1342     1121.5    58.4    RELAXATION TEST
108  1442     1120.8    58.1    RELAXATION TEST
109  1605     1120.7    57.0    RELAXATION TEST
110  1542     1119.9    56.8    RELAXATION TEST
111  1743     1119.5    56.1    RELAXATION TEST
112  1904     1119.5    55.8    RELAXATION TEST
113     2     1119.0    54.6    RELAXATION TEST
114   347     1119.0    52.7    RELAXATION TEST
 16   850     1116.5    55.8    249.8    2.70      35.1     10.8     12.1     24.3     18.9     3.249       0.67
 17   900     1099.5    63.5    252.0    2.84      39.4      8.3     15.5     31.1     18.7     4.745       0.57
 18   910     1075.8    65.2    252.2    3.03      40.8      8.3     16.2     32.5     19.1     4.915       0.55
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19	920	1062.8	65.5	251.9	3.14	41.2	8.5	16.4	32.7	19.4	4.851	0.53
20	934	1035.5	65.5	251.6	3.36	41.5	8.8	16.3	32.7	19.7	4.711	0.52
21	940	1024.3	65.2	251.5	3.45	41.2	8.8	16.2	32.4	19.6	4.679	0.52
22	950	1005.5	64.8	251.3	3.61	41.0	9.0	16.0	32.0	19.7	4.552	0.52
23	1000	987.5	64.2	251.0	3.75	40.8	9.4	15.7	31.4	19.9	4.339	0.52
24	1020	945.8	63.2	250.4	4.09	40.5	10.1	15.2	30.4	20.2	4.010	0.52
25	1040	904.8	61.8	249.7	4.43	39.7	10.6	14.5	29.1	20.3	3.745	0.52
26	1100	374.2	61.2	249.4	4.68	39.5	11.0	14.2	28.5	20.5	3.590	0.52
27	1120	834.9	60.0	248.6	5.00	39.1	11.7	13.7	27.4	20.8	3.340	0.50
28	1139	800.8	59.2	248.3	5.27	38.7	12.1	13.3	26.6	21.0	3.198	0.51
29	1238	685.7	56.5	247.2	6.21	37.1	13.0	12.0	24.1	21.0	2.850	0.52
30	1241	577.0	59.2	247.3	6.28	38.4	12.9	12.7	25.5	21.4	2.975	0.48
31	1245	640.5	58.0	247.1	6.58	38.2	12.9	12.6	25.3	21.3	2.957	0.48
32	1250	598.5	58.0	247.0	6.92	38.2	13.0	12.6	25.2	21.4	2.935	0.48
33	1255	566.3	58.0	246.9	7.19	38.2	13.1	12.5	25.1	21.5	2.915	0.47
34	1300	528.0	57.9	246.7	7.50	38.4	13.5	12.4	24.9	21.8	2.844	0.47
35	1305	489.1	57.8	246.7	7.82	38.2	13.5	12.4	24.7	21.7	2.832	0.47
36	1310	453.5	58.0	246.7	8.11	38.2	13.4	12.4	24.8	21.7	2.853	0.47
37	1315	415.2	58.0	246.5	8.42	38.3	13.5	12.4	24.8	21.8	2.834	0.46
38	1320	376.2	57.9	246.3	8.74	38.2	13.6	12.3	24.6	21.8	2.809	0.45
39	1325	341.2	58.0	246.4	9.02	38.2	13.6	12.3	24.6	21.8	2.808	0.46
40	1333	291.8	56.8	245.9	9.43	37.5	14.0	11.8	23.5	21.8	2.679	0.46
41	1340	278.5	56.2	245.8	9.54	37.1	14.1	11.5	23.0	21.8	2.630	0.47
42	1350	259.6	56.1	246.2	9.70	36.7	13.9	11.4	22.8	21.5	2.643	0.50
43	1400	239.6	55.8	246.0	9.85	36.6	14.0	11.3	22.6	21.5	2.612	0.49
44	1420	203.6	56.0	246.1	10.15	36.7	14.1	11.3	22.6	21.6	2.605	0.50
45	1440	165.7	56.2	246.2	10.46	36.7	14.0	11.4	22.7	21.6	2.623	0.50
46	1457	133.1	56.0	246.5	10.72	36.3	13.8	11.2	22.5	21.3	2.629	0.53
47	1530	72.3	55.9	245.8	11.22	36.5	14.2	11.2	22.3	21.6	2.571	0.49
48	1532	51.8	57.7	246.3	11.38	37.4	13.7	11.9	23.7	21.6	2.731	0.48
49	1535	27.3	58.0	246.5	11.58	37.7	13.8	11.9	23.9	21.8	2.730	0.48
50	1540	-12.1	58.0	246.5	11.91	37.5	13.7	11.9	23.8	21.6	2.737	0.49
51	1545	-46.9	58.2	246.3	12.19	37.6	13.7	11.9	23.9	21.7	2.744	0.47
52	1550	-85.7	58.3	246.1	12.51	37.8	13.9	11.9	23.9	21.9	2.719	0.46
53	1555	-117.2	59.1	246.4	12.76	37.4	13.8	11.8	23.6	21.7	2.713	0.48
54	1600	-159.2	58.3	246.4	13.11	37.6	13.9	11.8	23.7	21.8	2.705	0.48
55	1605	-194.7	58.5	246.2	13.39	37.7	13.9	11.9	23.8	21.8	2.712	0.47
56	1610	-233.2	58.5	246.2	13.71	37.5	13.8	11.9	23.7	21.7	2.719	0.47
57	1612	-240.8	58.2	245.9	13.77	37.7	14.3	11.7	23.4	22.1	2.640	0.46
58	1620	-254.8	57.5	246.4	13.88	36.8	14.0	11.4	22.8	21.6	2.632	0.51
59	1628	-269.3	57.5	246.1	14.00	37.0	14.2	11.4	22.8	21.8	2.608	0.49
60	1648	-295.7	57.2	246.2	14.22	36.5	14.0	11.3	22.5	21.5	2.610	0.51
61	1710	-331.4	59.0	246.1	14.51	37.2	14.1	11.5	23.1	21.8	2.638	0.48
62	1730	-373.7	58.0	246.1	14.85	37.1	14.1	11.5	23.0	21.8	2.631	0.49
63	1750	-412.7	59.0	246.2	15.17	36.9	14.0	11.5	22.9	21.6	2.636	0.49
64	1810	-445.9	58.2	245.8	15.44	37.2	14.2	11.5	23.0	21.9	2.620	0.46
65	1830	-433.2	57.5	245.8	15.75	36.7	14.3	11.2	22.4	21.8	2.565	0.49

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SAMPLE NO. = T 418        HOLE NO. =    6       DEPTH =    8.56 METRES TO    8.74 METRES

CONSOLIDATION AXIAL STRESS              =    31.60 KPA
PRECONSOLIDATION PRESSURE               =   380.00 KPA
NORMALIZING STRESS                      =    31.60 KPA


NORMALIZED SHEAR TEST RESULTS      START   19811211       END   19811212


 PT      PER        NRMLZD      NRMLZD     NRMLZD      NRMLZD
         CENT       HALF        DEV        OCT         CHANGE
         STRAIN     DEV         STRESS     STRESS      IN PWP
                    STRESS      KPA        KPA         KPA
                    KPA

  1      0.00       0.126       0.252      0.761       0.000
  2      0.04       0.204       0.409      0.719       0.101
  3      0.20       0.372       0.744      0.643       0.285
  4      0.30       0.410       0.821      0.628       0.323
  5      0.46       0.447       0.894      0.630       0.342
  6      0.62       0.463       0.927      0.616       0.367
  7      0.79       0.479       0.958      0.604       0.380
  8      0.91       0.480       0.960      0.595       0.405
  9      1.08       0.483       0.966      0.585       0.402
 10      1.38       0.492       0.985      0.594       0.408
 11      1.69       0.498       0.995      0.601       0.411
 12      2.00       0.500       1.000      0.602       0.411
 13      2.32       0.508       1.017      0.605       0.415
 14      2.46       0.504       1.008      0.602       0.405
 15      2.60       0.504       1.008      0.605       0.411
 16      2.70       0.384       0.769      0.598       0.348
 17      2.84       0.492       0.984      0.591       0.413
 18      3.03       0.514       1.028      0.605       0.424
 19      3.14       0.518       1.036      0.614       0.415
 20      3.36       0.517       1.033      0.623       0.405
 21      3.45       0.512       1.024      0.620       0.402
 22      3.61       0.506       1.012      0.622       0.396
 23      3.75       0.497       0.993      0.629       0.385
 24      4.09       0.481       0.962      0.640       0.367
 25      4.43       0.460       0.921      0.642       0.345
 26      4.68       0.451       0.902      0.649       0.335
 27      5.00       0.433       0.866      0.659       0.310
 28      5.27       0.421       0.842      0.663       0.301
 29      6.21       0.381       0.761      0.665       0.266
 30      6.28       0.403       0.806      0.677       0.269
 31      6.58       0.400       0.799      0.675       0.263
 32      6.92       0.398       0.796      0.677       0.259
 33      7.19       0.397       0.794      0.679       0.256
 34      7.50       0.394       0.788      0.690       0.250
 35      7.82       0.391       0.783      0.698       0.250
 36      8.11       0.393       0.786      0.686       0.250
 37      8.42       0.392       0.783      0.688       0.244
 38      8.74       0.389       0.778      0.690       0.237
 39      9.02       0.389       0.778      0.690       0.241
 40      9.43       0.372       0.744      0.691       0.225
 41      9.54       0.364       0.727      0.689       0.222
 42      9.70       0.361       0.723      0.681       0.234
 43      9.85       0.357       0.714      0.681       0.228
 44     10.15       0.358       0.716      0.685       0.231
 45     10.46       0.360       0.719      0.683       0.234
 46     10.72       0.356       0.711      0.674       0.244
 47     11.22       0.353       0.706      0.685       0.222
 48     11.39       0.375       0.750      0.684       0.237
 49     11.58       0.378       0.755      0.689       0.244
 50     11.91       0.376       0.753      0.685       0.244
 51     12.19       0.378       0.756      0.686       0.237
 52     12.51       0.378       0.756      0.692       0.231
 53     12.76       0.374       0.748      0.686       0.241
 54     13.11       0.375       0.750      0.690       0.241
 55     13.39       0.376       0.753      0.691       0.234
 56     13.71       0.375       0.751      0.687       0.234
 57     13.77       0.371       0.742      0.700       0.225
 58     13.88       0.362       0.723      0.684       0.241
 59     14.00       0.361       0.722      0.690       0.231
 60     14.22       0.357       0.713      0.681       0.234
 61     14.51       0.365       0.731      0.690       0.231
 62     14.85       0.364       0.728      0.689       0.231
 63     15.17       0.363       0.725      0.685       0.234
 64     15.44       0.364       0.728      0.692       0.222
 65     15.75       0.354       0.708      0.689       0.222
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UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 420       HOLE NO. =   6       DEPTH =   8.56 METRES TO   8.74 METRES

SAMPLE HEIGHT AFTER CONSOLIDATION =  11.732 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 522.990 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  44.578 SQUARE CENTIMETRES

CONSTANT LOAD                     =   14.13  N .
PROVING RING FACTOR               =  4.1560  N ./DIV
PISTON AREA                       =  2.8350 SQUARE CENTIMETRES

INITIAL DIAL READING              = 1077.90 DIVISIONS


SHEAR TEST RESULTS    START  19811214     END  19811214


CONSOLIDATED UNDRAINED TRIAXIAL TEST
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 PT  TIME       DISPL    RING     PORE     PER      EFFECT    EFFECT    HALF      DEV       EFFECT    RATIO OF        A
                DIAL     DIAL     PRESS    CENT     SIGMA1    SIGMA3    DEV       STRESS    OCT       EFF SIGMA1
                RDG      RDG      KPA      STRAIN   KPA       KPA       STRESS    KPA       STRESS    EFF SIGMA3
                                                                        KPA                 KPA

  1   945     1077.9     36.5     210.2    0.00      61.7      40.4      10.6      21.3      47.5      1.526      UUUUUUU
  2   950     1072.6     45.0     215.2    0.05      64.6      35.4      14.6      29.2      45.1      1.824         0.63
  3  1000     1055.0     56.8     221.5    0.20      69.3      29.2      20.1      40.1      42.6      2.373         0.60
  4  1010     1038.1     61.3     224.0    0.34      70.9      26.7      22.1      44.2      41.4      2.656         0.60
  5  1023     1017.0     64.3     225.8    0.52      71.8      24.9      23.5      46.9      40.5      2.885         0.61
  6  1030     1001.1     65.7     226.6    0.65      72.2      24.0      24.1      48.2      40.1      3.007         0.61
  7  1042      979.5     67.1     227.2    0.84      72.9      23.5      24.7      49.4      40.0      3.101         0.60
  8  1050      966.2     67.8     227.8    0.95      72.8      22.8      25.0      50.0      39.5      3.191         0.61
  9  1100      945.9     68.8     228.1    1.13      73.3      22.5      25.4      50.8      39.4      3.258         0.61
 10  1110      928.1     69.5     228.5    1.28      73.4      22.0      25.7      51.4      39.1      3.335         0.61
 11  1120      910.9     70.2     228.6    1.42      73.6      21.7      26.0      51.9      39.0      3.394         0.60
 12  1130      892.2     70.8     229.0    1.58      73.8      21.4      26.2      52.4      38.9      3.449         0.60
 13  1140      872.6     71.2     229.0    1.75      73.9      21.2      26.3      52.7      38.8      3.486         0.60
 14  1200      835.8     72.2     229.2    2.06      74.5      21.1      26.7      53.4      38.9      3.533         0.59
 15  1220      799.1     73.0     229.3    2.38      75.1      21.1      27.0      54.0      39.1      3.559         0.58
 16  1240      760.2     73.9     229.2    2.71      75.5      20.9      27.3      54.6      39.1      3.614         0.57
 17  1308      708.9     74.2     229.0    3.15      76.0      21.3      27.3      54.7      39.5      3.566         0.56
 18  1320      685.7     74.2     228.7    3.34      76.1      21.6      27.3      54.5      39.8      3.525         0.56
 19  1340      647.2     73.8     228.3    3.67      75.9      21.9      27.0      54.0      39.9      3.466         0.55
101  1343      642.6     73.1     RELAXATION TEST
102  1344      642.5     72.2     RELAXATION TEST
103  1346      642.3     71.4     RELAXATION TEST
104  1350      642.1     70.5     RELAXATION TEST
105  1357      642.0     69.5     RELAXATION TEST
106  1412      641.4     68.2     RELAXATION TEST
107  1442      640.5     67.0     RELAXATION TEST
108  1542      639.5     65.8     RELAXATION TEST
109  1642      639.0     64.8     RELAXATION TEST
110  1842      638.6     63.5     RELAXATION TEST
 20  1845      635.5     67.9     228.3    3.77      70.6      21.9      24.3      48.7      38.1      3.222         0.66
 21  1850      627.9     71.5     228.8    3.84      73.2      21.4      25.9      51.8      38.7      3.423         0.61
 22  1900      607.5     73.2     229.0    4.01      74.5      21.2      26.6      53.3      39.0      3.513         0.59
 23  1910      589.6     73.1     228.9    4.16      74.4      21.3      26.6      53.1      39.0      3.493         0.59
 24  1930      550.1     71.0     227.4    4.50      73.7      22.6      25.5      51.1      39.6      3.259         0.58
 25  1950      512.2     69.4     226.5    4.82      73.2      23.7      24.7      49.5      40.2      3.087         0.58
 26  2000      493.8     68.8     226.1    4.98      72.6      23.7      24.4      48.9      40.0      3.062         0.58
 27  2002      487.0     69.7     225.9    5.04      73.7      24.1      24.8      49.6      40.6      3.059         0.55
 28  2005      463.0     69.9     225.9    5.24      73.9      24.2      24.8      49.7      40.8      3.053         0.55
 29  2010      424.7     69.0     225.2    5.57      73.7      25.0      24.4      48.7      41.2      2.949         0.55
 30  2015      384.8     68.2     224.7    5.91      73.3      25.5      23.9      47.8      41.4      2.876         0.55
 31  2020      350.0     67.8     224.3    6.20      73.1      25.8      23.7      47.3      41.6      2.835         0.54
 32  2025      311.1     67.1     224.0    6.54      72.6      26.0      23.3      46.6      41.5      2.791         0.55
 33  2030      272.8     66.3     223.5    6.87      72.2      26.5      22.9      45.7      41.7      2.725         0.54
 34  2035      234.8     65.2     223.2    7.19      71.5      26.9      22.3      44.6      41.8      2.658         0.56
 35  2040      194.8     64.2     222.6    7.53      71.3      27.7      21.8      43.6      42.2      2.573         0.56
 36  2042      181.8     63.0     222.4    7.64      70.4      27.9      21.2      42.5      42.1      2.522         0.58
 37  2045      176.8     61.8     222.3    7.68      69.3      27.9      20.7      41.4      41.7      2.485         0.60
 38  2054      161.2     61.2     221.9    7.81      69.2      28.3      20.4      40.9      41.9      2.444         0.60
 39  2100      147.0     60.8     221.8    7.93      69.0      28.6      20.2      40.4      42.1      2.414         0.60
 40  2110      130.0     60.2     221.7    8.08      68.5      28.6      19.9      39.9      41.9      2.394         0.62
 41  2123      105.7     60.0     221.5    8.29      68.3      28.7      19.8      39.6      41.9      2.380         0.62
 42  2130       93.5     59.8     221.5    8.39      68.4      29.0      19.7      39.4      42.1      2.358         0.62
 43  2140       71.2     59.8     221.4    8.58      68.3      29.0      19.7      39.3      42.1      2.355         0.62
 44  2145       49.4     60.5     221.1    8.77      68.9      29.1      19.9      39.8      42.4      2.369         0.59
 45  2150       10.8     60.8     220.8    9.10      69.3      29.4      20.0      39.9      42.7      2.359         0.57
 46  2155      -27.8     60.5     220.5    9.42      69.1      29.5      19.8      39.6      42.7      2.341         0.56
 47  2200      -66.7     60.5     220.6    9.76      69.0      29.6      19.7      39.4      42.7      2.331         0.57
 48  2205     -102.2     60.5     220.5   10.06      69.1      29.8      19.6      39.3      42.9      2.318         0.57
 49  2210     -136.8     60.5     220.3   10.35      69.0      29.9      19.6      39.1      42.9      2.309         0.56
 50  2215     -173.2     60.5     220.2   10.66      68.9      29.9      19.5      39.0      42.9      2.305         0.56
 51  2220     -188.1     59.5     220.1   10.79      68.3      30.2      19.1      38.1      42.9      2.262         0.59
 52  2230     -206.1     59.3     220.4   10.94      68.1      30.2      18.9      37.9      42.8      2.254         0.61
 53  2240     -225.7     59.1     220.4   11.11      67.6      30.0      18.8      37.6      42.5      2.255         0.62
 54  2250     -244.8     59.2     220.3   11.27      67.8      30.1      18.8      37.7      42.7      2.251         0.62
 55  2300     -264.8     59.2     220.4   11.44      67.8      30.2      18.8      37.6      42.7      2.244         0.63
 56  2310     -280.1     59.3     220.1   11.58      67.9      30.3      18.8      37.6      42.8      2.241         0.61
 57  2320     -300.2     59.3     220.2   11.75      67.8      30.3      18.8      37.5      42.8      2.239         0.61
 58  2330     -319.0     59.3     220.2   11.91      67.7      30.2      18.7      37.5      42.7      2.241         0.62
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SAMPLE NO. = T 420      HOLE NO. =    6      DEPTH =   3.56 METRES TO   8.74 METRES

CONSOLIDATION AXIAL STRESS          =   61.90 KPA
PRECONSOLIDATION PRESSURE           =  380.00 KPA
NORMALIZING STRESS                  =   61.90 KPA


NORMALIZED SHEAR TEST RESULTS    START  19811214     END  19811214


 PT     PER        NRMLZD      NRMLZD     NRMLZD      NRMLZD
        CENT       HALF        DEV        OCT         CHANGE
        STRAIN     DEV         STRESS     STRESS      IN PWP
                   STRESS      KPA        KPA         KPA
                   KPA

  1     0.00       0.172       0.343      0.767       0.000
  2     0.05       0.236       0.471      0.729       0.081
  3     0.20       0.324       0.648      0.688       0.183
  4     0.34       0.357       0.714      0.669       0.223
  5     0.52       0.379       0.758      0.655       0.252
  6     0.65       0.389       0.778      0.647       0.265
  7     0.84       0.399       0.798      0.645       0.275
  8     0.95       0.404       0.807      0.637       0.284
  9     1.13       0.410       0.821      0.637       0.289
 10     1.28       0.415       0.830      0.632       0.296
 11     1.42       0.420       0.839      0.630       0.297
 12     1.58       0.423       0.847      0.628       0.304
 13     1.75       0.426       0.851      0.626       0.304
 14     2.06       0.432       0.863      0.629       0.307
 15     2.38       0.436       0.872      0.632       0.309
 16     2.71       0.441       0.883      0.632       0.307
 17     3.15       0.441       0.883      0.638       0.304
 18     3.34       0.441       0.881      0.643       0.299
 19     3.67       0.436       0.872      0.645       0.292
 20     3.77       0.393       0.786      0.616       0.292
 21     3.94       0.419       0.838      0.625       0.300
 22     4.01       0.430       0.861      0.629       0.304
 23     4.16       0.429       0.858      0.630       0.302
 24     4.50       0.412       0.825      0.640       0.278
 25     4.82       0.399       0.799      0.649       0.263
 26     4.98       0.395       0.789      0.646       0.257
 27     5.04       0.401       0.802      0.657       0.254
 28     5.24       0.401       0.803      0.659       0.254
 29     5.57       0.393       0.787      0.666       0.242
 30     5.91       0.386       0.773      0.670       0.234
 31     6.20       0.382       0.765      0.672       0.228
 32     6.54       0.376       0.752      0.671       0.223
 33     6.87       0.369       0.738      0.674       0.215
 34     7.19       0.360       0.720      0.675       0.210
 35     7.53       0.352       0.704      0.682       0.200
 36     7.64       0.343       0.686      0.679       0.197
 37     7.68       0.335       0.669      0.674       0.195
 38     7.81       0.330       0.660      0.677       0.189
 39     7.93       0.327       0.653      0.680       0.187
 40     8.08       0.322       0.644      0.677       0.186
 41     8.29       0.320       0.640      0.677       0.183
 42     8.39       0.318       0.636      0.681       0.183
 43     8.58       0.318       0.635      0.680       0.181
 44     8.77       0.322       0.644      0.685       0.176
 45     9.10       0.323       0.645      0.690       0.171
 46     9.42       0.320       0.639      0.690       0.166
 47     9.76       0.318       0.637      0.690       0.168
 48    10.06       0.317       0.634      0.693       0.166
 49    10.35       0.316       0.632      0.694       0.163
 50    10.66       0.315       0.630      0.693       0.162
 51    10.79       0.308       0.616      0.693       0.160
 52    10.94       0.306       0.612      0.692       0.165
 53    11.11       0.304       0.608      0.687       0.165
 54    11.27       0.304       0.608      0.689       0.163
 55    11.44       0.303       0.607      0.690       0.165
 56    11.58       0.304       0.608      0.692       0.160
 57    11.75       0.303       0.606      0.692       0.162
 58    11.91       0.303       0.605      0.690       0.162
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UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY


SAMPLE NO. = T 422       HOLE NO. =    6       DEPTH =    8.74 METRES TO   8.92 METRES

SAMPLE HEIGHT AFTER CONSOLIDATION =  11.050 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 505.790 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  45.773 SQUARE CENTIMETRES

CONSTANT LOAD                     =   14.03  N .
PROVING RING FACTOR               =  4.1560  N ./DIV
PISTON AREA                       =  5.0600 SQUARE CENTIMETRES

INITIAL DIAL READING              = 2000.00 DIVISIONS


SHEAR TEST RESULTS    START  19820112     END  19820113


CONSOLIDATED UNDRAINED TRIAXIAL TEST
::::::::::::::::::::::::::::::::::::


 PT  TIME      DISPL   PRING    PORE     PER      EFFECT   EFFECT    HALF      DEV      EFFECT   RATIO OF       A
               DIAL    DIAL     PRESS    CENT     SIGMA1   SIGMA3    DEV       STRESS   OCT      EFF SIGMA1
               RDG     RDG      KPA      STRAIN   KPA      KPA       STRESS    KPA      STRESS   EFF SIGMA3
                                                                     KPA                KPA

  1   850     2000.0    54.8   207.9   0.00      85.4     62.5      11.5      22.9     70.1     1.367    UUUUUUU
  2   900     1995.8    64.9   213.3   0.04      89.3     57.2      16.0      32.1     67.9     1.561       0.59
  4   910     1981.2    83.5   222.6   0.17      97.0     48.1      24.4      48.9     64.4     2.016       0.57
  5   920     1964.8    92.0   226.6   0.32     100.5     44.0      28.3      56.5     62.8     2.284       0.56
  6   930     1944.8    96.2   229.4   0.50     101.3     41.1      30.1      60.2     61.2     2.465       0.58
  7   940     1927.7    98.0   230.6   0.65     101.6     39.9      30.9      61.7     60.5     2.547       0.58
  8   950     1912.0    99.5   231.8   0.80     101.8     38.8      31.5      63.0     59.8     2.623       0.60
  9   958     1899.9   100.3   232.5   0.91     101.6     38.0      31.8      63.6     59.2     2.675       0.60
 10  1010     1874.8   102.0   233.5   1.13     102.0     37.0      32.5      65.0     58.7     2.758       0.61
 11  1030     1837.5   104.0   234.8   1.47     102.2     35.6      33.3      66.6     57.8     2.871       0.62
 12  1050     1800.8   105.8   235.5   1.80     102.7     34.7      34.0      68.0     57.4     2.960       0.61
 13  1110     1763.0   107.5   236.1   2.14     103.3     34.0      34.6      69.3     57.1     3.038       0.61
 14  1130     1723.3   109.0   236.5   2.50     103.7     33.3      35.2      70.4     56.8     3.114       0.60
 15  1140     1707.0   109.5   236.5   2.65     104.1     33.4      35.4      70.7     57.0     3.117       0.60
 16  1150     1586.4   110.2   236.7   2.84     104.4     33.2      35.6      71.2     56.9     3.145       0.60
 17  1200     1669.2   111.0   236.7   2.99     105.0     33.2      35.9      71.8     57.1     3.163       0.59
 18  1220     1532.2   112.2   236.9   3.33     105.5     32.9      36.3      72.6     57.1     3.207       0.58
 19  1240     1595.2   113.7   236.7   3.66     106.8     33.1      36.8      73.7     57.7     3.226       0.57
 20  1300     1555.8   114.7   236.7   4.02     107.4     33.1      37.1      74.3     57.9     3.244       0.56
 21  1320     1519.8   116.0   236.6   4.35     108.3     33.1      37.6      75.2     58.2     3.270       0.55
 22  1340     1480.2   117.1   236.2   4.70     109.3     33.5      37.9      75.8     58.8     3.264       0.53
 23  1400     1442.9   117.5   235.8   5.04     109.6     33.7      38.0      75.9     59.0     3.253       0.53
 24  1410     1423.5   117.5   235.3   5.22     109.9     34.1      37.9      75.8     59.4     3.223       0.52
 25  1420     1405.5   117.2   235.0   5.38     109.9     34.5      37.7      75.4     59.6     3.185       0.52
 26  1430     1389.0   117.2   234.5   5.53     110.3     35.0      37.6      75.3     60.1     3.151       0.51
 26  1440     1365.0   117.3   234.3   5.74     110.4     35.2      37.6      75.2     60.3     3.136       0.51
 27  1450     1349.4   116.9   234.0   5.89     110.1     35.4      37.4      74.7     60.3     3.112       0.50
101  1452     1345.8   115.3   RELAXATION TEST
102  1453     1346.5   115.1   RELAXATION TEST
103  1455     1346.5   113.2   RELAXATION TEST
104  1459     1346.0   112.0   RELAXATION TEST
105  1506     1345.5   110.8   RELAXATION TEST
106  1521     1345.2   108.5   RELAXATION TEST
107  1605     1343.9   106.5   RELAXATION TEST
108  1715     1343.1   104.5   RELAXATION TEST
109  2116     1341.8   101.2   RELAXATION TEST
110   830     1340.4    96.7   RELAXATION TEST
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28	834	1338.8	101.2	230.3	5.98	100.7	39.5	30.6	61.2	59.9	2.550	0.58
29	840	1330.5	103.9	233.4	6.06	100.0	36.5	31.7	63.5	57.7	2.739	0.63
30	850	1311.8	119.0	234.4	6.23	111.5	35.3	38.1	76.2	60.7	3.160	0.50
31	900	1293.5	117.5	233.9	6.39	110.7	35.9	37.4	74.8	60.8	3.084	0.50
32	920	1252.0	110.0	231.5	6.77	106.5	38.3	34.1	68.2	61.0	2.780	0.52
33	940	1214.8	102.0	228.6	7.11	102.4	41.2	30.6	61.2	61.6	2.485	0.54
34	1000	1176.2	98.0	226.5	7.46	100.8	43.2	28.8	57.6	62.4	2.333	0.54
35	1020	1138.5	94.5	225.1	7.80	99.0	44.5	27.2	54.5	62.7	2.224	0.55
36	1040	1097.5	92.9	224.5	8.17	97.9	45.0	26.5	52.9	62.6	2.176	0.55
37	1100	1061.2	90.8	223.7	8.50	95.7	45.7	25.5	51.0	62.7	2.116	0.56
38	1120	1027.8	90.5	223.5	8.80	96.6	46.0	25.3	50.6	62.9	2.099	0.56
39	1130	1005.1	90.0	223.3	9.00	96.6	46.6	25.0	50.0	63.3	2.073	0.57
40	1132	991.7	92.5	223.9	9.12	97.6	45.6	26.0	52.0	62.9	2.141	0.55
41	1135	970.0	93.0	223.6	9.32	98.1	45.8	26.2	52.3	63.2	2.143	0.53
42	1140	935.3	93.0	223.6	9.64	97.9	45.7	26.1	52.2	63.1	2.142	0.54
43	1145	893.1	92.5	223.2	10.02	97.6	46.1	25.8	51.5	63.3	2.118	0.53
44	1150	850.3	92.0	223.3	10.40	97.0	46.1	25.5	50.9	63.1	2.104	0.55
45	1155	819.6	91.8	222.8	10.68	97.1	46.5	25.3	50.6	63.4	2.088	0.54
46	1200	783.7	92.5	222.7	11.01	97.6	46.6	25.5	51.0	63.6	2.094	0.53
47	1202	780.1	89.5	222.2	11.04	95.5	47.0	24.3	48.5	63.2	2.033	0.56
48	1208	769.1	89.5	222.1	11.15	95.6	47.1	24.2	48.5	63.3	2.029	0.56
49	1252	594.4	89.3	221.6	11.91	95.3	47.4	24.0	47.9	63.4	2.011	0.55
50	1300	669.5	88.7	221.6	12.04	95.0	47.6	23.7	47.4	63.4	1.995	0.56
51	1320	628.8	88.0	221.5	12.41	94.2	47.6	23.3	46.6	63.1	1.979	0.57
52	1340	592.9	89.0	221.6	12.73	94.7	47.5	23.6	47.2	63.2	1.994	0.56
53	1400	555.5	88.0	221.5	13.07	93.8	47.5	23.1	46.3	62.9	1.974	0.58
54	1402	545.0	91.0	221.4	13.17	96.2	47.6	24.3	48.6	63.8	2.021	0.53
55	1405	523.8	91.0	221.3	13.36	96.2	47.7	24.2	48.5	63.9	2.016	0.52
56	1410	488.8	91.1	221.1	13.68	96.3	47.9	24.2	48.4	64.0	2.010	0.52
57	1415	446.8	91.0	221.1	14.06	96.0	47.9	24.0	48.1	63.9	2.004	0.52
58	1420	408.2	91.1	221.1	14.41	96.0	48.0	24.0	48.0	64.0	1.999	0.53
59	1425	369.8	91.0	220.6	14.75	96.0	48.3	23.9	47.7	64.2	1.988	0.51
60	1430	334.8	91.0	221.0	15.07	95.5	48.0	23.8	47.5	63.8	1.990	0.53
61	1435	323.3	89.0	220.6	15.17	94.3	48.4	23.0	45.9	63.7	1.949	0.55
62	1440	313.8	89.0	220.6	15.26	94.2	48.3	22.9	45.9	63.6	1.950	0.55
63	1500	276.5	89.3	220.7	15.60	94.0	48.1	23.0	45.9	63.4	1.955	0.56
64	1530	215.8	89.5	220.4	16.15	94.2	48.4	22.9	45.8	63.7	1.946	0.55
65	1550	178.0	89.5	220.7	16.49	93.9	48.3	22.8	45.6	63.5	1.944	0.56
66	1610	145.4	89.8	220.7	16.78	93.9	48.2	22.8	45.7	63.4	1.947	0.56
67	1630	104.2	89.5	220.7	17.16	93.3	48.1	22.6	45.2	63.2	1.941	0.57
68	1700	59.3	90.0	220.6	17.56	93.7	48.3	22.7	45.4	63.4	1.940	0.57

SAMPLE NO. = T 422 HOLE NO. = 6 DEPTH = 8.74 METRES TO 8.92 METRES

CONSOLIDATION AXIAL STRESS = 93.00 KPA
PRECONSOLIDATION PRESSURE = 380.00 KPA
NORMALIZING STRESS = 93.00 KPA

NORMALIZED SHEAR TEST RESULTS START 19820112 END 19820113

PT	PER CENT STRAIN	NRMLZD HALF DEV STRESS KPA	NRMLZD DEV STRESS KPA	NRMLZD OCT STRESS KPA	NRMLZD CHANGE IN PWP KPA
1	0.00	0.123	0.247	0.754	0.000
2	0.04	0.172	0.345	0.730	0.058
4	0.17	0.263	0.526	0.692	0.158
5	0.32	0.304	0.608	0.676	0.201
6	0.50	0.324	0.647	0.658	0.231
7	0.65	0.332	0.664	0.650	0.244
8	0.80	0.339	0.677	0.643	0.257
9	0.91	0.342	0.684	0.637	0.265
10	1.13	0.350	0.699	0.631	0.275
11	1.47	0.358	0.716	0.622	0.289
12	1.80	0.366	0.731	0.617	0.297
13	2.14	0.373	0.745	0.614	0.303
14	2.50	0.378	0.757	0.610	0.308
15	2.65	0.380	0.760	0.613	0.308
16	2.84	0.383	0.766	0.612	0.310
17	2.99	0.386	0.772	0.614	0.310
18	3.33	0.390	0.781	0.614	0.312
19	3.66	0.396	0.792	0.620	0.310
20	4.02	0.399	0.799	0.622	0.310
21	4.35	0.404	0.808	0.625	0.309
22	4.70	0.408	0.815	0.632	0.304
23	5.04	0.408	0.816	0.635	0.300
24	5.22	0.408	0.815	0.638	0.295
25	5.38	0.405	0.811	0.641	0.291
26	5.53	0.405	0.809	0.646	0.285
26	5.74	0.404	0.809	0.648	0.284
27	5.89	0.402	0.804	0.649	0.281
28	5.98	0.329	0.658	0.644	0.241
29	6.06	0.341	0.682	0.620	0.274
30	6.23	0.410	0.820	0.653	0.285
31	6.39	0.402	0.804	0.654	0.280
32	6.77	0.366	0.733	0.655	0.254
33	7.11	0.329	0.658	0.662	0.223
34	7.46	0.310	0.619	0.671	0.200
35	7.80	0.293	0.586	0.674	0.185
36	8.17	0.284	0.569	0.674	0.178
37	8.50	0.274	0.548	0.674	0.170
38	8.80	0.272	0.544	0.676	0.168
39	9.00	0.269	0.538	0.680	0.165
40	9.12	0.280	0.560	0.677	0.172
41	9.32	0.281	0.563	0.680	0.169
42	9.64	0.280	0.561	0.678	0.169
43	10.02	0.277	0.554	0.680	0.165
44	10.40	0.274	0.547	0.678	0.166
45	10.68	0.272	0.544	0.681	0.160
46	11.01	0.274	0.548	0.684	0.159
47	11.04	0.261	0.522	0.679	0.154
48	11.15	0.261	0.521	0.680	0.153
49	11.91	0.258	0.515	0.681	0.147
50	12.04	0.255	0.509	0.682	0.147
51	12.41	0.251	0.501	0.679	0.146
52	12.73	0.254	0.508	0.680	0.147
53	13.07	0.249	0.498	0.677	0.146
54	13.17	0.261	0.522	0.686	0.145
55	13.36	0.261	0.521	0.687	0.144
56	13.68	0.260	0.520	0.688	0.142
57	14.06	0.259	0.517	0.687	0.142
58	14.41	0.258	0.516	0.698	0.142
59	14.75	0.256	0.513	0.690	0.137
60	15.07	0.255	0.511	0.686	0.141
61	15.17	0.247	0.494	0.685	0.137
62	15.26	0.247	0.493	0.684	0.137
63	15.60	0.247	0.494	0.682	0.138
64	16.15	0.246	0.492	0.685	0.134
65	16.49	0.245	0.490	0.683	0.138
66	16.78	0.246	0.491	0.682	0.138
67	17.16	0.243	0.486	0.679	0.138
68	17.56	0.244	0.488	0.682	0.137

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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 401       HOLE NO. =   6       DEPTH =  11.48 METRES TO  11.66 METRES

TEST RESULTS   * START  19810520      END  19810614


 PT    EFFECT    EFFECT    DEV       EFFECT    AXIAL     RADIAL    VOL        LSSV    LSNV      DELTA     TOTAL
       SIGMA1    SIGMA3    STRESS    OCT       STRAIN    STRAIN    STRAIN                       ENERGY    ENERGY
       KPA       KPA       KPA       STRESS     %         %         %         KPA      %      KN-M/VOL  KN-M/VOL
                                     KPA

  1    118.7      77.2     41.5       91.0     1.556     0.220      1.995      0.0     0.0                0.000
                                                                                               0.493
  2    135.4      93.8     41.6      107.7     1.816     0.314      2.445     28.8     0.3                0.493
                                                                                               0.679
  3    153.1     111.6     41.5      125.4     2.098     0.447      2.992     59.6     0.6                1.172
                                                                                               0.682
  4    171.1     129.8     41.3      143.6     2.337     0.569      3.475     91.0     0.9                1.854
                                                                                               0.767
  5    187.8     146.2     41.6      160.1     2.583     0.687      3.957    119.6     1.2                2.621
                                                                                               0.895
  6    205.6     164.1     41.5      177.9     2.815     0.829      4.472    150.5     1.5                3.516
                                                                                               0.809
  7    222.7     181.2     41.5      195.0     3.026     0.932      4.890    180.1     1.8                4.325
                                                                                               0.880
  8    239.7     198.2     41.5      212.0     3.236     1.036      5.308    209.6     2.0                5.206
                                                                                               1.195
  9    256.5     214.9     41.6      228.8     3.473     1.183      5.839    238.6     2.4                6.401
                                                                                               1.512
 10    274.4     232.7     41.7      246.6     3.734     1.366      6.466    269.4     2.7                7.913
                                                                                               1.483
 11    292.3     250.8     41.5      264.6     3.980     1.528      7.037    300.7     3.1                9.395
                                                                                               1.609
 12    309.4     267.9     41.5      281.7     4.233     1.692      7.617    330.3     3.4               11.005
                                                                                               1.447
 13    326.2     284.6     41.6      298.5     4.457     1.825      8.107    359.3     3.7               12.451
                                                                                               1.956
 14    344.9     303.5     41.4      317.3     4.721     2.007      8.735    391.9     4.1               14.408
                                                                                               2.063
 15    360.4     318.4     42.0      332.4     4.994     2.184      9.362    418.1     4.4               16.471
                                                                                               2.008
 16    378.5     337.3     41.2      351.0     5.258     2.341      9.941    450.3     4.8               18.479
                                                                                               2.056
 17    395.0     353.4     41.6      367.3     5.527     2.488     10.504    478.4     5.1               20.535
                                                                                               2.337
 18    414.0     372.6     41.4      386.4     5.815     2.650     11.115    511.6     5.5               22.872
                                                                                               2.224
 19    430.9     389.5     41.4      403.3     6.604     2.504     11.613    540.9     6.0               25.096
                                                                                               2.005
 20    448.1     406.7     41.4      420.5     6.331     2.907     12.145    570.7     6.1               27.101
                                                                                               2.315
 21    465.5     424.1     41.4      437.9     6.596     3.040     12.676    600.8     6.4               29.417
                                                                                               2.116
 22    482.4     441.1     41.3      454.9     6.839     3.151     13.142    630.2     6.7               31.533
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 402       HOLE NO. =    6       DEPTH =  11.48 METRES TO  11.66 METRES

TEST RESULTS     START  19810525      END  19810728


 PT    EFFECT    EFFECT    DEV       EFFECT    AXIAL    RADIAL    VOL       LSSV    LSNV      DELTA      TOTAL
       SIGMA1    SIGMA3    STRESS    OCT       STRAIN   STRAIN    STRAIN                      ENERGY     ENERGY
       KPA       KPA       KPA       STRESS      %        %         %       KPA      %      KN-M/VOL  KN-M/VOL
                                     KPA

  1    118.9      77.2     41.7       91.1     1.508    0.276     2.061      0.0    0.0                 0.000
                                                                                           0.593
  2    136.6      95.2     41.4      109.0     1.847    0.369     2.585     31.0    0.4                 0.593
                                                                                           0.716
  3    154.4     113.0     41.4      126.8     2.096    0.539     3.174     61.8    0.7                 1.309
                                                                                           0.576
  4    170.8     129.4     41.4      143.2     2.316    0.629     3.574     90.2    0.9                 1.885
                                                                                           0.441
  5    189.2     147.9     41.3      161.7     2.505    0.665     3.836    122.2    1.1                 2.326
                                                                                           0.683
  6    205.0     163.5     41.5      177.3     2.708    0.755     4.221    149.4    1.4                 3.010
                                                                                           0.935
  7    223.3     181.9     41.4      195.7     2.922    0.835     4.711    181.2    1.7                 3.944
                                                                                           1.023
  8    239.9     199.3     40.6      211.8     3.141    1.030     5.202    209.1    2.0                 4.968
                                                                                           1.505
  9    257.7     215.2     42.5      229.4     3.425    1.224     5.873    239.5    2.3                 6.473
                                                                                           1.191
 10    274.8     233.3     41.5      247.1     3.638    1.363     6.364    270.3    2.6                 7.663
                                                                                           1.127
 11    292.1     250.7     41.4      264.5     3.829    1.484     6.797    300.3    2.9                 8.791
                                                                                           1.169
 12    309.1     267.6     41.5      281.4     4.043    1.585     7.214    329.7    3.1                 9.960
                                                                                           1.301
 13    326.8     285.4     41.4      299.2     4.233    1.712     7.656    360.4    3.4                11.261
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 403       HOLE NO. =    6       DEPTH =  11.48 METRES TO  11.66 METRES

TEST RESULTS     START  19810608      END  19810620


 PT    EFFECT    EFFECT    DEV       EFFECT    AXIAL    RADIAL    VOL       LSSV    LSNV      DELTA      TOTAL
       SIGMA1    SIGMA3    STRESS    OCT       STRAIN   STRAIN    STRAIN                      ENERGY     ENERGY
       KPA       KPA       KPA       STRESS      %        %         %       KPA      %      KN-M/VOL  KN-M/VOL
                                     KPA

  1    118.9      77.3     41.6       91.2     1.503    0.115     1.732      0.0    0.0                 0.000
                                                                                           0.328
  2    131.9      81.2     50.7       98.1     1.761    0.119     1.996     14.1    0.3                 0.328
                                                                                           0.426
  3    148.1      86.9     61.2      107.3     2.078    0.107     2.292     32.2    0.6                 0.754
                                                                                           0.431
  4    164.2      92.2     72.0      116.2     2.392    0.074     2.540     50.0    0.9                 1.186
                                                                                           0.347
  5    178.8      96.9     81.9      124.2     2.630    0.042     2.713     66.0    1.1                 1.532
                                                                                           0.283
  6    187.6     100.0     87.6      129.2     2.820    0.009     2.837     75.8    1.3                 1.815
                                                                                           0.254
  7    194.4     102.4     92.0      133.1     2.973   -0.010     2.952     83.4    1.5                 2.069
                                                                                           0.208
  8    200.9     104.3     96.6      136.5     3.112   -0.043     3.026     90.5    1.6                 2.277
                                                                                           0.576
  9    208.5     105.2    103.3      139.6     3.455   -0.103     3.249     97.9    2.0                 2.853
                                                                                           0.552
 10    223.1     112.7    110.4      149.5     3.795   -0.187     3.422    115.6    2.3                 3.405
                                                                                           1.101
 11    240.1     117.8    122.3      158.6     4.430   -0.347     3.735    134.1    3.0                 4.506
                                                                                           2.594
 12    255.1     123.4    131.7      167.3     6.030   -0.914     4.202    151.0    4.8                 7.100
                                                                                           0.431
 13    272.7     128.7    144.0      176.7     6.329   -1.056     4.217    170.1    5.1                 7.531
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 404      HOLE NO. =   6      DEPTH =  11.48 METRES TO  11.66 METRES

TEST RESULTS    START  19810626     END  19810819

 PT   EFFECT   EFFECT   DEV      EFFECT   AXIAL   RADIAL   VOL      LSSV    LSNV    DELTA     TOTAL
      SIGMA1   SIGMA3   STRESS   OCT      STRAIN  STRAIN   STRAIN                   ENERGY    ENERGY
      KPA      KPA      KPA      STRESS     %       %        %      KPA      %    KN-M/VOL  KN-M/VOL
                                 KPA

  1   118.8     77.2    41.6      91.1    1.253   0.362    1.978     0.0    0.0               0.000
                                                                                  0.405
  2   131.9     81.3    50.6      98.2    1.602   0.342    2.286    14.3    0.4               0.405
                                                                                  0.401
  3   147.2     85.9    61.3     106.3    1.922   0.315    2.552    31.0    0.7               0.806
                                                                                  0.502
  4   164.3     92.6    71.7     116.5    2.251   0.309    2.869    50.4    1.0               1.308
                                                                                  0.364
  5   179.7     98.0    81.7     125.2    2.502   0.273    3.049    67.6    1.3               1.672
                                                                                  0.343
  6   187.5    100.5    87.0     129.5    2.667   0.293    3.254    76.2    1.4               2.015
                                                                                  0.177
  7   194.9    103.0    91.9     133.6    2.807   0.249    3.305    84.4    1.6               2.192
                                                                                  0.148
  8   202.6    105.7    96.9     138.0    2.944   0.189    3.323    93.0    1.7               2.340
                                                                                  0.381
  9   211.0    108.9   102.1     142.9    3.124   0.194    3.511   102.5    1.9               2.721
                                                                                  0.354
 10   218.8    111.8   107.0     147.5    3.336   0.147    3.631   111.3    2.1               3.075
                                                                                  0.485
 11   225.4    113.5   111.9     150.8    3.586   0.116    3.819   118.3    2.4               3.560
                                                                                  0.528
 12   233.6    116.3   117.3     155.4    3.874   0.059    3.991   127.4    2.7               4.038
                                                                                  0.846
 13   241.0    118.7   122.3     159.5    4.346  -0.058    4.230   135.6    3.1               4.934
                                                                                  1.761
 14   256.0    123.9   132.1     167.9    5.289  -0.298    4.693   152.3    4.1               6.695
                                                                                  3.974
 15   268.9    128.7   140.2     175.4    7.766  -1.299    5.169   166.8    6.9              10.669
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 405      HOLE NO. =   6      DEPTH =  11.48 METRES TO  11.66 METRES

TEST RESULTS    START  19810630     END  19810706

 PT   EFFECT   EFFECT   DEV      EFFECT   AXIAL   RADIAL   VOL      LSSV    LSNV    DELTA     TOTAL
      SIGMA1   SIGMA3   STRESS   OCT      STRAIN  STRAIN   STRAIN                   ENERGY    ENERGY
      KPA      KPA      KPA      STRESS     %       %        %      KPA      %    KN-M/VOL  KN-M/VOL
                                 KPA

  1   117.8     76.9    40.9      90.5    1.472   0.244    1.960     0.0    0.0               0.000
                                                                                 -0.002
  2   117.6     58.1    49.5      84.6    1.549   0.180    1.909    12.4    0.1              -0.002
                                                                                  0.050
  3   118.9     60.2    58.7      79.8    1.702   0.078    1.858    23.6    0.3               0.048
                                                                                  0.145
  4   119.9     52.7    67.2      75.1    2.009  -0.118    1.773    34.3    0.7               0.193
                                                                                  0.214
  5   122.1     43.8    78.3      69.9    2.305  -0.267    1.770    47.0    1.1               0.407
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 406      HOLE NO. =    6      DEPTH =  11.30 METRES TO  11.48 METRES

TEST RESULTS     START  19810710     END  19810801

 PT    EFFECT    EFFECT    DEV     EFFECT    AXIAL    RADIAL    VOL        LSSV    LSNV     DELTA     TOTAL
       SIGMA1    SIGMA3    STRESS  OCT       STRAIN   STRAIN    STRAIN                     ENERGY    ENERGY
       KPA       KPA       KPA     STRESS      %        %         %        KPA      %     KN-M/VOL KN-M/VOL
                                   KPA

  1    116.9      75.9     41.0     89.6     1.480    0.362     2.204      0.0    0.0                0.000
                                                                                            0.002
  2    119.4      69.4     50.0     86.1     1.593    0.271     2.136      9.5    0.2                0.002
                                                                                           -0.119
  3    119.7      60.9     58.8     80.5     1.650    0.128     1.905     21.4    0.4               -0.117
                                                                                           -0.017
  4    120.2      52.5     67.7     75.1     1.715    0.044     1.803     33.3    0.5               -0.134
                                                                                            0.027
  5    120.6      48.5     72.1     72.5     1.790   -0.013     1.752     38.9    0.6               -0.108
                                                                                            0.057
  6    121.1      44.7     76.4     70.2     1.885   -0.081     1.723     44.3    0.7               -0.051
                                                                                            0.047
  7    120.6      39.8     80.8     66.7     1.998   -0.188     1.623     51.2    0.9               -0.004
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 407      HOLE NO. =    6      DEPTH =  11.30 METRES TO  11.48 METRES

TEST RESULTS     START  19810903     END  19810904

 PT    EFFECT    EFFECT    DEV     EFFECT    AXIAL    RADIAL    VOL        LSSV    LSNV     DELTA     TOTAL
       SIGMA1    SIGMA3    STRESS  OCT       STRAIN   STRAIN    STRAIN                     ENERGY    ENERGY
       KPA       KPA       KPA     STRESS      %        %         %        KPA      %     KN-M/VOL KN-M/VOL
                                   KPA

  1    115.3      74.7     40.6     88.2     0.000    0.000     0.000      0.0    0.0                0.000
                                                                                           0.046
  2    124.9      63.5     61.4     84.0     0.090   -0.045     0.000     18.5    0.1                0.046
                                                                                           0.067
  3    130.5      57.8     72.7     82.0     0.190   -0.095     0.000     28.3    0.2                0.113
                                                                                           0.061
  4    134.9      54.9     80.0     81.6     0.270   -0.135     0.000     34.2    0.3                0.174
                                                                                           0.101
  5    139.4      51.2     88.2     80.6     0.390   -0.195     0.000     41.1    0.5                0.275
                                                                                           0.082
  6    143.9      49.3     94.6     80.8     0.480   -0.240     0.000     45.9    0.6                0.357
                                                                                           0.126
  7    147.1      47.6     99.5     80.8     0.610   -0.305     0.000     49.8    0.7                0.483
                                                                                           0.319
  8    142.5      54.3     88.2     83.7     0.950   -0.475     0.000     39.7    1.2                0.802
                                                                                           0.189
  9    135.6      59.8     75.8     85.1     1.180   -0.590     0.000     29.3    1.4                0.991
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SOIL MECHANICS LABORATORY
ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 408      HOLE NO. =    6      DEPTH =  11.30 METRES TO  11.48 METRES

TEST RESULTS     START  19810913     END  19810914


  PT    EFFECT     EFFECT     DEV       EFFECT     AXIAL     RADIAL     VOL        LSSV     LSNV      DELTA      TOTAL
        SIGMA1     SIGMA3     STRESS    OCT        STRAIN    STRAIN     STRAIN                        ENERGY     ENERGY
        KPA        KPA        KPA       STRESS     %         %          %          KPA      %        KN-M/VOL   KN-M/VOL
                                        KPA

   1     75.0       50.1      24.9       58.4      0.000     0.000      0.000       0.0     0.0                  0.000
                                                                                                      0.012
   2     80.7       45.0      35.7       56.9      0.040    -0.020      0.000       9.2     0.0                  0.012
                                                                                                      0.051
   3     87.0       38.0      49.0       54.3      0.160    -0.080      0.000      20.9     0.2                  0.063
                                                                                                      0.064
   4     91.3       33.8      57.5       53.0      0.280    -0.140      0.000      28.2     0.3                  0.127
                                                                                                      0.073
   5     94.9       31.4      63.5       52.6      0.400    -0.200      0.000      33.1     0.5                  0.199
                                                                                                      0.092
   6     98.1       29.9      68.2       52.6      0.540    -0.270      0.000      36.7     0.7                  0.292
                                                                                                      0.069
   7    100.3       29.7      70.6       53.2      0.640    -0.320      0.000      38.4     0.8                  0.361
                                                                                                      0.080
   8    102.9       28.2      74.7       53.1      0.750    -0.375      0.000      41.7     0.9                  0.441
                                                                                                      0.099
   9    104.9       27.5      77.4       53.3      0.880    -0.440      0.000      43.8     1.1                  0.540
                                                                                                      0.177
  10    110.6       26.7      83.9       54.7      1.100    -0.550      0.000      48.6     1.3                  0.717
                                                                                                      0.250
  11    115.9       27.3      88.6       56.8      1.390    -0.695      0.000      52.1     1.7                  0.967
                                                                                                      0.259
  12    119.4       29.7      89.7       59.6      1.680    -0.840      0.000      52.9     2.1                  1.226
                                                                                                      0.254
  13    119.5       34.0      85.5       62.5      1.970    -0.985      0.000      50.0     2.4                  1.480
                                                                                                      0.207
  14    117.0       37.3      79.7       63.9      2.220    -1.110      0.000      45.7     2.7                  1.686
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 409      HOLE NO. =    6      DEPTH =   8.56 METRES TO   8.74 METRES

TEST RESULTS     START  19810930     END  19811002


  PT    EFFECT     EFFECT     DEV       EFFECT     AXIAL     RADIAL     VOL        LSSV     LSNV      DELTA      TOTAL
        SIGMA1     SIGMA3     STRESS    OCT        STRAIN    STRAIN     STRAIN                        ENERGY     ENERGY
        KPA        KPA        KPA       STRESS     %         %          %          KPA      %        KN-M/VOL   KN-M/VOL
                                        KPA

   1     29.5       19.5      10.0       22.8      0.000     0.000      0.000       0.0     0.0                  0.000
                                                                                                      0.015
   2     34.2       15.1      19.1       21.5      0.100    -0.050      0.000       7.8     0.1                  0.015
                                                                                                      0.027
   3     37.8       12.2      25.6       20.7      0.220    -0.110      0.000      13.2     0.3                  0.041
                                                                                                      0.034
   4     41.5       10.4      31.1       20.8      0.340    -0.170      0.000      17.6     0.4                  0.075
                                                                                                      0.045
   5     42.6        8.8      33.8       20.1      0.480    -0.240      0.000      20.0     0.6                  0.121
                                                                                                      0.053
   6     45.2        7.8      37.4       20.3      0.630    -0.315      0.000      22.8     0.8                  0.174
                                                                                                      0.050
   7     46.9        7.1      39.8       20.4      0.760    -0.380      0.000      24.7     0.9                  0.224
                                                                                                      0.053
   8     48.3        7.0      41.3       20.8      0.890    -0.445      0.000      25.8     1.1                  0.277
                                                                                                      0.119
   9     50.0        6.1      43.9       20.7      1.170    -0.585      0.000      27.9     1.4                  0.396
                                                                                                      0.128
  10     53.6        5.9      47.7       21.8      1.450    -0.725      0.000      30.8     1.8                  0.525
                                                                                                      0.137
  11     56.2        5.9      50.3       22.7      1.730    -0.865      0.000      32.9     2.1                  0.662
                                                                                                      0.267
  12     61.5        7.0      54.5       25.2      2.240    -1.120      0.000      36.6     2.7                  0.929
                                                                                                      0.071
  13     62.0        7.4      54.6       25.6      2.370    -1.185      0.000      36.7     2.9                  1.000
                                                                                                      0.160
  14     64.4        8.4      56.0       27.1      2.660    -1.330      0.000      38.3     3.3                  1.160
                                                                                                      0.158
  15     66.6        9.7      56.9       28.7      2.940    -1.470      0.000      39.6     3.6                  1.318
                                                                                                      0.168
  16     66.5       11.7      54.8       30.0      3.240    -1.620      0.000      38.6     4.0                  1.486
                                                                                                      0.076
  17     66.2       12.5      53.7       30.4      3.380    -1.690      0.000      38.0     4.1                  1.562
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 410      HOLE NO. =   6      DEPTH =   8.56 METRES TO   8.74 METRES

TEST RESULTS    START  19811005     END  19811009

 PT   EFFECT     EFFECT     DEV       EFFECT     AXIAL     RADIAL   VOL        LSSV     LSNV       DELTA      TOTAL
      SIGMA1     SIGMA3     STRESS    OCT        STRAIN    STRAIN   STRAIN                         ENERGY     ENERGY
      KPA        KPA        KPA       STRESS       %         %        %        KPA        %      KN-M/VOL  KN-M/VOL
                                      KPA

  1    29.6       19.1      10.5       22.6      1.225     0.386     1.997      0.0      0.0                  0.000
                                                                                                  0.123
  2    36.4       16.8      19.6       23.3      1.648     0.341     2.329      7.5      0.4                  0.123
                                                                                                  0.131
  3    42.1       13.2      28.9       22.8      2.068     0.227     2.521     15.0      0.9                  0.254
                                                                                                  0.209
  4    48.1       10.0      38.1       22.7      2.656    -0.015     2.625     22.5      1.5                  0.463
                                                                                                  0.268
  5    54.3        7.1      47.2       22.8      3.301    -0.382     2.537     30.0      2.3                  0.731
                                                                                                  0.172
  6    57.5        5.4      52.1       22.8      3.651    -0.573     2.505     34.0      2.8                  0.902
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 411      HOLE NO. =   6      DEPTH =   8.56 METRES TO   8.74 METRES

TEST RESULTS    START  19811012     END  19811014

 PT   EFFECT     EFFECT     DEV       EFFECT     AXIAL     RADIAL   VOL        LSSV     LSNV       DELTA      TOTAL
      SIGMA1     SIGMA3     STRESS    OCT        STRAIN    STRAIN   STRAIN                         ENERGY     ENERGY
      KPA        KPA        KPA       STRESS       %         %        %        KPA        %      KN-M/VOL  KN-M/VOL
                                      KPA

  1    89.2       57.8      31.4       68.3      0.000     0.000     0.000      0.0      0.0                  0.000
                                                                                                  0.014
  2    91.8       53.4      38.4       66.2      0.040    -0.020     0.000      6.7      0.0                  0.014
                                                                                                  0.021
  3    95.2       49.2      46.0       64.5      0.090    -0.045     0.000     13.6      0.1                  0.035
                                                                                                  0.066
  4    99.9       44.4      55.5       62.9      0.220    -0.110     0.000     21.8      0.3                  0.101
                                                                                                  0.070
  5   102.9       41.8      61.1       62.2      0.340    -0.170     0.000     26.5      0.4                  0.171
                                                                                                  0.122
  6   106.4       39.4      67.0       61.7      0.530    -0.265     0.000     31.2      0.6                  0.293
                                                                                                  0.083
  7   108.7       38.1      70.6       61.6      0.650    -0.325     0.000     34.0      0.8                  0.375
                                                                                                  0.072
  8   110.8       37.2      73.6       61.7      0.750    -0.375     0.000     36.3      0.9                  0.447
                                                                                                  0.223
  9   115.7       35.6      80.1       62.3      1.040    -0.520     0.000     41.1      1.3                  0.670
                                                                                                  0.223
 10   120.1       34.8      85.3       63.2      1.310    -0.655     0.000     44.9      1.6                  0.894
                                                                                                  0.261
 11   123.9       34.9      89.0       64.6      1.610    -0.805     0.000     47.5      2.0                  1.155
                                                                                                  0.245
 12   127.7       35.4      92.3       66.2      1.880    -0.940     0.000     49.9      2.3                  1.400
                                                                                                  0.372
 13   130.2       36.6      93.6       67.8      2.280    -1.140     0.000     50.8      2.8                  1.772
                                                                                                  0.188
 14   132.8       38.7      94.1       70.1      2.480    -1.240     0.000     51.3      3.0                  1.959
                                                                                                  0.318
 15   133.8       41.0      92.8       71.9      2.820    -1.410     0.000     50.5      3.5                  2.277
                                                                                                  0.102
 16   133.5       41.6      91.9       72.2      2.930    -1.465     0.000     49.9      3.6                  2.379
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 412      HOLE NO. =   6      DEPTH =   8.56 METRES TO   8.74 METRES

TEST RESULTS    START  19811017     END  19811024

 PT    EFFECT    EFFECT    DEV      EFFECT    AXIAL    RADIAL    VOL        LSSV    LSNV     DELTA     TOTAL
       SIGMA1    SIGMA3    STRESS   OCT       STRAIN   STRAIN    STRAIN                      ENERGY    ENERGY
       KPA       KPA       KPA      STRESS    %        %         %          KPA     %       KN-M/VOL  KN-M/VOL
                                    KPA

  1     89.1      57.9     31.2      68.3     3.635    1.032     5.700       0.0    0.0                0.000
                                                                                             0.246
  2     97.5      53.7     43.8      68.3     3.937    1.000     5.938      10.3    0.3                0.246
                                                                                             0.208
  3    105.7      49.4     56.3      68.2     4.254    0.890     6.034      20.5    0.7                0.454
                                                                                             0.236
  4    114.3      45.5     68.8      68.4     4.622    0.713     6.047      30.7    1.1                0.691
                                                                                             0.352
  5    122.5      41.4     81.1      68.4     5.090    0.480     6.050      40.7    1.7                1.043
                                                                                             0.300
  6    127.0      39.6     87.4      68.7     5.486    0.240     5.967      45.9    2.2                1.343
                                                                                             0.605
  7    130.2      36.9     93.3      68.0     6.205   -0.177     5.850      50.7    3.1                1.948

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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 413      HOLE NO. =   6      DEPTH =   8.56 METRES TO   8.74 METRES

TEST RESULTS    START  19811102     END  19811103

 PT    EFFECT    EFFECT    DEV      EFFECT    AXIAL    RADIAL    VOL        LSSV    LSNV     DELTA     TOTAL
       SIGMA1    SIGMA3    STRESS   OCT       STRAIN   STRAIN    STRAIN                      ENERGY    ENERGY
       KPA       KPA       KPA      STRESS    %        %         %          KPA     %       KN-M/VOL  KN-M/VOL
                                    KPA

  1     56.0      38.3     17.7      44.2     0.000    0.000     0.000       0.0    0.0                0.000
                                                                                             0.002
  2     56.5      36.1     20.4      42.9     0.010   -0.005     0.000       3.2    0.0                0.002
                                                                                             0.033
  3     63.0      28.6     34.4      40.1     0.130   -0.065     0.000      15.4    0.2                0.035
                                                                                             0.049
  4     66.6      25.3     41.3      39.1     0.260   -0.130     0.000      21.2    0.3                0.084
                                                                                             0.075
  5     69.7      22.9     46.8      38.5     0.430   -0.215     0.000      25.7    0.5                0.159
                                                                                             0.044
  6     71.6      21.2     50.4      38.0     0.520   -0.260     0.000      28.8    0.6                0.203
                                                                                             0.073
  7     73.6      20.1     53.5      37.9     0.660   -0.330     0.000      31.2    0.8                0.275
                                                                                             0.071
  8     75.1      19.0     56.1      37.7     0.790   -0.395     0.000      33.3    1.0                0.347
                                                                                             0.163
  9     78.4      17.8     60.6      38.0     1.070   -0.535     0.000      36.6    1.3                0.510
                                                                                             0.175
 10     81.7      17.4     64.3      38.8     1.350   -0.675     0.000      39.2    1.7                0.685
                                                                                             0.184
 11     84.6      17.6     67.0      39.9     1.630   -0.815     0.000      40.9    2.0                0.869
                                                                                             0.108
 12     86.0      18.2     67.8      40.8     1.790   -0.895     0.000      41.3    2.2                0.976
                                                                                             0.088
 13     86.8      18.9     67.9      41.5     1.920   -0.960     0.000      41.2    2.4                1.065
                                                                                             0.100
 14     86.1      20.7     65.4      42.5     2.070   -1.035     0.000      39.1    2.5                1.165
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 414      HOLE NO. =    6      DEPTH =   8.74 METRES TO   8.91 METRES

TEST RESULTS     START  19811105      END 198111122

 PT   EFFECT   EFFECT   DEV     EFFECT   AXIAL   RADIAL   VOL      LSSV    LSNV    DELTA    TOTAL
      SIGMA1   SIGMA3   STRESS  OCT      STRAIN  STRAIN   STRAIN                  ENERGY   ENERGY
      KPA      KPA      KPA     STRESS    %       %        %       KPA      %    KN-M/VOL KN-M/VOL
                                KPA

  1    59.5     38.5    21.0     45.5    2.529   0.784    4.097     0.0    0.0             0.000
                                                                                  0.096
  2    68.0     35.8    32.2     46.5    2.727   0.743    4.214     9.3    0.2             0.096
                                                                                  0.078
  3    72.0     32.4    39.5     45.6    2.886   0.695    4.276    15.2    0.4             0.174
                                                                                  0.149
  4    77.9     29.0    48.9     45.3    3.148   0.618    4.384    22.8    0.7             0.323
                                                                                  0.144
  5    84.5     26.0    58.5     45.5    3.399   0.509    4.417    30.6    1.0             0.467
                                                                                  0.088
  6    87.4     24.5    62.9     45.5    3.561   0.408    4.376    34.2    1.2             0.555
                                                                                  0.130
  7    90.6     22.9    67.7     45.5    3.749   0.330    4.408    38.1    1.4             0.686
                                                                                  0.179
  8    93.6     21.3    72.3     45.4    4.031   0.148    4.327    41.9    1.8             0.865
                                                                                  0.264
  9    96.5     19.8    76.7     45.4    4.403  -0.070    4.263    45.5    2.2             1.129
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 415      HOLE NO. =    6      DEPTH =  11.30 METRES TO  11.48 METRES

TEST RESULTS     START  19811027      END  19811031

 PT   EFFECT   EFFECT   DEV     EFFECT   AXIAL   RADIAL   VOL      LSSV    LSNV    DELTA    TOTAL
      SIGMA1   SIGMA3   STRESS  OCT      STRAIN  STRAIN   STRAIN                  ENERGY   ENERGY
      KPA      KPA      KPA     STRESS    %       %        %       KPA      %    KN-M/VOL KN-M/VOL
                                KPA

  1    78.0     50.8    27.2     59.9    0.665   0.053    0.772     0.0    0.0             0.000
                                                                                  0.098
  2    86.4     46.8    39.6     60.0    0.858  -0.008    0.841    10.1    0.2             0.098
                                                                                  0.145
  3    94.5     42.4    52.1     59.8    1.133  -0.125    0.883    20.3    0.5             0.243
                                                                                  0.201
  4   102.4     37.9    64.5     59.4    1.495  -0.313    0.858    30.5    1.0             0.444
                                                                                  0.294
  5   110.9     34.1    76.8     59.7    1.938  -0.566    0.806    40.5    1.5             0.738
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 416      HOLE NO. =   6      DEPTH =  11.30 METRES TO  11.48 METRES

TEST RESULTS    START  19811106     END  19811108

 PT    EFFECT    EFFECT    DEV       EFFECT    AXIAL    RADIAL     VOL        LSSV     LSNV       DELTA      TOTAL
       SIGMA1    SIGMA3    STRESS    OCT       STRAIN   STRAIN     STRAIN                          ENERGY     ENERGY
       KPA       KPA       KPA       STRESS      %        %          %        KPA        %      KN-M/VOL  KN-M/VOL
                                     KPA

  1     44.3      25.8      18.5      32.0     0.000    0.000      0.000      0.0      0.0                  0.000
                                                                                                0.002
  2     45.1      24.3      20.8      31.2     0.010   -0.005      0.000      2.3      0.0                  0.002
                                                                                                0.012
  3     49.4      20.8      28.6      30.3     0.060   -0.030      0.000      8.7      0.1                  0.014
                                                                                                0.043
  4     55.3      17.1      38.2      29.8     0.190   -0.095      0.000     16.5      0.2                  0.058
                                                                                                0.053
  5     59.0      15.4      43.6      29.9     0.320   -0.160      0.000     20.8      0.4                  0.111
                                                                                                0.064
  6     62.7      14.5      48.2      30.6     0.460   -0.230      0.000     24.4      0.6                  0.175
                                                                                                0.060
  7     65.0      14.0      51.0      31.0     0.580   -0.290      0.000     26.6      0.7                  0.235
                                                                                                0.079
  8     68.3      13.7      54.6      31.9     0.730   -0.365      0.000     29.5      0.9                  0.314
                                                                                                0.085
  9     71.9      13.8      58.1      33.2     0.880   -0.440      0.000     32.4      1.1                  0.398
                                                                                                0.077
 10     74.1      13.9      60.2      34.0     1.010   -0.505      0.000     34.2      1.2                  0.475
                                                                                                0.086
 11     77.0      14.2      62.8      35.1     1.150   -0.575      0.000     36.6      1.4                  0.561
                                                                                                0.095
 12     78.5      14.4      64.1      35.8     1.300   -0.650      0.000     37.8      1.6                  0.657
                                                                                                0.078
 13     80.8      15.0      65.8      36.9     1.420   -0.710      0.000     39.6      1.7                  0.735
                                                                                                0.197
 14     86.1      15.9      70.2      39.3     1.710   -0.855      0.000     44.1      2.1                  0.932
                                                                                                0.099
 15     87.8      16.8      71.0      40.5     1.850   -0.925      0.000     45.3      2.3                  1.031
                                                                                                0.100
 16     89.1      17.3      71.8      41.2     1.990   -0.995      0.000     46.4      2.4                  1.131
                                                                                                0.208
 17     91.5      19.7      71.8      43.6     2.280   -1.140      0.000     48.0      2.8                  1.339
                                                                                                0.107
 18     91.7      20.7      71.0      44.4     2.430   -1.215      0.000     47.9      3.0                  1.446
                                                                                                0.050
 19     91.7      21.2      70.5      44.7     2.500   -1.250      0.000     47.8      3.1                  1.495
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ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 417      HOLE NO. =   6      DEPTH =  11.30 METRES TO  11.48 METRES

TEST RESULTS    START  19811106     END  19811114


 PT    EFFECT   EFFECT   DEV     EFFECT   AXIAL    RADIAL    VOL       LSSV    LSNV     DELTA      TOTAL
       SIGMA1   SIGMA3   STRESS  OCT      STRAIN   STRAIN    STRAIN                     ENERGY     ENERGY
       KPA      KPA      KPA     STRESS     %        %         %       KPA      %     KN-M/VOL  KN-M/VOL
                                 KPA

  1     38.8     25.3    13.5     29.8    -0.076   -0.140    -0.356     0.0    0.0                0.000
                                                                                     -0.071
  2     37.5     21.7    15.8     27.0    -0.129   -0.203    -0.625     5.3    0.2               -0.071
                                                                                     -0.036
  3     38.1     19.9    18.2     26.0    -0.145   -0.319    -0.784     7.7    0.3               -0.107
                                                                                     -0.029
  4     37.7     17.3    20.4     24.1    -0.153   -0.388    -0.929    11.4    0.4               -0.135
                                                                                     -0.024
  5     37.3     14.5    22.8     22.1    -0.155   -0.460    -1.075    15.3    0.5               -0.159
                                                                                     -0.017
  6     37.1     13.1    24.0     21.1    -0.155   -0.521    -1.198    17.3    0.5               -0.176
                                                                                     -0.012
  7     36.9     11.8    25.1     20.2    -0.148   -0.578    -1.305    19.2    0.6               -0.188
                                                                                     -0.016
  8     37.0     10.8    26.2     19.5    -0.148   -0.640    -1.446    20.6    0.7               -0.203
                                                                                     -0.031
  9     36.4      9.1    27.3     18.2    -0.158   -0.785    -1.727    23.0    0.9               -0.234
                                                                                      0.021
 10     36.0      6.4    29.6     16.3     0.019   -1.059    -2.100    26.9    1.3               -0.213
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UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY
ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 418      HOLE NO. =   6      DEPTH =   8.56 METRES TO   8.74 METRES

TEST RESULTS    START  19811211     END  19811212


 PT    EFFECT   EFFECT   DEV     EFFECT   AXIAL    RADIAL    VOL       LSSV    LSNV     DELTA      TOTAL
       SIGMA1   SIGMA3   STRESS  OCT      STRAIN   STRAIN    STRAIN                     ENERGY     ENERGY
       KPA      KPA      KPA     STRESS     %        %         %       KPA      %     KN-M/VOL  KN-M/VOL
                                 KPA

  1     29.4     21.4     8.0     24.1     0.000    0.000     0.000     0.0    0.0                0.000
                                                                                      0.004
  2     31.3     18.4    12.9     22.7     0.040   -0.020     0.000     4.6    0.0                0.004
                                                                                      0.029
  3     36.0     12.5    23.5     20.3     0.200   -0.100     0.000    14.2    0.2                0.033
                                                                                      0.025
  4     37.1     11.2    25.9     19.8     0.300   -0.150     0.000    16.4    0.4                0.058
                                                                                      0.043
  5     38.7     10.5    28.2     19.9     0.460   -0.230     0.000    18.0    0.6                0.101
                                                                                      0.046
  6     39.0      9.7    29.3     19.5     0.620   -0.310     0.000    19.1    0.8                0.147
                                                                                      0.051
  7     39.3      9.0    30.3     19.1     0.790   -0.395     0.000    20.1    1.0                0.198
                                                                                      0.036
  8     39.0      8.7    30.3     18.8     0.910   -0.455     0.000    20.4    1.1                0.234
                                                                                      0.052
  9     38.8      8.3    30.5     18.5     1.080   -0.540     0.000    20.8    1.3                0.286
                                                                                      0.092
 10     39.5      8.4    31.1     18.8     1.380   -0.690     0.000    21.0    1.7                0.378
                                                                                      0.094
 11     39.9      8.5    31.4     19.0     1.680   -0.840     0.000    21.0    2.1                0.472
                                                                                      0.101
 12     40.1      8.5    31.6     19.0     2.000   -1.000     0.000    21.1    2.4                0.573
                                                                                      0.102
 13     40.5      8.4    32.1     19.1     2.320   -1.160     0.000    21.5    2.8                0.675
                                                                                      0.045
 14     40.3      8.4    31.9     19.0     2.460   -1.230     0.000    21.4    3.0                0.720
                                                                                      0.045
 15     40.4      8.5    31.9     19.1     2.600   -1.300     0.000    21.3    3.2                0.764
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SOIL MECHANICS LABORATORY
ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 419      HOLE NO. =   6      DEPTH =   8.74 METRES TO   8.92 METRES

TEST RESULTS     START  19811210     END  19811215


 PT    EFFECT   EFFECT   DEV      EFFECT   AXIAL    RADIAL   VOL       LSSV   LSNV    DELTA     TOTAL
       SIGMA1   SIGMA3   STRESS   OCT      STRAIN   STRAIN   STRAIN                  ENERGY    ENERGY
       KPA      KPA      KPA      STRESS     %        %        %       KPA     %    KN-M/VOL  KN-M/VOL
                                  KPA

  1     32.1     21.0     11.1     24.7     6.127    0.957    8.042     0.0    0.0              0.000
                                                                                   -0.006
  2     31.8     16.6     15.2     21.7     6.184    0.892    7.969     6.2    0.1             -0.006
                                                                                   -0.001
  3     32.5     13.2     19.3     19.6     6.262    0.805    7.875    11.0    0.3             -0.007
                                                                                   -0.003
  4     32.5      9.0     23.5     16.8     6.363    0.644    7.651    17.0    0.5             -0.010
                                                                                    0.054
  5     32.8      5.2     27.6     14.4     6.672    0.313    7.297    22.4    1.1              0.044
                                                                                    0.419
  6     33.8      3.2     30.6     13.4     7.661    1.374   10.409    25.2    1.6              0.462
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SOIL MECHANICS LABORATORY
ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 420      HOLE NO. =   6      DEPTH =   8.56 METRES TO   8.74 METRES

TEST RESULTS     START  19811214     END  19811214


 PT    EFFECT   EFFECT   DEV      EFFECT   AXIAL    RADIAL   VOL       LSSV   LSNV    DELTA     TOTAL
       SIGMA1   SIGMA3   STRESS   OCT      STRAIN   STRAIN   STRAIN                  ENERGY    ENERGY
       KPA      KPA      KPA      STRESS     %        %        %       KPA     %    KN-M/VOL  KN-M/VOL
                                  KPA

  1     61.7     40.4     21.3     47.5     0.000    0.000    0.000     0.0    0.0              0.000
                                                                                    0.013
  2     64.6     35.4     29.2     45.1     0.050   -0.025    0.000     7.6    0.1              0.013
                                                                                    0.052
  3     69.3     29.2     40.1     42.6     0.200   -0.100    0.000    17.6    0.2              0.065
                                                                                    0.059
  4     70.9     26.7     44.2     41.4     0.340   -0.170    0.000    21.4    0.4              0.124
                                                                                    0.082
  5     71.8     24.9     46.9     40.5     0.520   -0.260    0.000    24.1    0.6              0.206
                                                                                    0.062
  6     72.2     24.0     48.2     40.1     0.650   -0.325    0.000    25.5    0.8              0.267
                                                                                    0.093
  7     72.9     23.5     49.4     40.0     0.840   -0.420    0.000    26.4    1.0              0.360
                                                                                    0.055
  8     72.8     22.8     50.0     39.5     0.950   -0.475    0.000    27.3    1.2              0.415
                                                                                    0.091
  9     73.3     22.5     50.8     39.4     1.130   -0.565    0.000    27.8    1.4              0.506
                                                                                    0.077
 10     73.4     22.0     51.4     39.1     1.280   -0.640    0.000    28.5    1.6              0.582
                                                                                    0.072
 11     73.6     21.7     51.9     39.0     1.420   -0.710    0.000    29.0    1.7              0.654
                                                                                    0.083
 12     73.8     21.4     52.4     38.9     1.580   -0.790    0.000    29.5    1.9              0.738
                                                                                    0.089
 13     73.9     21.2     52.7     38.8     1.750   -0.875    0.000    29.8    2.1              0.827
                                                                                    0.164
 14     74.5     21.1     53.4     38.9     2.060   -1.030    0.000    30.1    2.5              0.992
                                                                                    0.172
 15     75.1     21.1     54.0     39.1     2.380   -1.190    0.000    30.4    2.9              1.164
                                                                                    0.179
 16     75.5     20.9     54.6     39.1     2.710   -1.355    0.000    30.8    3.3              1.343
                                                                                    0.240
 17     76.0     21.3     54.7     39.5     3.150   -1.575    0.000    30.6    3.9              1.583
                                                                                    0.104
 18     76.1     21.6     54.5     39.8     3.340   -1.670    0.000    30.2    4.1              1.687
                                                                                    0.179
 19     75.9     21.9     54.0     39.9     3.670   -1.835    0.000    29.8    4.5              1.866
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UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY
ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 421       HOLE NO. =    6       DEPTH =    8.74 METRES TO    8.91 METRES

TEST RESULTS     START  19820108      END  19820119

 PT    EFFECT     EFFECT    DEV      EFFECT    AXIAL    RADIAL    VOI       LSSV     LSNV      DELTA     TOTAL
       SIGMA1     SIGMA3    STRESS   OCT       STRAIN   STRAIN    STRAIN                       ENERGY    ENERGY
       KPA        KPA       KPA      STRESS      %        %         %       KPA       %      KN-M/VOL  KN-M/VOL
                                     KPA

  1     62.0       40.2     21.8      47.5      8.017    1.630    11.278     0.0     0.0                 0.000
                                                                                             0.121
  2     64.4       38.8     25.6      47.3      8.229    1.615    11.458     3.1     0.2                 0.121
                                                                                             0.142
  3     67.6       37.6     30.0      47.6      8.459    1.602    11.663     6.7     0.4                 0.264
                                                                                             0.096
  4     70.2       36.0     34.2      47.4      8.640    1.563    11.765    10.1     0.6                 0.359
                                                                                             0.086
  5     73.1       34.7     38.4      47.5      8.770    1.553    11.876    13.6     0.8                 0.446
                                                                                             0.061
  6     74.4       33.9     40.5      47.4      8.886    1.515    11.919    15.3     0.9                 0.506
                                                                                             0.038
  7     75.7       33.2     42.5      47.4      8.971    1.479    11.928    16.9     1.0                 0.544
                                                                                             0.068
  8     77.3       32.7     44.6      47.6      9.102    1.430    11.962    18.6     1.1                 0.613
                                                                                             0.094
  9     78.4       31.6     46.8      47.2      9.224    1.429    12.082    20.4     1.2                 0.707
                                                                                             0.119
 10     79.8       31.0     48.8      47.3      9.419    1.372    12.164    22.0     1.4                 0.826
                                                                                             0.163
 11     81.5       30.6     50.9      47.6      9.672    1.306    12.283    23.8     1.7                 0.989
                                                                                             0.200
 12     84.0       29.0     55.0      47.3     10.001    1.184    12.369    27.1     2.1                 1.189
                                                                                             0.352
 13     86.7       27.6     59.1      47.3     10.557    0.967    12.492    30.5     2.7                 1.541
                                                                                             0.516
 14     89.5       26.4     63.1      47.4     11.349    0.631    12.611    33.7     3.6                 2.057
                                                                                             0.584
 15     92.5       24.5     68.0      47.2     12.244    0.179    12.602    37.7     4.7                 2.641
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UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY
ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 422      HOLE NO. =   6      DEPTH =   8.74 METRES TO   8.92 METRES

TEST RESULTS    START  19820112     END  19820113

 PT   EFFECT    EFFECT    DEV      EFFECT    AXIAL    RADIAL    VOL       LSSV    LSNV     DELTA     TOTAL
      SIGMA1    SIGMA3    STRESS   OCT       STRAIN   STRAIN    STRAIN                     ENERGY    ENERGY
      KPA       KPA       KPA      STRESS    %        %         %         KPA     %      KN-M/VOL  KN-M/VOL
                                   KPA

  1    85.4      62.5      22.9     70.1     0.000    0.000     0.000      0.0    0.0                0.000
                                                                                          0.011
  2    89.3      57.2      32.1     67.9     0.040   -0.020     0.000      8.4    0.0                0.011
                                                                                          0.053
  3    97.0      48.1      48.9     64.4     0.170   -0.085     0.000     23.4    0.2                0.064
                                                                                          0.079
  4   100.5      44.0      56.5     62.8     0.320   -0.160     0.000     30.2    0.4                0.143
                                                                                          0.105
  5   101.3      41.1      60.2     61.2     0.500   -0.250     0.000     34.2    0.6                0.248
                                                                                          0.091
  6   101.6      39.9      61.7     60.5     0.650   -0.325     0.000     35.8    0.8                0.339
                                                                                          0.094
  7   101.8      38.8      63.0     59.8     0.800   -0.400     0.000     37.3    1.0                0.433
                                                                                          0.070
  8   101.6      38.0      63.6     59.2     0.910   -0.455     0.000     38.2    1.1                0.502
                                                                                          0.141
  9   102.0      37.0      65.0     58.7     1.130   -0.565     0.000     39.7    1.4                0.644
                                                                                          0.224
 10   102.2      35.6      66.6     57.8     1.470   -0.735     0.000     41.6    1.8                0.867
                                                                                          0.222
 11   102.7      34.7      68.0     57.4     1.800   -0.900     0.000     43.0    2.2                1.090
                                                                                          0.233
 12   103.3      34.0      69.3     57.1     2.140   -1.070     0.000     44.1    2.6                1.323
                                                                                          0.251
 13   103.7      33.3      70.4     56.8     2.500   -1.250     0.000     45.2    3.1                1.574
                                                                                          0.106
 14   104.1      33.4      70.7     57.0     2.650   -1.325     0.000     45.2    3.2                1.680
                                                                                          0.135
 15   104.4      33.2      71.2     56.9     2.840   -1.420     0.000     45.6    3.5                1.815
                                                                                          0.107
 16   105.0      33.2      71.8     57.1     2.990   -1.495     0.000     45.8    3.7                1.922
                                                                                          0.245
 17   105.5      32.9      72.6     57.1     3.330   -1.665     0.000     46.4    4.1                2.168
                                                                                          0.241
 18   106.8      33.1      73.7     57.7     3.660   -1.830     0.000     46.8    4.5                2.409
                                                                                          0.266
 19   107.4      33.1      74.3     57.9     4.020   -2.010     0.000     47.0    4.9                2.676
                                                                                          0.247
 20   108.3      33.1      75.2     58.2     4.350   -2.175     0.000     47.5    5.3                2.922
                                                                                          0.264
 21   109.3      33.5      75.8     58.8     4.700   -2.350     0.000     47.5    5.8                3.187
                                                                                          0.258
 22   109.6      33.7      75.9     59.0     5.040   -2.520     0.000     47.4    6.2                3.444
                                                                                          0.137
 23   109.9      34.1      75.8     59.4     5.220   -2.610     0.000     47.0    6.4                3.581
                                                                                          0.121
 24   109.9      34.5      75.4     59.6     5.380   -2.690     0.000     46.6    6.6                3.702
                                                                                          0.113
 25   110.3      35.0      75.3     60.1     5.530   -2.765     0.000     46.2    6.8                3.815
                                                                                          0.158
 26   110.4      35.2      75.2     60.3     5.740   -2.870     0.000     46.0    7.0                3.973
                                                                                          0.112
 27   110.1      35.4      74.7     60.3     5.890   -2.945     0.000     45.6    7.2                4.085
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